Department of Bioscience & Biotechnology

Banasthali Vidyapith, Banasthali

Minutes of the Board of Studies held on December 26, 2018 at 3:00 p.m. in the Conference Room, Department of Bioscience and Biotechnology, Banasthali Vidyapith

Present

1.	Prof. Arun Kumar Sharma	External Member
2.	Dr. Asheesh Shanker	External Member
3.	Prof. N. P. Singh	External Member
4.	Dr. Afroz Alam	Internal Member
5.	Shri Anand Prakash	Internal Member
6.	Dr. Aneesh Goyal	Internal Member
7.	Dr. Arindam Kuila	Internal Member
8.	Dr. Arun Sharma	Internal Member
9.	Prof. Dipjyoti Chakraborty	Convener (in the Chair)
10.	Dr. Girish C. Pandey	Internal Member
11.	Dr. Himani Kuntal	Internal Member
12.	Dr. Jyoti Mathur	Internal Member
13.	Dr. Kakoli Dutt	Internal Member
14.	Dr. Laxmi Parwani	Internal Member
15.	Dr. Monika Sharma	Internal Member
16.	Dr. Nidhi Srivastava	Internal Member
17.	Dr. Priyanka Singh	Internal Member
18.	Dr. Rashmi Tripathi	Internal Member
19.	Dr. Sangeeta Choudhary	Internal Member
20.	Dr. Sarika Gupta	Internal Member
21.	Dr. Sharad Vats	Internal Member
22.	Dr. Surbhi Bajpai	Internal Member
23.	Dr. Surya P Singh	Internal Member
24.	Mr. Sushil Buriya	Internal Member (Special Invitee)
25.	Dr. Swati Paliwal	Internal Member
26.	Dr. Teena Agarwal	Internal Member
27.	Prof. Veena Sharma	Internal Member
28.	Prof. Chandra Kumar Jha	Internal Member (Special Invitee)

Note: Prof. Partha Roy, Dr. Shashi Kumar, Dr. Anil Prakash and Dr. Ashok Sharma, External Members and Prof. Veena Garg, Prof. Nilima Kumari, Dr. Suphiya Khan, Dr. Rupesh Kumar, Dr. Manisha Sharma, Internal Member could not attend the meeting.

The meeting started with a welcome of the members, by the convener of Board of Studies for Bioscience and Biotechnology, Prof. Dipjyoti Chakarborty, Head, Department of Bioscience and Biotechnology, Banasthali Vidyapith, Rajasthan.

1. The Board took up for confirmation of the minutes of its last meeting held on 04th May, 2013.

   The Board resolved that the minutes of its last meeting be confirmed.

2. The board updated the panel of examiners for various examinations of Bachelor's and Master's degree ifn accordance with the Bye-laws 15.3.02 of the Vidyapith. The existing panel will continue to be retained. The updated list of examiners is submitted.
3. The Board discussed M. Tech. Bioinformatics programme and after considerable deliberations, it was suggested to discontinue the programme from the academic session 2018-19.

4. The various courses running in the department viz., B.Sc. Bioscience, B.Sc. Biotechnology, B.Tech. Biotechnology, M.Sc. Bioscience (Animal Science), M.Sc. Bioscience (Plant Science), M.Sc. Applied Microbiology and Biotechnology, M.Sc. Biotechnology, M.Sc. Bioinformatics, M.Tech. Biotechnology, Certificate Course in Molecular Modeling and Drug Designing, Diploma in Computational Biology were placed before the board, thoroughly discussed and revision proposed as under:

3. IA. B.Sc. Bioscience (Botany and Zoology):

i.	First Semester Examination, December, 2019	Change [a]
ii.	Second Semester Examination, April/May, 2020	Change [b]
iii.	Third Semester Examination, December, 2020	Change [c]
iv.	Fourth Semester Examination, April/May, 2021	Change [d]
v.	Fifth Semester Examination, December, 2021	Change [e]
vi.	Sixth Semester Examination, April/May, 2022	Change [f]

(a) In the first semester of B.Sc. Bioscience programme, laboratory course ZOO 102L is proposed to be modified by including the five major exercises: study of museum specimens, study of prepared slides, preparation of permanent mount, anatomical study of selected animals and collection & culture methods. Animals of invertebrate phyla (protozoa to protochordata) are included in these exercises. In the "anatomical study exercise", the name of the animals and their anatomical systems have been specified for clear understanding. In addition to that, exercise related to study of microscope, evolution & permanent mount preparation of mosquito are also proposed to be included in the revised syllabus.

Zoology course ZOO 102: Taxonomy, Classification and Evolution is proposed to be modified by inclusion of phyla of the non chordates for clear understanding of the topics to be covered.

The contents of the Botany course BOT 101: Algae, Fungi, Bryophyta, Pteridophyta and Gymnosperms and its laboratory course BOT 101L: Algae, Fungi, Bryophyta, Pteridophyta and Gymnosperms Lab are proposed to be revised and updated.

(b) In the second semester of B.Sc. Bioscience programme, laboratory course ZOO 101L is proposed to be modified by including the five major exercises as discussed in the first semester laboratory course ZOO 102L. These five major exercises are proposed to be included in laboratory courses of first (ZOO 102L) and second semester (ZOO 101L) because theory courses in these semesters deals with the study of invertebrates. Therefore, specimens of protozoa to protochordata phyla are placed in these five major exercises and are equally distributed in the first (ZOO 102L) and second semester (ZOO 101L) laboratory course. In addition to these five major exercises, permanent mount preparation of house fly is also proposed to be included.

In the second semester, the Zoology course ZOO 101: Non-Chordates and Proto-Chordates, is proposed to be modified.

(c) In the third semester, the Zoology course ZOO 201: Cell Biology, Molecular Biology, Histology and Genetics, Biochemistry is proposed to be modified with the contents of human genetics included in Unit-V.

The Laboratory course ZOO 201L: Cell Biology, Molecular Biology, Histology and Genetics Lab is proposed to be revised and updated.

The Botany course, BOT 201: Angiosperm Taxonomy and Economic Botany, is proposed to be modified with some topics from Unit-I elaborated for clear understanding.

The laboratory course BOT 201L: Angiosperm Taxonomy and Economic Botany is proposed to be modified with inclusion of preparation of herbarium sheets which is an important component of taxonomy.

(d) In the fourth semester, the course ZOO 202L: Comparative Anatomy and Embryology of Chordates Lab is proposed to be modified.

The course BOT 202: Microbiology and Plant Pathology, is proposed to be modified viz., bacteriological section in Unit-I and virology section in Unit-II is proposed to be more elaborated and related topics placed together. The laboratory course BOT 202L: Microbiology and Plant Pathology Lab is proposed to be modified by elaborating the existing microbiological exercises and including certain more relevant experiments in microbiology.

(e) In the fifth semester, discipline electives are proposed to be offered in the fifth semester. For Botany discipline, four elective courses along with their practical exercises are proposed. The courses “Introduction to Genetics and Genetic Engineering” and “Plant Physiology and Ecology” are offered as core courses in the existing syllabus but now these two courses are proposed to be offered as a discipline electives along with the two newly introduced discipline elective courses “Ethnobotany” and “Horticulture”.

The complete list of elective courses of Botany discipline offered in the fifth semester are as follows

- Introduction to Genetics and Genetic Engineering
- Plant Physiology and Ecology
- Ethnobotany (Newly introduced)
- Horticulture (Newly introduced)

Similarly, for Zoology discipline, four elective courses along with their practical exercises are proposed to be offered in the fifth and sixth semesters. Out of these four courses, two courses “Animal Physiology” and “Environmental Biology and Biostatistics” are offered as core courses in the existing syllabus but now these two courses are proposed to be offered as discipline electives. In the Zoology discipline, two elective courses “Developmental Biology” and “Applied Zoology” are newly introduced.

These four elective courses are as follows

- Animal Physiology
- Environmental Biology and Biostatistics
- Developmental Biology (Newly introduced)
- Applied Zoology (Newly introduced)

The elective courses of Botany and Zoology disciplines are common with B.Sc. Biotechnology Programme.

The benefit of offering the discipline elective courses in stead of the core courses in the fifth and sixth semester is that the students can choose the course of their interest. Student has to opt one elective course from Botany discipline and one elective course from Zoology discipline in the fifth semester.

In the fifth semester, the course ZOO 302: Environmental Biology, the topic - 'pollution' which is already covered as such in the course BOT 303: Plant Physiology and Ecology is proposed to be replaced by biostatistics. It will introduce the fundamental principles of biostatistics and its role in the data analysis which would help the students to apply the biostatistics tools for better presentation of the research data. The course is proposed to be renamed as 'Environmental Biology and Biostatistics'.

The laboratory course ZOO 302L: Environmental Biology Lab is proposed to be renamed as ‘Environmental Biology and Biostatistics Lab’.

The syllabus of the Botany courses BOT 303: Plant Physiology and Ecology and BOT 303L: Plant Physiology and Ecology Lab are proposed to be revised and updated.

The vocational course, Analytical Lab Practice-I from fifth semester is proposed to be discontinued in the revised syllabus.

(f) In the sixth semester, the elective courses of Botany and Zoology disciplines as mentioned above in the fifth semester minutes are also proposed to be offered in the sixth semester of B.Sc. Bioscience programme. Student has to opt one elective course from Botany discipline and one elective course from Zoology discipline in the sixth semester.

In the sixth semester, the course ZOO 301: Animal Physiology is proposed to be modified and certain topics elaborated. The sixth semester course BOT 302: Introduction to Genetics and Genetic Engineering is proposed to be modified. Experiments of molecular biology and basic bio-safety laboratory guidelines are proposed to be incorporated in the laboratory course BOT 302L: Introduction to Genetics and Genetic Engineering Lab.

The vocational course Analytical Lab Practice-II is proposed to be discontinued from the sixth semester.

Additionally, it is proposed that a student can opt for at most 2 additional Open (Generic) audit/credit Elective from other disciplines opting at most 1 per semester in Semesters III, IV, V or VI with prior permission of respective heads and time table permitting.

E-resources have been proposed for the theory courses and the list of recommended books has been updated. The board also reviewed the Programme Educational Objectives, Programme outcomes and the Learning outcomes of the courses keeping in view the proposed modifications.

The proposed Programme Educational Objectives, Programme outcomes and modified syllabus are included and marked as **Appendix-IA** (page 30), **Appendix-IB** (page 31) and **Appendix–IC** (pages 32-87) respectively.

3. IB. B.Sc. Biotechnology:

i.	First Semester Examination, December, 2019	Change [a]
ii.	Second Semester Examination, April/May, 2020	Change [b]

iii.	Third Semester Examination, December, 2020	Change [c]
iv.	Fourth Semester Examination, April/May, 2021	Change [d]
v.	Fifth Semester Examination, December, 2021	Change [e]
vi.	Sixth Semester Examination, April/May, 2022	Change [f]

(a) In the first semester of the B.Sc Biotechnology programme, the Botany course BOT 101: Algae, Fungi, Bryophyta, Pteridophyta and Gymnosperms and its laboratory course BOT 101L: Algae, Fungi, Bryophyta, Pteridophyta and Gymnosperms Lab are proposed to be modified as per the proposed changes in B.Sc. Bioscience programme.

Some topics of the Biotechnology course BT 102: Cell and Molecular Biology-I have been elaborated and specified for clear understanding of the topics to be covered. Some of the outdated laboratory experiments such as study of cell organelles under microscope are proposed to be replaced by more relevant experiments in the BT 102L: Cell and Molecular Biology-I Lab course.

(b) In the second semester, ZOO 101: Non-Chordates & Protochordates and ZOO 101L: Non-Chordates and Protochordates Lab courses are proposed to be modified as per the proposed changes in the same courses which are running common in second semester of B.Sc. Bioscience.

The contents of the course BT 101: Biostatistics, Bioinformatics and Instrumentation are proposed to be modified as per the present need of the course. Bioinformatics and biostatistics exercises have been elaborated and specified along with few modifications of existing practical exercises in the second semester course BT 101L: Biostatistics, Bioinformatics and Instrumentation Lab.

(c) In the third semester, the botany course BOT 201: Angiosperm Taxonomy and Economic Botany and its laboratory course i.e. BOT 201L: Angiosperm Taxonomy and Economic Botany Lab are proposed to be modified as per the proposed changes in the B.Sc. Bioscience programme.

Relevant modifications in the contents of Biotechnology course BT 202: Biochemistry, Biophysics and Enzymology and 202L: Biochemistry, Biophysics and Enzymology Lab are proposed. Enzymology exercises related to acid phosphatase extracted from moong is proposed to be replaced by the enzyme urease extracted from horse gram seeds.

(d) In the fourth semester, some experiments of the laboratory course ZOO 202L: Comparative Anatomy and Embryology of Chordates Lab are proposed to be more specified for clear understanding. The Genetics section in Unit-I is proposed to be extended by inclusion of some portion from the human genetics in the course BT 207: Genetics, Microbiology and Immunology. BT 207L: Genetics, Microbiology and

Immunology Lab is proposed to be modified by introduction of new microbiological exercises.

(e) In the fifth semester, elective courses along with their practical exercises specific to Botany and Biotechnology disciplines are proposed to be offered as "Discipline Elective". The course "Plant Physiology and Ecology" is already offered as a core course in the fifth semester but now it is proposed to be offered as a discipline elective course. Three elective courses of Botany discipline "Introduction to Genetics and Genetic Engineering", "Ethnobotany" and "Horticulture"are proposed to be included for the first time in B.Sc Biotechnology programme.

The four elective courses of Botany discipline which are proposed to be offered common with B.Sc. Bioscience programme are as follows

- Introduction to Genetics and Genetic Engineering (Newly introduced)
- Plant Physiology and Ecology
- Ethnobotany (Newly introduced)
- Horticulture (Newly introduced)

Similarly, for Biotechnology discipline, four elective courses along with their laboratory components are proposed to be offered in the fifth semester. Among these, the courses "Genetic Engineering, rDNA Technology and Cell & Tissue Culture Technology" and "Advances in Biotechnology" which are already offered as core courses in the fifth and sixth semester are proposed to be offered as discipline elective courses. Two elective courses "Animal and Plant Biotechnology" and "Environmental Biotechnology" are proposed to be offered for the first time in B.Sc. Biotechnology programme.

The list of Biotechnology elective courses are as follows

- Genetic Engineering, rDNA Technology and Cell & Tissue Culture Technology
- Advances in Biotechnology
- Animal and Plant Biotechnology (Newly introduced)
- Environmental Biotechnology (Newly introduced)

The student has to opt one elctive course from Botany discipline and another elective course from Biotechnology discipline.

Botany course BOT 303: Plant Physiology and Ecology and its laboratory course BOT 303L: Plant Physiology and Ecology Lab which are running common with B.Sc. Bioscience programme are proposed to be modified as per the proposed changes in the same courses/ semester of B.Sc. Bioscience programme.

The Biotechnology course BT 307: Genetic Engineering, rDNA Technology and Cell and Tissue Culture Technology is proposed to be modified as per the present need and advancement of the topic. Few modifications are proposed to be included in the practical course BT 307L: Genetic Engineering, rDNA Technology and Cell and Tissue Culture Technology Lab.

The vocational course Analytical Lab Practice-I is proposed to be discontinued from the fifth semester.

(f) In the sixth semester, elective courses along with their laboratory components specific to Zoology and Biotechnology disciplines are proposed to be offered as "Discipline Elective". Four elective courses of Biotechnology discipline as mentioned above in the fifth semester minutes are also proposed to be offered in the sixth semester. The course "Animal Physiology" is already running in the sixth semester as core course but now it is proposed to be offered as discipline elective course. Three elective courses of Zoology discipline "Environmental Biology and Biostatistics", "Developmental Biology" and "Applied Zoology" are proposed to be included for the first time in the B.Sc. Biotechnology programme.

The four elective courses of Zoology discipline which are proposed to be offered common with B.Sc. Bioscience programme are as follows

- Animal Physiology
- Environmental Biology and Biostatistics (Newly introduced)
- Developmental Biology (Newly introduced)
- Applied Zoology (Newly introduced)

The student has to opt one elctive course from Botany discipline and another elective course from Biotechnology discipline.

The Zoology course ZOO 301: Animal Physiology is proposed to be modified according to the proposed changes in the same courses/semester of the B.Sc. Bioscience programme.

The Biotechnology course BT 301: Advances in Biotechnology is proposed to be modified by elaboration of some topics. The elaboration is necessary for the better understanding.

The Bioinformatics exercise-1 & 2 from the laboratory course BT 301L: Advances in Biotechnology Lab is proposed to be replaced by more relevant exercises as per the course contents.

The vocational course "Analytical Lab Practice-II" is proposed to be discontinued from the sixth semester.

Additionally, it is proposed that a student can opt for at most 2 additional Open (Generic) audit/credit Elective from other disciplines opting at most 1 per semester in Semesters III, IV, V or VI with prior permission of respective heads and time table permitting.

E-resources have been proposed for the theory courses and the list of recommended books has been updated. The board also reviewed the Programme Educational

Objectives, Programme outcomes and the Learning outcomes of the courses keeping in view the proposed modifications.

The proposed Programme Educational Objectives, Programme outcomes and modified syllabi are included and marked as **Appendix-IIA** (pages 88), **Appendix-IIB** (pages 89) and **Appendix–IIC** (pages 90-162) respectively.

3. II. B.Tech. Biotechnology:

i.	First Semester Examination, December, 2019	Change [a]
ii.	Second Semester Examination, April/May, 2020	Change [a]
iii.	Third Semester Examination, December, 2020	Change [b]
iv.	Fourth Semester Examination, April/May, 2021	Change [c]
v.	Fifth Semester Examination, December, 2021	Change [d]
vi.	Sixth Semester Examination, April/May, 2022	Change [e]
vii.	Seventh Semester Examination, December, 2022	Change [f]
viii.	Eighth Semester Examination, April/May, 2023	Change [g]

(a) In the first and second semester of the B. Tech Biotechnology programme, the contents of BIO101: Biology and ENGG 102L: Measurement Technique Lab is proposed to be revised by adding relevant topics/experiments.

(b) In the third semester new experiments are proposed to be introduced in BT 204L: Biotechnology Lab-I.

(c) The fourth semester course BT 203: Biophysics and Structural Biology is proposed to be revised and irrelevant portions removed. BT 205L: Biotechnology Lab-II is proposed to be modified. Seminar (BT 208S) is proposed to be shifted from the fifth semester to the third semester.

(d) In the fifth semester, the course 'Probability and Statistics' is proposed to be introduced. Some practical's of the course BT 303L: Biotechnology Lab-III are proposed to be incorporated in the fourth semester laboratory course.

The course BT 306: Enzyme Engineering and Technology which is running as a core course is now proposed as an Elective in the eighth semester.

(e) In the sixth semester, some modifications are proposed in the topics of the course BIN 301: Basic Bioinformatics. The course BT 305: Cell and Tissue Culture Technology is proposed to be dropped and contents incorporated in other relevant courses. The contents of the course BT 311: Recombinant DNA Technology, CHEM 301: Analytical Techniques and BT 304L: Biotechnology Lab-IV are proposed to be revised and updated.

(f) In the seventh semester, the reading electives BT 7.1.1: Plant Genetic Engineering and BT 7.1.2: Renewable Energy Resources are proposed to be replaced with following three newly introduced and more relevant/updated reading electives:

- Molecular Diagnostics,
- Biodiversity and Conservation,
- Emerging Trends in Biofuel Technology

These courses will help in inculcating the habit of self study/reading in students.

Additionally, the following online reading elective courses are also proposed to be offered in the seventh semester:

- Drug Discovery
  https://www.coursera.org/learn/drug-discovery
- Proteins and Gel-Based Proteomics
  https://swayam.gov.in/course/1386-proteins-and-gel-based-proteomics
- Online course on IPR
  http://www.ili.ac.in/e-learnIPR.htm

(g) In the eighth semester, the courses 'Animal Biotechnology' and 'Plant Biotechnology' and laboratory course: Biotechnology Lab V are proposed to be revised.

The course Bioethics and Biosafety which is running as a core course is now proposed as an Elective.

Moreover, the contents of discipline elective course 'Food and Dairy Biotechnology' are proposed to be revised and updated, and a course 'Geoinformatics' is proposed to be introduced.

Additionally, it is proposed that students can opt for at most 2 additional Open (Generic) audit/credit Elective from other disciplines opting at most 1 per semester in Semesters III-VI with prior permission of respective heads and time table permitting.

E-resources have been proposed for the theory courses and the list of recommended books has been updated. The BOS has recommended all the above mentioned modifications to the degree of B. Tech. (Biotechnology).

The complete list of electives proposed to be offered in the eighth semester are as follows:

- Biomedicial Engineering
- Food and Dairy Biotechnology
- Genomics and Proteomics
- Immunotechnology
- Microbial Technology
- Molecular Modelling and Drug Designing

- Nanotechnology
- Plant Secondary Metabolites
- Bioethics and Biosafety
- Enzyme Engineering and Technology
- Geoinformatics (Newly proposed)

Additionally, the following online elective courses are also proposed to be offered in the eighth semester:

- Bioreactor
  https://swayam.gov.in/course/1339-bioreactors
- Principles of Downstream Techniques in Bioprocess
  http://nptel.ac.in/syllabus/102106048/
- Industrial Biotechnology
  https://www.coursera.org/learn/industrial-biotech

The board also reviewed the Programme Educational Objectives, Programme outcomes and the Learning outcomes of the courses keeping in view the proposed modifications.

The proposed Programme Educational Objectives, Programme outcomes, modified syllabi and details of the online courses offered are included and marked as **Appendix-IIIA** (pages 163), **Appendix-IIIB** (pages 164) and **Appendix–IIIC** (pages 165-228) and **Appendix–IIID** (pages 229) respectively.

3. IIIA. M.Sc. Bioscience (Animal Science):

i.	First Semester Examination, December, 2019	Change [a]
ii.	Second Semester Examination, April/May, 2020	Change [b]
iii.	Third Semester Examination, December, 2020	Change [c]
iv.	Fourth Semester Examination, April/May, 2021	Change [d]

(a) In the first semester, the course BIO 403: Biochemistry and Biophysics is proposed to be replaced by 'Biochemistry' as the subject needs to be dealt in more detail. The topics in enzymology are also proposed to be incorporated in this course from the course BT 406 Enzymology and Enzyme Technology running in the third senester which is proposed to be discontinued in its present form.
The syllabi of the courses 'Cell and Molecular Biology', 'Microbiology', 'Bioinformatics', 'Analytical Techniques-I' and 'Bioscience Lab-I' are proposed to be updated.

(b) In the second semester, the courses ‘Genetics’, ‘Genetic Engineering' and 'Bioscience Lab-II' are proposed to be modified.

The course BT 406 Enzymology and Enzyme Technology is proposed to be discontinued in its present form. The course contents are proposed to be in corporated in the newly proposed course 'Biochemistry' in the first semester and 'Enzyme Technology', a newly proposed elective course in the third semester.

A new course 'Environmental Biology and Biotechnology' is proposed to be included as a core course. The syllabus of this new course is designed by updating the contents of the existing third semester course BIO 408: Environmental Biology and Toxicology and shifting it from the third semester in M.Sc. Bioscience and incorporating as a common course in M.Sc. Biotechnology, AMBT and Bioscience in the second semester. This proposed new course also incorporated some contents of the M.Sc. Biotechnology third semester core course BT 509 Environmental Biotechnology which is proposed to be discontinued.

Relevant modification are proposed to be included in the course BIO 411: Immunology.

(c) In the third semester, BIO 408: Environmental Biology and Toxicology is proposed to be discontinued in the present form and with some updation it is proposed to be included as a core course in the second semester and named as 'Environmental Biology and Biotechnology'.

A new core course ‘Biosystematics, Taxonomy and Evolution’ is proposed to be introduced.

ZOO 503: Animal Diversity –I is proposed to be replaced by a new course ‘Biology of Non-Chordates’.

The addition of these two courses will enhance the core Animal science component of the programme and provide much needed knowledge to the students in their preparations for various competitive examinations and also recruitment in various institutions where classical Zoology is in demand.

The course ZOO 507: Ethology and Neurobiology is proposed to be shifted to the fourth semester.

A course common with M.Sc. Biotechnology, BT 507: Cell and Tissue Culture Technology is proposed to be included in the third semester.

The course ZOO 508: Histology, is propossed to be discontinued and its relevant contents are proposed to be incorporated in a new course ‘Biology of Chordates and Histology’ in the fourth semester.

In the course ZOO 505L: Animal Science Lab-I which is laboratory based course, relevant modifications have been proposed to cater to the proposed modification in the theory courses.

Further, the discipline elective courses are proposed to be offered in the third semester. Discipline elective course provides the opportunity to the students to select and study any discipline specific course of their choice from a pool of elective courses. The complete list of the elective courses are given in point (d).

(d) In the fourth semester, ZOO501: Advance Animal Physiology, ZOO 504: Animal Diversity-II, ZOO 510: Medical Pathology, ZOO 511: Reproductive Biology and Endocrinology is proposed to be discontinued, and relevant contents incorporated in new courses proposed to be introduced viz., ‘Animal Physiology and Endocrinology’, ‘Biology of Chordates and Histology’, ‘Reproduction and Developmental Biology’, ‘Neurobiology and Animal Behavior’.

ZOO 502: Animal Cell and Tissue Culture Techniques is proposed to be discontinued as the course BT 507: Cell and Tissue Culture Technology (c.w. M.Sc. Biotechnology) is proposed to be offered in the third semester.

The laboratory based course, ZOO 506L: Animal Science Lab-II is proposed to be run with modified contents.

Reading elective courses are proposed to be introduced for in the fourth semester.
The following discipline elective courses are proposed to be introduced:

- Insect Diversity, Morphology, Physiology and Ecology
- Fish Biology
- Animal Biotechnology-I
- Applied Entomology and Pest Management
- Capture Fishery
- Animal Biotechnology-II
- Immunotechnology-I
- Immunotechnology (c.w. M.Sc. Biotechnology/ AMBT)
- Biophysics-I (newly introduced, c.w. M.Sc. Biotechnology/ AMBT/ Plant Science / Physics)
- Ecology and Environment (c.w. M.Sc. Plant Science, Environmental Science)
- Biophysics-II (c.w. M.Sc. Plant Science/ Physics)
- Biodiversity and Conservation (c.w. M.Sc. Plant Science, Environmental Science)
- Fundamentals of Ecology for Sustainable Ecosystem (online elective, c.w. M.Sc. Plant Science)

  https://www.extension.harvard.edu/academics/courses/fundamentals-ecology/12779

The following reading elective courses are proposed to be newly offered in the fourth semester, viz.,

- Drug Discovery
- Human Genetics and Diseases
- Intellectual Property Rights

- Medical Microbiology
- Molecular Plant Breeding
- Protein Engineering

Additionally, the following online reading elective courses are also proposed to be offered in the fourth semester:

- Bio- organic Chemistry
  http://nptel.ac.in/courses/104103018/#
- Enzyme Science and Engineering
  http://freevideolectures.com/Course/85/Enzyme-Science-and-Engineering/1
- Biocatalysis in organic synthesis
  http://nptel.ac.in/courses/104105032/
- Comprehensive Disaster Risk Management Framework
  www.nidm.gov.in/online.asp
- General Course on Intellectual Property
  https://welc.wipo.int/acc/index.jsf?page=courseCatalog.xhtml
- Environmental Management - An Introduction
  http://www.algonquincollege.com/ccol/courses/environmental-management-an-introduction/

Students can opt for any one reading elective course (either in regular mode or in online mode) as per the above-mentioned lists in the IV semester.

These courses will help in inculcating the habit of self study/ reading amongst students.

Additionally, it is proposed that a students can opt for 1 Open (Generic) Elective as a credit course from any disciplines in Semester IV with prior permission of respective heads and time table permitting.

E-resources have been proposed for the theory courses and the list of recommended books has been updated. The proposed syllabus of M.Sc. Bioscience (Animal Science) will fulfill the needs of students in terms of their acquaintance regarding both the basic and advanced concepts of the programme.

The board also reviewed the Programme Educational Objectives, Programme outcomes and the Learning outcomes of the courses keeping in view the proposed modifications.

The proposed Programme Educational Objectives, Programme outcomes, modified syllabi and details of the online courses offered are included and marked as **Appendix-IVA** (pages 230), **Appendix-IVB** (pages 231), **Appendix–IVC** (pages 232-323) and **Appendix–IV D** (pages 324-325) respectively.

3. IIIB. M.Sc. Bioscience (Plant Science):

i.	First Semester Examination, December, 2019	Change [a]
ii.	Second Semester Examination, April/May, 2020	Change [b]
iii.	Third Semester Examination, December, 2020	Change [c]
iv.	Fourth Semester Examination, April/May, 2021	Change [d]

(a) In the first semester, the course BIO 403: Biochemistry and Biophysics is proposed to be replaced by "Biochemistry".

The syllabi of the courses 'Cell and Molecular Biology', 'Microbiology', 'Bioinformatics', 'Analytical Techniques-I' and 'Bioscience Lab-I' are proposed to be updated.

(b) In the second semester, the courses 'Genetics', 'Genetic Engineering' and 'Bioscience Lab-II' are proposed to be modified.

The course BT 406 Enzymology and Enzyme technology is proposed to be discontinued as the contents are repeated in other sections of the syllabi.

A new course 'Environmental Biology and Biotechnology' is proposed to be included as a core course. The syllabus of this new course is designed by updating the contents of the existing third semester course BIO 408: Environmental Biology and Toxicology and shifting it from the third semester in M.Sc. Bioscience and incorporating as a common course in M.Sc. Biotechnology, AMBT and Bioscience in the second semester. This proposed new course also incorporated some contents of the M.Sc. Biotechnology third semester core course BT 509 Environmental Biotechnology which is proposed to be discontinued. The contents of the course BIO 411: Immunology are proposed to be modified and revised.

(c) In the third semester, BIO 408: Environmental Biology and Toxicology is proposed to be discontinued in the present form and with some updation it is proposed to be included as a core course in the second semester renamed as 'Environmental Biology and Biotechnology'.

‘Phycology, Mycology and Lichenology’ and ‘Bryophyta, Pteridophyta and Gymnosperms’ are proposed to be introduced as new core courses. The addition of these two courses will enhance the core plant science component of the programme and provide much needed knowledge to the students in their preparations for various competitive examinations and also their recruitment in various institutions where classical botany is in demand.

The course BOT 511: Plant Tissue Culture & Experimental Embryology is proposed to be replaced by 'Cell and Tissue Culture Technology.

BOT 507: Plant Pathology is proposed to be shifted to semester IV and in its place BT 507: Cell and Tissue Culture Technology is proposed to be introduced. BOT 509L which is laboratory based is proposed to be modified to cater to the courses introduced/ replaced.

Further, the discipline elective courses are proposed to be offered for the first time in the third semester. Discipline elective course provides the opportunity to the students to select and study any discipline specific course of their choice from a pool of elective courses. The complete list of the discipline elective courses are given below in the point (d).

(d) In the fourth semester BOT 501: Advanced Horticulture and Ethnobotany is proposed to be replaced by BOT: Angiosperms, while BOT 503: Current Trends in Plant Biotechnology is proposed to be dropped, as the content of this paper is already present in other courses.

BOT 506: Plant Ecology and Biodiversity Conservation is proposed to be discontinued as the contents of this course will be covered in the proposed electives, ENVS 402 course of Elective-I and ENVS 502 course of Elective-II. BOT 508:

An online course, 'Plant Physiology and Taxonomy', (URL-https://www.acs.edu.au/courses/botany-i-plant-physiology-and-taxonomy-199.aspx)

offered by ACS distance education is proposed as an alternative for the core course - BOT 508 Plant Physiology.

Plant Pathology is proposed to be shifted from third semester to the fourth semester. The laboratory based course, BOT 510L: Plant Science Lab is proposed to be modified.

Reading elective courses are proposed to be introduced for the first time in the fourth semester.

The following discipline elective courses are proposed to be introduced.

- Phycology-I
- Bryology-I
- Angiosperms Taxonomy and Systematics-I
- Phycology-II,
- Bryology-II,
- Angiosperms Taxonomy and Biosystematics-II
- Advanced Plant Biotechnology
- Plant Biotechnology (c.w. M.Sc. Biotechnology/ AMBT)
- Biophysics-I (Newly introduced c.w. M.Sc. Biotechnology/ AMBT/Animal Science / Physics)
- Ecology and Environment (c.w. M.Sc Env. Sci./M.Sc. Animal Science)
- Biophysics-II (c.w. M.Sc. Physics / Animal Science)

- Biodiversity and Conservation (c.w. M.Sc. Animal Science, Environmental Science)
- Fundamentals of Ecology for Sustainable Ecosystem (Online elective, c.w. M.Sc. Biotechnology/ AMBT/Animal Science)

  https://www.extension.harvard.edu/academics/courses/fundamentals-ecology/12779.

The following reading elective courses are proposed to be offered in the fourth semester, viz.,

- Drug Discovery
- Human Genetics and Diseases
- Intellectual Property Rights
- Medical Microbiology
- Molecular Plant Breeding
- Protein Engineering

Additionally, the following online reading elective courses are also proposed to be offered in the fourth semester:

- Bio- organic Chemistry
  http://nptel.ac.in/courses/104103018/#
- Enzyme Science and Engineering
  http://freevideolectures.com/Course/85/Enzyme-Science-and-Engineering/1
- Biocatalysis in organic synthesis
  http://nptel.ac.in/courses/104105032/
- Comprehensive Disaster Risk Management Framework
  www.nidm.gov.in/online.asp
- General Course on Intellectual Property
  https://welc.wipo.int/acc/index.jsf?page=courseCatalog.xhtml
- Environmental Management - An Introduction
  http://www.algonquincollege.com/ccol/courses/environmental-management-an-introduction/

Students can opt for any one reading elective course (either in regular mode or in online mode) as per the above-mentioned lists in the IV semester.

These courses will help in inculcating the habit of self study/reading amongst students.

Additionally, it is proposed that a students can opt for 1 Open (Generic) Elective as a credit course from any disciplines in Semester IV with prior permission of respective heads and time table permitting.

E-resources have been proposed for the theory courses and the list of recommended books has been updated. The BOS has recommended all the above mentioned modifications to the degree of M.Sc. Bioscience (Plant Science) for the third and fourth semester.

The proposed syllabus of M.Sc. Bioscience (Plant Science) fulfills the needs of students in terms of their acquaintance regarding classical botany, especially lower plant groups and also the recent advances in the subject.

The board also reviewed the Programme Educational Objectives, Programme outcomes and the Learning outcomes of the courses keeping in view the proposed modifications.

The proposed Programme Educational Objectives, Programme outcomes, modified syllabi and details of the online courses offered are included and marked as **Appendix-VA** (pages 326), **Appendix-VB** (pages 327), **Appendix–VC** (pages 328-413) and **Appendix -VD** (pages 414-415**)** respectively.

3. IIIC. M.Sc. Applied Microbiology and Biotechnology:

i.	First Semester Examination, December, 2019	Change [a]
ii.	Second Semester Examination, April/May, 2020	Change [b]
iii.	Third Semester Examination, December, 2020	Change [c]
iv.	Fourth Semester Examination, April/May, 2021	Change [c]

(a) In the first semester, the course BIO 403: Biochemistry and Biophysics is proposed to be replaced by 'Biochemistry'.

The syllabi of the courses 'Cell and Molecular Biology', 'General Microbiology', 'Bioinformatics', 'Analytical Techniques-I' and 'Bioscience Lab-I' are proposed to be updated.

(b) In the second semester, the courses 'Microbial Physiology' and Genetics', 'Genetic Engineering' and 'Microbial Technology Lab-I' are proposed to be modified.

BT 406 Enzymology and Enzyme technology is proposed to be discontinued in the present form. Some relevant protions of the syllabus of the course BT 406 Enzymology and Enzyme technology is proposed to be integrated with first semester core course 'Biochemistry'. Remaining part of the syllabus of course is updated and proposed to be offered in the third semester as an elective course named as 'Enzyme Technology'.

A new course 'Environmental Biology and Biotechnology' is proposed to be included as a core course. The syllabus of this new course is designed by updating the contents of the existing third semester course BIO 408: Environmental Biology and Toxicology and shifting it from the third semester in M.Sc. Bioscience and incorporating as a common course in M.Sc. Biotechnology, AMBT and Bioscience in the second semester. This proposed new course also incorporated some contents of the M.Sc. Biotechnology third semester core course BT 509 Environmental Biotechnology which is proposed to be discontinued.

The change was suggested to fulfil the need for emerging environmental concerns. The course BIO 411 Immunology which is running in the second semester of M.Sc. Biotechnology programme is proposed to be introduced in the second semester. The contents of the course BIO 411: Immunology are proposed to be modified and revised. The course BIO 413 Medical Microbiology and Immunology is proposed to be discontinued as the course content will be covered in the proposed 'Immunology' course.

(c) In the third semester, the course BT 522: Recombinant DNA Technology which is offered as a core course in the existing syllabus but now this course is proposed to be offered as an elective course. “Discipline Elective” course is proposed to be introduced in the third semester. Discipline elective course provides the opportunity to the students to select and study any discipline specific course of their choice from a pool of elective courses.

The core courses 'Bioprocess Engineering and Technology', and ‘Microbial Ecology and Diversity’ are proposed to be modified and updated.

BT507: Cell and Tissue Culture Technology is proposed to be discontinued.

'Critical Analysis of Classical Papers/ Landmark Discoveries' is proposed to be introduced in Seminar mode.

A new elective course 'Enzyme Technology' is proposed to be introduced incorporating relevant portions of the syllabus of the second semester course BT 406 “Enzymology and Enzyme Technology which is proposed to be discontinued.

The following list of elective courses is proposed to be offered in the third semester:

- Fundamentals of Bioentrepreneurship (Modified)
- Microbial Technology
- Food Process and Biotechnology (Modified)
- Genomics and Proteomics (Modified)
- Immunotechnology (Modified)
- Plant Biotechnology (Modified)
- Recombinant DNA Technology (Modified)
- Enzyme Technology (Newly introduced)
- Animal Biotechnology-I (Newly introduced)
- Biophysics-I (Newly introduced c.w. M.Sc. Biotechnology/ Animal Science /Plant Science/ Physics)

Additionally, the following online elective courses are also proposed to be offered in the third semester:

- Forensic Biology and Serology
  https://swayam.gov.in/course/264-forensic-biology-and-serology
- Water and Waste Treatment Engineering: Biochemical Technology
  https://www.edx.org/course/water-wastewater-treatment-engineering-tsinghuax-40050455-2x-0
- Industrial Biotechnology
  https://onlinecourses.nptel.ac.in/noc17_bt23/preview
  https://swayam.gov.in/search?keyword=Industrial%20Biotechnology
- Fundamentals of Ecology for Sustainable Ecosystem
  https://www.extension.harvard.edu/academics/courses/fundamentals-ecology/12779

Students can opt for any one elective course (either in regular mode or in online mode) as per the above mentioned lists.

The following reading electives are proposed to be newly offered in the third and fourth semesters, viz.,

- Drug Discovery
- Human Genetics and Diseases
- Intellectual Property Rights
- Medical Microbiology
- Molecular Plant Breeding
- Protein Engineering

Additionally, the following online reading elective courses are also proposed to be offered in the third and fourth semesters:

- Bio- organic Chemistry
  http://nptel.ac.in/courses/104103018/#
- Enzyme Science and Engineering
  http://freevideolectures.com/Course/85/Enzyme-Science-and-Engineering/1
- Biocatalysis in organic synthesis
  http://nptel.ac.in/courses/104105032/
- Comprehensive Disaster Risk Management Framework
  www.nidm.gov.in/online.asp
- General Course on Intellectual Property
  https://welc.wipo.int/acc/index.jsf?page=courseCatalog.xhtml
- Environmental Management - An Introduction

http://www.algonquincollege.com/ccol/courses/environmental-management-an-introduction/

The reading electives are common for third and fourth semester. Students can opt for any one reading elective course (either in regular mode or in online mode) as per the above-mentioned lists in each of the III /IV semester.

These courses which will help in inculcating the habit of self study/ reading amongst students.

Additionally, it is proposed that a students can opt for 1 Open (Generic) Elective as a credit course from any disciplines in Semester III with prior permission of respective heads and time table permitting. E-resources have been proposed for the theory courses and the list of recommended books has been updated. All modifications have been done to suit the current requirements of various preparative exams and enhance the knowledge and skill component.

The board also reviewed the Programme Educational Objectives, Programme outcomes and the Learning outcomes of the courses keeping in view the proposed modifications. The proposed Programme Educational Objectives, Programme outcomes, modified syllabi and details of the online courses offered are included and marked as **Appendix-VIA** (pages 416), **Appendix-VIB** (pages 417) , **Appendix–VIC** (pages 418-486) and **Appendix VID** (pages 487-489) respectively.

3**. IIID M.Sc. Biotechnology**:

i.	First Semester Examination, December, 2019	Change [a]
ii.	Second Semester Examination, April/May, 2020	Change [b]
iii.	Third Semester Examination, December, 2020	Change [c]
iv.	Fourth Semester Examination, April/May, 2021	Change [d]

(a) In the first semester, the course BIO 403: Biochemistry and Biophysics is proposed to be replaced by 'Biochemistry'.

The syllabi of the courses 'Cell and Molecular Biology', 'Microbiology', 'Bioinformatics', 'Analytical Techniques-I' and 'Bioscience Lab-I' are proposed to be updated.

(b) In the second semester, the courses 'Genetics', 'Genetic Engineering' and 'Bioscience Lab-II' are proposed to be modified.

BT 406: Enzymology and Enzyme technology is proposed to be discontinued in the present form. Some relevant protions of the syllabus of the course BT 406 Enzymology and Enzyme technology is proposed to be integrated with first semester core course 'Biochemistry'. Remaining part of the syllabus of course is updated and proposed to be offered in the third semester as an elective course named as 'Enzyme Technology'.

A new course 'Environmental Biology and Biotechnology' is proposed to be included as a core course. The syllabus of this new course is designed by updating the contents of the existing third semester course BIO 408: Environmental Biology and Toxicology and shifting it from the third semester in M.Sc. Bioscience and incorporating as a common course in M.Sc. Biotechnology, AMBT and Bioscience in the second semester. This proposed new course also incorporated some contents of the M.Sc. Biotechnology third semester core course BT 509 Environmental Biotechnology which is proposed to be discontinued. The change was suggested to fulfil the need for emerging environmental concerns. The contents of the course BIO 411: Immunology are proposed to be updated.

(c) In the third semester, the course BT 522: Recombinant DNA Technology which is offered as a core course in the existing syllabus but now contents of this course have been modified and proposed to be offered as an elective course. “Discipline Elective” course is proposed to be introduced in the third semester. Discipline elective course provides the opportunity to the students to select and study any discipline specific course of their choice from a pool of elective courses.

The core courses 'Bioprocess Engineering and Technology', and 'Biotechnology Lab-I' are proposed to be modified. BT 509: Environmental Biotechnology which is a core course is proposed to be discontinued in the present form and with some updataion it is proposed to be reintroduced as a core course 'Environmental Biology and Biotechnology' in the second semester.

'Critical Analysis of Classical Papers/ Landmark Discoveries' is proposed to be introduced in Seminar mode.

The following is the list of elective courses that are proposed to be offered in the third semester:

- Fundamentals of Bioentrepreneurship (Modified)
- Microbial Technology
- Food Process and Biotechnology (Modified)
- Genomics and Proteomics (Modified)
- Immunotechnology (Modified)
- Plant Biotechnology (Modified)
- Recombinant DNA Technology (Modified)
- Enzyme Technology (Newly introduced)
- Animal Biotechnology-I (Newly introduced)
- Biophysics-I (Newly introduced c.w. M.Sc. AMBT/ Animal Science /Plant Science/ Physics)

Additionally, the following online elective courses are also proposed to be offered in the third semester:

- Forensic Biology and Serology
  https://swayam.gov.in/course/264-forensic-biology-and-serology
- Water and waste treatment engineering: Biochemical Technology
  https://www.edx.org/course/water-wastewater-treatment-engineering-tsinghuax-40050455-2x-0
- Industrial Biotechnology
  https://onlinecourses.nptel.ac.in/noc17_bt23/preview
  https://swayam.gov.in/search?keyword=Industrial%20Biotechnology
- Fundamentals of Ecology for Sustainable Ecosystem
  https://www.extension.harvard.edu/academics/courses/fundamentals-ecology/12779

Students can opt for any one elective course (either in regular mode or in online mode) as per the above mentioned lists.

(d) The following reading electives are proposed to be newly offered in the third and the fourth semesters, viz.,

- Drug Discovery
- Human Genetics and Diseases
- Intellectual Property Rights
- Medical Microbiology
- Molecular Plant Breeding
- Protein Engineering

Additionally, the following online reading elective courses are also proposed to be offered in the third and fourth semester:

- Bio- organic Chemistry
  http://nptel.ac.in/courses/104103018/#
- Enzyme Science and Engineering
  http://freevideolectures.com/Course/85/Enzyme-Science-and-Engineering/1
- Biocatalysis in organic synthesis
  http://nptel.ac.in/courses/104105032/
- Comprehensive Disaster Risk Management Framework
  www.nidm.gov.in/online.asp
- General Course on Intellectual Property
  https://welc.wipo.int/acc/index.jsf?page=courseCatalog.xhtml
- Environmental Management - An Introduction

http://www.algonquincollege.com/ccol/courses/environmental-management-an-introduction/

The reading electives are common for third and fourth semester. Students can opt for any one reading elective course (either in regular mode or in online mode) as per the above-mentioned lists in each of the III /IV semester.

These courses will help in inculcating the habit of self study/reading amongst students.

Additionally, it is proposed that a students can opt for 1 Open (Generic) Elective as a credit course from any disciplines in Semester III with prior permission of respective heads and time table permitting. E-resources have been proposed for the theory courses and the list of recommended books has been updated. All modifications have been done to suit the current requirements of various preparative exams and enhance the knowledge and skill component. The board also reviewed the Programme Educational Objectives, Programme outcomes of the programme and the Learning outcomes of the courses keeping in view the proposed modifications.

The proposed Programme Educational Objectives, Programme outcomes, modified syllabi and details of the online courses offered are included and marked as **Appendix-VIIA** (pages 490), **Appendix-VIIB** (pages 491), **Appendix–VIIC** (pages 492-568) **Appendix-VIID** (pages 569-571) respectively.

3**. IIIE M.Sc. Bioinformatics**:

i.	First Semester Examination, December, 2019	Change [a]
ii.	Second Semester Examination, April/May, 2020	Change [b]
iii.	Third Semester Examination, December, 2020	Change [c]
iv.	Fourth Semester Examination, April/May, 2021	Change [d]

(a) In the first semester, the course BIO 402: Basic Cell, molecular Biology and Biological Database is proposed to be replaced by BIO407: Cell and Molecular Biology (c.w.: M.Sc. BT/ AMBT/ Bioscience. I sem).

The course of MATH406: Introductory Mathematic’ is proposed to be modified with inclusion of relevant content of Statistics.

The course STAT405: Statistical Techniques is proposed to be discontinued. 'Biological Databases’ is proposed as new core course.

The course CS410: Computer Fundamentals and Perl Programming is proposed to be discontinued and a new course - 'Fundamentals of Computer and Programming' is proposed to be introduced.

The course STAT405L: Statistical Techniques Lab is proposed to be discontinued.

To provide wet lab training, the course BIO404L: Bioscience Lab I (c.w. MSc. BT/AMBT/Bioscience I sem) is proposed to be introduced.

The syllabi of the courses ‘Structural Biology’ and ‘Computer Fundamentals and Programming Lab’ is proposed to be updated.

(b) In the second semester, the courses BIN402: Computational Biology and Molecular Modeling’, ‘BIN403: Proteomics, Sequence Analysis and Systems Biology’ ‘CS412: Computer Networks and Web Technologies’ and ‘BIO413: Medical Microbiology and Immunology’ are proposed to be discontinued.

The courses ‘Algorithms in Computational Biology’, ‘Sequence Analysis and Phylogenetics’, ‘Programming with Perl and R’ and 'Genetic Engineering (c.w. MSc. BT/AMBT/Biosc. II sem) ' are being proposed to be introduced and some of the relevant portions of the discontinued courses have been incorporated with suitable updations into these newly proposed courses. The modifications are suggested to fulfill the need for emerging technologies in bioinformatics.

(c) In third semester, the core courses BIN504: Evolutionary Computing, ‘BIN502: Computer Aided Drug Designing', 'BIN505: Functional and Comparative Genomics', ‘BIN508: Molecular Structure Prediction and Visualization' and 'BIN508L: Molecular Structure Prediction and Visualization Lab' are proposed to be discontinued.

The courses ‘Biomolecular Modelling and Computational Drug Design’ is proposed to be newly introduced.

The course 'Genomics and Proteomics’ currently offered as a elective course in the IIIrd sem. in M.Sc. Biotechnology and M.Sc AMBT is proposed to be offered as a core course.

The courses ‘RNA Structure Function and Transcriptomics’ ‘Biomolecular Modelling and Computational Drug Design Lab' are proposed to be newly introduced and some of the relevant portions of the discontinued courses have been incorporated with suitable updations into these newly proposed courses.

'Python Programming’ and ‘Python Programming Lab’ are proposed as new core courses to meet the current demands of Bioinformatics in academia and industry.

The core course ‘BIN507: Mining and Warehousing of Biological Data’ is being proposed as to be run as an elective course.

The courses ‘CS512: Cloud Computing’, ‘CS530: Neural Networks’ and ‘Systems Biology’ are proposed to be retained as elective courses.

(d) In the fourth semester the course ‘CS427: Parallel Computing’ is proposed to be discontinued.

A full semester ‘Project Dissertation’ is proposed to be introduced to develop in depth knowledge of the subject and skill development for writing projects and reports among students.

The following reading electives are proposed to be introduced:

- BIN601R:Chemoinformatics’ (previously run in M.Tech. Bioinformatics)
- BIN602:Immunoinformatics’ (previously run in M.Tech. Bioinformatics)
- Human Genetics and Diseases (c.w. M.Tech. BT, M.Sc. AMBT, BT, Biosci)
- Drug Discovery (c.w. M.Tech. BT, M.Sc. AMBT, BT, Biosci)
- Protein Engineering (c.w. M.Tech. BT, M.Sc. AMBT, BT, Biosci).

These courses will help in inculcating the habit of self study/reading amongst students. E-resources have been proposed for the theory courses and the list of recommended books has been updated. All modifications have been done to suit the current requirements of various preparative exams and enhance the knowledge and skill component.

The board also reviewed the Programme Educational Objectives (**Appendix-VIIIA**, page no.572), Programme outcomes (**Appendix–VIIIB**, page no. 573) and the Learning outcomes of the courses keeping in view the proposed modifications.

The proposed course of study, curricula and scheme of examination of the M. Sc. Bioinformatics (2019-2020) programme is attached and marked as **Appendix-VIIIC,** page no. 574-633.

3. IV M.Tech. Biotechnology:

i.	First Semester Examination, December, 2019	Change [a]
ii.	Second Semester Examination, April/May, 2020	Change [b]
iii.	Third Semester Examination, December, 2020	Change [c]
iv.	Fourth Semester Examination, April/May, 2021	Change [c]

(a) In the first semester, the courses ‘Biological Databases and Computational Biology’, ‘Advanced Cell Biology’, ‘Biotechnology Lab – I’ are proposed to be updated with more relevant topics.

The course “Bioprocess Engineering-I” is proposed to be discontinued.

An elective course ‘Elective-I’ is proposed to be introduced.

Term paper-I/Minor project is proposed to be introduced in the first semester. The term paper essentially will help to enhance the critical thinking, writing and communication skills of the students. The core course BT 511: ‘Enzyme Technology’ of the first semester is proposed to be offered as an elective course.

(b) The contents of the second semester core course BT 503: “Bioprocess Engineering-II” and first semester core course BT 502: “Bioprocess engineering-I” are proposed to be merged and modified, and offered as new course named as “Bioprocess engineering” in the second semester of the programme.

Another elective course named as ‘Elective-II’ is proposed to be introduced. Term paper-II/Minor project is also proposed to be introduced in the second semester. The course BT 516: ‘Immunotechnology’ is proposed to be offered as an elective course. In the second semester, core course BT 520: ‘Plant and Animal Cell Culture Technology’ is proposed to be discontinued.

The contents of the course ‘Genetic Manipulation Technology’ are proposed to be rearranged in all the sections with incorporation of new and relevant topics. In the course ‘Biotechnology Lab – II’, the modifications in the practical exercises are proposed to properly categorize and introduce relevant experiments. The contents of the elective paper ‘Food Biotechnology’, is proposed to be updated with the removal of some repetitive portions.

The complete lists of elective courses proposed to be offered in the first and second semester are as follows:

- Computer Aided Drug Designing
- Elements of Bioinformatics
- Structural Biology
- Bioentrepreneurship
- Cancer Biology
- Environmental Biotechnology
- Food Biotechnology (Modified)
- Medical Biotechnology
- Nanobiotechnology
- Enzyme Technology (Newly introduced)
- Immunotechnology (Newly introduced)

Additionally, it is proposed that a student can opt for 1 Open (Generic) Elective as a credit course from any disciplines in Semester II with prior permission of respective heads and time table permitting.

(c) The reading electives viz., BIO 601R: Biodiversity and Conservation, BIO 602R: Bioethics, Biosafety and IPR and BT 604R: Renewable Energy Sources, which were offered in the third and fourth semesters are proposed to be replaced with newly introduced and more relevant reading electives viz.:

- Drug Discovery,
- Human Genetics and Diseases,
- Intellectual Property Rights,

- Medical Microbiology,
- Molecular Plant Breeding and
- Protein Engineering.

Additionally, the following online reading elective courses are also proposed to be offered in the third and fourth semester:

- Downstream Processing
  http://nptel.ac.in/syllabus/102106022
- Mass Spectrometry based Proteomics
  https://onlinecourses.nptel.ac.in/noc15_bt05/preview
  https://swayam.gov.in/search?keyword=Mass%20spectrometry%20based%20proteomics
- Bioreactor
  https://swayam.gov.in/course/1339-bioreactors

The above courses will help in inculcating the habit of self study/reading in students. Moreover, the books of all the theory and practical papers have been updated following same format and e-resources have been introduced. E-resources have been proposed for the theory courses and the list of recommended books has been updated. The BOS has recommended all the above mentioned modifications to the degree of M. Tech. Biotechnology. The proposed syllabus of M. Tech. Biotechnology would fulfill the needs of students in terms of their knowledge of fundamental concepts and latest developments in the field of biotechnology. The board also reviewed the Programme Educational Objectives, Programme outcomes of the programme and the Learning outcomes of the courses keeping in view the proposed modifications.

The proposed Programme Educational Objectives, Programme outcomes, modified syllabi and details of the online courses offered are included and marked as **Appendix-VIIIA** (pages 572), **Appendix-VIIIB** (pages 573), **Appendix–VIIIC** (pages 574-621), **Appendix–VIIID** (pages 622) respectively.

3. V Certificate Course in Molecular Modeling and Drug Designing

The Convener briefed the board of the objectives for introducing the Certificate Course in Molecular Modeling and Drug Designing in the department. The Course is structured to provide theoretical and practical knowledge of computational methods used in biomolecular studies and the drug discovery programs to the students with background in biology, chemistry and pharmaceutical sciences. Further, this course also includes computer programming in order to enable the students to solve complex biological problems computationally. Theoretical introduction to drugable targets and biomolecular structures helps in understanding the complexities in drug discovery process. The hands on experiences with software and programming further augment the skills to take on the challenges of drug discovery. The external experts appreciated the proposed certificate course and mentioned that the students trained could have better placement opportunity in the pharmaceutical industries as well as in research programmes. The proposed syllabus is included and marked as **Appendix –X** (pages –685-689).

3. **VI Diploma in Computational Biology**

The Convener briefed the board of the objectives for introducing the Diploma Course in Computational Biology in the department**.** The course has been structured to provide theoretical and practical knowledge of computational methods, used in the era of molecular biology, to the students without any prior knowledge of Bioinformatics. Theoretical introduction to computational biology methods will help in understanding the complexities in drug discovery process, sequence analysis and phylogenetic reconstruction. The hands on experiences with relevant software and programming further augment the skills to take on the current challenges of molecular biology research and pharmaceutical industries. The external experts appreciated the proposed certificate course and were of the opinion that the students trained could have better placement opportunity in the pharmaceutical industries as well be absorbed in various research programmes. The proposed syllabus is included and marked as **Appendix – XI** (pages 690-696).

A complete list of newly proposed online courses in the abovementioned courses viz., B.Tech. Biotechnology, M.Sc. Bioscience (Animal Science), M.Sc. Bioscience (Plant Science), M.Sc. Applied Microbiology and Biotechnology, M.Sc. Biotechnology, M.Tech. Biotechnology is enlisted below:

Table-1: List of proposed online elective courses

S. No	**Online Course Name**	**URL**
B.Tech. Biotechnology VIII Semester		
1.	Bioreactor	https://swayam.gov.in/course/1339-bioreactors
2.	Principles of Downstream techniques in Bioprocess	http://nptel.ac.in/syllabus/102106048/
3.	Industrial Biotechnology	https://www.coursera.org/learn/industrial-biotech
M.Sc. Bioscience (Animal Science, Plant Science) III Semester		
1.	Fundamentals of Ecology for Sustainable Ecosystem	https://www.extension.harvard.edu/academics/courses/fundamentals-ecology/12779

S. No	Online Course Name	URL
M.Sc. Applied Microbiology and Biotechnology, Biotechnology III Semester		
1.	Forensic Biology and Serology	https://swayam.gov.in/course/264-forensic-biology-and-serology
2.	Water and waste treatment engineering: Biochemical Technology	https://www.edx.org/course/water-wastewater-treatment-engineering-tsinghuax-40050455-2x-0
3.	Industrial Biotechnology	https://onlinecourses.nptel.ac.in/noc17_bt23/preview https://swayam.gov.in/search?keyword=Industrial%20Biotechnology
4.	Fundamentals of Ecology for Sustainable Ecosystem	https://www.extension.harvard.edu/academics/courses/fundamentals-ecology/12779

Table-2: List of proposed online reading elective courses

S. No.	Online Course Name	URL
B.Tech. Biotechnology VII Semester		
1.	Drug Discovery	https://www.coursera.org/learn/drug-discovery
2.	Proteins and Gel-Based Proteomics	https://swayam.gov.in/course/1386-proteins-and-gel-based-proteomics
3.	Online course on IPR	http://www.ili.ac.in/e-learnIPR.htm
M.Sc. Bioscience (Animal Science, Plant Science), Applied Microbiology and Biotechnology, Biotechnology - IV Semester		
1.	Bio- organic Chemistry	http://nptel.ac.in/courses/104103018/#
2.	Enzyme Science and Engineering	http://freevideolectures.com/Course/85/Enzyme-Science-and-Engineering/1
3.	Biocatalysis in organic synthesis	http://nptel.ac.in/courses/104105032/
4.	Comprehensive Disaster Risk Management Framework	www.nidm.gov.in/online.asp
5.	DL101E - DL-101 General Course on Intellectual Property	https://welc.wipo.int/acc/index.jsf?page=courseCatalog.xhtml
6.	Environmental Management - An Introduction	http://www.algonquincollege.com/ccol/courses/environmental-management-an-i
M.Tech. Biotechnology III & IV Semester		
1.	Downstream Processing	http://nptel.ac.in/syllabus/102106022/
2.	Mass spectrometry based proteomics	https://onlinecourses.nptel.ac.in/noc15_bt05/preview https://swayam.gov.in/search?keyword=Mass%20spectrometry%20based%20proteomics
3.	Bioreactor	https://swayam.gov.in/course/1339-bioreactors

Table-3: List of proposed online alternative core courses

S.No.	Online Course Name	URL
IIIB. M.Sc. Bioscience-Plant Science IV Semester - BOT 508: Plant Physiology		
1.	Plant Physiology and Taxonomy	https://www.acs.edu.au/courses/botany-i-plant-physiology-and-taxonomy-199.aspx

5. The Board noted the Curriculum for the courses running in the other programmes of the Vidyapith. The courses which are proposed to be modified/ updated/ discontinued are reviewed under point number 3 above.

6. The board considered the reports of examiners in various examinations of 2017-2018.

Most of the examiners found the content of answers satisfactory or good and overall were quite satisfied with the performance of the students. In a few cases, wherever necessary, the reports were brought to the notice of concerned teachers so that corrective measures could be taken.

7. In view of the note of the Vice-Chancellor regarding the standard of the question papers, the Board examined the question papers of periodical test and annual examinations of the session 2017-18.

The question papers were thoroughly studied by the various subject teachers and it was observed that quality of question papers has not deteriorated in the session 2017-18 vis-à-vis the previous years. At UG level, on an average, more than 80% questions belong to either High (Excellent) or Medium (Good) category. Similarly, at PG level too, the results are nearly same.

The analysis of the question papers summarized in **Appendix XIIA** (pages 697-698) and details given in various tables and figures **Appendix XIIB** (UG, pages 699-723), **Appendix XIIC** (PG, pages 724-732) and **Appendix XIID** (PG Bioinformatics, pages 733-736).

The meeting ended with vote of thanks.

BANASTHALI VIDYAPITH

Department of Bioscience and Biotechnology

B.Sc. BIOSCIENCE PROGRAMME EDUCATIONAL OBJECTIVES

The B.Sc. Bioscience programme aims at holistic development of the students through the innovative and comprehensive educational ideology of Banasthali Vidyapith.

This course include exposure to many core subjects of botany, zoology and chemistry and aims to provide an understanding of fundamental biological processes such as metabolism, homeostasis, reproduction, development and genetics of plants and animals. The basic and advanced understanding of relationships between form and function of biological structures at the molecular, cellular, organismal, population and ecosystem levels of the biological hierarchy will enable overall understanding of the subject. The necessary competencies in the respective areas for which all essential theoretical, practical and field based skills will be provided.

On completion of the Programme, students will be able to:

- gain in depth knowledge of all core subjects of biosciences
- develop independent learning abilities and analytical thinking through problem-based assignments, exams and laboratory exercises
- understand a scientific problem and conduct experiments that would make a substantial contribution to its solution
- apply knowledge and understanding in order to initiate and carry out an extended piece of work or project for societal benefit
- develop team work and awareness amongst students towards the importance of multidisciplinary approach for problem solving skills in biological sciences
- train the students for attainment of technical skills, intellectual capability with exposure to modern technologies to serve as an individual or as a team leader in industries
- raise sensitivity to professional ethical codes of conduct, social values and respect for all
- create awareness among students about conservation and sustainability of environment.

BANASTHALI VIDYAPITH
Department of Bioscience and Biotechnology
B.Sc. BIOSCIENCE PROGRAMME OUTCOMES

PO1: Biosciences knowledge: Obtain in depth knowledge of morphology, taxonomy, evolution and genetics of the algae, fungi, bryophyates, pteridophytes, gymnosperm, angiosperm plants, invertebrates and vertebrates animals.

PO2: Planning ability: Demonstrate effective planning abilities including time management, resource management and organizational skills. Develop and implement plans and organize work to meet deadlines.

PO3: Problem analysis: Develop the ability to think originally, conceptually, design experiments, conduct experiments, draw important conclusions form obtained data and to use integrated approaches for solving biological problem.

PO4: Modern tool usage: Apply appropriate methods, resources and computational tools with an understanding of their limitations.

PO5: Leadership skills: Develop potential among students in biosciences who can excel as leaders in entrepreneurship, industry and management

PO6: Professional identity: As biologist, fulfill the needs of society for solving technical, medical, agricultural and environmental problems using biological principles, tools and practices in an ethical and responsible manner.

PO7: Hands-on training: Gain hands-on experience in a number of the practical methods and techniques used in biological research. Expertise in the operation of biological instruments, adherence to laboratory safety standards and good practices.

PO8: Bioethics: Develop ethics in biological sciences, including confidentiality and scientific accountability. Apply bioethical principles and commit to professional ethics, responsibilities, and norms of biological science practices.

PO9: Communication: Ability to express effectively, write effective reports, design documentation, make effective presentations, give and receive clear instructions and effectively communicate with professional bodies.

PO10: Environment and sustainability: Understand impact of biological sciences based solutions in society in the context of environment and demonstrate knowledge of, and need for sustainability.

PO11: Life-long learning: Ability to recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broad context of biological changes.

Department of Bioscience and Biotechnology, Banasthali Vidyapith

B.Sc. Bioscience Programme

Existing Courses					
B. Sc. Bioscience I Sem.		**L**	**T**	**P**	**C**
BOT 101 :	Algae, Fungi, Bryophyta, Pteridophyta and Gymnosperms (CW B.Sc Biotech BOT 101)	6	0	0	6
BOT 101L:	Algae, Fungi, Bryophyta, Pteridophyta and Gymnosperms Lab (CW B.Sc Biotech BOT 101 L)	0	0	4	2
ZOO 102:	Taxonomy, Classification & Evolution	6	0	0	6
ZOO 102L:	Taxonomy, Classification & Evolution Lab	0	0	4	2
	Total	**12**	**0**	**8**	**16**

Proposed Courses					
B. Sc. Bioscience I Sem.		**L**	**T**	**P**	**C**
BOT	Algae, Fungi, Bryophyta, Pteridophyta and Gymnosperms (CW B.Sc Biotech BOT 101)	6	0	0	6
BOT L	Algae, Fungi, Bryophyta, Pteridophyta and Gymnosperms Lab (CW B.Sc Biotech BOT 101 L)	0	0	4	2
ZOO	Taxonomy, Classification and Evolution	6	0	0	6
ZOO L	Taxonomy, Classification and Evolution Lab	0	0	4	2
	Total	**12**	**0**	**8**	**16**

Existing Courses					
B. Sc. Bioscience II Sem.		**L**	**T**	**P**	**C**
BOT 102 :	Angiosperm Anatomy, Embryology and Tissue Culture	6	0	0	6
BOT 102L:	Angiosperm Anatomy, Embryology and Tissue Culture Lab	0	0	4	2
ZOO 101:	Non Chordates and Protochordates (CW B.Sc Biotechnology ZOO 101)	6	0	0	6
ZOO 101L:	Non Chordates and Protochordates Lab (CW B.Sc Biotechnology ZOO 101L)	0	0	4	2
	Total	**12**	**0**	**8**	**16**

Proposed Courses					
B. Sc. Bioscience II Sem.		**L**	**T**	**P**	**C**
BOT 102 :	Angiosperms Anatomy, Embryology and Tissue Culture	6	0	0	6
BOT 102L:	Angiosperms Anatomy, Embryology and Tissue Culture Lab	0	0	4	2
ZOO	Non Chordates and Protochordates (CW B.Sc. Biotechnology ZOO 101)	6	0	0	6
ZOO L	Non Chordates and Protochordates Lab (CW B.Sc. Biotechnology ZOO 101L)	0	0	4	2
	Total	**12**	**0**	**8**	**16**

Existing Courses					
B. Sc. Bioscience III Sem.					
BOT 201:	Angiosperm, Taxonomy and Economic Botany (CW B.Sc Biotech BOT 201)	6	0	0	6
BOT 201L:	Angiosperm, Taxonomy and Economic Botany Lab (CW B.Sc Biotech BOT 201 L)	0	0	4	2
ZOO 201:	Cell Biology, Molecular Biology, Histology & Genetics	6	0	0	6
ZOO 201L:	Cell Biology, Molecular Biology, Histology & Genetics Lab	0	0	4	2
	Total	**12**	**0**	**8**	**16**

Proposed Courses					
B. Sc. Bioscience III Sem.		**L**	**T**	**P**	**C**
BOT	Angiosperms Taxonomy and Economic Botany (CW B.Sc. Biotech BOT 201)	6	0	0	6
BOT L	Angiosperms Taxonomy and Economic Botany Lab (CW B.Sc. Biotech BOT 201 L)	0	0	4	2
ZOO	Cell Biology, Molecular Biology, Histology and Genetics	6	0	0	6
ZOO L	Cell Biology, Molecular Biology, Histology and Genetics Lab	0	0	4	2
	Total	**12**	**0**	**8**	**16**

Existing Syllabus					
B. Sc. Bioscience IV Sem.		**L**	**T**	**P**	**C**
BOT 202:	Microbiology and Plant Pathology	6	0	0	6
BOT 202L:	Microbiology and Plant Pathology Lab	0	0	4	2
ZOO 202:	Comparative Anatomy and Embryology of Chordates (CW B.Sc Biotechnology ZOO 202)	6	0	0	6

Proposed Courses					
B. Sc. Bioscience IV Sem.		**L**	**T**	**P**	**C**
BOT	Microbiology and Plant Pathology	6	0	0	6
BOT L	Microbiology and Plant Pathology Lab	0	0	4	2
ZOO 202:	Comparative Anatomy and Embryology of Chordates (CW B.Sc. Biotechnology ZOO 202)	6	0	0	6

		L	T	P	C
ZOO 202L:	Comparative Anatomy and Embryology of Chordates Lab (CW B.Sc Biotechnology ZOO 202L)	0	0	4	2
	Total	**12**	**0**	**8**	**16**

		L	T	P	C
ZOO L	Comparative Anatomy and Embryology of Chordates Lab (CW B.Sc. Biotechnology ZOO 202L)	0	0	4	2
	Total	**12**	**0**	**8**	**16**

Existing Courses

B. Sc. Bioscience V Sem.		**L**	**T**	**P**	**C**
5.1:	Plant Physiology and Ecology (CW B.Sc Biotech 5.1)	6	0	0	6
5.2:	Plant Physiology and Ecology Lab (CW B.Sc Biotech Lab 5.2)	0	0	4	2
5.1:	Environmental Biology	6	0	0	6
5.2:	Environmental Biology Lab	0	0	4	2
	Analytical Lab Practice-I	0	0	4	2
	Total	**12**	**0**	**12**	**18**

Proposed Courses

B. Sc. Bioscience V Sem.		**L**	**T**	**P**	**C**
BOT	Botany Elective I	6	0	0	6
BOT L	Botany Elective I Lab	0	0	4	2
ZOO	Zoology Elective I	6	0	0	6
ZOO L	Zoology Elective I Lab	0	0	4	2
	Total	**12**	**0**	**8**	**16**

Existing Syllabus

B. Sc. Bioscience VI Sem.		**L**	**T**	**P**	**C**
6.1:	Introduction to Genetics and Genetic Engineering	6	0	0	6
6.2:	Genetics and Genetic Engineering Lab	0	0	4	2
6.1:	Animal Physiology (CW B.Sc Biotechnology 6.3)	6	0	0	6
6.2:	Animal Physiology Lab (CW B.Sc Biotechnology 6.4)	0	0	4	2
	Analytical Lab Practice-II	0	0	4	2
	Total	**12**	**0**	**12**	**18**

(yellow)	Syllabus modified
(red)	Course discontinued
(green)	New course introduced

Proposed Courses

B. Sc. Bioscience VI Sem.		**L**	**T**	**P**	**C**
BOT	Botany Elective II	6	0	0	6
BOT L	Botany Elective II Lab	0	0	4	2
ZOO	Zoology Elective II	6	0	0	6
ZOO L	Zoology Elective II Lab	0	0	4	2
	Total	**12**	**0**	**8**	**16**

Proposed List of Discipline Elective courses to be offered in V & VI Semester		**L**	**T**	**P**	**C**
List of Discipline Electives I & II (Botany)					
BOT 302/ BOT 302L	Introduction to Genetics and Genetic Engineering	6	0	4	8
BOT 303/ BOT 303L	Plant Physiology and Ecology	6	0	4	8
BOT / BOT L	Ethnobotany	6	0	4	8
BOT / BOT L	Horticulture	6	0	4	8
Proposed List of Discipline Electives I & II (Zoology)					
ZOO 301/ ZOO 301L	Animal Physiology	6	0	4	8
ZOO302/ ZOO 302L	Environmental Biology and Biostatistics	6	0	4	8
ZOO / ZOO L	Developmental Biology	6	0	4	8
ZOO / ZOO L	Applied Zoology	6	0	4	8

Comparative Table: B.Sc. Bioscience: Existing and Modified syllabus, Suggested Books and Suggested e-Resources

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
B. Sc. Bioscience I Semester					
1.	**BOT 101:** Algae, Fungi, Bryophyta, Pteridophyta and Gymnosperms	On completion of the course students will be able to: • Acquaint with the general characters and classification of cryptogams and phanerogames. • Understand the evolutionary relationship among lower to higher plant species with differentiating characteristics. • Appreciate and understand economic importance and application of every group of plants.	**Unit 1** • Algae: Classification, General account with special reference to *Anabaena*, *Oscillatoria*, *Volvox*, ~~*Chlamydomonas*,~~ *Chara*, *Oedogonium*, *Ectocarpus*, *Polysiphonia*. Economic importance of Algae. **Unit 2** • Fungi: Classification, General account with special reference to *Albugo*, *Aspergillus*, ~~*Erysiphe*,~~ *Puccinia*, *Ustilago* and *Alternaria*. Economic importance of Fungi. **Unit 3** • Bryophytes: Classification, General account with special reference to important features in the life cycles of *Riccia*, *Marchantia*, *Anthoceros* and Mosses: *Funaria*, *Sphagnum*. **Unit 4** • Pteridophytes: Classification, General account, Evolution of steler systems, apospory, apogamy and seed habit. Outline of life cycle of *Selaginella*, *Equisetum* and *Marsilea*. **Unit 5** • Gymnosperms: Classification and Evolution, Distribution with special reference to Indian Gymnosperms. Special features in life cycle of *Cycas*, *Pinus* and *Ephedra*. Economic importance. **Books Recommended:** ➢ College Botany Vol. II: Ganguli. ➢ A Text Book of Botany Vol. I & II: Saxena & Sarabhai, Ratan Prakash Mandir, Agra. ➢ Text Book of Fungi: J.S.Gupta, Oxford & IBH, New Delhi. ➢ Introduction to Fungi: J. Webster, Cambridge University Press and McMillan, New York	**Unit 1** • Algae: Classification, general account with special reference to *Anabaena*, *Oscillatoria*, *Volvox*, *Chara*, *Oedogonium*, *Ectocarpus*, *Polysiphonia*. Economic importance of algae. **Unit 2** • Fungi: Classification, general account with special reference to *Albugo*, *Aspergillus*, *Puccinia*, *Ustilago* and *Alternaria*. Economic importance of fungi. **Unit 3** • Bryophytes: Classification, general account with special reference to important features in the life cycles of *Riccia*, *Marchantia*, *Anthoceros* and Mosses: *Funaria*, *Sphagnum*. **Unit 4** • Pteridophytes: Classification, general account, evolution of steler systems, apospory, apogamy and seed habit. Outline of life cycle of *Selaginella*, *Equisetum* and *Marsilea*. **Unit 5** • Gymnosperms: Classification and evolution, distribution with special reference to Indian gymnosperms. Special features in life cycle of *Cycas*, *Pinus* and *Ephedra*. Economic importance. **Suggested Books:** ➢ Alam, A. (2015). *Text book of Bryophyta*. New Delhi: I K International Publishers. ➢ Alexopoulus, C. (1979). *Introductory Mycology*. New York: John Wiley & Sons. ➢ Bhatia, K. (1975). *A Treatise on Algae*. New Delhi: S. Chand & Company. ➢ Biswas, C., & Johri, B.M. (2010). *Gymnosperm*.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Bryophyta & Pteridophyta: N.S. Parihar, Central Book Depot, Allahabad. ➢ Introductory Mycology: C.M Alexopoulus, John Wiley & Sons, New York. ➢ Introduction to Fungi: H.C. Dubey, Vikas Publishing House. ➢ Bryophyta: B.R. Vashistha, S. Chand Publication, New Delhi. ➢ Pteridophyta: P.C. Vashistha, S. Chand Publication, New Delhi. ➢ Morphology of Pteridophytes: K.R. Sporne. B.I. Publications, New Delhi. ➢ Botany (For degree students) – Part III Bryophyta: B.R. Vashishtha., S. Chand & Co. Ltd., New Delhi. ➢ A Treatise on Algae: K.N. Bhatia, S. Chand & Company, New Delhi. ➢ Algae: V. J. Chapman and D. J. Chapman, The English language Book Society. ➢ Introductory Phycology: H.D. Kumar, Affiliated East-West, New Delhi. ➢ An Introduction to Pteridophyta: A. Rashid, Vikas, New Delhi ➢ Introduction to Gymnosperms: S.C. Dutta, Asia, Bombay. ➢ Gymnosperms: P.C. Vashistha, S. Chand and Company, New Delhi. ➢ Morphology of Gymnosperms: J.M. Coulter and C.J. Chamberlian, Central Book Depot, Allahabad. ➢ Text Book of Gymnosperm, G.L. Chopra. ➢ University Botany I, S.M. Reddy, New Age Publisher.	Springer-Verlag Berlin and Heidelberg GmbH & Co. KG ➢ Chamberlian, C.J. (1919). *Morphology of Gymnosperms*. Allahabad: Central Book Depot. ➢ Chapman, V.J. (2013). *An Introduction to the Study of Algae*. UK: Cambridge University Press. ➢ Dubey, H.C. (2011). *Introduction to Fungi*. India: Vikas Publishing House. ➢ Dutta, S.C. (1967). *Introduction to Gymnosperms*. Asia Publishing House. ➢ Ganguli, H.C., Das, K.S., & Dutta C. (2011). *College Botany* Vol. I. India: New Central Book Agency. ➢ Kumar, H.D. (1999). *Introductory Phycology*. New Delhi: Affiliated East-West. ➢ Parihar, N.S. (1956). *Bryophyta Pteridophyta*. Allahabad: Central Book Depot. ➢ Rashid, A. (1999). *An Introduction to Pteridophyta*. New Delhi: Vikas publications. ➢ Saxena, S. (2000). *A text book of Botany* (Vol. I & II). Agra: Ratan Prakash Mandir. ➢ Sharma, O.P., & Gupta, R.C. (2010). *Text Book of Fungi*. IBH. New Delhi, India: Vedams eBooks (P) Ltd. ➢ Sporne, K.R. (1966). *Morphology of Pteridophytes*. London: Hutchinson University Library. ➢ Vashistha, B.R., & Sinha, A.K. (2010). *Botany for Degree Students-Algae*. New Delhi: S. Chand Publication. ➢ Vashistha, B.R., & Sinha, A.K. (2016). *Botany for Degree Students-Fungi*. New Delhi: S. Chand Publication. ➢ Vashistha, B.R., Sinha, A.K., & Kumar, A. (1987). *Botany for Degree classes- Gymnosperms*. New Delhi: S. Chand Publication. ➢ Vashistha, B.R., Sinha, A.K., & Kumar, A. (2010). *Botany for Degree Students-Bryophyta*. New Delhi: S. Chand Publication.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				➢ Vashisthai, B.R., & Vashistha, P.C. (1987). *Botany for Degree Students Pteridophyta*. New Delhi: S. Chand Publication. ➢ Webster, J., & Weber, R. (2007) *Introduction to Fungi*. New York: Cambridge University Press. **Suggested e-Resources:** ➢ **Bryophytes: General account, classification and structure** http://nsdl.niscair.res.in/jspui/bitstream/123456789/150/1/BRYOPHYTES%20.pdf ➢ **Gymnosperms** http://www-plb.ucdavis.edu/courses/bis/1c/text/Chapter24nf.pdf ➢ **Pteridophytes** http://nsdl.niscair.res.in/jspui/bitstream/123456789/556/1/PTERIDOPHYTES%20april609%20-%20formatted.pdf	
2.	**BOT 101L:** Algae, Fungi, Bryophyta, Pteridophyta and Gymnosperms Lab	On completion of the course, students will be able to: • Identify bryophyte and pteridophyte. • Interpret the characteristics & life cycles of various lower plants. • Learn about practical technique in lab for detail study of plant structure, anatomy and reproduction.	**BOT 101L** 1. Study of Algae and Fungi as mentioned in the syllabus (museum specimen of the affected plants and permanent prepared slides). 2. Study of vegetative and reproductive parts in *Selaginella*, *Equisetum* and *Marsilea*. 3. Study of vegetative and reproductive parts in *Riccia*, *Marchantia*, *Anthoceros* and *Funaria*. 4. Gymnosperms: study of *Cycas* (coralloid root, rachis, leaflet, male cone, megasporophyll), *Pinus* (needle, dwarf shoot, long shoot, male cone, female cone) *Ephedra* (morphology, stem, male cone, female cone).	**BOT 101L** 1. Study of algae and fungi as mentioned in the syllabus (museum specimen of the affected plants and permanent prepared slides). 2. Study of vegetative and reproductive parts in *Selaginella*, *Equisetum* and *Marsilea*. 3. Study of vegetative and reproductive parts in *Riccia*, *Marchantia*, *Anthoceros* and *Funaria* by the preparation of temporary slides. **4.** Gymnosperms: Study of *Cycas* (coralloid root, rachis, leaflet, male cone, megasporophyll), *Pinus* (needle, dwarf shoot, long shoot, male cone, female cone) *Ephedra* (morphology, stem, male cone, female cone) by the preparation of temporary slides. **Suggested Books:** ➢ Bendre, A., & Kumar, A. (2009). *A Textbook of Practical Botany- I*. Meerut: Rastogi Publications.	
3.	**ZOO 102:** Taxonomy,	On completion of the course, students	**Unit 1** • Basic concept of taxonomy and systematics: Terms,	**Unit 1** • Basic concept of taxonomy and systematics: Terms,	The principal animal

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
	Classification and Evolution	will be able to: • Gain fundamental understanding of the taxonomy and systematics. • Describe salient features and classification of major phyla of invertebrates and protochordates. • Develop a better understanding about classical and modern theories of evolution along with factors affecting evolution and detail of evolution of man, camel and horse.	definition, contribution and role of systematics. • Zoological Classification: International code of zoological nomenclature, principles of nomenclature, kinds of classification, Linnaean hierarchy. **Unit 2** • Distinguishing characters and classification up to orders (excluding extinct forms) of the followings: • Lower non-chordates. • Higher non-chordates. • Protochordates. **Unit 3** • Lamarckism, Neo Lamarckism, Darwinism and Neo Darwinism • Theory of Mutation with special reference to chromosomal aberrations and gene mutations. • Modern synthetic theory of evolution. **Unit 4** • Evidences in favour of organic evolution. • Role of variations, adaptation, speciation and isolation in the process of evolution. • Fossils: Formation of fossils, kinds of fossils, significance of the study of fossils. **Unit 5** • Genetic basis of evolution including Hardy-Weinberg's law. • Geological time scale and the distribution of animals in time and space. • Evolution of man, horse and camel. **Recommended Books :** ➢ Principles of Systematics: Erenst Mayr, New Delhi, TMH. ➢ Invertebrates: R. L. Kotpal, Rastogi Publications, Meerut.	definition, contribution and role of systematics. • Zoological classification: International code of zoological nomenclature, principles of nomenclature, kinds of classification, Linnaean hierarchy. **Unit 2** • Distinguishing characters and classification up to orders (excluding extinct forms) of the followings: • Lower non-chordates (protozoa, porifera, coelenterata, platyhelminthes & nematods). • Higher non-chordates (annelida, arthropoda, mollusca and echinodermata). • Protochordates. **Unit 3** • Lamarckism, Neo Lamarckism, Darwinism and Neo Darwinism. • Theory of mutation with special reference to chromosomal aberrations and gene mutations. • Modern synthetic theory of evolution. **Unit 4** • Evidences in favour of organic evolution. • Role of variations, adaptation, speciation and isolation in the process of evolution. • Fossils: Formation of fossils, kinds of fossils, significance of the study of fossils. **Unit 5** • Genetic basis of evolution including Hardy-Weinberg's law. • Geological time scale and the distribution of animals in time and space. • Evolution of man, horse and camel. **Suggested Books:** ➢ Arora, M.P., & Arora, H. (2013). *A Textbook of Organic Evolution*. New Delhi: Himalaya Publishing House. ➢ Chaki, K.K., Kundu, G., & Sarkar, S. (2016). *Introduction to General Zoology* Vol-II. Kolkata: New	phyla are specified because in some books other principal lower non chordates and higher non chordates are mentioned such as ectoprocta, ctenophora, acanthocephala, rotifera and brachiopoda etc are also mentioned.

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Invertebrate Zoology: S.N. Prasad, Allahabad : Kitab Mahal. ➢ Invertebrate Zoology: H.C.Nigam, Delhi, S. Nagin. ➢ Organic Evolution: V.B. Rastogi, Ram Nath Kedar Nath, Meerut. ➢ Organic Evolution: M.P. Arora, Himalaya Publishing House**.**	Central Book Agency. ➢ Ghoshe, K.C., & Manna, B. (2012). *Fundamentals of Zoology*. Kolkata: New Central Book Agency. ➢ Kapoor, V.C. (2018). *Theory & Practice of Animal Taxonomy and Biodiversity* (8^{th} ed.). New Delhi: CBS Publishers & Distributors. ➢ Kotpal, R.L. (2014). *Modern Textbook of Zoology: Invertebrates* (11^{th} ed.). Meerut: Rastogi Publications. ➢ Mayr, E., & Ashlock, P.D. (1991). *Principles of Systematic Zoology* **(**2nd ed.). New Delhi: McGraw-Hill College. ➢ Nigam, H.C. (2013). *Biology of Non-Chordates*. New Delhi: Vishal Publishing Co. ➢ Prasad, S.N., & Kashyap, V. (2012). *A text book of Invertebrate Zoology* (14^{th} ed.). New Delhi: New Age International (P) Limited. ➢ Rastogi, V.B. (2016). *Organic Evolution* (1^{st} ed.). Medtech. **Suggested e-Resources:** ➢ **Taxonomy & classification** http://www.austincc.edu/sziser/Biol%201413/LectureNotes/lnexamI/taxonomyClassification.pdf http://www.iaszoology.com/zoological-nomenclature/ ➢ **Evolution** http://www.iaszoology.com/category/evolution/ ➢ **Origin of life** https://nptel.ac.in/courses/122103039/10 ➢ **Chromosomal mutations** http://www.wou.edu/~guralnl/311Chromosomal%20Mutations.pdf https://facultystaff.richmond.edu/~lrunyenj/bio554/lectnotes/chapter9.pdf ➢ **Invertebrate phyla** https://www.slideshare.net/godhxbwnkkdn/animal-diversity-zoology-notes	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				➢ **Geological time scale** http://geoscience.msc.sa.edu.au/library/3-3%20Geological%20Timescale.pdf	
4.	**ZOO 102L:** Taxonomy, Classification and Evolution Lab	On completion of the course, students will be able to: • Identify and characterize different organisms of major phyla of non chordates based on the morphology. • Understand the internal structures of lower non chordates through microscopic study of prepared slides. • Understand the anatomy of *Fasciola*, *Pheretima* and *Unio* with the help of charts. • Learn the technique of preparation of permanent slide. • Apply acquired knowledge for the preparation of phylogenetic tree of invertebrates.	~~1. Permanent preparation and study of the following:~~ • Protozoa: *Paramecium*. • Porifera: Sponge spicules, spongin fibers and gemmule. • Coelenterata: *Hydra* with extended tentacles, *Hydra* with bud, *Obelia* colony and Medusa of *Obelia*. • Annelida : Parapodium of *Nereis* ~~-~~ and *Heteronereis*. • Arthropoda : Statocyst of Prawn, Nauplius, Zoea, and Mysis Larva of Crustaceans, *Cyclops* and *Daphnia*. • Mollusca: Glochidium larva of *Unio*. • Echinodermata: ~~-~~Tube feet of starfish. 2. Preparation of phylogentic tree of invertebrates including minor phyla 3. Study of Microscopic slides: • Protozoa: ~~Micro and macro spheric forms of~~ *Polystomella*; W.M. of Euglena, ~~Sporozoite and trophozoite stages of~~ *Monocystis* ~~in the smear of sperm, morula of Earthworm,~~ Binary fission and conjugation in *Paramecium*. • Porifera: W.M. of *Leucosolenia*, T.S. and L.S. of *Sycon*. • Coelenterata: ~~Section passing through the statocyst of medusa of~~ *Obelia* ~~(or *Aurelia*).~~ • Platyhelminthes: W.M. of *Planaria*, ~~T.S. of *Fasciola* through different regions of the body~~, W.M. of miracidium, sporocyst, redia, cercaria and metacercaria larva of *Fasciola*; W.M. of scolex, gravid proglottid, onchosphere and bladderworm of *Taenia*; T.S. of the proglottid of *Taenia*. • Nemathelminthes: T.S. through the body of male and female *Ascaris*.	**1. Study of museum specimens:** • Porifera: *Sycon*, *Hyalonema*, *Euspongia*. • Coelenterata: *Porpita*, *Velella*, *Gorgonia*, *Pennatula*, *Alcyonium*, *Adamsia*. • Platyhelminthes: *Fasciola*, *Echinococcus*. • Nemathelminthes: *Dracunculus* and *Enterobius*. • Annelida: *Pheretima*, *Aphrodite*, *Terebella*, *Pontobdella* • Arthropoda: *Lepus*, *Sacculina*, Crab, Hermit crab, *Melanopus*, Queen-termite, *Limulus* and *Peripatus*. • Mollusca: *Chiton*, *Aplysia*, *Dentalium*, *Mytilus*, *Teredo*, *Sepia*, *Loligo*. • Echinodermata: *Asterias*, *Holothuria*, *Echinus*, *Clypeaster*. • Protochordata: *Ascidia*, *Botryllus*. **2. Study of microscopic slides:** • Protozoa: *Euglena*, *Plasmodium*, *Opalina*, *Nyctotherus*, *Vorticella*, *Balantidium*, *Foraminiferous* shells. • Porifera: W.M. of *Leucosolenia*, Sponge gemmule. • Coelenterata: *Hydra*, *Obelia* medusa. • Platyhelminthes: W.M. of *Planaria*, W.M. of scolex, gravid proglottid, onchosphere and bladder worm of *Taenia*, T.S. of the proglottid of *Taenia*. • Nemathelminthes: T.S. through the body of male and female *Ascaris*. • Annelida: T.S. of *Hirudinaria* through jaws, pharynx and crop region. • Arthropoda: Male and female *Drosophila*, sex comb of *Drosophila*. • Mollusca: V.S. of molluscan shell, T.S. of gill of *Pila*, radula of *Pila*. • Echinodermata: T.S. through the arm of *Asterias*,	The laboratory course ZOO 102L is proposed to be modified by including the five major exercises: study of museum specimens, study of prepared slides, preparation of permanent mount, anatomical study of selected animals and collection & culture methods. Animals of invertebrate phyla (protozoa to protochordata) are included in these exercises. In addition to that, exercise related to study of microscope, evolution & permanent mount preparation of mosquito are also proposed to be included in the revised syllabus.

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			• Annelida: T.S. of *Neries* through trunk region; T.S. of Earthworm through gizzard, typhlosolar region, prostrate glands, and seminal vesicles; T.S. of *Hirudinaria* through jaws, pharynx and crop region. • Arthropoda: V.S. of compound eye. • Mollusca: V.S. of molluscan shell, ~~T.S. of gill of *Unio*.~~ • Echinodermata: T.S. through the arm of *Asterias*. • Hemichordata: T.S. of *Balanoglossus* through proboscis, collar and trunk region; W.M. of Tornaria larva. • Protochordata: W.M. velum and pharyngeal wall of *Amphioxus*, T.S. of *Amphioxus* through various regions; Tadpole larva of *Ascidia*; W.M. of *Pyrosoma*, *Doliolum* and *Oikopleura*. ~~4. Comparative study with the help of permanent slides- Annelida (setae and parapodia) and Echinodermata (pedicilaria).~~	Pedicillaria of *Asterias*. • Hemichordata: W.M. of tornaria larva. • Protochordata: W.M. of *Pyrosoma*, *Doliolum* and *Oikopleura*. **3. Anatomy:** • Anatomical study of various systems with the help of chart/model/CD. ***Fasciola hepatica*** 1. Digestive system 2. Excretory system 3. Reproductive system ***Pheretima posthuma*** 1. Digestive system 2. Nervous system 3. Reproductive system ***Unio*** 1. Digestive system 2. Nervous system **4.** Organization and working of optical microscope: Dissecting and compound microscopes. **5. Preparation of permanent slides:** • Protozoa: *Euglena*. • Porifera: Sponge spicules. • Coelenterata: *Hydra* with extended tentacles, *Hydra* with bud. • Annelida: Setae of earthworm, Parapodium of *Nereis*. • Arthropoda: Statocyst of *Palaemon*, *Cyclops*, Mysis and *Daphnia*. • Mollusca: Radula of *Pila*. • Echinodermata: Pedicillaria. **6. Collection and culture methods** (i) Collection of animals from their natural habitat: *Amoeba, Paramecium, Euglena*. (ii) Culture of *paramecium* in the laboratory and study of its structure, life processes and behavior in live state.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				7. Preparation of phylogentic tree/cladogram of invertebrates including minor phyla. **8.** Preparation of permanent mount of mouth parts of mosquito. **9.** Study the evidences of evolution (Analogy and homology) through charts/ models. **Suggested Books:** ➢ Lal, S.S. (2015). *Practical Zoology: Invertebrates* (11th ed.). Meerut: Rastogi Publication. ➢ Verma, P.S. (2010). *A Manual of Practical Zoology: Invertebrates* (11th ed.). New Delhi: S Chand Publishing.	
B. Sc. Bioscience II Semester					
5.	**BOT 102:** Angiosperms Anatomy, Embryology and Tissue Culture	On the completion of the course, students will be able to: • Gain knowledge of plant cells, tissues and their functions. • To identify and compare structural differences among different taxa of vascular plants. • To correlate anatomical structure with ecological adaptation of plants for survival under drought, salinity & aqueous environment.	**Unit 1** • Angiosperm: Tissues, structure and function. • Meristematic and permanent tissues, simple, complex and secretory tissue. • Anamolous secondary growth in stem and roots: *Boerhaavia*, *Bignonia*, *Salvadora*, *Nycatanthes*, *Dracaena* and *Aristolochia.* **Unit 2** • Ecological anatomy: General adaptations of hydrophytes, xerophytes and halophytes. • Anatomical adaptations of hydrophytes: *Hydrilla*, *Nymphaea.* • Anatomical adaptation of xerophytes: *Calotropis*, *Nerium*, *Capparis.* • Halophytes: Mangrove plants- *Rhizophora*, *Avicennia.* **Unit 3** • Angiosperm embryology: Structure and development of culture, male gametophyte, ovule. • Monosporic, bisporic and tetrasporic types of embryo sacs (one example each of *Polygonum*, *Allium* and *Adoxa*). • Pollination and fertilization. **Unit 4** • Experimental embryology: Apomixis, agamospermy,	No Modification In The Syllabus List of suggested books added List of E-resources added **Suggested Books:** ➢ Bhojwani, S.S., Bhatnagar, S.P., & Dantu, P.K. (2014). *The embryology of Angiosperms* (6th ed.). Vikas Publishing House Pvt. Ltd. ➢ Eames, A.J. (1961). *Morphology of the Angiosperms*. New York: McGraw Hill. ➢ Eames, A.J., & MacDaniels, L.H. (1947). *Introduction to Plant Anatomy*. New York: McGraw Hill. ➢ Fahn, A. (1997). *Plant Anatomy*. New Delhi: Aditya Books (Pvt) Ltd. ➢ Kumar, V. (2011). *Methods in Plant tissue culture* (3rd ed.). Jodhpur: Agrobios. ➢ Maheswari, P. (1950) Introduction To The *Embryology Of Angiosperms*. New York: McGraw Hills. ➢ Pandey, B.P. (2018). *A Text Book of Botany: Angiosperms Taxonomy, Anatomy and embryology*. New Delhi: S Chand and Company Ltd. ➢ Pandey, S.N., & Chadha, A. (2007). *Plant Anatomy And Embryology*. New Delhi: UBS publishers and distributors Pvt. Ltd.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			apospory and parthenocarpy. • Adventive embryony. • Control of fertilization. • Endosperm and embryo development. **Unit 5** • Tissue culture: Basic techniques- sterilization and media preparation. • Concept of totipotency. • Protoplast isolation and culture; somatic hybridization; anther, embryo and organ culture. • Tissue culture as a technique in regeneration of plants and its role in industry. **Books recommended:** ➢ Morphology of the Angiosperms: A.J. Eames, McGraw Hill, New York. ➢ Introduction to Plant Anatomy: A.J. Eames & MacDaniel, McGraw Hill, New York. ➢ Plant Anatomy: A. Fahn, Aditya Books (Pvt) Ltd., New Delhi. ➢ Plant Anatomy: M.S. Tayal, Rastogi Publication, Meerut. ➢ Embryology of Angiosperms: S.S.Bhojwani and Bhatnagar, Vikas Publications. ➢ Introduction to the Embryology of angiosperms: P. Maheswari, McGraw Hills New York ➢ Plant Tissue Culture: S.S. Bhojwani and M.K. Razdan, Elsevier. ➢ Plant Tissue-Applications and Limitations: S.S. Bhojwani, Elsevier, The Netherlands. ➢ Methods in Plant tissue culthse : V.Kumar, Agrobios, 2011 IIIrd resised Ed.	➢ Razdan, M.K. (2018). *Introduction To Plant Tissue Culture*. New Delhi: CBS Publishers and Distributors Pvt. Ltd. ➢ Tayal, M.S. (2004). *Plant Anatomy*. Meerut: Rastogi Publication. **Suggested e-Resources:** ➢ **Plant tissues types, structure and functions** http://edudel.nic.in/PAHAL/biology_260309/biology_dt_270309.pdf http://lib.du.ac.ir/documents/10157/60298/Anatomy+of+Flowering+Plants.pdf ➢ **Secondary anomalous structures** http://www.biologydiscussion.com/anatomy/anatomy-of-anomalous-dicot-stems-botany/56969 ➢ **General account of angiosperms** http://www.nhptv.org/natureworks/nwep14f.htm ➢ **Secondary growth** http://egyankosh.ac.in/bitstream/123456789/16401/1/Unit-10.pdf ➢ **Embryology of angiosperms** krishikosh.egranth.ac.in/bitstream/1/2023583/1/BPT10611.pdf ➢ **Plant tissue culture techniques** https://nptel.ac.in/courses/102103016/4 ➢ **Introduction to plant tissue culture** http://shodhganga.inflibnet.ac.in/bitstream/10603/110292/12/12_chapter%202.pdf	
6.	**BOT 102L:** Angiosperms Anatomy, Embryology	On completion of the course, students will have: • Detailed knowledge	1. Vegetative structure of hydro - and xerophytes (ecological anatomy of *Calotropis*, *Capparis*, *Nerium*, *Hydrilla* and *Nymphaea*) by preparation of temporary slides.	No Modification In The Syllabus List of suggested books added **Suggested Books:** ➢ Bendre, A., & Kumar, A. (2010). *A Textbook of*	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
	and Tissue Culture Lab	of angiosperm families and plant adaptations in different environment. • Understanding plant tissue culture and preparation of MS medium for in vitro culture of plants.	2. Anamolous secondary growth in stem/root of angiosperms (*Boerhaavia*,*Bignonia*, *Salvadora*, *Aristolochia*, *Nyctanthes*and *Dracaena*) by preparation of temporary slides. 3. Slides and models on embryology. 4. MS media preparation 5. Embryo culture.	*Practical Botany*- II. Meerut: Rastogi Publications.	
7.	**ZOO 101:** Non-Chordates and Proto-Chordates	On completion of the course, students will be able to: • Describe the habit, habitat, morphology, structure and functions of important animals of different major phyla of invertebrates and lower chordates. • Understand the economic importance of various invertebrate phyla and affinities of lower chordate animals. • Gain a high degree of competence in its field of specialization in	**Unit 1** **Protozoa** • Habitat, habits, external features, locomotion, osmoregulation, nutrition, reproduction and life cycle of *Euglena, Paramecium* and *Monocystis.* • Economic importance of protozoans. **Porifera** • Habitat, habits, structural organization, canal system, reproduction and development of *Sycon* including evolution of canal system in sponges. • Economic importance of sponges. **Unit 2** **Coelenterata** • Habitat, habits, external features, nutrition, structural organization, reproduction and life cycle of *Obelia*. • Corals and coral reefs. **Helminthes** • Habitat, habits, external features, different systems and life history of following animal types: *Fasciola, Taenia* and *Ascaris.* • Parasitic adaptations and diseases caused by helminthes. **Unit 3** **Annelida** • Habitat, habits, external features, different systems and	**Unit 1** **Protozoa** • Habitat, habits, external features, locomotion, osmoregulation, nutrition, reproduction and life cycle of *Euglena, Paramecium* and *Monocystis.* • Economic importance of protozoans. **Porifera** • Habitat, habits, structural organization, canal system, reproduction and development of *Sycon* including evolution of canal system in sponges. • Economic importance of sponges. **Unit 2** **Coelenterata** • Habitat, habits, external features, nutrition, structural organization, reproduction and life cycle of *Obelia*. • Corals and coral reefs. **Helminthes** • Habitat, habits, external features, different systems and life history of following animal types: *Fasciola, Taenia* and *Ascaris.* • Parasitic adaptations and diseases caused by helminthes. **Unit 3** **Annelida** • Habitat, habits, external features, different systems and	

<table>
<tr><th>S No.</th><th>Course List</th><th>Learning Outcomes</th><th>Existing Syllabus</th><th>Suggested Syllabus</th><th>Remarks</th></tr>
<tr><td></td><td></td><td>response to the changing demands of the times.</td><td>development of Pheretima.
• Salient features of Neanthes.
Arthropoda
• Habitat, habits, external features and different systems of Palaemone.
• Economic importance of insecta.
Unit 4
Mollusca
• Habitat, habits, external features, various organs and organ systems of Pila and Unio; pearl formation.
• Economic importance of mollusca.
Echinodermata
• Habitat, habits, external features and water-vascular system of Asterias.
• Larval forms of echinoderms.
Hemichordata
• Habitat, habits, external features and different system of Balanoglossus.
• Affinities of hemichordates.
Unit 5
Urochordata
• Habitat, habits, structural organisation and various systems of Herdmania.
• Tadpole larva and retrogressive metamorphosis in Herdmania.
Cephalochordata
• Habitat, habits, morphology, different systems and affinities of Amphioxus.
• Development of coelom and atrium of Amphioxus.

Books recommended:
➢ Invertebrates: R. L. Kotpal, Rastogi Publications, Meerut.
➢ A text book of Zoology: S.N. Prasad, Allahabad, Kitab Mahal.</td><td>development of Pheretima.
• Habitat, habits, external features and life history of Neanthes.
Arthropoda
• Habitat, habits, external features and different systems of Palaemone.
• Economic importance of insecta.
Unit 4
Mollusca
• Habitat, habits, external features, various organs and organ systems of Pila and Unio; pearl formation.
• Economic importance of mollusca.
Echinodermata
• Habitat, habits, external features and water-vascular system of Asterias.
• Larval forms of echinoderms.
Hemichordata
• Habitat, habits, external features and different system of Balanoglossus.
• Affinities of hemichordates.
Unit 5
Urochordata
• Habitat, habits, structural organisation and various systems of Herdmania.
• Tadpole larva and retrogressive metamorphosis in Herdmania.
Cephalochordata
• Habitat, habits, morphology, different systems and affinities of Amphioxus.
• Development of coelom and atrium of Amphioxus.
Suggested Books:
➢ Chaki, K.K., Kundu, G., & Sarkar, S. (2014). Introduction to Economic Zoology. Kolkata: New Central Book Agency.
➢ Chaki, K.K., Kundu, G., & Sarkar, S. (2015).</td><td></td></tr>
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S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ A text book of Zoology: H.C. Nigam Delhi, S.Nagin. ➢ A text book of Zoology: P.S. Dhami, New Delhi, R. Chand. ➢ A text book of Zoology: T.C. Majupuria, Jallundhur City, S. Nagin. ➢ A text book of Zoology: V.B. Rastogi, Ram Nath Kedar Nath, Meerut. ➢ Kotpal Series Vol. I to IX, Rastogi Publication, Meerut. ➢ CNH Series Vol. I to IX. ➢ Hymen Series Vol. I to IX, Mc Graw Hill.	*Introduction to General Zoology* Vol-I. Kolkata: New Central Book Agency. ➢ Dhami P.S., & Dhami, J.K. (2015). *Invertebrate Zoology*. New Delhi: R. Chand and Co. ➢ Hyman, L.H. *The Invertebrtaes*. Vol-I-IX. New York: McGraw Hill. ➢ Jordan, E.L., & Verma, P.S. (2018). *Invertebrate Zoology*. New Delhi: S. Chand & Company Ltd. ➢ Kotpal, R.L. (2014). *Modern Textbook of Zoology: Invertebrates* (11th ed.). Meerut: Rastogi Publications. ➢ Kotpal, R.L. (2018). *Modern Text book of Zoology: Vertebrates* (4th ed.). Meerut: Rastogi Publications. ➢ Lahiri, B.K. (2013). *College Zoology* Vol-I. Mumbai: Himalaya Publishing House. ➢ Majupuria, T.C. (1962). *A textbook of invertebrate Zoology* (1st ed.). Jullundur City: S. Nagin Publishers. ➢ Nigam, H.C. (2013). *Biology of Non-Chordates*. New Delhi: Vishal Publishing Co. ➢ Pechenik, J.A. (2015). *Biology of the Invertebrates* (7th ed.). New Delhi: Mc Graw Hill Education. ➢ Prasad, S.N., & Kashyap, V. (2012). *A Textbook of Invertebrate Zoology* (XIV Ed.). New Delhi: New Age International (P) Limited. ➢ Rastogi, V.B. (2017). *Invertebrate Zoology*. Meerut: Kedar Nath Ram Nath. ➢ Shukla, G.S., & Upadhyay, V.B. (2017). *Economic Zoology* (5th ed.). Meerut: Rastogi Publication. **Suggested e-Resources:** ➢ **Corals** https://www.icriforum.org/about-coral-reefs/what-are-corals ➢ ***Paramecium*** https://www.microscopemaster.com/paramecium.html ➢ **Prawn** http://www.biologydiscussion.com/invertebrate-	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				zoology/phylum-arthropoda/study-notes-on-prawn/33417 ➢ ***Amphioxus*** https://embryology.med.unsw.edu.au/embryology/index.php/Book_-_Text-Book_of_Embryology_4 ➢ **Invertebrate animals** http://www.iaszoology.com/category/animal-diversity-nonchordata/ ➢ **Non chordate animals** https://www.slideshare.net/godhxbwnkkdn/animal-diversity-zoology-notes http://abacus.bates.edu/acad/depts/biobook/AnimPhyl.pdf	
8.	**ZOO 101L:** Non-Chordates and Proto-Chordates Lab	On completion of the course, students will be able to: • Identify and characterize different organisms of invertebrate based on the external features. • Describe different organ systems of important invertebrate animals like *Palaemone*, *Pila* and *Asterias*. • Gain practical understanding of preparation of permanent slide and study of internal structures of higher invertebrate animals through	1. **Anatomy :** • Anatomical study of various systems with the help of chart/model/CD. • Identification, localization and labeling of various organs in dissected animal specimen/models/chart/CD. ~~**2. Study of Museum Specimens :**~~ • Porifera: Sycon, Euplectella, Hyalonema, Euspongia and Spongilla. • Coelenterata: ~~—~~Porpita, ~~—~~Velella, ~~—~~Physalia, Aurelia~~,~~ Gorgonia, ~~–~~Pennatula, Alcyonium, ~~–~~Millipora, Tubipora~~,~~ Corallium, Antipathes (Black only), Fungia, (Mushroom, Coral) and Adamsia. • ~~Platyhelminthes:~~ Fasciola, Schistosoma, Echinococcus ~~and~~ Taenia. • Nemathelminthes: Male and Female Ascaris~~,~~ Dracunculus and Entrobius. • Annelida: Aphrodite, Chaetopterus, Terebella, Sabella~~,~~ Arenicola, Pontobdella ~~and~~ Hirudinaria. • Arthropoda: Lepus, Balanus, Sacculina, Squilla, Crab, Hermitcrab, Julus, Scolopendra, Locust, Melanopus, Butterfly, Queen-termite, Cimex, Limulus, Scorpion, Spider and Peripatus. • Mollusca: Chiton, Patella, Cyprea, Aplysia, Dentalium, Mytilus, Pecten, Teredo, Sepia, Loligo, Octopus,	**1. Study of museum specimens:** • Porifera: *Euplectella*, *Chalina, Grantia* and *Spongilla*. • Coelenterata: *Physalia*, *Aurelia*, *Millipora*, *Tubipora*, *Corallium*, *Antipathes* (black only), *Fungia* (mushroom coral). • Platyhelminthes: *Schistosoma* and *Taenia*. • Nemathelminthes: Male and female *Ascaris*. • Annelida: *Nereis*, *Chaetopterus*, *Sabella*, *Arenicola*, *Hirudinaria*. • Arthropoda: *Balanus*, *Squilla*, *Julus*, *Scolopendra*, Locust, Butterfly, *Cimex*, Scorpion, Spider. • Mollusca: *Patella*, *Cyprea*, *Pecten*, *Octopus*, Pearl oyster, *Nautilus*. • Echinodermata: *Antedon*, *Clypeaster*, Cucumara, *Ophiothrix*. • Hemichordata: *Balanoglossus*. • Protochordata: *Ciona* and *Salpa*. **2. Study of microscopic slides:** • Protozoa: *Amoeba*, *Polystomella*, *Monocystis*, Binary fission and conjugation in *Paramecium*. • Porifera: T.S. and L.S. of *Sycon*, Spicules of sponge, Canal system of sponge. • Coelenterata: *Obelia*.	The laboratory course ZOO 101L is proposed to be modified by including the five major exercises: study of museum specimens, study of prepared slides, preparation of permanent mount, anatomical study of selected animals and collection & culture methods. Animals of invertebrate phyla (protozoa to protochordata) are included in these exercises. In addition to these five major exercises, permanent mount preparation of house fly and to study the methods of museum specimens

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		microscopic study of prepared slides. • Understand the collection of certain arthropods from their natural habitat and develop the skills of vermiculture.	Nautilus. • Echinodermata: Antedon, Holothuria, Echinus, Clypeaster and Ophiothrix. • Hemichordata: Balanoglossus. • Protochordata: Ascidia, Ciona, Botryllus and Salpa.	• Platyhelminthes: W.M. of miracidium, sporocyst, redia, cercaria and metacercaria larva of *Fasciola*. • Annelida: T.S. of *Nereis* through trunk region, T.S. of *Pheretima posthuma* through gizzard, typhlosolar region, prostrate glands and seminal vesicles. • Arthropoda: V.S. of compound eye, *Pediculus*. • Mollusca: T.S. of gill of *Unio*, Glochidium larva. • Echinodermata: Larval forms (Bipinnaria, Echinopluteus, Ophiopluteus). • Hemichordata: T.S. of *Balanoglossus* through proboscis, collar and trunk region. • Protochordata: W.M. velum and pharyngeal wall of *Amphioxus*, T.S. of *Amphioxus* through various regions; tadpole larva of *Ascidia*. **3. Anatomy:** • Anatomical study of various systems with the help of chart/model/CD. ***Palaemon*** 1. Appendages 2. Digestive system 3. Nervous system ***Pila globosa*** 1. Digestive system 2. Structure of radula 3. Nervous system ***Asterias*** 1. Water vascular system **4.** To study methods of preservation of museum specimens. **5. Preparation of permanent slides** • Protozoa: *Paramecium*. • Porifera: Spongin fibers and gemmule. • Coelenterata: *Obelia* colony and medusa of *Obelia*. • Annelida: Parapodium of heteronereis. • Arthropoda: Crustacean larva (nauplius, metanauplius, megalopa, Zoea).	preservation are also proposed to be included.

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				• Mollusca: Glochidium larva of *Unio*. • Echinodermata: Tube feet of *Asterias*. **6. Collection and culture methods** (i) Collection of animals from their natural habitat: *Pheretima*, *Daphnia*, *Cyclops*, house flies, mosquitoes. (ii) Culture of *Pheretima*. **7.** Preparation of permanent mount of mouth parts of cockroach/housefly. **Suggested Books:** ➢ Lal, S.S. (2015). *Practical Zoology: Invertebrates* (11th ed.). Meerut: Rastogi Publication. ➢ Lal, S.S. (2015). *Practical Zoology: Vertebrates* (11th ed.). Meerut: Rastogi Publication. ➢ Verma, P.S. (2010). *A Manual of Practical Zoology: Invertebrates* (11th ed.). New Delhi: S Chand Publishing.	
B. Sc. Bioscience III Semester					
9.	**BOT 201** Angiosperms Taxonomy and Economic Botany	On completion of the course, students will be able to: • Identify characteristic features of angiosperm families and their interdisciplinary approaches Understand plant morphology terminologies and distinguishing features with morphological peculiarities. • Know the economic	**UNIT 1** • ~~Taxonomy: importance, a brief account of the historical development~~ • ~~Code, binomial nomenclature, international rules of Botanical nomenclature~~ • ~~Units of classification, principles of priority, type method~~, citation of author's name • Numerical taxonomy and Chemical Taxonomy (brief ideas only) • A brief account of National Herbaria and Botanical Gardens of India **UNIT 2** • Classification: System of Bentham and Hooker, a brief account of classification by Engler and Prantl, Hutchinson and Takhtajan, merits and demerits • Study of following families with emphasis on their diagnostic features: a. Ranunculaceae	**Unit-I** • International code of nomenclature for algae, fungi and plants- history, rules, principles. Concept of family, genus and species, citation of author's name. • Numerical taxonomy and chemical taxonomy (brief ideas only). • A brief account of national herbaria and botanical gardens of India. **Unit 2** • Classification: System of Bentham and Hooker, a brief account of classification by Engler and Prantl, Hutchinson and Takhtajan, merits and demerits. • Study of following families with emphasis on their diagnostic features: -Ranunculaceae	This brings more clarity to the syllabus. These are already covered in Code. This inclusion will help in explaining plant taxonomy The suggested families are of more relevance

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		importance of angiosperms and its use in various industries.	b. Papavaraceae c. Capparidaceae d. Caryophyllaceae e. Rutaceae f. Myrtaceae g. Malvaceae **UNIT 3** • Study of following families with emphasis on their diagnostic features: a. Cucurbitaceae b. Rubiaceae c. Asclepiadaceae d. Apocyanaceae e. Asteraceae ~~f. Boraginaceae~~ g. Acanthaceae ~~h. Scrophulariaceae~~ i. Lamiaceae j. Euphorbiaceae k. Brassicaceae l. Fabaceae m. Caesalpinaceae n. Mimosaceae o. Poaceae p. Arecaceae q. Liliaceae **UNIT 4** • Food plants: Maize, bajra, wheat, legumes, potato, sugarcane • Spices: general account (coriander, turmeric, chillies, cumin, fennel, Asafoetida) • Beverages: tea and coffee • Fatty oils: mustard, groundnut, sesame, coconut	-Papaveraceae -Capparidaceae -Caryophyllaceae -Rutaceae -Myrtaceae -Malvaceae **Unit 3** • Study of following families with emphasis on their diagnostic features: -Cucurbitaceae -Rubiaceae -Asclepiadaceae -Apocynaceae -Asteraceae -Amaranthaceae -Acanthaceae -Solanaceae -Apiaceae -Lamiaceae -Euphorbiaceae -Brassicaceae -Fabaceae -Caesalpinaceae -Mimosaceae -Poaceae -Arecaceae -Liliaceae **Unit 4** • Food plants: Maize, bajra, wheat, legumes, potato, sugarcane. • Spices: General account (coriander, turmeric, chillies, *Cumin*, fennel, *Asafoetida*). • Beverages: Tea and coffee.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			UNIT 5 • Fibre plants: *Gossypium, Corchorus, Saccharaum munja* • Drug plants: *Cinchona, Rauwolfia, Papaver, Digitalis* • Timber plants: *Tectona, Dalbergia, Pinus,* Rubber: *Hevea brasiliensis.* **Books recommended :** ➢ A Hand Book of Systematic Botany: S.C. Dutta, Asia. ➢ An Introduction to the Taxonomy of Angiosperms: Y.D. Tiagi & S. Khetrapal, Ramesh Book Depot, Jaipur. ➢ Economic Botany: Bendre & Kumar, Rastogi Publications, Meerut. ➢ Economic Botan: Sambamurthy. ➢ A text book of economic botany: V. Verma, Emkay publications, New Delhi. ➢ Economic Botany: S. Kumar, Campus Books, New Delhi. ➢ Fundamentals of Plant systematics - Albert E. Radford. ➢ Taxonomy of vascular plants: G.H.M. Lawrence. ➢ Economic Botam of the Tropics– S.L. Kochhar. ➢ Taxonomy of Angiosperm: R.K. Jain & V. Singh. ➢ Taxonomy of Angiosperm: O.P. Sharma.	• Fatty oils: Mustard, groundnut, sesame, coconut. **Unit** 5 • Fibre plants: *Gossypium, Corchorus, Saccharaum munja*. • Drug plants: *Cinchona, Rauwolfia, Papaver, Digitalis*. • Timber plants: *Tectona, Dalbergia, Pinus.* Rubber: *Hevea brasiliensis.* **Suggested Books :** ➢ Alam, A., & Sharma, V. (2012). *Economic Botany*. Jaipur: Pointer Publishers. ➢ Dutta, S. (2009). *A Hand Book of Systematic Botany*. New Delhi: New Age International (P) Limited. ➢ Khetrapal, Y.T. *An Introduction to the Taxonomy of Angiosperms*. Jaipur: Ramesh Book Depot. ➢ Kochhar, S.L. (2016). *Economic Botany of the Tropics*. London: Macmillan India Limited ➢ Kumar, A., & Bendra, A. (1983). *Economic Botany: for university students*. Meerut: Rastogi Publications. ➢ Lawrence, G.H.M. (2017). *Taxonomy of vascular plants*. Jodhpur: Scientific publisher ➢ Radford, A.R., & Caddell, G.M. (1986). *Fundamentals of Plant systematics*. USA: Harper & Row Publishers. ➢ Sharma, O.P. (2011).*Taxonomy of Angiosperm*. New Delhi: TATA McGraw-Hill. ➢ Singh, V., & Jain, D.K. (2010).*Taxonomy of Angiosperm*. Meerut: Rastogi Publication. ➢ Verma, V. (2010). *A text book of economic botany*. New Delhi: Emkay publications. **Suggested e-Resources:** ➢ **Angiosperms: APG system of classification** https://academic.oup.com/botlinnean/article/181/1/1/2416499 ➢ **Angiosperms: Classification and reproduction** https://www.toppr.com/guides/biology/plant-kingdom/angiosperms/ ➢ **Economic botany**	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				http://nsdl.niscair.res.in/jspui/bitstream/123456789/130/1/beverages.pdf	
10.	**BOT 201 L:** Angiosperms Taxonomy and Economic Botany Lab	On completion of the course, students will be able to: • Develop skills for plant identification, with reference to systematic position, morphological characters, floral formula and floral diagram. • Diagnose the structural features of plant organs and differentiate microscopically their tissue elements. • Study fiber, gum, resin, timber, spices and medicinal plants and its applications.	1. Study of locally available ~~flowers~~ of the families mentioned in the syllabus. 2. Study of economically important plant products as mentioned in the syllabus	1. Study of locally available plants of the families mentioned in the syllabus. 2. Study of economically important plant products as mentioned in the syllabus. 3. Preparation of herbarium. **Suggested Books:** ➢ Sahu, A.C. (2015). *Text book of Practical Botany*. New Delhi: Kalyani Publishers.	Preparation of herbarium is important part in the taxonomy.
11.	**ZOO 201**: Cell Biology, Molecular Biology, Histology and Genetics	On completion of the course, students will be able to: • Understand the fundamental knowledge of cell and its organization. • Describe the classification,	**Unit 1** • Definition of Cell and Molecular Biology and the difference between the two Sciences, ~~Modern concept of a typical cell, Difference between prokaryotic and eukaryotic cells.~~ • ~~Physical organization of cell: Colloidal properties of protoplasm,~~ formation of cell membranes and movement of protoplasm. • ~~Chemical organization of protoplasm: Inorganic and organic constituents of protoplasm,~~ Structural and	**Unit 1** • Definition of cell and molecular biology and the differences between the two sciences. Cell theory; morphology, size, shape and characteristics of prokaryotic and eukaryotic cells. • Physical and biochemical makeup of protoplasm, formation of cell membranes and movement of protoplasm. • Classification, structure and functions of carbohydrates, proteins and lipids. Classification, nomenclature and	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		structure and functions of carbohydrates, proteins and lipids. • Understand the theoretical aspects of structure and location of various tissues and histology of various body organs. • Describe the molecular structure and types of nucleic acids along with DNA replication and translation. • Describe fundamental and molecular principles of genetics and human genetic traits.	molecular organization of carbohydrates, proteins, ~~fats,~~ vitamins, enzymes and hormones. **Unit 2** Biological organization of cell : • Plasma membrane, Cell wall and Endoplasmic Reticulum (Rough and Smooth) • Mitochondria, Golgi body and Lysosomes • Nucleus, Nucleolus and Chromosomes with special reference to polytene and lampbrush chromosomes. **Unit 3** • An idea about the structure and location of various tissues: Epithelial, Connective, Cartilage, Bone, ~~Muscular and Nervous~~. • Histology of ~~Skin,~~ Digestive organs and associated glands, Blood vessels, Trachea and Lung. • Histology of Kidney, Ovary, Testis, Vas deferens and Oviduct **Unit 4** • Occurrence, morphology, chemical composition, molecular structure, functions and replication of DNA. • Occurrence, morphology, chemical composition, molecular structure and functions of various types of RNA. • Mechanism of protein synthesis and genetic code. **Unit 5** • ~~Genetical terminology,~~ Mendel's law of inheritance, ~~Gene-gene interaction~~, Multiple alleles, Linkage and Crossing over. • Sex-determination: Chromosomes theory, Genetic balance theory and hormone theory, factors affecting sex determination, sex-linked inheritance. ~~Cytoplasmic inheritance, Heredity and Environment with special reference to the study of twins.~~ **Books recommended:**	functions of enzymes. Structure and functions of vitamins and hormones. **Unit 2** Biological organization of cell: • Plasma membrane, cell wall and endoplasmic Reticulum (rough and smooth) • Structure and functions of mitochondria, golgi body and lysosomes. • Nucleus, nucleolus and chromosomes with special reference to polytene and lampbrush chromosomes. **Unit 3** • An idea about the structure and location of epithelial and connective tissue; cartilage and bone. • Histology of digestive organs and associated glands, blood vessels, trachea and lung. • Histology of kidney, ovary, testis, vas deferens and oviduct. **Unit 4** • Occurrence, morphology, chemical composition, molecular structure, functions and replication of DNA. • Occurrence, morphology, chemical composition, molecular structure and functions of various types of RNA. • Mechanism of protein synthesis and genetic code. **Unit 5** • Overview of Mendel's law of inheritance, concept of gene: allele, multiple alleles, extensions of Mendelian principles: codominance, incomplete dominance, gene interactions, pleiotropy, linkage and crossing over. • Sex chromosomes, sex determination in animals, sex-linked inheritance. • Human genetics: Pedigree analysis, karyotypes, disorders of allosomes & autosomes. Quantitative genetics: Polygenic inheritance, heritability and its measurements. **Suggested Books:**	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Cell and Molecular Biology: G. Karp, Palgcave Mcmillan. ➢ Cell and Molecular Biology: De Robertis & De Robertis, B.I. Waverly, Pub. Lippin Cott Williams Philadelphia. ➢ Cell and Molecular Biology: P.K. Gupta, Rastogi Publications, Meerut, Rastogi Pub. Meerut. ➢ Histology & Genetics: M. Ullah, Ram Nath Kedar Nath, Cell Briology, Molecular Biology, Geneties, Evolution Meerut & Ecology : Verma and Aggarwal, R. Chand & Co. ➢ Molecular Cell Biology: Lodish, Baltimore, W. H. Freeman & Co. ➢ Essentials of Cytology: C.B. Powar, Himalaya Publications. ➢ Cytology: V.B. Rastogi, Pub. Kedarnath Ramnath, Meerut. ➢ Concepts of Genetics 7th Ed.: William S. Klug, Pearson Education. ➢ Genetics: P.J. Russell. ➢ Principles of Genetics: R.H. Tamarin, Tata McGraw Hill. ➢ Principles of Genetics: Gardner, Simmons, Snustad, John Wiley & Sons. ➢ Gene VIII: Lewin, Pearson Education. ➢ Advanced Genetics: G.S. Miglani, Narosa, New Delhi. ➢ Molecular Biology: David Freifelder, Narosa, New Delhi. ➢ Molecular Biology and Biotechnology: H.D. Kumar, Vikas, New Delhi.	➢ De Robertis, E.D.P., & De Robertis, E.M.F. (1987). *Cell and Molecular Biology* (8^{th} ed.). USA: Lea & Febiger. ➢ Gardner, E.J., Simmons, M.J., & Snustad, D.P. (2005). *Principles of Genetics* (8^{th} ed.). New Jersey, USA: John Wiley & Sons Ltd. ➢ Gardner, E.J., Simmons, M.J., & Snustad, D.P. (2006). *Principles of Genetics* (8^{th} ed.). USA: John Wiley & Sons. ➢ Gartner, L.P. (2016). *Text Book of Histology* (4^{th} ed.). Elsevier. ➢ Gupta, P.K. (2018). *Cell and Molecular Biology* (5^{th} ed.). Meerut: Rastogi Publications. ➢ Gupta, S.N. (2015). *Biochemistry* (2^{nd} ed.). Meerut: Rastogi Publication. ➢ Kar, D.K., & Halder, S. (2018). *Cell Biology, Genetics & Molecular Biology*. Kolkata: New Central Book Agency. ➢ Karp, G., Iwasa, J., & Marshall, W. (2018). *Karp's Cell Biology*. New Jersey: Wiley Publication. ➢ Klug, W.S., Cummings, M.R., Spencer, C.A., Palladino, M.A., & Killian, D. (2018). *Concepts of Genetics* (12^{th} ed.). USA: Pearson. ➢ Lodish, H., Berk, A. Kaiser, C.A., Krieger, M., & Scott, M.P. (2007). *Molecular Cell Biology* (6^{th} ed.). USA: W H Freeman. ➢ Malacinski, G.M. (2015). *Freifelders Essentials of Molecular Biology* (4^{th} ed.). USA: Jones & Bartlett. ➢ Miglani, G.S. (2007). *Advanced Genetics*. New Delhi: Narosa. ➢ Powar, C.B. (2014). *Essentials of Cytology*. Mumbai: Himalaya Publishing House**.** ➢ Rastogi, V.B. (2010). *Fundamental of Molecular Biology*. New Delhi: ANE Books. ➢ Rastogi, V.B. (2016). *Introductory Cytology – Knrn*. Meerut: Kedar Nath Ram Nath Publishers. ➢ Rej, S.K. (2018). *General Concepts of Histology &*	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				Endocrinology. Kolkata: New Central Book Agency. ➢ Russell, P.J. (2009). *iGenetics: A Molecular Approach* (3rd ed.). Pearson Education India. ➢ Satyanarayana, U., & Chakrapani, U. (2017). *Essentials of Biochemistry* (2nd ed.). Kolkata: Booka & Allied Ltd. ➢ Tamarin, R.H. (2004). *Principles of Genetics* (7th ed.). USA: McGraw-Hill Higher Education. ➢ Verma, G. P. (2001). *Fundamentals of Histology*. New Delhi: New Age International (P) Limited Publishers. ➢ Verma, P.S., & Agarwal, V.K. (2004). *Cell Biology, Genetics, Molecular Biology, Evolution & Ecology*. New Delhi: S. Chand Publisher. **Suggested e-Resources:** ➢ **Introductory genetics** http://depts.washington.edu/genetics/courses/genet371b-aut99/overheads/pdfs/all_lect.pdf ➢ **Cell biology** https://nptel.ac.in/courses/102103012/6 ➢ **Cell biology & organelles** https://www.nicholls.edu/biol-ds/biol155/Lectures/Cell%20Biology.pdf ➢ **Biomolecules** http://www.biologie.ens.fr/~mthomas/L3/intro_biologie/2-sucres-lipides-acides-nucleiques.pdf ➢ **Enzymology** https://nptel.ac.in/courses/102102033/14 ➢ **Human genetics** https://nptel.ac.in/courses/102104052/ ➢ **Mendelian genetics & deviation** https://www.khanacademy.org/science/biology/classical-genetics/variations-on-mendelian-genetics/a/multiple-alleles-incomplete-dominance-and-codominance http://download.nos.org/srsec314newE/PDFBIO.EL21.pdf	
12.	**ZOO 201L:**	On completion of	**1.** Tests for Carbohydrates :	1. Preparation of normal and molar solutions.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
	Cell Biology, Molecular Biology, Histology and Genetics Lab	the course, students will be able to: • Learn the preparation of buffers and different concentration solutions. • Demonstrate the practical skills of various biochemical tests of carbohydrates, proteins and lipids. • Carry out enzyme assay and salt precipitation of protein from moong seeds. • Develop competency in the genetic problems.	(i) Molisch's Test for general carbohydrates. (ii) Benedict's test and Fehling's test for glucose. (iii) Tests for disaccharides-sucrose, lactose and maltose. (iv) Tests for polysaccharides-starch and glycogen. **2.** Tests for Proteins: (i) Biuret's Test (ii) Million's Test (iii) Xanthoprotec Test (iv) Ninhydrin Test **3.** Test for lipids: (v) Sudan IV Test ~~**4.** Measurement of enzyme activity.~~ **5.** Acetocarmine preparation from the material available and identifying mitotic or meotic stages. ~~**6.** Maintaining culture of paramecium and to study cyclosis and trichocyst discharge in paramecium.~~ **7.** Study of permanent slides: (i) Study of the prepared slides of nucleic acids proteins and mucopolysaccharides. (ii) Study of salivary gland, lampbrush and polytene chromosomes. **8.** Purification of an enzymatic protein by salt precipitation. **9.** Genetic problem (Linkage and crossing over).	2. Preparation of buffers. 3. Tests for carbohydrates: i. Molisch's test for general carbohydrates ii. Benedict's test and Fehling's test for reducing sugars (glucose, maltose, lactose) iii. Tollen's phloroglucinol test for galactose iv. Tests for non reducing sugar (sucrose) v. Barfoed's test for monosacharides vi. Seliwanoff's test for ketoses (fructose) vii. Iodine tests for polysaccharides-starch and glycogen 4. Tests for proteins: i. Biuret's test ii. Million's test iii. Xanthoproteic test iv. Ninhydrin test v. Sakaguchi test vi. Fohl's test (sulfur test) 5. Test for lipids: i. Sudan IV test ii. Emulsion test iii. Saponification test 6. To prepare standard curve of ammonium sulfate. 7. Preparation of enzyme extract from mung seeds and measurement of asparaginase activity. 8. Purification of an enzymatic protein by salt precipitation. 9. Demonstration of salivary amylase activity. 10. Acetocarmine preparation from the material available and identifying mitotic or meiotic stages. 11. Study of permanent slides: i. Study of the prepared slides of nucleic acids proteins and mucopolysaccharides. ii. Study of salivary gland, lampbrush and polytene chromosomes. 12. Genetic problem (Linkage and crossing over). **Suggested Books:**	Some important test (Barfoed's test and Seliwanoff's test) are added One important test (Sakaguchi test) is required to detect the presence of arginine amino acid is added in modified syllabus. Acid phosphatase enzyme activity measurement will be followed by precipitation of enzyme by ammonium sulfate salt.

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				➢ Boya, R.F. (2006). *Modern Experimental Biochemistry* (3rd ed.). Noida: Pearson Education. ➢ Deb, A.C. (2013). *Comprehensible Viva & Practical Biochemistry* (2nd ed.). Kolkata: New Central Book Agency. ➢ Kumar, A., Grg, S., & Garg, N. (2017). *Biochemical Tests: Principles & Protocols*. New Delhi: Viva Books. ➢ Rao, B.S., & Deshpande, V. (2012). *Experimental Biochemistry*. New Delhi: I.K. International Publisher. ➢ Sadasivam, S., & Manickam, A. (1996). *Biochemical Methods* (2nd ed.). New Delhi: New Age International Publishers. ➢ Sharma, S. (2007). *Experiments and Techniques in Biochemistry* (1st ed.). New Delhi: Galgotia Publication.	
B. Sc. Bioscience IV Semester					
13.	**BOT 202:** Microbiology and Plant Pathology	On completion of the course, students will be able to: • Understand the structure and life process of prokaryotes and virus. • Know about sources of plant pathogens, identify symptoms & methods of studying plant diseases • Identify the role of various microbes in food and beverage industries.	**Unit 1** • Microbiology-Brief history, ~~Media preparation,~~ Techniques for sterilization, Pure culture techniques, ~~streak technique~~, staining techniques-brief idea. • Cultivation of Viruses. • Preservation of Microorganisms. **Unit 2** • General account of Bacteria: Brief classification, structure, types, nutrition, ~~reproduction.~~ • General account of Viruses: Introduction, structure, composition, ~~classification of plant viruses~~ and replication. • ~~Myxomycetes and Mycoplasma.~~ **Unit 3** • Microbiology of foods and beverages: Meat, Milk, Rumen Symbiosis, Yogurt, Butter, Sauerkraut, Silage, Alcoholic beverages, Bread making. • Microbes as spoilage of food.	**Unit 1-** • Microbiology- Brief history. • General account of bacteria- Brief classification and structure; nutrition-types, media; bacterial growth- brief idea, factors affecting growth. • Recombination in bacteria- conjugation, transformation and transduction. • Pure culture techniques, staining techniques- a brief idea. **Unit-2** • Techniques for sterilization. • Preservation of microorganisms. • General account of viruses: introduction, structure and composition. • Replication of viruses: lytic and lysogenic cycles. • Cultivation of viruses. **Unit-3** • Microbiology of foods and beverages: Bread making, alcoholic beverages (beer and whisky), cheese, fermented milk products, sauerkraut. • Microbes in spoilage of food.	Without explaining bacteria, one cannot explain pure culture etc. also media is an integral part of nutrition. Therefore, it need not be taken separately. There is no reason to particularly discuss myxomycetes and mycoplasma. Also, related topics should be placed together Those products should be mentioned which are most popular and

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			Unit 4 • Bacterial diseases: General symptoms and types of bacterial diseases. (i) Soft rot of carrot (ii) Bacterial wilt of maize (iii) Brown rot of potato (iv) *Citrus* canker • Viral diseases : General symptoms, survival and transmission of plant viruses (i) Tomato leaf curl (ii) Cucumber mosaic (iii) Potato Mosaic (iv) Tobacco Mosaic **Unit 5** • Fungal Diseases : General symptoms, and disease cycle (i) Wart disease of Potato (ii) Damping off (iii) Green ear of Bajra (iv) Powdery mildew on Wheat (v) Black Rust (vi) Smut - Wheat and Bajra (vii) White Rust (viii) Early blight of Potato **Books Recommended :** ➢ Introductory Mycology: C.M. Alexopoulus, John Wiley & Sons, New York. ➢ An Introduction to Viruses: S.B. Biswas, Vani Education. ➢ Plant Pathology- Fungi & Diseases in Plants: E.J. Butler, Thanker Spink & Co., Kolkata. ➢ Plant Disease: R.S. Singh, Oxford & IBH, New Delhi. ➢ Plant Pathology: R.S. Mehrotra, Vikas Publishing House. ➢ Introduction to Fungi: H.C. Dubey, Vikas Publishing House.	**Unit 4** • Bacterial diseases: General symptoms and types of bacterial diseases. (i) Soft rot of carrot (ii) Bacterial wilt of maize (iii) Brown rot of potato (iv) *Citrus* canker • Viral diseases: General symptoms, survival and transmission of plant viruses. (i) Tomato leaf curl (ii) Cucumber mosaic (iii) Potato Mosaic (iv) Tobacco Mosaic **Unit 5** • Fungal diseases: General symptoms and disease cycle. (ix) Wart disease of potato (x) Damping off (xi) Green ear of bajra (xii) Powdery mildew on wheat (xiii) Black rust (xiv) Smut - Wheat and bajra (xv) White rust (xvi) Early blight of potato. **Suggested Books:** ➢ Agrios, G.N. (2005). *Plant Pathology* (5th ed.). Elsevier Science. ➢ Alexopoulus, C.J., Mims, C.W., & Blackwell, M. (2007). *Introductory Mycology*. New York: John Wiley & Sons. ➢ Ananthanarayan, R., & Paniker, C.K.J. (2009). *Ananthnarayan and Paniker's Textbook of Microbiology* (9th ed). Universities Press (India) Private Limited. ➢ Biswas, S.B. (2009). *An Introduction to Viruses*. New Delhi: Vani Education. ➢ Butler, E.J. *Plant Pathology- Fungi & Diseases in*	studied. Rumen symbiosis is not a part of microbiology of foods and beverages. Silage is feed not food.

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Microbiology: M.J. Pelczar, E.C.S. Chan and N.R. Kreig, Tata McGraw Hill. ➢ A Text book of Microbiology: R.C. Dubey and D.K. Maheshwari, S. Chand and Company. ➢ Introductory Microbilogy: F.C. Ross, Columbus Charles E. Mehrill. ➢ Microbiology - Fundamentals and Applications: S.S. Purohit, Agro Botanical Publishers, Bikaner. ➢ Modern Concepts of Microbiology: H.D. Kumar and S. Kumar, Vikas Publishing House, New Delhi. ➢ Micrsology by RD Sharma.	*Plants*. Kolkata: Thanker Spink & Co. ➢ Dubey, H.C. (2013). *Introduction to Fungi*. Jodhpur: Scientific Publishers. ➢ Dubey, R.C., & Maheshwari, D.K. (2008). *A Text book of Microbiology*. New Delhi: S. Chand and Company. ➢ Kumar, H.D., & Kumar S. (2001). *Modern Concepts of Microbiology*. New Delhi: Vikas Publishing House. ➢ Madigan, M., Martinko, J., Stahl, D., & Clark, D. (2010). *Brock Biology of Microorganisms* (13^{th} ed.). Pearson. ➢ Mehrotra R.S. (2006). *Plant Pathology*. New Delhi: Tata McGraw-Hill. ➢ Pelczar, M.J., Chan, E.C.S., & Kreig N.R. (2008). *Microbiology*: New Delhi: Tata McGraw Hill. ➢ Purohit, S.S. (2009). *Microbiology - Fundamentals and Applications*. Bikaner: Agro Botanical Publishers. ➢ Ross, F.C. (1983). *Introductory Microbiology*. Columbus: Charles E. Mehrill. ➢ Sharma, P.D. (2016). *Microbiology & Plant Pathology*. Meerut: Rastogi Publications ➢ Sharma, P.D. (2017). *Plant Pathology*. Meerut: Rastogi Publications ➢ Singh, R.S. (2013). *Plant Disease*. New Delhi: Oxford & IBH. ➢ Willey, J.M., Sherwood, L.M., & Woolverton, C.J. (2014). *Prescott's Microbiology* (9^{th} ed). McGraw-Hill Education. **Suggested e- Resources:** ➢ **Plant diseases: Identification and control** https://www.planetnatural.com/pest-problem-solver/plant-disease/	
14.	**BOT 202L:** Microbiology and Plant Pathology	On completion of the course, students will be able to: • Learn techniques	1. ~~A~~ knowledge of instruments and equipments used in microbiology and plant pathology. 2. Isolation of soil microorganisms by Warcup method. 3. Study of bacterial and viral diseases of plants mentioned	1. Knowledge of instruments and equipments used in microbiology and plant pathology. 2. Preparation of media: PDA, NA, EMB. 3. Isolation of soil microorganisms by Warcup method.	1. This should be the series in which the experiments be mentioned.

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
	Lab	for microbial isolation, purification, handling and maintenance. • Gain knowledge of different methods for the isolation of microbial organisms. • Identify the plant diseases based upon symptoms & its causal organism.	in the syllabus (Cucumber mosaic, Tobacco mosaic, Brown rot of potatoes, *Citrus* canker). 4. Preparation of media. 5. Study of fungal diseases in plants mentioned in the syllabus by : Museum specimens and prepared slides. (Smut-Wheat and Bajra, Early Blight of Potato). 6. Bacterial staining. ~~7. Different techniques used in Microbiology: dilution plating, streaking, spreading.~~ 8. Isolation of microorganisms.	4. Isolation of microorganisms from air, water and soil. 5. Measurement of thermal death time and thermal death point of bacterial culture. 6. Streaking techniques: Continuous and discontinuous. 7. Bacterial staining: Simple staining, negative staining, differential staining, endospore staining. 8. Preservation of cultures by making glycerol stock and revival of culture. 9. Study of bacterial and viral diseases of plants mentioned in the syllabus with help of specimens (Cucumber mosaic, tobacco mosaic, brown rot of potatoes, *Citrus canker*). 10. Study of fungal diseases in plants mentioned in the syllabus by: a) Museum specimens; b) temporary and prepared slides (Smut-wheat and bajra, early blight of potato). **Suggested Books :** ➢ Aneja, K.R. (2003). *Experiments in microbiology, plant pathology and biotechnology*. New Age International Publishers. ➢ Mitra, A. (2013). *Practical manual of modern microbiology*. Mumbai: Himalaya Pub. House.	2. Isolation can be worked out from air, soil and water. With the latter sources, dilution technique and spreading is done to obtain bacterial colonies. So there is no necessity of mentioning these techniques separately. 3. Staining should be elaborated and corresponding to their theory various techniques should be taught. Since we teach preservation of culture in theory at least one experiment should be present in practical. 4. Only specimen studies are not enough. As material for these three fungal specimens are available, slide
15.	**ZOO 202:** Comparative Anatomy and Embryology of Chordates	On completion of the course, students will be able to: • Understand the comparative anatomy of various	**Unit 1** • Comparative anatomy with special reference to *Scoliodon, Rana, Uromastix, Columba* and *Oryctolagus*: • Integumentary system: Skin and its derivatives. • Skeleton system: Development of chondrocranium and vertebra; jaw suspension.	No change in the syllabus List of suggested books incorporated List of suggested E-resources incorporated **Suggested Books:** ➢ Balinsky, B.I. (2012). *An Introduction to Embryology*	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		organ systems with special reference to *Scoliodon*, *Rana*, *Uromastix*, *Columba* and *Oryctolagus*. • Gain the fundamental knowledge about the development of frog, Hen's egg and chick to understand the principles of developmental biology. • Gain an elementary idea about reproductive biology.	• Digestive system: Alimentary canal and associated glands. **Unit 2** • Comparative anatomy with special reference to *Scoliodon*, *Rana*, *Uromastix*, *Columba* and *Oryctolagus*: • Respiratory system: Respiratory organs. • Circulatory system: Evolution of heart and aortic arches. • Urinogenital system: Evolution of kidney and urinogential ducts. **Unit 3** • Comparative anatomy with special reference to *Scoliodon*, *Rana*, *Uromastix*, *Columba* and *Oryctolagus*: • Nervous System: Brain and spinal cord. • Eye. • Ear. **Unit 4** • Elementary idea about the formation of egg and sperm. • Fertilization, parthenogenesis, induction and regeneration. • Development of frog upto the end of neurulation, tadpole larva and its metamorphosis. **Unit 5** • Detailed structure of Hen's egg and its development upto 4th somite stage. • Structure, development and functions of extra embryonic membranes in chick. • Definition of placenta, types and functions of mammalian placenta. **Recommended Books:** ➢ Chordates: R. L. Kotpal, Rastogi Publications, Meerut. ➢ A text book of Zoology: Chordates (Comparative	(5th ed.). New Delhi: Cengage Learning India. ➢ Chaki, K.K., Kundu, G., & Sarkar, S. (2016). *Introduction to General Zoology* Vol-II. Kolkata: New Central Book Agency. ➢ Dhami P.S., & Dhami, J.K. (2015). *Chordate Zoology*. New Delhi: R. Chand and Co. ➢ Jain, P.C. (2013). *Elements of Developmental Biology* (Chordate Embryology) (7th ed.). New Delhi: Vishal Publishing Co. ➢ Kardong, K.V. (2011). *Vertebrates: Comparative Anatomy, Function, Evolution* (6th ed.). McGraw-Hill Education. ➢ Kent, G. C., & Carr, R. K. (2000). *Comparative Anatomy of the Vertebrates* (9th ed.). Europe: McGraw-Hill Science. ➢ Kotpal, R.L. (2018). *Modern Text book of Zoology: Vertebrates* (4th ed.). Meerut: Rastogi Publications. ➢ Kotpal, R.L., Sastry, K.V., & Shukla, V. (2017). *Comparative Anatomy & Developmental Biology*. Meerut: Rastogi Publication. ➢ Lahiri, B.K. (2014). *College Zoology* Vol-II. Mumbai: Himalaya Publishing House. ➢ Prasad, S.N., & Kashyap, V. (2010). *A text book of Vertebrate Zoology* (14th ed.). New Delhi: New Age International (P) Limited. ➢ Sastry, K.V., & Shukla, V. (2017). *Developmental Biology*. Meerut: Rastogi Publications. ➢ Saxena, R.K. & Saxena, S. (2016). *Comparative Anatomy of Vertebrates* (2nd ed.). Viva Books Private Limited. ➢ Srivastava, M.L. (1985). *An Introduction to the Comparative Anatomy of Vertebrates*. Allahabad: Central Book Depot. ➢ Verma, P.S., & Agrawal, V.K. (2017). *Chordate Embryology: Developmental Biology*. New Delhi: S	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			anatomy): P.S. Dhami and J.K. Dhami, Pradeep's Publication. ➢ Vertebrates: Comparative Anatomy, fanctron Evolution 3rd Ed.: Kardong, TMH. ➢ A text book of Chordate Zoology: S.N. Prasad. ➢ A text book of Chordate Zoology: H.C. Nigam, Pub. Sohanlal Nagin Chand, 1995. ➢ Comparative anatomy of Chordates: Charles. J. Weichert. ➢ Development Biology: P.C. Jain. ➢ Development Biology: Balinsky.	Chand. **Suggested e-Resources:** ➢ **Comparative anatomy** http://www.iaszoology.com/category/comparative-anatomy/ ➢ **Chick development** http://www.notesonzoology.com/vertebrates/chick/development-of-chick-with-diagram-vertebrates-chordata-zoology/8645 http://www.macollege.in/app/webroot/uploads/department_materials/doc_139.pdf ➢ **Developmental biology** https://www.shomusbiology.com/developmental-biology.html ➢ **Frog development** http://www.notesonzoology.com/frog/development-of-frog-with-diagram-vertebrates-chordata-zoology/8626	
16.	**ZOO 202L:** Comparative Anatomy and Embryology of Chordates Lab	On completion of the course, students will be able to: • Identify higher chordate animals based on the external features. • Identify and distinguish bones of *Rana*, *Varanus*, Fowl and *Oryctolagus*. • Understand histology of organs and endocrine glands through microscopic study of slides.	1. Permanent mountings : i. Placoid and Chenoid Scales ii. Cartilage and Striated muscle fibres of amphibian. iii. Filoplumes. iv. Blood film of mammal. 2. Osteology: A comparative study of articulated and disarticulated bones of *Rana*, *Varanus*, Fowl and *Oryctolagus*. 3. Study of Microscopic slides. i. Comparative study of microscopic slides with special reference to ~~Rana, Varanus, bird~~ and Mammal: V.S. of skin, oesophagus, stomach, intestine, liver, pancreas, Lung, Kidney, Testis, Ovary, Spinal Cord. ii. T.S. of endocrine glands of a mammal. 4. Study of Museum specimens : i. Cyclostomata : Amnocoete larva, *Petromyzon*, *Myxine* and *Bdellostoma*.	1. Permanent mountings: i. Placoid and ctenoid scales ii. Cartilage and striated muscle fibres of amphibian. iii. Filoplumes. iv. Blood film of mammal. 2. Osteology: A comparative study of articulated and disarticulated bones of *Rana*, *Varanus*, Fowl and *Oryctolagus*. 3. Comparative study of microscopic slides with special reference to amphibian and mammal: i. V.S. of skin, oesophagus, stomach, intestine, liver, pancreas, lung, kidney, testis, ovary, spinal cord. ii. T.S. of endocrine glands of a mammal (pituitary, thyroid, parathyroid, adrenal). 4. Study of museum specimens: i. Cyclostomata: Amnocoete larva, *Petromyzon*, *Myxine* and *Bdellostoma*. ii. Pisces: *Sphyrna*, *Torpedo*, *Pristis*, Stingray,	

<table>
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<tr><td></td><td></td><td>• Understand the development of frog and chick through microscopic slides.</td><td>ii. Pisces: Sphyrna, Torpedo, Pristis, Stingray, Chimaera, Acipensor, Amia, Labeo, Wallago, Saccobranclus, Anguilla,Exocoetus, Belone, Hippocampus, Syngnathus, Echeries, Porcupine and Protopterus.
iii. Amphibia: Ichthyophis, Ambystoma, Axolotal Larva, Salamandra, Necturus, Siren, Alytes, Pipa, Hyla and Rhacophorus.
iv. Reptilia: Chelone, Turtle, Testudo, Sphenodon, Phrynosoma, Chaemeleon, Calotes, Hemidactylus, Draco, Hydrophis, Eryx, Python, Naja, Viper, Bungarus and Crocodilus.
v. Aves: Archaeopteryx, Psittaculla, Passer, Columba and Pavo.
vi. Mammalia: Ornithorynchus, Tachyglossus, Pteropus, Funambulus, Hedgehog, Mongoose and Oryctolagus.
5. Development of Chordates :
i. Study of the development and metamorphosis of Frog with the aid of permanent prepared slides.
ii. W.M. of Primitive steak, head folds, 18hrs, 24 hrs 33hrs and of chick embryo, T.S. of chick embryo through various regions upto 4th somite state with aid of permanent prepared slides.</td><td>Chimaera, Acipensor, Amia, Labeo, Wallago, Saccobranclus, Anguilla, Exocoetus, Belone, Hippocampus, Syngnathus, Echeries, Porcupine and Protopterus.
iii. Amphibia: Ichthyophis, Ambystoma, Axolotal larva, Salamandra, Necturus, Siren, Alytes, Pipa, Hyla and Rhacophorus.
iv. Reptilia: Chelone, Turtle, Testudo, Sphenodon, Phrynosoma, Chaemeleon, Calotes, Hemidactylus, Draco, Hydrophis, Eryx, Python, Naja, Viper, Bungarus and Crocodilus.
v. Aves: Archaeopteryx, Psittaculla, Passer, Columba and Pavo.
vi. Mammalia: Ornithorynchus, Tachyglossus, Pteropus, Funambulus, Hedgehog, Mongoose and Oryctolagus.
5. Development of Chordates:
i. Study of the development and metamorphosis of frog with the aid of permanent prepared slides.
ii. W.M. of primitive steak, head folds, 18hrs, 24hrs and 33hrs of chick embryo, T.S. of chick embryo through various regions upto 4th somite state with aid of permanent prepared slides.
Suggested Books:
➢ Ghose, K., & Manna, B. (2016). Practical Zoology (4th ed.). Kolkata: New Central Book Agency.
➢ Lal, S.S. (2015). Practical Zoology: Vertebrates (11th ed.). Meerut: Rastogi Publication.
➢ Poddar, T., Mukhopadhyay, S., & Das, S.K. (2003). An advanced Laboratory Manual of Zoology. Kolkata: Macmillan India Limited.
➢ Verma, P.S. (2010). A Manual of Practical Zoology: Chordates (11th ed.). New Delhi: S Chand Publishing.</td><td></td></tr>
<tr><td colspan="6">B. Sc. Bioscience V & VI Semester</td></tr>
<tr><td colspan="6">Botany Discipline Elective-I & II</td></tr>
<tr><td>1)</td><td>Discipline</td><td>On completion of</td><td></td><td>Discipline Elective:</td><td></td></tr>
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<tr><td></td><td>Elective:
~~6.1:~~
Introduction to Genetics and Genetic Engineering</td><td>the course, students will be able to:
• Acquire knowledge of the structure and arrangement of the genome in living organisms.
• Understand the biochemical nature of nucleic acids, their role in living systems.
• Impart basic genetic manipulation techniques and their application for human welfare.
• Translate concepts in genetic engineering to their own research.</td><td>Unit 1
• Organization of Eukaryotic Chromosomes.
• Bacterial Genetics.
• Cell cycle, Mitosis and Meiosis.
• Eugenics and Genetic Counseling.
Unit 2
• Mendel’s experiments: Laws of inheritance, interaction of factors (Modified dihybrid ratios).
• Quantitative inheritance, Linkage, crossing over, multiple alleles, Sex determination, Sex Linked inheritance.
• Extra chromosomal inheritance.
Unit 3
• Chromosomal aberrations- structural and numerical
• Mutations
• Gene: Basic concept
• Isolation of eukaryotic mRNA, cDNA synthesis and library
• Genomic library
Unit 4
• Restriction enzymes
• Vectors- plasmids, phages, cosmids
• Construction of recombinant DNA
• Screening and selection of recombinant clones
Unit 5
• Isolation of DNA- plasmid, plant genomic DNA, phage DNA
• General idea of Patents and Bio safety Guidelines.
• Biotechnology: Definition, Application of Biotechnology, Basic concept of Biotechnological processes
• Edible vaccines</td><td>BOT 302: Introduction to Genetics and Genetic Engineering
Unit 1
• Organization of eukaryotic chromosomes.
• Bacterial genetics.
• Cell cycle, mitosis and meiosis.
• Eugenics and genetic counseling.
Unit 2
• Genetic terminology, Mendel’s experiments: Laws of inheritance, interaction of factors (Modified dihybrid ratios).
• Quantitative inheritance, linkage, crossing over, multiple alleles.
• Sex determination and sex linked inheritance.
• Extra chromosomal inheritance.
Unit 3
• Chromosomal aberrations- structural and numerical.
• Mutations.
• Gene: Basic concept.
• Isolation of eukaryotic mRNA, cDNA synthesis and library.
• Genomic library.
Unit 4
• Restriction enzymes.
• Vectors- plasmids, phages, cosmids.
• Construction of recombinant DNA.
• Screening and selection of recombinant clones.
Unit 5
• Isolation of DNA- plasmid, plant genomic DNA, phage DNA.
• General idea of patents and bio safety guidelines.
• Biotechnology: Definition, application of biotechnology, basic concept of biotechnological processes.
• Edible vaccines.</td><td></td></tr>
</table>

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			Books recommended: ➢ Genetics: Stirckberger Prentice Hall of India. ➢ Principles of Genetics 9th Ed: Gardner, Simmons, Snustad, John Wiley & Sons. ➢ Genetics: P.K. Gupta, Rastogi Publications Meerut. ➢ Genetics –A molecular approach: T.A. Brown, Chapman and Hall. ➢ Concepts of Genetics 7th Ed.: William S. Klug, Pearson Education. ➢ Principles of Genetics: R.H. Tamarin, Tata McGraw Hill. ➢ Genetics-From Genes to Genomes: Hartwell, McGraw Hill. ➢ Genetics 5th Ed.: D.L. Hartl and E.W. Jones, Jones and Barlett Publishers, Canada. ➢ An Introduction to Genetic Ananlysis: Suzuki, Griffith, Miller & Lewonith. ➢ Microbial Genetics: D. Friefelder, Narosa Publications, New Delhi ➢ Molecular Biology of Gene: J.D.Watson, Pearson Education. ➢ Gene VIII: Lewin, Pearson Education. ➢ Biotechnology by B.D. Singh. ➢ Plant Biotechnology by P.K. Gupta. ➢ Principles of Gene Manipulation: Old & Primrose, Blackwell Scientific Publications. ➢ Understanding Biotechnology: Aluizo Borem, Pearson Education. ➢ Molecular Biotechnology: B.R. Glick and J.J. Pasternak, ASM Press, Washington, USA. ➢ An Introduction to Gene Technology-From genes to clones: Winnacker, VCH.	**Suggested Books:** ➢ Borem, A., Santos, F.R., & Bowen, D.E. (2003). *Understanding Biotechnology* (1^{st} d.). USA: Prentice Hall. ➢ Brown, T. (2011). *Introduction to Genetics –A molecular approach* (1^{st} ed.). USA: Garland Science. ➢ Brown, T.A. (2010). *Gene Cloning and DNA Analysis: An Introduction* (6^{th} ed.). USA: Wiley-Blackwell. ➢ Gardner, E.J., Simmons, M.J., & Snustad, D.P. (2005). *Principles of Genetics* (8^{th} ed.). New Jersey, USA: John Wiley & Sons Ltd. ➢ Glick, B.R., & Patten, C.L. (2017). *Molecular Biotechnology: Principles and Applications of Recombinant DNA* (5^{th} ed.). USA: American Society for Microbiology Press. ➢ Griffiths, A.J.F., Miller, J.H., Suzuki, D.T., Lewonith, R.C. & Gelbert, W.M. (2000). *An Introduction to Genetic Ananlysis* (7^{th} ed.). New York, U.S.: W. H. Freeman. ➢ Gupta, P.K. (2009). *Genetics.* Meerut: Rastogi Publications. ➢ Gupta, P.K. (2010). Plant biotechnology. Meerut: Rastogi Publications. ➢ Hartl, D.L. & Jones, E.W. (1997). *Genetics: Analysis of Genes and Genome* (9^{th} ed.). Canada: Jones and Barlett Publishers. ➢ Hartwell, L., Hood., Goldberg, M., Reynolds, A.E., & Silver, L. (2010). *Genetics: From Genes to Genomes* (4^{th} ed.). New York: McGraw-Hill Education. ➢ Klug, W.S., Cummings, M.R., Spencer, C.A., Palladino, M.A., Killian, D. (2018). *Concepts of Genetics* (12^{th} ed.). USA: Pearson Education. ➢ Krebs, J.E., Goldstein, E.S., & Kilpatrick, S.T. (2012). *Lewin's Genes XI* (11^{th} ed.). USA: Jones and Bartlett Publishers.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				➢ Maloy, S.R., Cronan, J.E., & Friefelder, D. (1994). *Microbial Genetics* (2nd ed.). USA: Jones and Bartlett. ➢ Primrose, S.B., & Twyman, R. (2006). *Principles of Gene Manipulation and Genomics* (7th ed.) UK: Oxford University Press. ➢ Singh, B.D. (2015). Biotechnology. New Delhi: Kalyani Publishers. ➢ Strickberger, M.W. (1995). Genetics (3rd ed.). New Delhi: Prentice Hall India Learning Private Limited. ➢ Tamarin, R.H. (2004). *Principles of Genetics* (7th ed.). USA: McGraw-Hill Higher Education. ➢ Watson, J.D., Tania, A.B., & Stephen, P.B. (2017). *Molecular Biology of the Gene* (7th ed.). USA: Pearson Education. ➢ Winnacker, E.L. (1987). *From Genes to Clones: Introduction to Gene Technology*. Germany: Wiley VCH. **Suggested e- Resources:** ➢ **Genetics** https://www.britannica.com/science/genetics ➢ **Recombinant-DNA-technology** https://www.britannica.com/science/recombinant-DNA-technology https://nptel.ac.in/courses/102103013/4 http://www.agbioworld.org/biotech-info/topics/dev-world/policies4.html ➢ **Principles & processes of recombinant-DNA-technology** https://www.toppr.com/guides/biology/biotechnology-principles-and-process/processes-of-recombinant-dna-technology/ ➢ **Vectors used in genetic engineering** http://www.biologydiscussion.com/genetic-engineering/vectors-used-in-genetic-engineering-biotechnology/61382 ➢ **Patent rights in India**	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				https://www.hg.org/legal-articles/patent-rights-in-india-4995	
2)	**Discipline Elective:** ~~6.2:~~ Genetic and Genetic Engineering Lab	On completion of the course, students will be able to: • Develop skills and understanding about different techniques used in genetics and genetic engineering • Critically analyze and interpret data generated from each practical • Develop knowledge about genetic problems such as genetic mapping, test cross etc.	1. Problems of Genetics 2. Models based on Mendel's law 3. Human Genetics: Tongue rolling, Widow's peak, Ear lobes, Little finger. 4. Estimation of standard DNA. 5. Determination of purity of standard DNA 6. Determination of λ_{max} of standard DNA. 7. Isolation of DNA from plant cells.	**Discipline Elective:** **BOT 302L: Genetic and Genetic Engineering Lab** 1. Problems of genetics. 1. Models based on Mendel's law. 2. Human genetics: Tongue rolling, widow's peak, ear lobes, little finger. 3. Estimation of standard DNA by DPA method. 4. Determination of purity of standard DNA. 5. Determination of λ_{max} of standard DNA. 6. Isolation of DNA from plant cells. 7. Restriction digestion of DNA. 8. Agarose gel electrophoresis of DNA. 9. Basic biosafety guidelines in the laboratory. **Suggested Books:** ➢ Purohit, S.D. (2007). *Molecular Biology and Biotechnology: A Practical Manual*. Udaipur: Apex Publishing House. ➢ Vats, S. (2015). *A Laboratory Textbook of Biochemistry, Molecular biology and Microbiology*. GRIN Verlag.	
3)	**Discipline Elective:** ~~5.1:~~ Plant Physiology and Ecology	On completion of the course, students will be able to: • Comprehend about life processes happening inside plants and how they cope with varied biotic and abiotic factors. • Understand maintenance of ecological balance and role of man in	**Unit 1** • Plant water relations: Importance of water to plant life; movement of water across the membranes, ascent of sap; transpiration. • Mineral nutrition: Methods to study the availability of macro and micro elements, uptake and roles of mineral elements. • Translocation of organic substances: General principle and mechanism. **Unit 2** • Photosynthesis: Photosynthetic pigments, factors affecting photosynthesis, mechanism of photosynthesis, role of light, carbon fixation in plants,	**Discipline Elective:** **BOT 303: Plant Physiology and Ecology** **Unit 1** • Plant water relations: Importance of water to plant life; movement of water across the membranes, ascent of sap; transpiration. • Mineral nutrition: Methods to study the availability of macro and micro elements, uptake and roles of mineral elements. • Translocation of organic substances: General principle and mechanism. **Unit 2** • Photosynthesis: Photosynthetic pigments, factors affecting photosynthesis, mechanism of photosynthesis,	

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<tr><td></td><td></td><td>the degradation of the environment and to suggest remedies.
• Highlight the potential of these studies to become an entrepreneur.</td><td>Photophosphorylation.
• Respiration: Significance and mechanism, factors affecting respiration, release and utilization of biochemical energy, ATP synthesis.
Unit 3
• Fat Metabolism: Mechanism of synthesis and break down of fats.
• Nitrogen metabolism: Nitrate assimilation, nitrogen fixation, amino acid synthesis and nitrogen cycle.
• Growth and Development: Physiology of dormancy and seed germination, vegetative and reproductive growth, Vernalization and Photoperiodism.
• Growth regulators: Auxins, gibberellins, cytokinins, ethylene and abscissic acid, their physiological importance.
Unit 4
• Ecology: Plant environment: Climatic, edaphic, topographic and biotic factors.
• Ecosystem: Brief concept, food chains, ecological pyramids (Pyramids of number, mass and energy), energetics, biochemical cycling.
Unit 5
• Plant communities: Structure, classification, diversity, dynamics.
• Applied ecology: Introduction to restoration ecology.
• Environmental pollution (Air, Water, and Radioactive), Conservation, Plant indicators.

Books Recommended:
➢ Plant Physiology: Devlin & Witham, Van Narst, New Delhi: East West Press, 1974.
➢ Plant Physiology: Salisbury & Ross, Prentice Hall of India.
➢ Introductory Plant Physiology: Noggle & Fritz, Prentice Hall of India.</td><td>role of light, carbon fixation in plants, Photophosphorylation.
• Respiration: Significance and mechanism, factors affecting respiration, release and utilization of biochemical energy, ATP synthesis.
Unit 3
• Fat Metabolism: Mechanism of synthesis and break down of fats.
• Nitrogen metabolism: Nitrate assimilation, nitrogen fixation, amino acid synthesis and nitrogen cycle.
• Growth and development: Physiology of dormancy and seed germination, vegetative and reproductive growth, vernalization and photoperiodism.
• Growth regulators: Auxins, gibberellins, cytokinins, ethylene and abscissic acid, their physiological importance.
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• Ecology.
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• Ecosystem: Brief concept, food chains, ecological pyramids (pyramids of number, mass and energy), energetics, biochemical cycling.
Unit 5
• Plant communities: Structure, classification, diversity, dynamics.
• Applied ecology: Introduction to restoration ecology.
• Environmental pollution (air, water, noise and radioactive), Conservation, plant indicators.
Suggested Books:
➢ Ambhast, R.S. (2008). Plant Ecology. New Delhi: CBS.
➢ Dutta, S.C. (2012). Plant Physiology. New Delhi: New age International Publishers.
➢ Hopkins, W.G., & Huner, N.P.A. (2008). Introduction to Plant Physiology. New Jersey: John Wiley and Sons Inc.</td><td></td></tr>
</table>

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			➢ Plant Physiology: Taiz and Zeiger. ➢ Introduction to Plant Physiology: W.G. Hopkins and Hunner John Wiley and Sons Inc. ➢ Plant Physiology: Pandey & Sinha. ➢ Ecology & Environment: P.D. Sharma, Rastogi Publications, Meerut. ➢ Fundamentals of Ecology: E.P. Odum, Natraj Publishers, Dehradun, India. ➢ Plant Physiology: H.N. Srivastava, Vikas Publishing House. ➢ Plant Physiology: S. C. Dutta. ➢ Plant Ecology: Ambhast and Ambhast.	➢ Narst, V., Devlin & Witham. (1974) *Plant Physiology*. New Delhi: East West Press. ➢ Noggle, G.R., & Fritz, G.J. (1992). *Introductory Plant Physiology*. New Delhi: Prentice Hall of India. ➢ Odum, E.P. (2004). *Fundamentals of Ecology*. Dehradun: Natraj Publishers. ➢ Pandey, S.N., & Sinha, B.K. (2015). *Plant Physiology*. New Delhi: Vikas Publishing House. ➢ Salisbury & Ross. (2012). *Plant Physiology*. New Delhi: Prentice Hall of India. ➢ Sharma, P.D. (2003). Ecology & Environment. Meerut: Rastogi Publications. ➢ Srivastava, H.S. (2005). *Plant Physiology*: Meerut: Rastogi Publications. ➢ Taiz, L., & Zeiger, E. (2010). *Plant Physiology*. London: Sinauer Associates. **Suggested e- Resources:** ➢ **Plant Physiology** https://www.udemy.com/plant-physiology/?siteID=zOCYiUhWwNM-1RExiYvhsJfnMd_rZR_ivg&LSNPUBID=zOCYiUhWwNM ➢ **Ecological communities** http://www-plb.ucdavis.edu/courses/bis/1c/text/Chapter27nf.pdf	
4)	**Discipline Elective:** ~~5.2:~~ Plant Physiology and Ecology Lab	On completion of the course, students will be able to: • Understand the physiological details of photosynthesis and respiration. • Design experiments, collect	List of Physiology experiments 1. Osmosis a. Grapes and dried raisins. b. Potato osmoscope and semi permeable membrane. c. Plasmolysis and deplasmolysis. 2. Root pressure a. An experiment on root pressure. 3. Transpiration a. Ganong's potometer and Farmer's potometer b. Unequal transpiration from two surfaces of a leaf	**Discipline Elective:** **BOT 303L: Plant Physiology and Ecology Lab** A. List of Physiology experiments 1. Osmosis a. Grapes and dried raisins. b. Potato osmoscope and semi permeable membrane. c. Plasmolysis and deplasmolysis. 2. Root pressure a. An experiment on root pressure. 3. Transpiration	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		and analyze data, critically evaluate and present the data produced in physiology or ecology. • Demonstrate skills related to laboratory as well as field based studies.	i. Cobalt chloride paper method. ii. Four leaf method with greased surface. c. Demonstration of water lifting power of transpiration (suction force). d. Ringing experiment. e. Study of stomata 4. Photosynthesis a. Oxygen is given off during photosynthesis (Wilmott's bubbler apparatus). b. Light is necessary for photosynthesis. c. Chlorophyll is necessary for photosynthesis. d. CO_2 is necessary for photosynthesis. ~~e. No oxygen liberation without CO_2.~~ f. RQ by Ganong's respirometer ~~of carbohydrate, fatty seeds and *Opuntia* phylloclade.~~ 5. Respiration a. CO_2 is produced during respiration. b. Loss of dry weight in respiration. c. Anaerobic respiration. B. List of Ecological experiments 1. To determine the soil temperature by soil thermometer. 2. To measure relative humidity of the atmosphere by wet and dry–bulb thermometer or psychrometer. 3. To determine soil texture. 4. To test the presence of carbonate, nitrate, pH value and base deficiency in soil. 5. To measure the light intensity. 6. To study the structure of the plant community of an area by quadrat method and to determine the plant density, abundance and frequency ~~(the density, abundance and frequency can be calculated from a given data in laboratory during practical examination).~~ 7. To determine the water holding capacity of different	a. Ganong's potometer and Farmer's potometer b. Unequal transpiration from two surfaces of a leaf i. Cobalt chloride paper method. ii. Four leaf method with greased surface. c. Demonstration of water lifting power of transpiration (suction force). d. Ringing experiment. e. Study of stomata 4. Photosynthesis a. Oxygen is given off during photosynthesis (Wilmott's bubbler apparatus). b. Light is necessary for photosynthesis. c. Chlorophyll is necessary for photosynthesis. d. CO_2 is necessary for photosynthesis. e. RQ by Ganong's respirometer (Demonstration). 5. Respiration a. CO_2 is produced during respiration. b. Loss of dry weight in respiration. c. Anaerobic respiration. B. List of Ecological experiments 1. To determine the soil temperature by soil thermometer. 2. To measure relative humidity of the atmosphere by wet and dry–bulb thermometer or psychrometer. 3. To determine soil texture. 4. To test the presence of carbonate, nitrate, pH value and base deficiency in soil. 5. To measure the light intensity. 6. To study the structure of the plant community of an area by quadrat method and to determine the plant density, abundance and frequency. 7. To determine the water holding capacity of different soils. **Suggested Books:** ➢ Bendre, A., & Kumar, A. (2010). *A Textbook of*	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			soils. 8. ~~A record of the experiments done during the year is to be submitted by the candidates.~~	*Practical Botany- II*. Meerut: Rastogi Publications.	
5)	**Discipline Elective: Ethnobotany**	**Learning outcomes:** On completion of the course, students will be able to: • Understand the science of ethnobotany, its concept, scope and objectives • Know the types, distribution and life style of ethnic groups in India. • Know the importance of tribals in present era. • Know the various uses of plants by the ethnic people in their daily life. • Know the miscellaneous uses of plants • Understand the methodology of ethnobotanical		**Discipline Elective: Ethnobotany** **Unit 1: Ethnobotany** • Introduction, concept, scope and objectives; Ethnobotany as an interdisciplinary science. • The relevance of ethnobotany in the present context. • Major and minor ethnic groups or Tribals of India, and their life styles. **Unit 2: Ethnobotanical Uses** • Plants used by the tribals: a) Food plants b) Fodder c) intoxicants and beverages d) Resins and oils and miscellaneous uses. • Plants of mythological and religious. • Plants mentioned in Folklore and Folk songs. • Plants as totems, taboos and superstition. **Unit 3: Methodology of Ethnobotanical studies** • Field work b) Herbarium c) Ancient Literature d) Archaeological findings e) temples and sacred places. • Major centers of Ethnobotany in India. **Unit 4: Role of ethnobotany in modern Medicine** • Medico-ethnobotanical sources in India; Significance of the following plants in ethno botanical practices (along with their habitat and morphology):(a) *Azadiractha indica* (b) *Ocimum sanctum* (c) *Vitex negundo* (d) *Gloriosa superba* (e) *Tribulus terrestris* (f) *Pongamia pinnata* (g) *Cassia auriculata* (h) *Indigofera tinctoria*. • Role of ethnobotany in modern medicine with special example *Rauvolfia sepentina, Trichopus zeylanicus, Artemisia,Withania*. • Role of ethnic groups in conservation of plant genetic resources. • Endangered taxa and forest management (participatory forest management).	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		work • Know the medicinal uses of plants in crude ways. • Aware about the legal aspects associated with ethnobotany.		**Unit 5: Ethnobotany and legal aspects** • Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India. • Biopiracy, Intellectual Property Rights and Traditional Knowledge. **Suggested Readings** ➢ Colton C.M. 1997. Ethnobotany – Principles and applications. John Wiley and sons, Chichester ➢ Ethnobotany: Vinay Sharma and Afroz Alam, Rastogi Publishing House, Meerut ➢ Faulks, P.J. 1958.An introduction to Ethnobotany, Moredale pub. Ltd. ➢ Jain S.K. (1990). Contributions of Indian ethnobotany. Scientific publishers, Jodhpur. ➢ Jain S.K. (1995). *Glimpses of Indian. Ethnobotny*, Oxford and I B H, New Delhi – 1981 ➢ Jain S.K. (1995). *Manual of Ethnobotany*, Scientific Publishers, Jodhpur, 1995. ➢ Jain S.K. (ed.) (1989). *Methods and approaches in ethnobotany*. Society of ethnobotanists, Lucknow, India. ➢ Lone et al. (1980). *Palaeoethnobotany*, Oxford and I B H, New Delhi – 1981 ➢ Rajiv K. Sinha (1996). Ethnobotany The Renaissance of Traditional Herbal Medicine – INA –SHREE Publishers, Jaipur ➢ Rama Ro, N and Henry A.N. (1996). The Ethnobotany of Eastern Ghats in Andhra Pradesh, India.Botanical Survey of India. Howrah. **Suggested e- Resources:** http://botanicaldimensions.org/what-is-ethnobotany/ https://www.plantsnap.com/blog/casual-ethnobotany/ https://trove.nla.gov.au/work/36470887?selectedversion=NBD44743330	
6)	**Discipline**			**Discipline Elective: Ethnobotany Lab**	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
	Elective: Ethnobotany Lab			1. Study of wild plants of different families at taxonomical level. 2. Collection of locally growing plants of ethnic importance. 3. Herbarium preparation. 4. Study of ethnic groups through photographs and available literature. 5. Preparation of plants' extract. **6.** Analysis of phytochemicals.	
7)	**Discipline Elective: Horticulture**	After completion of the course students will be able to: • Understand the basic technique of plant propagation. • Perform cutting, grafting, budding, layering etc. • Grow plants in the absence of soil medium • Start bonsai creation • Know various aspects of Green House Technology • Start commercial cultivation of fruits and vegetables		**Discipline Elective: Horticulture** **Unit 1** • Basic horticultural techniques (soil preparation, bed preparation, transplantation & pruning) • Vegetative propagation of plants (a) cutting (b) grafting (c) budding (d) layering (e) other special structures. **Unit 2** • Soil less culture (hydroponic, Aeroponics). • Application of Coco peat, Perlite, Vermiculite and Peat moss in horticultural practices • Indoor and outdoor plants. • Bonsai: Types, forms, structure and styles. **Unit 3** • Greenhouse Technology: Importance, types and operation techniques. • Commercial uses of Green House Technology. • Benefits and Risks associated with Green House Technology. **Unit 4** • Commercial cultivation of cut flowers (Roses, Gerberas & Carnations). • Study of foliage plants (*Ficus*, Croton & Coleus). • Study of one locally available vegetables (root, leafy, cole crops). **Unit 5**	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				• Study of tropical fruits (Mango, Amla, Date palm). • Study of temperate fruits (Apple). • Commercial cultivation of exotic fruits. **Suggested Books** ➢ Ankur: (Magazine). ➢ Bajaj, Y.P.S. & Narosa. Biotechnology in agriculture and forestry. ➢ Chalam, Venkateshwarlu, G.V.I. *Introduction to Agricultural Botany in India*. Asia Publishing House, New Delhi. ➢ Hartmann and Kester. Plant Propagation. ➢ Jain, S.K. & Rao, R.R. *A Hand book of Field & Herbarium Methods*. Today & Tomorrow's Printers & Publications, New Delhi. ➢ Sandhu, M.K. Plant Propagation. **Suggested e- Resources:** https://icar.org.in/content/horticultural_division http://tnhorticulture.tn.gov.in/horti/ https://www.onionseek.com/in/search/web/?pk=nQMhNzQd8g9IZLslSBEH6g&q=Online%20Horticulture%20Degree%20Program&id_event=5cc7d0693778ea7e85ea4bc6 https://www.longdom.org/horticulture.html	
8)	**Discipline Elective: Horticulture Lab**			**Discipline Elective: Horticulture Lab** 1. Layout of kitchen garden. 2. Vegetative propagation by cutting and grafting Herbarium preparation. 3. Vegetative propagation by budding and layering (Gootee). 4. To perform emasculation & hybridization. **5.** Preparation of compost.	
Zoology: Discipline Elective-I & II					
1)	**Discipline Elective** ~~**6.1**~~ Animal	On completion of the course, students will be able to:	**Unit 1** • Physiology of Digestion: Various kinds of digestive enzymes (Carbohydrases, Proteinases and Lipases) and	**Discipline Elective** **ZOO 301: Animal Physiology** **Unit 1**	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
	Physiology	• Gain basic understanding of structure and functions of each physiological system of human. • Describe principles and pathway of metabolism of carbohydrate, protein and lipids. • Develop an understanding about principles of human anatomy and physiology.	their digestive action to corresponding food stuffs in the alimentary canal of mammals; Hormonal control of digestive functions; Mechanism of absorption of various end-products of digestion and other materials such as vitamins, minerals and trace elements. • Physiology of Respiration in mammals: Mechanism and control of breathing; Transport of oxygen and carbon dioxide; oxygen dissociation curves of Hemoglobin, Bohr's effect, Chloride shift, Respiration at cellular level. **Unit 2** • Metabolism: (Structure formula of metabolites not essential) Carbohydrate metabolism oxidation of glucose (glycolysis); The Embden–Meyerhof Parnas pathway, Tricarboxylic Acid Cycle (TCA) and Oxidative phosphorylation Glycogenolysis and Glycogenesis; Gluconeogenesis and the role of dicarboxylic acid Shuttle, role of insulin and glucagons on carbohydrate metabolism. • Protein metabolism: Essential and non-essential amino-acids, oxidative deamination, transamination and decarboxylation of amino acids, fate of glucogenic and ketogenic amino acids, Role of hormones in protein metabolism. • Fat metabolism: -oxidation of fatty acids, oxidation of glycerol and unsaturated fatty acids; fate of Acetyl CoA; Synthesis of lipids; Role of hormones in fat metabolism. **Unit 3** • Physiology of Excretion: Kinds of nitrogenous excretory products, Role of liver in the formation of urea; ~~Relationship between the nature of excretory products to~~	• Physiology of Digestion: Various kinds of digestive enzymes (carbohydrases, proteinases and lipases) and their digestive action to corresponding food stuffs in the alimentary canal of mammals; hormonal control of digestive functions; mechanism of absorption of various end-products of digestion and other materials such as vitamins, minerals and trace elements. • Physiology of respiration in mammals: Mechanism and control of breathing; transport of oxygen and carbon dioxide; oxygen dissociation curves of hemoglobin, Bohr effect, chloride shift, Haldane effect, lung volumes and capacities, regulation of respiration, respiration at cellular level. **Unit 2** • Metabolism: (structure formula of metabolites not essential) Carbohydrate metabolism oxidation of glucose (glycolysis); Embden–Meyerhof-Parnas pathway, tricarboxylic acid cycle and oxidative phosphorylation, shuttle mechanisms (malate-aspartate and glycerol-phosphate), glycogenolysis and glycogenesis; gluconeogenesis and the role of dicarboxylic acid shuttle, role of insulin and glucagons on carbohydrate metabolism. • Protein metabolism: Essential and non-essential amino-acids, oxidative deamination, transamination and decarboxylation of amino acids, fate of glucogenic and ketogenic amino acids, role of hormones in protein metabolism. • Fat metabolism: Oxidation of fatty acids (β-oxidation), glycerol, and unsaturated fatty acids; fate of Acetyl CoA; synthesis of fatty acids & lipids; role of hormones in fat metabolism. **Unit 3** • Physiology of excretion: Kinds of nitrogenous excretory products, structure of kidney, role of liver in the formation	The topic "Relationship between the nature of excretory products to the habitat

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			~~the habitat (Fresh water, Marine water and Terrestrial);~~ ~~C~~omposition and formation of urine; Role of hormones. • Physiology of Vascular system: Composition and functions of blood and lymph; Blood groups, Rh factor; Blood ~~Coagulation~~ (clotting) mechanism and its physiological significance; Structure and functions of Hemoglobin. Blood pressure; origin, conduction and regulation of heart beat; Nervous and hormonal regulation of heart beat; Cardiac cycle. **Unit 4** • Physiology of Muscle Contraction: Functional architecture of smooth, skeletal and cardiac muscles; mechanism of muscle contractions (skeletal muscle). Mechanical properties of muscle: simple muscle twitch; tetanus and muscle fatigue. • Physiology of nerve impulse and reflex action: Functional architecture of neuron, nature, origin and propagation of nerve impulse along a neuron, synapse; reflex arc, reflex action and its central control. **Unit 5** • Physiology of Endocrine Glands: Structure and functions of Hypothalamus; Pituitary; Thyroid; Parathyroid; Adrenal and Pancreas; • An elementary idea about neuro secretion. • Physiology of Reproduction: Structure and Physiology of human male and female reproductive system; reproductive cycles- Estrous and Menstrual cycle • Hormonal regulation of ovulation, fertilization, implantation, abortion, gestation, parturition and lactation. **Recommended Books :** ➢ Text book of Medical Physiology: A.C. Guyton, Saunders College Publications.	of urea; composition and formation of urine; role of hormones in urine formation; micturition. • Physiology of vascular system: Composition and functions of blood; lymph & lymphatic system; blood groups, Rh factor; platelet plug formation; blood clotting mechanism and its significance; structure and functions of hemoglobin. Blood pressure & its regulation; origin, conduction and regulation of heart beat; nervous and hormonal regulation of heart beat; cardiac cycle. **Unit 4** • Physiology of muscle contraction: Functional architecture of smooth, skeletal and cardiac muscles; mechanism of muscle contractions (skeletal muscle). Fuel for muscle contraction, mechanical properties of muscle: simple muscle twitch; wave summation, tetanus and muscle fatigue. • Physiology of nerve impulse and reflex action: Functional architecture and classification of neuron; nature, origin and propagation of nerve impulse along a neuron (myelinated and unmyelinated), synapse; reflex arc, reflex action and its central control. **Unit 5** • Physiology of endocrine glands: Structure and functions of hypothalamus; pituitary; thyroid; parathyroid; adrenal and pancreas. • An elementary idea about neuro-secretion. • Physiology of reproduction: Structure and physiology of human male and female reproductive system; spermatogenesis and oogenesis; reproductive cycles- estrous and menstrual cycle. • Hormonal regulation of ovulation, fertilization, implantation, abortion, gestation, parturition and lactation. **Suggested Books :** ➢ Chaterjee, C.C. (2005). *Human Physiology* Vol-II (11th	(Fresh water, Marine water and Terrestrial)" is proposed to be remove from existing syllabus because it is usually covered in the another topic i.e. Kinds of nitrogenous excretory products. This is important for the students to learn about structure of kidney, therefore this topic is proposed to be part of modified syllabus. It is important to learn about the different fuels available for muscular contraction. It is important for the students to learn about the classification of neuron based on their functionality and number of process emerges from cell body.

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Text book of Animal Physiology: P.S. Verma. ➢ Text book of Human Physiology Vol. I & II: C.C. Chaterjee. ➢ A text book of Human Anatomy & Physiology: G.M. Tortora. ➢ Regulatory Mechanisms in Vertebrates: Pandey and Shukla Rastogi Publication, Meerut. ➢ Text book of Animal Physiology – Eckert.	ed.). ➢ Chaterjee, C.C. (2018). *Human Physiology* Vol-I (12th ed.). New Delhi: CBS Publishers & Distributors. ➢ Guyton, A.C., & Hall, J.E. (2015). *Textbook of Medical Physiology* (13th ed.). USA: Saunders. ➢ Jurd, R.D. (2003). *Instant notes in Animal Biology*. New Delhi: Viva Books Pvt. Ltd. ➢ Kumar, N. (2016). *Animal Physiology*. Jaipur: RSBA Publishers. ➢ Pandey, K., & Shukla, J.P. (2005). *Regulatory Mechanism in Vertebrates*. Meerut: Rastogi Publications. ➢ Randall, D., Burggren, W., & French, K. (2001). *Eckert Animal Physiology* (5th ed.). W. H. Freeman. ➢ Roy, R.N. (2018). *Textbook of Physiology: with Biochemistry & Biophysics* Vol-I. Kolkata: New Central Book Agency. ➢ Tortora, G.J., & Grabowski. (2003). *Principles of Anatomy & Physiology* (10th ed.). New Jersey, USA: John Wiley & Sons. ➢ Verma, P.S., Tyagi, B.S., & Agarwal, V.K. (2000). *Animal Physiology*. New Delhi: S. Chand publisher. **Suggested e-Resources:** ➢ **Digestive system** https://www2.estrellamountain.edu/faculty/farabee/biobk/BioBookDIGEST.html ➢ **Unsaturated fatty acid oxidation** https://pharmaxchange.info/2013/10/oxidation-of-unsaturated-fatty-acids/ ➢ **Urine formation** http://medschool.slu.edu/gpbs/syllabus/2008/renal2/Kidney%20Lecture-2%20Core%202008.pdf ➢ **Muscles** http://www.onlinebiologynotes.com/muscular-tissue-skeletal-smooth-cardiac-muscle/ ➢ **Endocrine glands**	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				http://what-when-how.com/nursing/the-endocrine-system-structure-and-function-nursing-part-1/ ➢ **Physiological systems** https://nptel.ac.in/courses/102104042/ https://nptel.ac.in/courses/122103039/18	
2)	**Discipline Elective:** ~~**6.2**~~ Animal Physiology Lab	On completion of the course, students will be able to: • Gain hands on experience in hematological tests such as counting of RBCs, WBCs, preparation of haemin crystals, determination of blood haemoglobin, calcium, cholesterol, sugar, protein, cloting time. • Demonstrate the skills of pathological analysis of urine through the detection glucose and albumin.	1. Preparation of haemin crystals. 2. Estimation of haemoglobin percentage by haemometer. 3. Enumeration of the total number of red blood corpuscles (RBC). 4. Enumeration of the total number of white blood corpuscles (WBC). 5. Determination of ABO blood groups and Rh factor. 6. Study of effect of isotonic, hypotonic and hypertonic solutions on RBC. 7. Determination of the presence of sugar and albumin in the urine sample. 8. Determination of blood sugar content. 9. Estimation of total protein from blood. 10. Estimation of total calcium from blood. 11. Estimation of total cholesterol from blood. 12. Determination of the clotting time of blood.	**Discipline Elective:** **ZOO 301L: Animal Physiology Lab** No modification in the syllabus. **Suggested Books:** ➢ Poddar, T., Mukhopadhyay, S., & Das, S.K. (2003). *An advanced Laboratory Manual of Zoology*. Kolkata: Macmillan India Limited. ➢ Sharma, S. (2007). *Experiments and Techniques in Biochemistry* (1st ed.). New Delhi: Galgotia Publication. ➢ Sharma, S., & Sharma, R. (2016). *Practical Manual of Biochemistry* (2nd ed.). New Delhi: Medtech.	
3)	**Discipline Elective:** ~~**5.1**~~ ~~Environmental Biology~~	On completion of the course, students will be able to: • Understand the physical and biological characters of the	~~**5.1 Environmental Biology**~~ **Unit 1 • Terminology and scope of ecology.** Environment : i. Biosphere – Lithosphere, Hydrosphere and Atmosphere. ii. Physical factors – with special reference to temperature, light and water.	**Discipline Elective:** **ZOO 302:Environmental Biology and Biostatistics** **Unit 1** • Terminology and scope of ecology. • Environment: i. Biosphere -Lithosphere, hydrosphere and atmosphere. ii. Physical factors-with special reference to temperature,	Title of the paper is renamed as Environmental Biology and Biostatistics

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		environment and the interrelationship between biotic and abiotic components of nature as well as relationship among the individuals of the biotic components. • Realize the importance of ecosystem and biodiversity for maintaining ecological balance. • Understand the basic principles of population and community ecology. • Understand the fundamental principles of biostatistics and its role in the data analysis generated by scientific research.	iii. Biotic factors – Intra and Inter specific relationship among animals. iv. Principles of limiting factors – Leibig's law of minimum, Shelford's Law of tolerance, combined concept of limiting factors. Biogeochemical Cycles: Carbon, Oxygen, Nitrogen and Phosphorus cycles. **Unit 2** **1.** Ecosystem Ecology: Structure and dynamics of the ecosystem including food chain, food webs trophic levels, productivity and energetics. 2. Fresh Water Ecosystem: Physiochemical factors, Biotic communities and lake eutrophication. 3. Marine Ecosystem: Zonation factors and biotic communities of deep sea only. 4. Terrestrial Ecosystem: Salient features of grass land, forest and desert ecosystem. **Unit 3** 5. *Population Ecology.* i. Definition and attributes of animal population: Population density and its measurement, natality, mortality, growth form, age distribution, age pyramids, Sex ratio, dispersal and dispersion. ii. Regulation of Population density: Population fluctuations and interactions. 6. Community Ecology : i. Definition of types of communities (micro and macro communities). ii. Community dominance and species diversity. iii. Ecotone, edge effect and ecological Niche. iv. Succession and Climax. **Unit 4** ~~7. *Pollution Ecology :*~~ ~~i. Pollution, Biodegradable and non-biodegradable pollutants.~~	light and water. iii. Biotic factors -Intra and inter specific relationship among animals. iv. Principles of limiting factors-Leibig's law of minimum, Shelford's law of tolerance, combined concept of limiting factors. • Biogeochemical cycles: Carbon, oxygen, nitrogen and phosphorus cycles. **Unit 2** • Ecosystem ecology: Structure and dynamics of the ecosystem including food chain, food webs trophic levels, productivity and energetics. • Fresh water ecosystem: Physiochemical factors, biotic communities and lake eutrophication. • Marine ecosystem: Zonation factors and biotic communities of deep sea only. • Terrestrial ecosystem: Salient features of grass land, forest and desert ecosystem. **Unit 3** • Population ecology: i. Definition and attributes of animal population: Population density and its measurement, natality, mortality, growth form, age distribution, age pyramids, sex ratio, dispersal and dispersion. ii. Regulation of population density: Population fluctuations and interactions. • Community ecology: i. Definition of types of communities (micro and macro communities). ii. Community dominance and species diversity. iii. Ecotone, edge effect and ecological niche. iv. Succession and climax. **Unit 4** • Applied ecology: i. Conservation of natural resources.	Unit-4 of this paper is already mentioned in

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			~~ii. Air pollution: Sources, nature, prevention and control.~~ ~~iii. Water pollution: Source, nature abatement.~~ ~~iv. Noise pollution~~ ~~v. Radioactive pollution and effects of radioactive substance on living organisms.~~ ~~vi. Environmental health and welfare.~~ **Unit 5** 8. *Applied Ecology* : i. Conservation of Natural resources. ii. Wild life management. iii. National parks and Wild life sanctuaries in India. iv. Extinction in animals. v. Zoogeographical regions of the world along with the boundaries and fauna **Recommended Books :** ➢ Elements of Ecology: Clarke. ➢ Ecology: E.P. Odum, New Delhi : Amerind Publishing, 1965. ➢ Environmental Analysis: M.M. Saxena, Bikaner Agro Botanical Pub., 1990. ➢ Ecology with special reference to animal and man : S. Charles Kendeigh. ➢ Principles of Animal Ecology: Allee, Emeroon, Park and Schmidt. ➢ Animal Ecology : S.P. Singh. ➢ Ecology and Environment: P.D. Sharma, Rastogi Publications. ➢ Ecology: C.V.S. Bahura. ➢ Ecology: C.J. Krebs. ➢ Ecology 2000: Edited by Edmand Hillary, London Michael Joseph, 1984.	ii. Wild life management. iii. National parks and wild life sanctuaries in India. iv. Extinction in animals. v. Zoogeographical regions of the world along with the boundaries and fauna. **Unit 5** • Biostatistics: i. Introduction, scope and applications. ii. Sampling, data collection and presentation. iii. Types of data, methods of collection of primary and secondary data, data presentation-Histogram, polygon, bar diagram, pie diagram. iv. Frequency distribution. Measures of central tendency-Mean, median, mode. v. Measures of variability-Standard deviation, standard error. **Suggested Books:** ➢ Alllee W.C., Emerson, A.E., Park, O., Parl, T., & Schmidt, K.P. (1967). *Principles of Animal Ecology*. USA: W.B. Saunders Company. ➢ Banerjee, P.K. (2007). *Introduction to Biostatistics* (3rd ed.). New Delhi: S Chand and company Pvt. Ltd. ➢ Bhuyan, K.C. (2017). *Advanced Biostatistics*. Kolkata: New Central Book Agency. ➢ Chaudhary, B.L., & Pandey, J. (2007). *Fundamentals of Ecology & Environment*. Jaipur: Apex Publishing House. ➢ Clarke, G.L. (1965). *Elements of Ecology*. New Jersey: John Wiley & Sons Inc. ➢ Datta, A.K. (2014). *Basic Biostatistics and Application*. Kolkata: New Central Book Agency. ➢ Hillary, E. (1984). *Ecology 2000: The Changing Face of Earth*. Michael Joseph Ltd. ➢ Kendeigh, S.C. (1974). *Ecology with special reference*	plant physiology and ecology paper, therefore contents of unit-V has shifted to Unit-IV and Introduction to biostatistics is proposed to be include in the Unit-V

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				to animal and man. New Jersey: Prentice Hall. ➢ Krebs, C.J. (2001). *Ecology* (5th ed.). San Francisco, USA: Benjamin Cummings. ➢ Kumar, A. (2015). *Biodiversity & Conservation*. New Delhi: APH Publishing Corporation. ➢ Miller, G.T. (2004). *Environmental Science: Working with the Earth* (10th ed.). Singapore: Thomson Asia. ➢ Misra, S.P., & Pandey, S.N. (2016). *Essentials of Environmental Sciences* (4th ed.). New Delhi: Ane Books Pvt. Ltd. ➢ Odum, E.P. (1965). *Ecology*, New Delhi: Amerind Publishing. ➢ Pandey, M. (2015). *Biostatistics: Basic and Advanced*. New Delhi: MV Learning. ➢ Saxena, M.M. (1990). *Environmental Analysis*: Bikaner: Agro Botanical. ➢ Sharma, P.D. (2011). *Ecology and Environment*. Meerut: Rastogi Publication. ➢ Singh, S.P. (2005.). *Animal Ecology*. Meerut: Rastogi Publications. ➢ Tripathi, G. (2002). *Modern Trends in Environmental Biology*. New Delhi: CBS Publishers & Distributors. **Suggested e-Resources:** ➢ **Aquatic ecology** https://nptel.ac.in/courses/120108002/ ➢ **Ecosystem** https://nptel.ac.in/courses/122103039/38 ➢ **Biostatistics** https://nptel.ac.in/courses/102101056/ ➢ **Measures of central tendency** https://www.tutorialspoint.com/statistics/arithmetic_mean.htm ➢ **Population characteristics** http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.534.5462&rep=rep1&type=pdf	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
4)	~~5.2: Environmental Biology Lab~~ **Discipline Elective: ZOO 302L: Environmental Biology and Biostatistics Lab**	On completion of the course, students will be able to: • Demonstrate skills in the quality assessment of water through testing of water for CO_2, O_2, chloride and hardness. • Gain an understanding of parasitic, aquatic, desert and aerial adaptations of animals with the help of charts and specimens. • Describe symbiosis, commensalism and socialization among organisms with the help of charts and specimens. • Understand analysis of data by solving biostatistical problems.	~~**5.2:Environmental Biology Lab**~~ 1. To find the depth and visibility in a pond by Sachi disc method. 2. To determine the pH of water sample. 3. To determine the content of dissolved oxygen in the water sample. 4. To determine free CO2 content in the water sample. 5. To determine the Chloride content of the water sample. 6. To determine the total hardness of water. 7. To study the effect of environmental stimulation on *paramecium.* 8. To study parasitic, desert, aquatic and aerial adaptations in animals i. Parasite : *Hirudinaria*, *Taenia*, *Ascaris*, *Schistosoma*, *Fasciola*, ~~Head louse.~~ ii. Desert : *Phrynosoma*, *Uromastix*, Camel, *Heloderma*, Rattle snake, Golden mole. iii. Aquatic : *Pleuronectus*, *Exocoetus*, Turtle, *Hippocampus, Dolphin, Hydrophis, Duck,* Crocodile. iv. Aerial: Any Bird, Draco, Bat. 9. To study different types of associations existing among living organisms. i. Symbiosis: Chlorohydra, Termite and Aphid. ii. Commensalism: Harmit-crab and Sea anemone and Gastropod shell, Euplectella and Shrimps. iii. Socialization: Ants, Termites, Honey bees. 10. Draw a map of world and identify the Zoogeographical regions of the world along with their major fauna. Report on any current topic related to Environmental Biology.	**Discipline Elective:** **ZOO 302L: Environmental Biology and Biostatistics Lab** 1. To find the depth and visibility in a pond by Sachi disc method. 2. To determine the pH of water sample. 3. To determine the content of dissolved oxygen in the water sample. 4. To determine the chemical oxygen demand in the water sample. 5. To determine free CO_2 content in the water sample. 6. To determine the chloride content of the water sample. 7. To determine the total hardness of water. 8. To study the effect of environmental stimulation on *Paramecium*. 9. To study parasitic, desert, aquatic and aerial adaptations in animals: i. Parasite: *Hirudinaria*, *Taenia*, *Ascaris*, *Schistosoma*, *Fasciola*, *Pediculus*. ii. Desert: *Phrynosoma*, *Uromastix*, Camel, *Heloderma*, Rattle snake, Golden mole. iii. Aquatic: *Pleuronectus*, *Exocoetus*, Turtle, *Hippocampus*, *Dolphin*, *Hydrophis*, Duck, Crocodile. iv. Aerial: Any bird, *Draco*, bat. 10. To study different types of associations existing among living organisms. i. Symbiosis: *Chlorohydra*, termite and aphid. ii. Commensalism: Harmit-crab, sea anemone and gastropod shell, *Euplectella* and shrimps. iii. Socialization: Ants, termites and honey bees. 11. Draw a map of world and identify the Zoogeographical regions of the world along with their major fauna. 12. Biostatistics exercise-mean, median, mode, standard deviation and standard error. 13. Report on any current topic related to environmental biology.	Exercise on biostatistics is introduced in the revised laboratory syllabus

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				Suggested books: ➢ Lal, S.S. (2015). *Practical Zoology: Invertebrates* (11th ed.). Meerut: Rastogi Publication. ➢ Lal, S.S. (2015). *Practical Zoology: Vertebrates* (11th ed.). Meerut: Rastogi Publication. ➢ Lal, S.S. (2016). *A Textbook of Practical Zoology* Vol-III (2nd ed.). Meerut: Rastogi Publication. ➢ Poddar, T., Mukhopadhyay, S., & Das, S.K. (2003). *An advanced Laboratory Manual of Zoology*. Kolkata: Macmillan India Limited. ➢ Verma, P.S. (2010). *A Manual of Practical Zoology: Chordates* (11th ed.). New Delhi: S Chand Publishing.	
5)	**Discipline Elective: Developmental Biology**	**Learning Outcomes:** On completion of the course, students will be able to • Gain expertise in explaining how a variety of interacting processes generate an organism's heterogeneous shapes, size and structural features that arise on the trajectory from embryo to adult or more generally throughout a life cycle. • Gain an understanding of		**Discipline Elective: Developmental Biology** **Unit 1: Introduction to developmental biology** • History, scope and applications of developmental biology. • Basic concepts: Phases of development, cell-cell interaction, pattern formation, differentiation and growth, differential gene expression, cytoplasmic determinants and asymmetric cell division. • Gametogenesis: spermatogenesis and oogenesis. Polarity and gradients. • Fertilization: Types, mechanism and theories. **Unit 2: Early embryonic development** • Cleavage: Definition, planes and patterns of cleavage, classification of cleavage based on distribution and amount of yolk. • Morulation, blastulation and gastrulation in ambhibia and bird. • Morphogenetic movements, embryonic induction and competence, primary organizers. **Unit 3: Late embryonic development** • Differentiation of germinal layers. • Method of organ formation: an overview of neural tube formation, types of mesoderm, somite	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		systematic and organized learning about the knowledge and concepts of growth and development of organisms. • Demonstrate a rich array of material and conceptual practices that could be analysed to better understand the scientific reasoning exhibited in experimental life sciences.		formation, endoderm and its derivatives in amphibians and birds. • Extra-embryonic membranes in birds, their development and functions. • Paedogenesis and neoteny in ambhibians. **Unit 4: Post embryonic development** • Metamorphic events and its hormonal regulations in amphibians. • Regeneration: types, regeneration of limbs in salamanders, regeneration of lost tail in lizard. • Introduction to senescence and apoptosis. **Unit 5: Implications of developmental biology** • Teratogenesis: Teratogenic agents and their effects on embryonic development. • Embryonic stem cells and their applications. • Cloning of animals: Nuclear transfer technique and embryo transfer technique. • *In vitro* fertilization, artificial insemination in cattle, amniocentesis. **Suggested Books** ➢ Balinsky, B.I. & Fabian, B.C. (1981). *An Introduction to Embryology* (5th ed.). International Thompson Computer Press. ➢ Carlson, B.M. (1999). *Patten's foundations in embryology*. (6th ed.). New York, USA: McGraw Hill. ➢ Chattopadhyay, S. (2017). *An introduction to developmental Biology*. Kolkata, India: Books and Allied. ➢ Gilbert, S.F. (2010). *Developmental Biology* (9th ed.). Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA. ➢ Kalthoff (2008). *Analysis of Biological Development* (2nd ed.). McGraw-Hill Publishers. ➢ Lewis, Wolpert (2002). *Principles of Development*	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				(2nd ed.). Oxford University Press. ➢ Rastogi, V.B. & Jayaraj, M.S. (2005). Developmental Biology (A Text book of embryology). Kedar Nath Ram Nath Publisher, Meerut. **Suggested e-Resources:** **Developmental Biology** ➢ https://nptel.ac.in/courses/nptel_download.php?subjectid=102101068 ➢ http://cmb.i-learn.unito.it/mod/book/tool/print/index.php?id=3288	
6)	**Discipline Elective: Developmental Biology Lab**	On completion of the course, students will be able to • Understand the different stages of development of frog and chick through microscopic slides. • Understand the development and life cycle of *Drosophila* through microscopic slides.		**Discipline Elective: Developmental Biology Lab** 1. Study of whole mounts and sections of developmental stages of frog through permanent slides/charts/models: Eggs, cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpole (external and internal gill stages). 2. Study of whole mounts of developmental stages of chick through permanent slides/charts/models: Primitive streak (13 and 18 hours), 21, 24, 28, 33, 36, 48, 72, and 96 hours of incubation (Hamilton and Hamburger stages). 3. Study of the developmental stages and life cycle of *Drosophila* with the help of chart/specimen/models. **Suggested Books** ➢ Lal, S.S. (2015). *Practical Zoology: Vertebrates* (11th ed.). Meerut: Rastogi Publication. ➢ Verma, P.S. (2010). *A Manual of Practical Zoology: Chordates* (11th ed.). New Delhi: S Chand Publishing.	
7)	**Discipline Elective: Applied Zoology**	On completion of the course, students will be able to • Explore the important of earthworms in		**Discipline Elective: Applied Zoology** **Unit-1** • **Parasitic protozoans:** Life history and pathogenicity of *Entamoeba histolytica*, *Plasmodium vivax*, *Giardia*, *Leishmania* and *Trypanosoma gambiense*. • **Parasitic Helminthes:** Life history and	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		agro-ecosystems and utilize gained knowledge for production of vermicompost in small scale for garden/household plant. • Demonstrate their knowledge for setting up poultry farm, sericulture, apiculture, lacculture plant. • Understand biology, life cycle and control measures of crop pests, stored grain pests and insects serve as vectors for human diseases.		pathogenicity of *Ancylostoma duodenale* and *Wuchereria bancrofti*. **Unit-2** • **Insects of agriculture importance:** Biology, control and damage caused by crop pests (*Helicoverpa armigera*, *Pyrilla perpusilla*, *Papilio demoleus*) and stored grain pests (*Callosobruchus chinensis*, *Sitophilus oryzae* and *Tribolium castaneum*). • **Insects of medical importance and their control**: *Pediculus humanus corporis*, *Anopheles*, *Culex*, *Aedes*, *Xenopsylla cheopis*. **Unit 3** • **Apiculture:** Different species of honey bees, pollen calendar, bee keeping and management practices, honey extraction techniques, bee products, pests of honey bees and their control. • **Sericulture:** Different silkworm species and their host plants, silkworm rearing and management practices, pests of silkworms and their control. • **Lac culture:** Lac insect, culture practices, pests of lac insect and their control. **Unit 4** • **Aquaculture:** Types of fishery: Marine, inland. Composite fish culture, induced breeding and hybridization. Transportation of fish seed. Fish diseases and their control. • **Prawn culture:** Culture practices of giant fresh water prawn (*Macrobrachium rosenbergii*), biology and life history. • Pearl culture, pearl formation, composition, colour, size and quality of pearl. **Unit 5** • **Vermiculture:** Definition, scope and importance, culture methods: indoors and out door, monoculture and polyculture, vermicomposting.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				• **Poultry farming:** Principles of poultry breeding, management of breeding stock and broilers, processing and preservation of eggs, diseases of poultry and their control. • **Animal Husbandry:** Preservation and artificial insemination in cattle, induction of early puberty and synchronization of estrus in cattle. **Suggested Books:** ➢ Arora, D.R & Arora, B. (2001). *Medical Parasitology* (2nd ed.). CBS Publications and Distributors. ➢ Atwal, A.S. (1986). *Agricultural Pests of India and South East Asia*, Kalyani Publishers. ➢ Dennis, H. (2009). *Agricultural Entomology*. Timber Press (OR). ➢ Dunham R.A. (2004). *Aquaculture and Fisheries Biotechnology Genetic Approaches*. CABI publications, U.K. ➢ Hafez, E.S.E. (1962). *Reproduction in Farm Animals*. Lea & Fabiger Publisher. ➢ Kumar and Corton. *Pathological Basis of Diseases*. ➢ Pedigo, L.P. (2002). *Entomology and Pest Management*, Prentice Hall. ➢ Sarkar, S., Kundu, G. & Chaki, K.K. (2014). *Introduction to Economic Zoology*. Kolkata: New Central Book Agency (P) Ltd. ➢ Shukla & Upadhyaya (1999-2000). *Economic Zoology*. Meerut: Rastogi Publishers. ➢ Venkitaraman (1983). *Economic Zoology*. Sudarsana Publishers. **Suggested e-Resources** **Sericulture** ➢ https://swayam.gov.in/courses/152-silkworm-crop-protection	
8)	**Discipline**	On completion of		**Discipline Elective:**	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
	Elective: Applied Zoology Lab	the course, students will be able to • Understand the life cycle of protozoan and helminthes parasites through microscopic slides. • Explore the knowledge of life cycle of honey bees, silk moths and lac insects for setting up apiculture, sericulture and lac culture farm. • Gain an understanding of biology, life cycle and control of stored grain pests, crop pests and insect of medical importance.		**Applied Zoology Lab** 1. Study of life cycle of *Plasmodium vivax, Entamoeba histolytica, Giardia, Leishmania, Trypanosoma gambiense, Ancylostoma duodenale* and *Wuchereria bancrofti* through permanent slides/photomicrographs or specimens. 2. Study of different types of bees (Queens, drones and worker bees) permanent slides/photomicrographs or specimens. 3. Study of different types of silk moths (*Bombyx, Samia and Antheraea*) through permanent slides/photomicrographs or specimens. 4. Study of *Tachardia lacca* through permanent slides/photomicrographs or specimens. 5. Study of different types of pearls through photomicrographs or specimens. 6. Study of arthropod vectors associated with human diseases: *Pediculus, Culex, Anopheles, Aedes* and *Xenopsylla* through permanent slides/photomicrographs or specimens. 7. Study of some stored grains insect pests through damaged products/photographs. 8. Identifying feature and economic importance of *Helicoverpa (Heliothis) armigera, Papilio demoleus, Pyrilla perpusilla* and *Callosobruchus chinensis.* 9. Aquarium design and maintenance.	

* Matter in contrast (black background & white letters) is shifted to some other units, and material brought as a result of shift is also in contrast.
# Matter in square brackets, bold, italic and crossed is deleted.
@ Proposed added materials are shaded in grey.

BANASTHALI VIDYAPITH

Department of Bioscience and Biotechnology

B.Sc. BIOTECHNOLOGY PROGRAMME EDUCATIONAL OBJECTIVES

The B.Sc. Biotechnology programme aims at holistic development of the students through the innovative and unique Five fold Educational ideology of Banasthali Vidyapith. This programme broadly includes core subjects of biotechnology, botany, zoology and chemistry. The courses in the programme aim to provide a basic and advanced understanding of the different disciplines of each core subject by means of a lecture series and laboratory work. The program has identified necessary competencies in the respective areas for which all essential theoretical, practical and field based skills will be provided.

The main objectives of the B. Sc. Biotechnology programme are to:

- provide an introduction to the basic concepts of biotechnology and its recent advances
- gain in-depth knowledge of different areas of biotechnology such as biochemistry immunology, bioinformatics, molecular biology, cell biology, environmental biology, cell and tissue culture techniques, genetic engineering etc.
- develop logical thinking, analytical and independent learning skills
- create awareness amongst students towards the importance of multidisciplinary approach for problem solving skills in biotechnology
- provide broad exposure to various societal, ethical and commercial issues in the various aspects of biotechnology
- raise sensitivity to professional ethical codes of conduct, social values and respect for all,
- train the students for an academic and professional fields of biotechnology
- develop an ability to work in collaboration with expertise of different subjects in industries and research
- imbibe and inculcate the basic foundation of biotechnology among students so that they can excel in esteemed academic institutes, various public and private sector organizations with professional competence, technical knowledge and analytical skills.

BANASTHALI VIDYAPITH
Department of Bioscience and Biotechnology
B.Sc. BIOSCIENCE PROGRAMME OUTCOMES

PO1: Biotechnology knowledge: This course provides necessary theoretical and practical experience in all divisions of biotechnology to pursue a professional career in this field.

PO2: Planning ability: Demonstrate effective planning abilities including time management, resource management and organizational skills. Develop and implement plans and organize work to meet deadlines.

PO3: Problem analysis: Utilize subject and practical knowledge to think analytically, design experiments, handle scientific instruments, drawing logical inferences from the scientific experiments while solving problems for the betterment of society.

PO4: Modern tool usage: Utilize gained knowledge to apply appropriate methods, resources and related computational tools with an understanding of their limitations.

PO5: Leadership skills: Develop students with sound concepts in biotechnology who can excel as leaders both in academics and industries. Develop enterpreunership skills to explore the market potential of products and processes, creating business plans and raising money from venture capitalists.

PO6: Professional identity: Understand, analyse and communicate the value of their professional roles in society (e.g. biotechnologist, researchers, educators, managers, employers, employees).

PO7: Hands-on training: Laboratory experiments will provide hands-on training on experimenting with biomolecules and thereby develop a research aptitude for various allied fields of biotechnology.

PO8: Bioethics: Imbibe ethical, moral and social values in personal and social life leading to highly cultured and civilized personality.

PO9: Communication: Develop various communication skills such as reading, listening, speaking, writing and make effective presentations, which will help them in expressing their ideas and views clearly and effectively.

PO10: Environment and sustainability: Utilize the acquired knowledge to maintain the environmental friendly philosophy with sustainability of various environmental resources. Also to create awareness amongst others to keep the environment safe and clean.

PO11: Life-long learning: Develop trained human resources in biotechnology to promote quality education and to initiate lifelong learning process for productive career.

Department of Bioscience and Biotechnology, Banasthali Vidyapith
B.Sc. Biotechnology Programme

Existing Courses						Proposed Courses					
B. Sc. Biotechnology I Sem.		**L**	**T**	**P**	**C**	**B. Sc. Biotechnology I Sem.**		**L**	**T**	**P**	**C**
BT 102:	Cell and Molecular Biology-I	6	0	0	6	BT	Cell and Molecular Biology-I	6	0	0	6
BT102L:	Cell and Molecular biology-I Lab	0	0	4	2	BT	Cell and Molecular Biology-I Lab	0	0	4	2
BOT 101:	Algae, Fungi, Bryophyta, Pteridophyta and Gymnosperms (cw B.Sc Botany BOT 101)	6	0	0	6	BOT	Algae, Fungi, Bryophyta, Pteridophyta and Gymnosperms (cw B.Sc. Bioscience)	6	0	0	6
BOT 101L:	Algae, Fungi, Bryophyta, Pteridophyta and Gymnosperms Lab (cw B.Sc Botany BOT 101 L)	0	0	4	2	BOT	Algae, Fungi, Bryophyta, Pteridophyta and Gymnosperms Lab (cw B.Sc. Bioscience)	0	0	4	2
	Total	**12**	**0**	**8**	**16**		**Total**	**12**	**0**	**8**	**16**

Existing Courses						Proposed Courses					
B. Sc. Biotechnology II Sem.		**L**	**T**	**P**	**C**	**B. Sc. Biotechnology II Sem.**		**L**	**T**	**P**	**C**
BT 101:	Biostatistics, Bioinformatics and Instrumentation	6	0	0	6	BT	Biostatistics, Bioinformatics and Instrumentation	6	0	0	6
BT101L:	Biostatistics, Bioinformatics and Instrumentation Lab	0	0	4	2	BT	Biostatistics, Bioinformatics and Instrumentation Lab	0	0	4	2
ZOO 101:	Non-Chordates and Protochordates (cw B.Sc Zoology ZOO 101)	6	0	0	6	ZOO	Non-Chordates and Protochordates (cw B.Sc. Bioscience)	6	0	0	6
ZOO 101L:	Non-Chordates and Protochordates Lab (cw B.Sc Zoology ZOO 101L)	0	0	4	2	ZOO	Non-Chordates and Protochordates Lab (cw B.Sc. Bioscience)	0	0	4	2
	Total	**12**	**0**	**8**	**16**		**Total**	**12**	**0**	**8**	**16**

Existing Courses						Proposed Courses					
B. Sc. Biotechnology III Sem.		**L**	**T**	**P**	**C**	**B. Sc. Biotechnology III Sem.**		**L**	**T**	**P**	**C**
BT 202:	Biochemistry, Biophysics and Enzymology	6	0	0	6	BT	Biochemistry, Biophysics and Enzymology	6	0	0	6
BT 202L:	Biochemistry, Biophysics and Enzymology Lab	0	0	4	2	BT	Biochemistry, Biophysics and Enzymology Lab	0	0	4	2
BOT 201:	Angiosperm Taxonomy and Economic Botany (cw B.Sc Botany BOT 201)	6	0	0	6	BOT	Angiosperms Taxonomy and Economic Botany (cw B.Sc. Bioscience)	6	0	0	6
BOT 201L:	Angiosperm Taxonomy and Economic Botany Lab (cw B.Sc Botany BOT 201 L)	0	0	4	2	BOT	Angiosperms Taxonomy and Economic Botany Lab (cw B.Sc. Bioscience)	0	0	4	2
	Total	**12**	**0**	**8**	**16**		**Total**	**12**	**0**	**8**	**16**

Existing Courses						Proposed Courses					
B. Sc. Biotechnology IV Sem.		**L**	**T**	**P**	**C**	**B. Sc. Biotechnology IV Sem.**		**L**	**T**	**P**	**C**
BT 207:	Genetics, Microbiology and Immunology	6	0	0	6	BT	Genetics, Microbiology and Immunology	6	0	0	6
BT 207L:	Genetics, Microbiology and Immunology Lab	0	0	4	2	BT	Genetics, Microbiology and Immunology Lab	0	0	4	2
ZOO 202:	Comparative Anatomy and Embryology of Chordates (cw B.Sc Zoology ZOO 202)	6	0	0	6	ZOO 202	Comparative Anatomy and Embryology of Chordates (cw B.Sc. Bioscience)	6	0	0	6
ZOO 202L:	Comparative Anatomy and Embryology of Chordates Lab (cw B.Sc Zoology ZOO 202 L)	0	0	4	2	ZOO	Comparative Anatomy and Embryology of Chordates Lab (cw B.Sc. Bioscience)	0	0	4	2
	Total	**12**	**0**	**8**	**16**		**Total**	**12**	**0**	**8**	**16**

Existing Courses		L	T	P	C
B. Sc. Biotechnology V Sem.		**L**	**T**	**P**	**C**
5.1:	Plant Physiology and Ecology (cw B.Sc Botany 5.1)	6	0	0	6
5.2:	Plant Physiology and Ecology Lab (cw B.Sc Botany Lab 5.2)	0	0	4	2
5.3:	Genetic Engineering, rDNA Technology and Cell & Tissue Culture Technology	6	0	0	6
5.4:	Genetic Engineering, rDNA Technology and Cell & Tissue Culture Technology Lab	0	0	4	2
	Analytical Lab Practice-I	0	0	4	2
	Total	**12**	**0**	**12**	**18**

Proposed Courses					
B. Sc. Biotechnology V Sem.		**L**	**T**	**P**	**C**
BT	Biotechnology Elective I	6	0	0	6
BT L	Biotechnology Elective I Lab	0	0	4	2
BOT	Botany Elective I	6	0	0	6
BOT L	Botany Elective I Lab	0	0	4	2
	Total	**12**	**0**	**8**	**16**

Existing Courses					
B. Sc. Biotechnology VI Sem.					
6.1:	Advances in Biotechnology	6	0	0	6
6.2:	Advances in Biotechnology Lab	0	0	4	2
6.3:	Animal Physiology (cw B.Sc Zoology 6.1)	6	0	0	6
6.4:	Animal Physiology Lab (cw B.Sc Zoology 6.2)	0	0	4	2
	Analytical Lab Practice-II	0	0	4	2
	Total	**12**	**0**	**12**	**18**

Proposed Courses					
B. Sc. Biotechnology VI Sem.		**L**	**T**	**P**	**C**
BT	Biotechnology Elective II	6	0	0	6
BT L	Biotechnology Elective II Lab	0	0	4	2
ZOO	Zoology Elective II	6	0	0	6
ZOO L	Zoology Elective II Lab	0	0	4	2
	Total	**12**	**0**	**8**	**16**

(yellow)	Syllabus modified
(red)	Course discontinued
(green)	New Course introduced

Proposed List of Discipline Electives to be offered in V & VI Semester		**L**	**T**	**P**	**C**
Proposed List of Discipline Elective I & II (Botany)					
BOT 302/ BOT 302L	Introduction to Genetics and Genetic Engineering	6	0	4	8
BOT 303/ BOT 303L	Plant Physiology and Ecology	6	0	4	8
BOT / BOT L	Ethnobotany	6	0	4	8
BOT / BOT L	Horticulture	6	0	4	8
Proposed List of Discipline Elective I & II (Zoology)					
ZOO 301/ ZOO 301L	Animal Physiology	6	0	4	8
ZOO302/ ZOO 302L	Environmental Biology and Biostatistics	6	0	4	8
ZOO / ZOO L	Developmental Biology	6	0	4	8
ZOO / ZOO L	Applied Zoology	6	0	4	8
Proposed List of Discipline Electives I & II (Biotechnology)					
BT /BT L	Genetic Engineering, rDNA Technology and Cell & Tissue Culture Technology	6	0	4	8
BT /BT L	Advances in Biotechnology	6	0	4	8
BT /BT L	Animal and Plant Biotechnology	6	0	4	8
BT /BT L	Environmental Biotechnology	6	0	4	8

Comparative Table: B.Sc. Biotechnology: Existing and Modified syllabus, Suggested Books and Suggested e-Resources

<table>
<tr><th>S No.</th><th>Course List</th><th>Learning Outcomes</th><th>Existing Syllabus</th><th>Suggested Syllabus</th><th>Remarks</th></tr>
<tr><td colspan="6">B.Sc. Biotechnology I Semester</td></tr>
<tr><td>1.</td><td>BOT 101: Algae, Fungi, Bryophyta, Pteridophyta and Gymnosperms</td><td>On completion of the course students will be able to:
• Acquaint with the general characters and classification of cryptogams and phanerogames.
• Understand the evolutionary relationship among lower to higher plant species with differentiating characteristics.
• Appreciate and understand economic importance and application of every group of plants.</td><td>Unit 1
• Algae: Classification, General account with special reference to Anabaena, Oscillatoria, Volvox, <s>Chlamydomonas</s>, Chara, Oedogonium, Ectocarpus, Polysiphonia. Economic importance of Algae.
Unit 2
• Fungi: Classification, General account with special reference to Albugo, Aspergillus, Erysiphe, Puccinia, Ustilago and Alternaria. Economic importance of Fungi.
Unit 3
• Bryophytes: Classification, General account with special reference to important features in the life cycles of Riccia, Marchantia, Anthoceros and Mosses: Funaria, Sphagnum.
Unit 4
• Pteridophytes: Classification, General account, Evolution of steler systems, apospory, apogamy and seed habit. Outline of life cycle of Selaginella, Equisetum and Marsilea.
Unit 5
• Gymnosperms: Classification and Evolution, Distribution with special reference to Indian Gymnosperms. Special features in life cycle of Cycas, Pinus and Ephedra. Economic importance
Books Recommended:
➢ College Botany Vol. II: Ganguli.
➢ A Text Book of Botany Vol. I & II: Saxena & Sarabhai, Ratan Prakash Mandir, Agra.
➢ Text Book of Fungi: J.S.Gupta, Oxford & IBH, New Delhi.
➢ Introduction to Fungi: J. Webster, Cambridge University Press and McMillan, New York</td><td>Unit 1
• Algae: Classification, general account with special reference to Anabaena, Oscillatoria, Volvox, Chara, Oedogonium, Ectocarpus, Polysiphonia. Economic importance of algae.
Unit 2
• Fungi: Classification, general account with special reference to Albugo, Aspergillus, Puccinia, Ustilago and Alternaria. Economic importance of fungi.
Unit 3
• Bryophytes: Classification, general account with special reference to important features in the life cycles of Riccia, Marchantia, Anthoceros and Mosses: Funaria, Sphagnum.
Unit 4
• Pteridophytes: Classification, general account, evolution of steler systems, apospory, apogamy and seed habit. Outline of life cycle of Selaginella, Equisetum and Marsilea.
Unit 5
• Gymnosperms: Classification and evolution, distribution with special reference to Indian gymnosperms. Special features in life cycle of Cycas, Pinus and Ephedra. Economic importance.
Suggested Books:
➢ Alam, A. (2015). Text book of Bryophyta. New Delhi: I K International Publishers.
➢ Alexopoulus, C. (1979). Introductory Mycology. New York: John Wiley & Sons.
➢ Bhatia, K. (1975). A Treatise on Algae. New Delhi: S. Chand & Company.
➢ Biswas, C., & Johri, B.M. (2010). Gymnosperm.</td><td></td></tr>
</table>

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Bryophyta & Pteridophyta: N.S. Parihar, Central Book Depot, Allahabad. ➢ Introductory Mycology: C.M Alexopoulus, John Wiley & Sons, New York. ➢ Introduction to Fungi: H.C. Dubey, Vikas Publishing House. ➢ Bryophyta: B.R. Vashistha, S. Chand Publication, New Delhi. ➢ Pteridophyta: P.C. Vashistha, S. Chand Publication, New Delhi. ➢ Morphology of Pteridophytes: K.R. Sporne. B.I. Publications, New Delhi. ➢ Botany (For degree students) – Part III Bryophyta: B.R. Vashishtha., S. Chand & Co. Ltd., New Delhi. ➢ A Treatise on Algae: K.N. Bhatia, S. Chand & Company, New Delhi. ➢ Algae: V. J. Chapman and D. J. Chapman, The English language Book Society. ➢ Introductory Phycology: H.D. Kumar, Affiliated East-West, New Delhi. ➢ An Introduction to Pteridophyta: A. Rashid, Vikas, New Delhi ➢ Introduction to Gymnosperms: S.C. Dutta, Asia, Bombay. ➢ Gymnosperms: P.C. Vashistha, S. Chand and Company, New Delhi. ➢ Morphology of Gymnosperms: J.M. Coulter and C.J. Chamberlian, Central Book Depot, Allahabad. ➢ Text Book of Gymnosperm, G.L. Chopra. ➢ University Botany I, S.M. Reddy, New Age Publisher.	Springer-Verlag Berlin and Heidelberg GmbH & Co. KG ➢ Chamberlian, C. J. (1919). *Morphology of Gymnosperms*. Allahabad: Central Book Depot. ➢ Chapman, V.J. (2013). *An Introduction to the Study of Algae*. UK: Cambridge University Press. ➢ Dubey, H.C. (2011). *Introduction to Fungi*. India: Vikas Publishing House. ➢ Dutta, S.C. (1967). *Introduction to Gymnosperms*. Asia Publishing House. ➢ Ganguli, H.C., Das, K.S., Dutta C. (2011). *College Botany* Vol. I. India: New Central Book Agency. ➢ Kumar, H.D. (1999). *Introductory Phycology*. New Delhi: Affiliated East-West. ➢ Parihar, N.S. (1956). *Bryophyta Pteridophyta*. Allahabad: Central Book Depot. ➢ Rashid, A. (1999). *An Introduction to Pteridophyta*. New Delhi: Vikas publications. ➢ Saxena, S. (2000). *A text book of Botany* (Vol. I & II). Agra: Ratan Prakash Mandir. ➢ Sharma, O.P., & Gupta, R.C. (2010). *Text Book of Fungi.* IBH. New Delhi, India: Vedams eBooks (P) Ltd. ➢ Sporne, K.R. (1966). *Morphology of Pteridophytes*. London: Hutchinson University Library. ➢ Vashistha, B.R., & Sinha, A.K. (2010). *Botany for Degree Students-Algae*. New Delhi: S. Chand Publication. ➢ Vashistha, B.R., & Sinha, A.K. (2016). *Botany for Degree Students-Fungi*. New Delhi: S. Chand Publication. ➢ Vashistha, B.R., Sinha, A.K., & Kumar, A. (1987). *Botany for Degree classes- Gymnosperms*. New Delhi: S. Chand Publication. ➢ Vashistha, B.R., Sinha, A.K., & Kumar, A. (2010). *Botany for Degree Students-Bryophyta*. New Delhi: S.	

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				Chand Publication. ➢ Vashisthai, B.R., & Vashistha, P.C. (1987). *Botany for Degree Students Pteridophyta*. New Delhi: S. Chand Publication. ➢ Webster, J., & Weber, R. (2007). *Introduction to Fungi*. Cambridge University Press, New York Press. **Suggested e-Resources:** ➢ **Bryophytes: General account, classification and structure** http://nsdl.niscair.res.in/jspui/bitstream/123456789/150/1/BRYOPHYTES%20.pdf ➢ **Gymnosperms** http://www.plb.ucdavis.edu/courses/bis/1c/text/Chapter24nf.pdf ➢ **Pteridophytes** http://nsdl.niscair.res.in/jspui/bitstream/123456789/556/1/PTERIDOPHYTES%20april609%20-%20formatted.pdf	
2.	**BOT 101L:** Algae, Fungi, Bryophyta, Pteridophyta and Gymnosperms Lab	On completion of the course students will be able to: • Identify bryophyte and pteridophyte material for specimens of lower group of plants. • Interpret the characteristics & life cycles of various lower plants. • Learn about practical technique in lab for detail study of plant	1. Study of Algae and Fungi as mentioned in the syllabus (museum specimen of the affected plants and permanent prepared slides). 2. Study of vegetative and reproductive parts in *Selaginella, Equisetum* and *Marsilea*. 3. Study of vegetative and reproductive parts in *Riccia*, *Marchantia*, *Anthoceros* and *Funaria*. 4. Gymnosperms: study of *Cycas* (coralloid root, rachis, leaflet, male cone, megasporophyll), *Pinus* (needle, dwarf shoot, long shoot, male cone, female cone,) *Ephedra* (morphology, stem, male cone, female cone)	1. Study of algae and fungi as mentioned in the syllabus (museum specimen of the affected plants and permanent prepared slides). 2. Study of vegetative and reproductive parts in *Selaginella*, *Equisetum* and *Marsilea*. 3. Study of vegetative and reproductive parts in *Riccia*, *Marchantia*, *Anthoceros* and *Funaria* by the preparation of temporary slides. 4. Gymnosperms: Study of *Cycas* (coralloid root, rachis, leaflet, male cone, megasporophyll), *Pinus* (needle, dwarf shoot, long shoot, male cone, female cone) *Ephedra* (morphology, stem, male cone, female cone) by the preparation of temporary slides. **Suggested Books:** ➢ Bendre, A., & Kumar, A. (2009). *A Textbook of Practical Botany- I*. Meerut: Rastogi Publications.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		structure and anatomy, reproduction.			
3.	**BT102:** Cell and Molecular Biology - I	On completion of the course, students will be able to: • Gain expertise in the ultra structural information of cell besides the detailed views of the cell interior. • Understand the complex molecular mechanisms occurring in the cell. • Describe types, structural organization and packaging of chromosomes.	**Unit 1** • General introduction to the science of Biotechnology, Cell Biology, Molecular Biology and their scope. • Structural and functional organization of prokaryotic and eukaryotic cell, difference between prokaryotic and eukaryotic cell. • Molecular structure of cell wall and plasma membrane. • Ultrastructural organization of cilia, flagella and basal bodies. • Basic idea of different types of cell junctions. **Unit 2** • Transport across cell membrane: active and passive transport. • Role of extra cellular signals in cellular metabolism. • Basic concept of receptors that mediate the response to extra cellular signals. • Basic concept of signal transduction (inositol lipid pathway and adenylate cyclase pathway). • Cell division and cell cycle. **Unit 3** • A study of ultrastructural organization and functions of eukaryotic cell organelles: • Mitochondria. • Chloroplast. • Endoplasmic reticulum. • Golgi complex. • Lysosomes. • Peroxisomes.	**Unit 1** • General introduction to the science of biotechnology, cell biology, molecular biology and their scope. • Structural and functional organization of prokaryotic and eukaryotic cell, difference between prokaryotic and eukaryotic cell. • Molecular structure of cell wall and plasma membrane of eukaryotic cell. • Ultrastructural organization of cilia, flagella and basal bodies. • Basic idea of different types of cell junctions. **Unit 2** • Transport across cell membrane: Passive transport (simple & facilitated diffusion) and active transport (primary & secondary). • Role of extra cellular signals in cellular metabolism. • Basic concept of receptors (GPCR, receptor tyrosine kinase and intracellular receptors) that mediate the response to extra cellular signals. • Basic concept of signal transduction (adenylate cyclase pathway and inositol lipid pathway). • Cell division, cell cycle & its regulation. **Unit 3** • A study of ultrastructural organization and functions of eukaryotic cell organelles: - Mitochondria. - Chloroplast. - Endoplasmic reticulum. - Golgi complex. - Lysosomes. - Peroxisomes.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			Unit 4 • Ultrastructural organization of nucleus and nucleolus. • Structural organization of chromosomes including lampbrush and polytene chromosomes. • Molecular structure and types of DNA, denaturation and renaturation, Tm value. • Molecular structure and types of RNA. ~~• Replication of genetic material.~~ **Unit 5** • Mechanism of transcription in prokaryotes. • Mechanism of transcription in eukaryotes, RNA processing. • Genetic code. • Translation in prokaryotes. • Difference between translation of eukaryotes and prokaryotes. **Books recommended:** ➢ The world of cell: W.M. Backer, Pearson Education. ➢ Gene VIII: Lewin, Pearson Education. ➢ Cell and Molecular Biology: De Robertis & De Robertis, B.I. Waverly Pvt. Ltd., New Delhi. ➢ Cell and Molecular Biology: P.K. Gupta, Rastogi Publications, Meerut. ➢ Molecular Cell Biology: Lodish, Baltimore, W. H. Freeman & Co. ➢ Essentials of Cytology: C.B. Powar, Himalaya Publications. ➢ Cytology: V.B. Rastogi, Kedarnath and Ramnath, Meerut. ➢ Concepts of Genetics 7th Ed.: William S. Klug, Pearson Education. ➢ Principles of Genetics: R.H. Tamarin, Tata McGraw	**Unit 4** • Ultrastructural organization of nucleus and nucleolus. • Structural organization of chromosomes including lampbrush and polytene chromosomes. DNA packaging into chromosomes. • Types of chromosomes based on number and position of centromere. Karyotype. • Molecular structure and types of DNA, denaturation and renaturation, Tm value. • Molecular structure and types of RNA. • DNA replication in prokaryotes and eukaryotes. **Unit 5** • Mechanism of transcription in prokaryotes. • Mechanism of transcription in eukaryotes, RNA processing. • Genetic code. • Mechanism of translation in prokaryotes and eukaryotes. • Difference between translation of prokaryotes and eukaryotes. **Suggested Books:** ➢ De Robertis, E.D.P., De Robertis, E.M.F. (1987). *Cell and Molecular Biology* (8th ed.). USA: Lea & Febiger. ➢ Gupta, P.K. (2005). *Cell and Molecular Biology*. Meerut: Rastogi Publications. ➢ Hardin, J., Bertoni, G.P. (2016). *Becker's World of the Cell* (9th ed.). USA: Pearson education. ➢ Klug, W.S., Cummings, M.R., Spencer, C.A., Palladino, M.A., Killian, D. (2018). *Concepts of Genetics* (12th ed.). USA: Pearson. ➢ Krebs, J.E., Goldstein, E.S., Kilpatrick, S.T. (2012). *Lewin's Genes XI* (11th ed.). USA: Jones and Bartlett Publishers. ➢ Lodish, H., Berk, A. Kaiser, C.A., Krieger, M. Scott, M.P. (2007). *Molecular Cell Biology* (6th ed.). USA: W H Freeman.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			Hill. ➢ Principles of Genetics: Gardner, Simmons, Snustad, John Wiley & Sons. ➢ Molecular Biology: David Freifelder, Narosa Publishing House, New Delhi ➢ Molecular Biology: R. Weaver, WCB Mc Graw Hill. ➢ Cell Biology, Genetics, Molecular Biology, Ecology and Evolution: Verma and Aggarwal, S. Chand & Co. ➢ Fundamentals of Molecular Biology. Veer Bala Rastogi, Ane Books, India. ➢ Biotechnology, B.D. Singh, Kalyani Publishers.	➢ Malacinski, G.M. (2015). *Freifelders Essentials of Molecular Biology* (4^{th} ed.). USA: Jones & Bartlett. ➢ Paul, A. (2011). *Textbook of Cell & Molecular Biology*. Kolkata: Books & Allied Ltd. ➢ Powar, C.B. (2014). *Essentials of Cytology*. Mumbai: Himalaya Publishing House. ➢ Rastogi, V.B. (2010). *Fundamental of Molecular Biology*. New Delhi: ANE Books. ➢ Rastogi, V.B. (2016). *Introductory Cytology – Knrn*. Meerut: Kedar Nath Ram Nath Publishers. ➢ Singh, B.D. (2015). *Biotechnology*. New Delhi: Kalyani Publishers. ➢ Tamarin, R.H. (2004). *Principles of Genetics* (7^{th} ed.). USA: McGraw-Hill Higher Education. ➢ Verma, P.S., Agarwal, V.K. (2004). *Cell Biology, Genetics, Molecular Biology, Evolution & Ecology*. New Delhi: S. Chand Publisher. ➢ Weaver, R.F. (2011). *Molecular Biology* (5^{th} ed.). USA: McGraw-Hill Education. **Suggested e-Resources:** ➢ **Cell organelles** https://www.khanacademy.org/test-prep/mcat/cells/eukaryotic-cells/a/organelles-article https://www.ncbi.nlm.nih.gov/books/NBK21743/ ➢ **DNA packaging** https://www.nature.com/scitable/topicpage/dna-packaging-nucleosomes-and-chromatin-310 ➢ **Replication, transcription, translation** https://www.atdbio.com/content/14/Transcription-Translation-and-Replication ➢ **Signal transduction pathway** https://www.ncbi.nlm.nih.gov/books/NBK9870/ ➢ **Cell biology** https://nptel.ac.in/courses/102103012/6 ➢ **Cell biology & organelles**	

<table>
<tr><th>S No.</th><th>Course List</th><th>Learning Outcomes</th><th>Existing Syllabus</th><th>Suggested Syllabus</th><th>Remarks</th></tr>
<tr><td></td><td></td><td></td><td></td><td>https://www.nicholls.edu/biol-ds/biol155/Lectures/Cell%20Biology.pdf
➢ Molecular cell biology
https://nptel.ac.in/courses/102106025/
https://nptel.ac.in/courses/122103039/22</td><td></td></tr>
<tr><td>4.</td><td>BT 102L: Cell and Molecular Biology - I Lab</td><td>On completion of the course, students will be able to:
• Understand the basics of cell structure and transport mechanism.
• Gain knowledge about isolation and estimation of nucleic acid from cell.
• Perform analysis of chromosomes and types of cell division.</td><td>1. To examine the phenomenon of cell permeability using hypotonic, isotonic and hypertonic solutions.
2. Preparation of salivary gland chromosomes.
3. <s>Study and</s> preparation of various stages of mitosis and meiosis <s>and to find out mitotic index.</s>
4. <s>Study of cell organelles with the aid of slides available in the lab.</s>
<s>5. Find out the O.D. of the samples provided with the aid of colorimeter/spectrophotometer (Preparation of standard curve).</s>
6. Cell counting (RBC) using Hemocytometer.
<s>7. Measurement of cell size using ocular micrometer.</s>
<s>8. Colorimetric estimation of DNA.</s>
<s>9. Preparation of permanent slides by some commonly used method of double staining.</s>
10. To determine the λmax for given DNA sample.</td><td>1. Organization and working of optical microscope: Dissecting and compound microscopes.
2. To examine the phenomenon of cell permeability using hypotonic, isotonic and hypertonic solutions.
3. Study of salivary gland chromosomes.
4. Preparation of various stages of mitosis and meiosis.
5. Cell counting (RBC) using hemocytometer.
6. Calibration of microscope using stage and ocular micrometer with the help of camera lucida.
7. Determination of DNA content by DPA method.
8. To determine the λ_{max} for given DNA sample.
9. Double staining of Calotropis sp. stem, leaf material.
10. To observe cyclosis through temporary mount of a plant cell.
11. Preparation and precipitation of casein from buffalo milk.
Suggested Books:
➢ Ghose, K., & Manna, B. (2016). Practical Zoology (4th ed.). Kolkata: New Central Book Agency.
➢ Lal, S.S. (2016). A Textbook of Practical Zoology Vol-III (2nd ed.). Meerut: Rastogi Publication.</td><td></td></tr>
<tr><td colspan="6">B.Sc. Biotechnology II Semester</td></tr>
<tr><td>5.</td><td>BT 101: Biostatistics, Bioinformatics and Instrumentation</td><td>On completion of the course, students will be able to:
• Gain fundamental knowledge of biostatistics including</td><td>Unit 1
• Introduction to Biostatistics and its scope.
• Sampling techniques.
• Collection of data, frequency distribution, tabulation, graphical representation of data by histogram, frequency polygon, frequency curve and cumulative frequency curve.</td><td>Unit 1
• Introduction to biostatistics and its scope.
• Sampling techniques.
• Collection of data, frequency distribution, tabulation, graphical representation of data by histogram, frequency polygon, frequency curve and cumulative frequency curve.</td><td></td></tr>
</table>

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		sampling, data collection, measures of central tendency and dispersion. • Gain introductory knowledge of bioinformatics including biological databases, protein structure prediction and phylogenetic analysis. • Understand the working principle and applications of various analytical instruments to explore biological activities.	• Measures of central tendency: Mean, Median, Mode. **Unit 2** • Measures of dispersion: Mean Deviation, Standard Deviation and Variance. • Correlation and regression analysis. • Law of Probability, concept and calculation. • Introduction to computer, ~~its evolution, different generation, classification and characteristics.~~ • ~~Basic components and their functions: Hardware, various input and output devices, concept of CD-ROM, Software.~~ **Unit 3** • ~~Internal representation of data: Bits and bytes, binary, decimal, octal and hexadecimal system.~~ • ~~Introduction and applications of programming languages.~~ • ~~Elementary idea of development of computer programme.~~ • ~~Concept of Internet, Networking, Websites, e-mail~~. • Introduction to Bioinformatics, Biological databases. • Scope of Bioinformatics, ~~Bioinformatics centres in India.~~ **Unit 4** • ~~Principle, working~~ and applications of: • ~~Balance (Electrical and Electronic)~~ • ~~pH meter (with the example of glass electrode)~~ • Colorimeter and Spectrophotometer (UV-VIS) and fluorimetry. • Microscopy (Compound, Phase Contrast and Electron) **Unit 5** • ~~Principle, working~~ and applications of Centrifuge • Chromatography: Paper, TLC, brief idea about different	• Measures of central tendency: Mean, median, mode. • Measures of dispersion: Mean deviation, standard deviation and variance. **Unit 2** • Correlation and regression analysis. • Law of probability, concept and calculation. • Introduction to computers; hardware and software. • Data representation • Number systems; binary, octal, decimal and hexadecimal. • Computer programming; Algorithm and flowchart. **Unit 3** • Introduction and scope of bioinformatics • Introduction to biological database. • Databases at NCBI; nucleotide, gene protein, MMDB, Pubmed and Bookshelf. • Introduction to sequence alignment; dot plot method. • Concept of phylogenetics tree; sequence analysis based phylogenetics. **Unit 4** • Introduction to protein secondary structure prediction; Chou-Fasman method. • A brief introduction to computational drug design. • Working principle and applications of: - Colorimeter and spectrophotometer (UV-VIS) and fluorimetry. - Microscopy (compound, phase contrast and electron). **Unit 5** • Working principle and applications of: - Centrifuge.	

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			types of columns. Electrophoresis: Paper, PAGE, Agarose gel. **Books Recommended:** ➢ Introduction to Bioinformatics: T.K. Attwood, Pearson Education. ➢ Fundamentals of Computers: P.K. Sinha, New Delhi, BPB Publication. ➢ Statistical Methods: S.P. Gupta, S. Chand & Company, New Delhi. ➢ Practical Biochemistry: Keith Wilson and John Walker, Cambridge University Press. ➢ At the Bench of laboratory Navigator: Kathy Barker, I.K. International. ➢ Biotechniques: S.V.S. Rana, Rastogi Publications, Meerut. ➢ Physical Biochemistry: David Friefelder, New York: W.H. Freeman, C 1982. ➢ Instrumental Methods of Chemical Analysis: Chatwal and Anand, Himalaya Publishing House. ➢ Instrumental Methods of Chemical Analysis: B.K. Sharma, Goel Publishing House. ➢ Text Book of Bioinformatics, Sharma, Munjal and Shankar, Rastogi Publications.	- Chromatography: Paper, TLC, brief idea about different types of columns. - Electrophoresis: Paper, PAGE (native and SDS), agarose gel. **Suggested Books:** ➢ Attwood, T. (2007). *Introduction to Bioinformatics*. USA: Pearson Education. ➢ Barker, K. (2004). *At the Helm: A Laboratory Navigator*. New Delhi: I K International Publishing House. ➢ Bhuyan, K.C. (2017). *Advanced Biostatistics*. Kolkata: New Central Book Agency. ➢ Chatwal, G.R., Anand, S. (2011). *Instrumental Methods of Chemical Analysis*. Mumbai: Himalaya Publishing House. ➢ Datta, A.K. (2014). *Basic Biostatistics and Application*. Kolkata: New Central Book Agency. ➢ Freifelder, D.M. (1983). *Physical Biochemistry: Applications to Biochemistry and Molecular Biology*. USA: W. H. Freeman. ➢ Gupta, S.P. (2018). *Statistical Methods* (45th ed.). New Delhi: Sultan Chand & Sons. ➢ Pandey, M. (2015*). Biostatistics: Basic and Advanced*. New Delhi: MV Learning. ➢ Rana, S.V.S. (2012). *Biotechniques: Theory & Practice* (3rd ed.). Meerut: Rastogi Publications. ➢ Rao, P.H., & Janardhan, K. (2014). *Fundamentals of Biostatistics*. New Delhi: I. K. International Publishing House. ➢ Rastogi, S.C., Mendiratta, N., & Rastogi, P. (2018). *Bioinformatics: Concepts, Skills & Applications* (2nd ed.). New Delhi: CBS Publishers & Distributors. ➢ Sharma, B.K. (2011). *Instrumental Methods of Chemical Analysis*. Mumbai: Meerut: Goel Publishing House.	

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				➢ Sharma, V., Munjal, A., & Shanker, A. (2008). *A Text Book of Bioinformatics*. Meerut: Rastogi Publications. ➢ Sinha, P.K., & Sinha, P. (2004). *Computer Fundamentals* (6th ed.). New Delhi: BPB Publications. ➢ Walker, J,M., & Wilson, K. (2000). *Practical Biochemistry Principles and Techniques* (5th ed.). New Delhi: Cambridge University Press. **Suggested e-Resources:** ➢ **Analytical techniques** https://nptel.ac.in/courses/102107028/ http://www.tulane.edu/~wiser/methods/notes.pdf ➢ **Basic bioinformatics** https://courses.cs.ut.ee/MTAT.03.242/2017_fall/uploads/Main/Basics_of_Bioinformatics.pdf ➢ **Analytical techniques & bioinformatics** https://nptel.ac.in/courses/102103044/38 ➢ **Biostatistics** https://nptel.ac.in/courses/102106051/ https://nptel.ac.in/courses/102101056/ ➢ **Measures of central tendency** https://www.tutorialspoint.com/statistics/arithmetic_mean.htm	
6.	**BT 101L:** Biostatistics, Bioinformatics and Instrumentation Lab	On completion of the course, students will be able to: • Separate the obtained biological data and make valid inferences that can be used to solve problems in various disciplines of science and technology. • Learn sequence	1. Demonstration including working, principle and applications of the following instruments: i. pH meter ii. Balance iii. Centrifuge iv. Autoclave v. Different types of Microscopes vi. Incubator and Oven vii. Shaker viii. Spectrophotometer/Colorimeter ~~ix. Computer (Hardware)~~ 2. Statistical problem ~~3.~~ Bioinformatics exercise: ~~Inter-conversion of values~~	1. Demonstration including working principle and applications of the following instruments: i. pH meter ii. Balance iii. Centrifuge iv. Autoclave v. Different types of microscopes vi. Incubator and oven vii. Shaker viii. Spectrophotometer/Colorimeter ix. Server 2. Statistical problems (exercise on mean, mode, median, standard deviation, standard error).	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		analysis and molecular visualization using bioinformatics tools. • Safety measures in laboratory, handling and care of instruments.	~~in various number systems.~~ 4. Preparation of solutions of different of molarities. Concept of buffers- preparations of few buffers e.g. Tris (alkaline range), acetate/ citrate (acidic range). 5. To determine the pH of five aliquots of the given sample and plot a graph of the same. ~~6. To prepare a pellet from the sample provided by centrifugation technique.~~ 7. Separation of cell organelles using sucrose density gradient. 8. Separation of amino acids by paper chromatography. ~~9. Sterilization of glassware and surgical instruments.~~ ~~10.~~ Demonstration of SDS-PAGE for separation of proteins.	3. Bioinformatics exercise: • Dot plot; palindrome and repeat sequence identification. • Visualization of biomolecular structures; PyMol. 4. Preparation of solutions of different of molarities. Concept of buffers- preparations of few buffers e.g. Tris (alkaline range), acetate/ citrate (acidic range). 5. To determine the pH of five aliquots of the given soil sample and plot a graph of the same. 6. Separation of cell organelles using sucrose density gradient. 7. Separation of amino acids by paper chromatography and thin layer chromatography. 8. Demonstration of SDS-PAGE for separation of proteins. 9. To prepare standard curve of ammonium sulfate. **Suggested Books:** ➢ Boya, R.F. (2006). *Modern Experimental Biochemistry* (3^{rd} ed.). Noida: Pearson Education. ➢ Ghose, K., & Manna, B. (2016). *Practical Zoology* (4^{th} ed.). Kolkata: New Central Book Agency. ➢ Lal, S.S. (2016). *A Textbook of Practical Zoology* Vol-III (2^{nd} ed.). Meerut: Rastogi Publication. ➢ Sharma, S., & Sharma, R. (2016). *Practical Manual of Biochemistry* (2^{nd} ed.). New Delhi: Medtech.	
7.	**ZOO 101:** Non-Chordates and Proto-Chordates	On completion of the course, students will be able to: • Describe the habit, habitat, morphology, structure and functions of important animals of different major	**Unit 1** **Protozoa** • Habitat, habits, external features, locomotion, osmoregulation, nutrition, reproduction and life cycle of *Euglena*, *Paramecium* and *Monocystis*. • Economic importance of protozoans. **Porifera** • Habitat, habits, structural organization, canal system, reproduction and development of *Sycon* including evolution of canal system in sponges.	**Unit 1** **Protozoa** • Habitat, habits, external features, locomotion, osmoregulation, nutrition, reproduction and life cycle of *Euglena*, *Paramecium* and *Monocystis*. • Economic importance of protozoans. **Porifera** • Habitat, habits, structural organization, canal system, reproduction and development of *Sycon* including evolution of canal system in sponges.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		phyla of invertebrates and lower chordates. • Understand the economic importance of various invertebrate phyla and affinities of lower chordate animals. • Gain a high degree of competence in its field of specialization in response to the changing demands of the times.	• Economic importance of sponges. **Unit 2** **Coelenterata** • Habitat, habits, external features, nutrition, structural organization, reproduction and life cycle of *Obelia*. • Corals and coral reefs. **Helminthes** • Habitat, habits, external features, different systems and life history of following animal types: *Fasciola*, *Taenia* and *Ascaris*. • Parasitic adaptations and diseases caused by helminthes. **Unit 3** **Annelida** • Habitat, habits, external features, different systems and development of *Pheretima*. • Salient features of *Neanthes*. **Arthropoda** • Habitat, habits, external features and different systems of *Palaemone*. • Economic importance of insecta. **Unit 4** **Mollusca** • Habitat, habits, external features, various organs and organ systems of *Pila* and *Unio*; pearl formation. • Economic importance of mollusca. **Echinodermata** • Habitat, habits, external features and water-vascular system of *Asterias*. • Larval forms of echinoderms. **Hemichordata** • Habitat, habits, external features and different system of *Balanoglossus*. • Affinities of hemichordates.	• Economic importance of sponges. **Unit 2** **Coelenterata** • Habitat, habits, external features, nutrition, structural organization, reproduction and life cycle of *Obelia*. • Corals and coral reefs. **Helminthes** • Habitat, habits, external features, different systems and life history of following animal types: *Fasciola*, *Taenia* and *Ascaris*. • Parasitic adaptations and diseases caused by helminthes. **Unit 3** **Annelida** • Habitat, habits, external features, different systems and development of *Pheretima*. • Habitat, habits, external features and life history of *Neanthes*. **Arthropoda** • Habitat, habits, external features and different systems of *Palaemone*. • Economic importance of insecta. **Unit 4** **Mollusca** • Habitat, habits, external features, various organs and organ systems of *Pila* and *Unio*; pearl formation. • Economic importance of mollusca. **Echinodermata** • Habitat, habits, external features and water-vascular system of *Asterias*. • Larval forms of echinoderms. **Hemichordata** • Habitat, habits, external features and different system of *Balanoglossus*. • Affinities of hemichordates.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			Unit 5 **Urochordata** • Habitat, habits, structural organisation and various systems of *Herdmania*. • Tadpole larva and retrogressive metamorphosis in *Herdmania*. **Cephalochordata** • Habitat, habits, morphology, different systems and affinities of *Amphioxus*. • Development of coelom and atrium of *Amphioxus*. **Books recommended :** ➢ Invertebrates: R. L. Kotpal, Rastogi Publications, Meerut. ➢ A text book of Zoology: S.N. Prasad, Allahabad, Kitab Mahal. ➢ A text book of Zoology: H.C. Nigam Delhi, S.Nagin. ➢ A text book of Zoology: P.S. Dhami, New Delhi, R. Chand. ➢ A text book of Zoology: T.C. Majupuria, Jallundhur City, S. Nagin. ➢ A text book of Zoology: V.B. Rastogi, Ram Nath Kedar Nath, Meerut. ➢ Kotpal Series Vol. I to IX, Rastogi Publication, Meerut. ➢ CNH Series Vol. I to IX. ➢ Hymen Series Vol. I to IX, Mc Graw Hill.	**Unit 5** **Urochordata** • Habitat, habits, structural organisation and various systems of *Herdmania*. • Tadpole larva and retrogressive metamorphosis in *Herdmania*. **Cephalochordata** • Habitat, habits, morphology, different systems and affinities of *Amphioxus*. • Development of coelom and atrium of *Amphioxus*. **Suggested Books:** ➢ Chaki, K.K., Kundu, G., & Sarkar, S. (2014). *Introduction to Economic Zoology*. Kolkata: New Central Book Agency. ➢ Chaki, K.K., Kundu, G., & Sarkar, S. (2015). *Introduction to General Zoology* Vol-I. Kolkata: New Central Book Agency. ➢ Dhami P.S., & Dhami, J.K. (2015). *Invertebrate Zoology*. New Delhi: R. Chand and Co. ➢ Hyman, L.H. *The Invertebrtaes*. Vol-I-IX. New York: McGraw Hill. ➢ Jordan, E.L., & Verma, P.S. (2018). *Invertebrate Zoology*. New Delhi: S. Chand & Company Ltd. ➢ Kotpal, R.L. (2014). *Modern Textbook of Zoology: Invertebrates* (11th ed.). Meerut: Rastogi Publications. ➢ Kotpal, R.L. (2018). *Modern Text book of Zoology: Vertebrates* (4th ed.). Meerut: Rastogi Publications. ➢ Lahiri, B.K. (2013). *College Zoology* Vol-I. Mumbai: Himalaya Publishing House. ➢ Majupuria, T.C. (1962). *A textbook of invertebrate Zoology* (1st ed.). Jullundur City**:** S. Nagin Publishers. ➢ Nigam, H.C. (2013). *Biology of Non-Chordates*. New Delhi: Vishal Publishing Co. ➢ Pechenik, J.A. (2015). *Biology of the Invertebrates* (7th ed.). New Delhi: Mc Graw Hill Education.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				➢ Prasad, S.N., & Kashyap, V. (2012). *A text book of Invertebrate Zoology* (14^{th} ed.). New Delhi: New Age International (P) Limited. ➢ Rastogi, V.B. (2017). *Invertebrate Zoology*. Meerut: Kedar Nath Ram Nath. ➢ Shukla, G.S., & Upadhyay, V.B. (2017). *Economic Zoology* (5^{th} ed.). Meerut: Rastogi Publication. **Suggested e-Resources:** ➢ **Corals** https://www.icriforum.org/about-coral-reefs/what-are-corals ➢ ***Paramecium*** https://www.microscopemaster.com/paramecium.html ➢ **Prawn** http://www.biologydiscussion.com/invertebrate-zoology/phylum-arthropoda/study-notes-on-prawn/33417 ➢ ***Amphioxus*** https://embryology.med.unsw.edu.au/embryology/index.php/Book_-_Text-Book_of_Embryology_4 ➢ **Invertebrate animals** http://www.iaszoology.com/category/animal-diversity-nonchordata/ ➢ **Non chordate animals** https://www.slideshare.net/godhxbwnkkdn/animal-diversity-zoology-notes http://abacus.bates.edu/acad/depts/biobook/AnimPhyl.pdf	
8.	**ZOO 101L:** Non-Chordates and Proto-Chordates Lab	On completion of the course, students will be able to: • Identify and characterize different organisms of invertebrate based	1. **Anatomy :** • Anatomical study of various systems with the help of chart/model/CD. • Identification, localization and labeling of various organs in dissected animal specimen/models/chart/CD. ~~**1. Study of Museum Specimens :**~~ • Porifera: ~~Sycon,~~ Euplectella, ~~Hyalonema~~, ~~Euspongia~~	**1. Study of museum specimens:** • Porifera: *Euplectella*, *Chalina, Grantia* and *Spongilla*. • Coelenterata: *Physalia*, *Aurelia*, *Millipora*, *Tubipora*, *Corallium*, *Antipathes* (black only), *Fungia* (mushroom coral). • Platyhelminthes: *Schistosoma* and *Taenia*. • Nemathelminthes: Male and female *Ascaris*.	Name of the animals and their anatomical systems have been specified for clear understanding of the practical. Study of museum

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		on the external features. • Describe different organ systems of important invertebrate animals like *Palaemone*, *Pila* and *Asterias*. • Gain practical understanding of preparation of permanent slide and study of internal structures of higher invertebrate animals through microscopic study of prepared slides. • Understand the collection of certain arthropods from their natural habitat and develop the skills of vermiculture.	and Spongilla. • Coelenterata:~~ Porpita, Velella, ~~Physalia, Aurelia~~,~~ ~~Gorgonia, Pennatula, Alcyonium, ~~Millipora, Tubipora~~,~~ Corallium, Antipathes (Black only), Fungia, (Mushroom, Coral) and~~ Adamsia.~~ ~~• Platyhelminthes: Fasciola, ~~Schistosoma~~, Echinococcus and ~~Taenia. • Nemathelminthes: Male and Female Ascaris~~, Dracunculus and Entrobius.~~ ~~• Annelida: Aphrodite, ~~Chaetopterus~~, Terebella, ~~Sabella~~,~~ Arenicola~~, Pontobdella and ~~Hirudinaria. • Arthropoda: ~~Lepus,~~ Balanus, ~~Sacculina,~~ Squilla, ~~Crab, Hermitcrab~~ Julus, Scolopendra, Locust, ~~Melanopus~~, Butterfly, ~~Queen termite~~, Cimex, ~~Limulus~~, Scorpion, Spider and ~~Peripatus.~~ • Mollusca~~: Chiton~~, Patella, Cyprea~~, Aplysia~~, ~~Dentalium~~, ~~Mytilus,~~ Pecten, ~~Teredo~~, ~~Sepia~~, ~~Loligo~~, Octopus, Nautilus. • Echinodermata: Antedon, ~~Holothuria,~~ ~~Echinus,~~ ~~Clypeaster~~ and Ophiothrix. • Hemichordata: Balanoglossus. • Protochordata: ~~Ascidia~~, Ciona~~, Botryllus~~ and Salpa.	• Annelida: *Nereis*, *Chaetopterus*, *Sabella*, *Arenicola*, *Hirudinaria*. • Arthropoda: *Balanus*, *Squilla*, *Julus*, *Scolopendra*, Locust, Butterfly, *Cimex*, Scorpion, Spider. • Mollusca: *Patella*, *Cyprea*, *Pecten*, *Octopus*, Pearl oyster, *Nautilus*. • Echinodermata: *Antedon*, *Clypeaster*, Cucumara, *Ophiothrix*. • Hemichordata: *Balanoglossus*. • Protochordata: *Ciona* and *Salpa*. **2. Study of microscopic slides:** • Protozoa: *Amoeba*, *Polystomella*, *Monocystis*, Binary fission and conjugation in *Paramecium*. • Porifera: T.S. and L.S. of *Sycon*, Spicules of sponge, Canal system of sponge. • Coelenterata: *Obelia*. • Platyhelminthes: W.M. of miracidium, sporocyst, redia, cercaria and metacercaria larva of *Fasciola*. • Annelida: T.S. of *Nereis* through trunk region, T.S. of *Pheretima posthuma* through gizzard, typhlosolar region, prostrate glands and seminal vesicles. • Arthropoda: V.S. of compound eye, *Pediculus.* • Mollusca: T.S. of gill of *Unio*, Glochidium larva. • Echinodermata: Larval forms (Bipinnaria, Echinopluteus, Ophiopluteus). • Hemichordata: T.S. of *Balanoglossus* through proboscis, collar and trunk region. • Protochordata: W.M. velum and pharyngeal wall of *Amphioxus*, T.S. of *Amphioxus* through various regions; tadpole larva of *Ascidia*. **3. Anatomy:** • Anatomical study of various systems with the help of chart/model/CD. ***Palaemon***	specimens have been replaced by preparation of permanent slides and study of microscopic slides.

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				1. Appendages 2. Digestive system 3. Nervous system ***Pila globosa*** 1. Digestive system 2. Structure of radula 3. Nervous system ***Asterias*** 1. Water vascular system **4.** To study methods of preservation of museum specimens. **5. Preparation of permanent slides** • Protozoa: *Paramecium*. • Porifera: Spongin fibers and gemmule. • Coelenterata: *Obelia* colony and medusa of *Obelia*. • Annelida: Parapodium of heteronereis. • Arthropoda: Crustacean larva (nauplius, metanauplius, megalopa, Zoea). • Mollusca: Glochidium larva of *Unio*. • Echinodermata: Tube feet of *Asterias*. **6. Collection and culture methods** (i) Collection of animals from their natural habitat: *Pheretima*, *Daphnia*, *Cyclops*, house flies, mosquitoes. (ii) Culture of *Pheretima*. **7.** Preparation of permanent mount of mouth parts of cockroach/housefly. **Suggested Books:** ➢ Lal, S.S. (2015). *Practical Zoology: Invertebrates* (11th ed.). Meerut: Rastogi Publication. ➢ Lal, S.S. (2015). *Practical Zoology: Vertebrates* (11th ed.). Meerut: Rastogi Publication. ➢ Verma, P.S. (2010). *A Manual of Practical Zoology: Invertebrates* (11th ed.). New Delhi: S Chand Publishing.	
B.Sc. Biotechnology III Semester					

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
9.	**BOT 201:** Angiosperms Taxonomy and Economic Botany	On completion of this course, students will be able to: • Identify characteristic features of angiosperm families and their interdisciplinary approaches. • Understand plant morphology terminologies and distinguishing features with morphological peculiarities. • Know the economic importance of angiosperms and its use in various industries.	**Unit 1** • ~~Taxonomy: Importance, a brief account of the historical development. Code, binomial nomenclature, International rules of Botanical nomenclature, Units of classification, Principles of priority,~~ ~~Type method,~~ Citation of author's name. • Numerical Taxonomy and Chemical Taxonomy (brief ideas only). • A brief account of National Herbaria and Botanical Gardens of India. **Unit 2** • Classification : System of Bentham and Hooker, a brief account of classification by Engler and Prantl, Hutchinson and Takhtajan, merits and demerits. • Study of following families with emphasis on their diagnostic features: • Ranunculaceae, Papaveraceae, Capparidaceae, Caryophy-llaceae, Rutaceae, Myrtaceae, Malvaceae. **Unit 3** • Study of following families with emphasis on their diagnostic features : Cucurbitaceae, Rubiaceae, Asclepiadaceae, Apocynaceae, Asteraceae, ~~Boraginaceae~~, Acanthaceae, ~~Scrophulariaceae~~, Lamiaceae, Euphorbiaceae Brassicaceae, Fabaceae, Caesalpinaceae, Mimosaceae, Poaceae, Arecaceae, Liliaceae.	**Unit-I** • International code of nomenclature for algae, fungi and plants- history, rules, principles. Concept of family, genus and species, citation of author's name. • Numerical taxonomy and chemical taxonomy (brief ideas only). • A brief account of national herbaria and botanical gardens of India. **Unit 2** • Classification: System of Bentham and Hooker, a brief account of classification by Engler and Prantl, Hutchinson and Takhtajan, merits and demerits. • Study of following families with emphasis on their diagnostic features: - Ranunculaceae - Papaveraceae - Capparidaceae - Caryophyllaceae - Rutaceae - Myrtaceae - Malvaceae **Unit 3** • Study of following families with emphasis on their diagnostic features: - Cucurbitaceae - Rubiaceae - Asclepiadaceae - Apocynaceae - Asteraceae - Amaranthaceae - Acanthaceae - Solanaceae	This brings more clarity to the syllabus. These are already covered in Code. This inclusion will help in explaining plant taxonomy. The suggested families are of more relevance

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			Unit 4 • Food Plants: Maize, Bajra, Wheat, Legumes, Potato, Sugarcane. • Spices: General account (Coriander, Turmeric, Chillies, Cumin, Fennel, Asafoetida). • Beverages: Tea and Coffee • Fatty Oils: Mustard, Groundnut, Sesame, Coconut. **Unit 5** • Fibre Plants: Gossypium, Corchorus, Saccharaum munja. • Drug Plants: Cinchona, Rauwolfia, Papaver, Digitalis. • Timber Plants: Tectona, Dalbergia, Pinus. Rubber : Hevea brasiliensis **Books recommended :** ➢ A Hand Book of Systematic Botany: S.C. Dutta, Asia. ➢ An Introduction to the Taxonomy of Angiosperms: Y.D. Tiagi & S. Khetrapal, Ramesh Book Depot, Jaipur. ➢ Economic Botany: Bendre & Kumar, Rastogi Publications, Meerut. ➢ Economic Botan: Sambamurthy. ➢ A text book of economic botany: V. Verma, Emkay publications, New Delhi. ➢ Economic Botany: S. Kumar, Campus Books, New	- Apiaceae - Lamiaceae - Euphorbiaceae - Brassicaceae - Fabaceae - Caesalpinaceae - Mimosaceae - Poaceae - Arecaceae - Liliaceae **Unit 4** • Food plants: Maize, bajra, wheat, legumes, potato, sugarcane. • Spices: General account (coriander, turmeric, chillies, *Cumin*, fennel, *Asafoetida*). • Beverages: Tea and coffee. • Fatty oils: Mustard, groundnut, sesame, coconut. **Unit** 5 • Fibre plants: *Gossypium*, *Corchorus*, *Saccharaum munja*. • Drug plants: *Cinchona*, *Rauwolfia*, *Papaver*, *Digitalis*. • Timber plants: *Tectona*, *Dalbergia*, *Pinus*. Rubber: *Hevea brasiliensis.* **Suggested Books:** ➢ Alam, A., & Sharma, V. (2012). *Economic Botany*. Jaipur: Pointer Publishers. ➢ Dutta, S. (2009). *A Hand Book of Systematic Botany*. New Delhi: New Age International (P) Limited. ➢ Khetrapal, Y.T. *An Introduction to the Taxonomy of Angiosperms*. Jaipur: Ramesh Book Depot. ➢ Kochhar, S.L. (2016). *Economic Botany of the Tropics*. London: Macmillan India Limited. ➢ Kumar, A., & Bendra, A. (1983). *Economic Botany: for university students*. Meerut: Rastogi Publications. ➢ Lawrence, G.H.M. (2017). *Taxonomy of vascular plants*.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			Delhi. ➢ Fundamentals of Plant systematics - Albert E. Radford. ➢ Taxonomy of vascular plants: G.H.M. Lawrence. ➢ Economic Botam of the Tropics– S.L. Kochhar. ➢ Taxonomy of Angiosperm: R.K. Jain & V. Singh. ➢ Taxonomy of Angiosperm: O.P. Sharma.	Jodhpur: Scientific publisher ➢ Radford, A.R., & Caddell, G.M. (1986). *Fundamentals of Plant systematics*. USA: Harper & Row Publishers. ➢ Sharma, O.P. (2011).*Taxonomy of Angiosperm*. New Delhi: TATA McGraw-Hill. ➢ Singh, V. & Jain, D.K. (2010).*Taxonomy of Angiosperm*. Meerut: Rastogi Publication. ➢ Verma , V. (2010). *A text book of economic botany*. New Delhi: Emkay publications. **Suggested e-Resources:** ➢ **Angiosperms: APG system of classification** https://academic.oup.com/botlinnean/article/181/1/1/2416499 ➢ **Angiosperms: Classification and reproduction** https://www.toppr.com/guides/biology/plant-kingdom/angiosperms/ ➢ **Economic botany** http://nsdl.niscair.res.in/jspui/bitstream/123456789/130/1/beverages.pdf	
10.	**BOT 201L:** Angiosperms Taxonomy and Economic Botany Lab	On completion of this course, students will be able to: • Develop skills for plant identification, with reference to systematic position, morphological characters, floral formula and floral diagram. • Diagnose the structural features of plant organs and differentiate	1. Study of locally available ~~flowers~~ of the families mentioned in the syllabus. 2. Study of economically important plant products as mentioned in the syllabus.	1. Study of locally available plants of the families mentioned in the syllabus. 2. Study of economically important plant products as mentioned in the syllabus. 3. Preparation of herbarium. **Suggested Books:** ➢ Sahu, A.C. (2015). *Textbook of Practical Botany*. New Delhi: Kalyani Publishers.	Preparation of herbarium Is important part in the taxonomy.

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		microscopically their tissue elements. • Study fiber, gum, resin, timber, spices and medicinal plants and its applications			
11.	**BT 202:** Biochemistry, Biophysics and Enzymology	On completion of the course, students will be able to: • To demonstrate an understanding of fundamental biochemical principles, such as the structure/function of biomolecules, metabolic pathways, and the regulation of biological/biochemical processes. • Gain knowledge of basic energy metabolism of cells and identify some of common reaction mechanisms in biochemical processes. • Describe structure, functions, kinetics,	**Unit 1** • Structure and colligative properties of water • pH, pK, acids, bases, buffers. Ionic product of water, Henderson-Hasselbach equation. • Carbohydrates – structure, classification and properties. • Amino acids and proteins– structure, classification and properties. • Lipids – Structure, nomenclature and properties. **Unit 2** • Bioenergetics – Energy and its forms, Principles of Thermodynamics. • Energy rich biomolecules –(ATP, NADP and other phosphorylated compounds). • Coordinated control of metabolism: Methods of studying metabolism. Some key metabolic pathways: Glycolysis, citric acid cycle and pentose phosphate pathway. • Metabolism of Tryptophan, Palmitic acid, Purine and Pyrimidines. **Unit 3** • Classification, nomenclature and general properties of enzymes • Coenzymes. • Vitamins: structure and functions. • Classification, properties and metabolic significance of	**Unit 1** • Structure and colligative properties of water. • pH, pK, acids, bases, buffers. Ionic product of water, Henderson-Hasselbalch equation. • Carbohydrates-Classification, structure, properties and functions. • Amino acids and proteins-Classification, structure, properties and functions. • Lipids-Classification, structure, properties and functions. **Unit 2** • Bioenergetics-Energy and its forms, principles of thermodynamics. • Energy rich biomolecules-(ATP, NADP and other phosphorylated compounds). • Coordinated control of metabolism: Various techniques used to study metabolism. Some key metabolic pathways: Glycolysis, citric acid cycle and pentose phosphate pathway. • Metabolism of tryptophan, palmitic acid, purine and pyrimidines. **Unit 3** • Classification, structure and functions of coenzymes. • Vitamins: Classification, structure and functions. • Classification, properties and metabolic significance of secondary metabolites (terpenoids, alkaloids, phenols). • Three dimensional structure of proteins: Peptide bonds,	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		regulation and the mechanisms of action of enzymes. • Explain chemical messenger molecules of the nervous system including neurotransmitters and synaptic neurotransmission.	secondary metabolites (Terpenoids, alkaloids, phenols). **Unit 4** • Three dimensional structure of proteins: Peptide bonds, disulphide cross links, Alpha-helix, β-sheet, helix-coil transitions. Ramachandran plots. • Nucleic acids – Various confirmations of nucleotides, glycosidic bond rotation. Base stacking. • Electrical properties of biological compartments, Electrochemical gradients, membrane potential. • Mechanism of ATP synthesis: Oxidative phosphorylation, chemiosmotic hypothesis and photophosphorylation. • Nerve transmission: resting membrane potential, Propagation of nerve impulse and an idea about neurotransmitters. • Structure of striated muscle, muscle proteins and biophysical events of muscle contraction. **Unit 5** • Introduction to mechanism of enzyme action (Lock and Key hypothesis, Induced fit hypothesis) • Enzyme inhibition: competitive and non- competitive type • Isolation and purification of enzymes. • Kinetics of enzyme catalyzed reaction (Michaelis-Menten law), Double reciprocal plot. **Books recommended :** ➢ Principles of Biochemistry: A.L. Lehninger, Nelson and Cox, McMillan Worth Publishers. ➢ Biochemistry: Christopher K. Mathews Von Holde & Ahern, Pearson Education. ➢ Biochemistry: Voet and Voet, John Wiley and Sons, Inc. USA.	disulphide cross links, α-helix, β-sheet, helix-coil transitions. Ramachandran plots. **Unit 4** • Nucleic acids-Various confirmations of nucleotides, glycosidic bond rotation. Base stacking. • Electrical properties of biological compartments, electrochemical gradients, membrane potential. • Mechanism of ATP synthesis: Oxidative phosphorylation, chemiosmotic hypothesis and photophosphorylation. • Nerve transmission: Resting membrane potential, propagation of nerve impulse and an idea about neurotransmitters. • Structure of striated muscles, muscle proteins and biophysical events of muscle contraction. **Unit 5** • Classification, nomenclature and general properties of enzymes. • Introduction to mechanism of enzyme action (lock and key hypothesis, induced fit hypothesis). • Enzyme inhibition: competitive, non- competitive and uncompetitive. • Isolation and purification of enzymes. • Kinetics of enzyme catalyzed reaction (Michaelis-Menten law), double reciprocal plot. **Suggested Books:** ➢ Berg, J.M., Stryer, L. Tymoczko, J.L. & Gatto, G.J. (2015). *Biochemistry* (8th ed.). New York, USA: WH Freeman. ➢ Cantor, C.R., & Schimmel, P.R. (1980). *Biophysical Chemistry, Part 2: Techniques for the Study of Biological Structure and Function* (1st ed.). New York,	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Harper's review of Biochemistry: R.K. Murray et al., Prentice-Hall International Inc. ➢ Fundamentals of Biochemistry: Cohn and Stumf. ➢ Molecular Biophysics-Structure in Motion: Michel Daune, Oxford University Press. ➢ Basic Biophysics: R. Narayanan, New Age Publisher. ➢ Biophysical Chemistry Vol. I, II & III: Cantor and Schimmel, Freeman. ➢ Biochemistry: Zubey, WCB, Place Dabuque ➢ Biochemistry: Stryer, W. H. Freeman, New York. ➢ Understanding Enzymes: T. Palmer, Pub. Horword, Chichester, England. ➢ Fundamentals of Biochemistry: J.L. Jain, S. Chand & Company limited.	USA: W. H. Freeman and Company. ➢ Cantor, C.R., & Schimmel, P.R. (1980). *Biophysical Chemistry: Part 1: The Conformation of Biological Macromolecules*. New York, USA: W. H. Freeman and Company. ➢ Cantor, C.R., & Schimmel, P.R. (1980). *Biophysical Chemistry: Part 3: The Behaviour of Biological Macromolecules*. New York, USA: W. H. Freeman and Company. ➢ Conn, E.E., Stumpf, P.K., & Bruening, G. (2006). *Outlines of Biochemistry* (5th ed.). New Jersey: Wiley-Blackwell. ➢ Copeland, R.A. (2008). *Enzymes: A Practical Introduction to Structure, Mechanism & Data Analysis* (2nd ed.). India: Wiley-VCH. ➢ Daune, M., Duffin, W.J., & Blow, D. (1999). *Molecular Biophysics: Structures in Motion*. UK: UK: Oxford University Press. ➢ Gupta, S.N. (2015). *Biochemistry* (2nd ed.). Meerut: Rastogi Publication. ➢ Jain, J.L., Jain, S., & Jain, N. (2016). *Fundamentals of Biochemistry* (7th ed.). New Delhi: S Chand. ➢ Mathews, C.K., Van Holde, K.E., Appling, D.R., & Anthony-Cahill, S.J. (2012). *Biochemistry* (4th ed.). London, UK: Pearson Education. ➢ Narayanan, P. (2007). *Essentials of Biophysics* (2nd ed.). New Delhi: New Age Internationals. ➢ Nelson, D.L., & Cox, M.M. (2017). *Lehninger Principles of Biochemistry* (7th ed.). USA: W H Freeman & Co. ➢ Palmer, T. (2001). *Enzymes: Biochemistry, Biotechnology, Clinical Chemistry* (V Ed.). Cambridge: Horwood Publishing Ltd. ➢ Rajeswari, M.R. (2013). *An Introduction to Biophysics* (1st ed.). Meerut: Rastogi Publication.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				➢ Rodwell, V., Bender, D., Kennelly, P., & Weil, P.A. (2015). *Harpers Illustrated Biochemistry* (30th ed.). New York, USA: McGraw-Hill Education / Medical. ➢ Satyanarayana, U., & Chakrapani, U. (2017). *Essentials of Biochemistry* (end ed.). Kolkata: Booka & Allied Ltd. ➢ Voet, D., & Voet, J.G. (2010). *Biochemistry* (4^{th} ed.). New York, USA: John Wiley & Sons Inc. ➢ Zubay, G., Parson, W.W., & Vance, D.E. (1995). *Principles of Biochemistry*. USA: Brown (William C.) Co. **Suggested e-Resources:** ➢ **Enzymology** https://nptel.ac.in/courses/102102033/14 ➢ **Biomolecules** http://www.biologie.ens.fr/~mthomas/L3/intro_biologie/2-sucres-lipides-acides-nucleiques.pdf ➢ **ETC** https://www.khanacademy.org/science/biology/cellular-respiration-and-fermentation/oxidative-phosphorylation/a/oxidative-phosphorylation-etc http://courses.chem.indiana.edu/c483/documents/lecture23.pdf ➢ **Biochemistry** https://nptel.ac.in/courses/102105034/3 ➢ **Muscle structure & contraction** https://opentextbc.ca/biology/chapter/19-4-muscle-contraction-and-locomotion/	
12.	**BT 202L:** Biochemistry, Biophysics and Enzymology Lab	On completion of this course, students should be able to: • Apply the scientific method to the biochemical processes of	1. To find out the λmax of protein (BSA). 2. Qualitative analysis of carbohydrates (Reducing and Non Reducing). 3. Qualitative test for Proteins. 4. Qualitative analysis of Lipids. 5. Determination of Iodine number. 6. Determination of the acid value of Lipid.	1. To find out the λ_{max} of protein (BSA). 2. Qualitative analysis of carbohydrates (reducing and non Reducing): Molisch's test, Benedict's test, Fehling's test, Tollen's phloroglucinol, Barfoed's test, Seliwanoff's test, acidic hydrolysis test for sucrose. 3. Qualitative test for proteins: Biuret's test, Ninhydrin test, Xanthoproteic test, Million's test, Sakaguchi test,	Qualitative test have been specified

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		experimentation and hypothesis testing. • Identify and distinguish the carbohydrates, proteins and lipids based on specific biochemical tests. • Understand the molecular basis of various pathological conditions from the perspective of biochemical reactions. • Gain an understanding of the preparation of crude protein lysate, enzymatic assay, effect of time and enzyme concentration on its activity.	~~7. Separation of amino acids using T.L.C.~~ 8. Titration curve of Glycine (Determination of Isoelectric point). 9. Preparation of Enzyme extract. 10. Determination of Enzyme activity. 11. Stability of Enzyme (Salivary amylase) with respect to temperature and pH.	Fohl's test. 4. Qualitative analysis of lipids: Solubility test, Grease spot test, Emulsification test, Saponification test, Unsaturation test, Acrolein test, Salkowski test, Lieberman-Burchard's test. 5. Determination of iodine number. 6. Determination of the acid value of lipid. 7. Determination of saponification value of fats and oil. 8. Titration curve of glycine (determination of isoelectric point). 9. Preparation of enzyme extract from horse gram seeds and determination of urease activity. 10. To check time linearity and protein linearity of urease catalyzed reaction. 11. Determination of salivary amylase activity. 12. Stability of salivary amylase with respect to temperature and pH. **Suggested Books:** ➢ Deb, A.C. (2013). *Comprehensible Viva & Practical Biochemistry* (2nd ed.). Kolkata: New Central Book Agency. ➢ Kumar, A., Grg, S., & Garg, N. (2017). *Biochemical Tests: Principles & Protocols*. New Delhi: Viva Books. ➢ Rao, B.S., & Deshpande, V. (2012). *Experimental Biochemistry*. New Delhi: I.K. International Publisher. ➢ Sadasivam, S., & Manickam, A. (1996). *Biochemical Methods* (2nd ed.). New Delhi: New Age International Publishers. ➢ Saxena, J., Baunthiyal., & Ravi, I. (2015). *Laboratory Manual of Microbiology, Biochemistry and Molecular Biology*. Jodhpur: Scientific Publishers. ➢ Sharma, S. (2007). *Experiments and Techniques in Biochemistry* (1st ed.). New Delhi: Galgotia Publication.	
B.Sc. Biotechnology IV Semester					
13.	**BT 207:**	On completion of	**Unit 1**	**Unit 1**	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
	Genetics, Microbiology and Immunology	the course, students will be able to: • Learn fundamental molecular principles of genetics and relationship between phenotype and genotype in human genetic traits. • Understand the characteristic features and ultrastructure of bacteria, fungi, yeast and viruses. • Gain theoretical knowledge of techniques in microbiology. • Understand about the immune system and various related mechanisms of cells and molecules involved in fighting pathogens.	• ~~Genetic terminology~~ • Mendel's laws • Gene-gene interaction, multiple alleles • Linkage and Crossing over • Sex determination, Sex linked inheritance • Cytoplasmic inheritance **Unit 2** • Chromosomal aberrations: Structural and Numerical • Mutation: Spontaneous and Induced, Chemical and Physical mutagens, Induced mutations in plants, animals and microbes for economic benefit of ~~man~~ • Regulation of gene expression in prokaryotes: Lac and Trp operons • Population genetics: Hardy Weinberg law **Unit 3** • Characteristic features and ultrastructure of bacteria. • General account of different groups : cyanobacteria, fungi, yeast, viruses, mycoplasma and actinomycetes • General characteristics of bacteriophage (T_4, ~~lambda~~ and phi X174) • Industrial applications of microorganisms in food and medicines **Unit 4** • Bacterial genetics: Brief idea of plasmids, transposable elements, transformation, transduction, conjugation. • Techniques in Microbiology: Media preparation, sterilization methods, isolation and pure culture techniques, staining techniques, preservation and maintenance of culture. • An introduction to science of Immunology • Innate and Acquired immunity, Active and Passive Immunity. **Unit 5**	• An overview of Mendel's law of inheritance. • Gene-gene interaction, multiple alleles. • Linkage and crossing over. • Sex determination, sex linked inheritance. • Cytoplasmic inheritance. • Human genetics: Pedigree analysis. **Unit 2** • Chromosomal aberrations: Structural and numerical. • Mutation: Spontaneous and induced, chemical and physical mutagens, induced mutations in plants, animals and microbes for economic benefit of human. • Regulation of gene expression in prokaryotes: Lac and Trp operons. • Population genetics: Hardy Weinberg law. **Unit 3** • Characteristic features and ultrastructure of bacteria. • General account of different groups: Cyanobacteria, fungi, yeast, viruses, *Mycoplasma* and actinomycetes. • General characteristics of bacteriophage (T_4, λ and phi x 174). • Industrial applications of microorganisms in food and medicines. **Unit 4** • Bacterial genetics: Brief idea of plasmids, transposable elements, transformation, transduction, conjugation. • Techniques in microbiology: Media preparation, sterilization methods, isolation and pure culture techniques, staining techniques (Gram's, negative and endospore staining), preservation and maintenance of culture. • An introduction to science of immunology. • Innate and acquired immunity, active and passive immunity. **Unit 5**	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			• Phylogeny and ontogeny of immune system: Cells of immune system and preliminary idea about their differentiation, organization and structure of lymphoid organs. • Nature of antigens: Antigenicity and immunogenicity, Factors affecting them, Epitopes and Haptens, • Structure and function of Antibodies: Classes and subclasses, ~~gross and fine structure.~~ • Nature of immune response: Cell mediated and Humoral immune response • General idea of Major Histocompatibility complex (MHC) and their significance. Monoclonal Antibodies and their applications **Books recommended :** ➢ Concepts of Genetics 7th Ed.: William S. Klug, Pearson Education. ➢ Principles of Genetics: R.H. Tamarin, Tata McGraw Hill. ➢ Principles of Genetics 8th: Gardner, Simmons, Snustad, John Wiley & Sons. ➢ Genetics: P.K. Gupta, Rastogi Publications. ➢ Genetics –A molecular approach: T.A. Brown, Chapman and Hall. ➢ Gardner Principles of Genetics – Snustad & Simmons. ➢ Genetics-From Genes to Genomes: Hartwell, McGraw Hill. ➢ Genetics 5th Ed: D.L. Hartl and E.W. Jones, Jones and Barlett Publishers, Canada. ➢ Molecular Biology: R. Weaver, WCB Mc Graw Hill. ➢ Immunology 4th Ed: J. Kuby, W.H. Freeman. ➢ Immunology: Nandini Shetty, New Age Publishers. ➢ Microbiology - An Introduction 8th Ed: Tortora, Pearson Education. ➢ Microbiology: Pelczar, Tata McGraw Hill. ➢ Microbial Genetics: D. Friefelder.	• Phylogeny and ontogeny of immune system: Cells of immune system and preliminary idea about their differentiation, organization and structure of lymphoid organs. • Nature of antigens: Antigenicity and immunogenicity, factors affecting them, epitopes and haptens, • Structure and function of antibodies: Classes and subclasses. • Nature of immune response: Humoral and cell mediated immune response. • General idea of Major Histocompatibility Complex (MHC) and their significance. Monoclonal antibodies and their applications. **Suggested Books :** ➢ Gardner, E.J., Simmons, M.J., & Snustad, D.P. (2005). *Principles of Genetics* (8^{th} ed.). New Jersey, USA: John Wiley & Sons Ltd. ➢ Hartl, D.L. & Jones, E.W. (1998). *Genetics: Principles & Analysis* (4^{th} ed.). Canada: Jones and Barlett Publishers. ➢ Hartwell (2010). *Genetics-From Genes to Genomes* (4^{th} ed.) USA: McGraw-Hill Education. ➢ Khan, F. H. (2009). *Elements of Immunology* (1^{st} ed.). Pearson Education India. ➢ Kindt, T.J., Osborne, B.A., & Goldsby, R.A. (2006). *Kuby Immunology* (6^{th} ed.). New York, USA: W. H. Freeman & Company. ➢ Klug, W.S., Cummings, M.R., Spencer, C.A. & Palladino, M.A. (2015). *Essential of Genetics* (9^{th} ed.). Noida: Pearson Education India. ➢ Madigan, M. T., Martinko, J. M., Dunlap, P. V., & Clark, D. P. (2005). *Brock Biology of Microorganisms* (12^{th} ed.). San Fransisco: Benjamin Cummings. ➢ Maloy, S.R., Cronan, J.E., & Friefelder, D. (1994). *Microbial Genetics* (2^{nd} ed.). USA: Jones and Bartlett.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ An introduction to Immunology: I.R. Tizzard. ➢ Genetics: VB Rastogi. ➢ Immunology: Fahim Khan, Pearson Publisher. ➢ Microbiology: Prescott, Harley and Klein. ➢ Biology of Microorganism: Brock. ➢ Genetics: Peter J. Russell.	➢ Owen, J., Punt, J., Stranford, S., & Jones, P. (2018). *Kuby Immunology* (7th ed.). USA: W. H. Freeman and Company. ➢ Pelczar, M.J., Chan, E.C.S., & Krieg, N.R. (2007). *Microbiology* (5th ed.). New York, U.S.: Tata McGraw-Hill Inc. ➢ Rastogi, V.B. (2018). *Genetics* (4th ed.). Medtech. ➢ Shetty, N. (2005). Immunology: Introductory Textbook. New Delhi: New Age International Publishers. ➢ Singh, B.D. (2014). *Fundamentals of Genetics* (332nd ed.). New Delhi: Kalyani Publishers. ➢ Tamarin, R.H. (2004). *Principles of Genetics* (7th ed.). USA: McGraw-Hill Higher Education. ➢ Tizard, I.R. (1995). *Immunology: Introduction* (4th ed.). Philadelphia: Saunders College Publishing. ➢ Tortora, G.J., Funke, B.R., & Case, C.L. (2016) *Microbiology: An Introduction* (12th ed.). London, UK: Pearson. ➢ Verma, P.S. & Agarwal, V.K. (2010). *Genetics* (9th ed.). New Delhi: S. Chand and company. ➢ Weaver, R.F. (2011). *Molecular Biology* (5th ed.). New York, USA: McGraw-Hill Education. ➢ Willey, J.M., Sherwood, L., & Woolverton, C.J. (2007). *Prescott, Harley and Klein's Microbiology,* (7th ed.). USA: Mc Graw Hill Higher Education. **Suggested e-Resources:** ➢ **Immunology** https://nptel.ac.in/courses/102103038/3 ➢ **Immunity** https://www.khanacademy.org/science/high-school-biology/hs-human-body-systems/hs-the-immune-system/a/hs-the-immune-system-review ➢ **Microbiology** https://nptel.ac.in/courses/102103015/ ➢ **Structure of bacteria & viruses**	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				https://instruct.uwo.ca/biology/090b/1290b%201-7.pdf http://ocw.jhsph.edu/courses/EpiInfectiousDisease/PDFs/EID_lec2_Dick.pdf ➢ **Mendelian genetics & deviation** https://www.khanacademy.org/science/biology/classical-genetics/variations-on-mendelian-genetics/a/multiple-alleles-incomplete-dominance-and-codominance http://download.nos.org/srsec314newE/PDFBIO.EL21.pdf	
14.	**BT 207L:** Genetics, Microbiology and Immunology Lab	On completion of the course, students will be able to: • Understand the clinical relevance of genetic concepts, inheritance and expression of human blood groups. • Acquire and demonstrate competency in routine microbiological laboratory skills applicable to microbiological research and clinical methods. • Explain basic immunological laboratory techniques and use immunoassays to	~~1. Media preparation: L.B., preparation of slants.~~ 2. Streak plate technique. ~~3. Dilution plate technique.~~ 4. Gram staining and endospore staining. 5. Lactic acid estimation. 6. Antibiotic sensitivity test using *Bacillus subtilis*. 7. Problems of Genetics. 8. Slides of Meiosis showing chiasma formation and calculation of chiasma frequency. 9. ~~Practicals related to~~ Human Genetics : Widow's peak, earlobe, index finger, straight and curly hair, rolling of tongue. 10. Testing of blood groups including Rh factors to observe the phenomenon of agglutinization. 11. To study the various lymphoid glands (Spleen and Thymus). 12. To study different type of cells participating in specific and non-specific immunity. 13. Immunological diagnosis of pregnancy / infection / cancer. 14. Immuno precipitation by precipitin reaction	1. To prepare basic liquid media, solid media, agar slants and agar deep tube for the routine cultivation of bacteria and fungi. 2. Isolation of pure culture by streak plate method. 3. Isolation of microorganisms from soil by serial dilution and determination of CFU. 4. Isolation of microorganisms from air by direct plate exposure method. 5. Preservation of microbial cultures by making glycerol stock and revival of culture. 6. To perform Gram's staining, endospore staining and negative staining of bacteria. 7. Assessment of bacterial motility by hanging drop method. 8. Antibiotic sensitivity test using *Bacillus subtilis*. 9. Lactic acid estimation. 10. Study of chiasma formation and calculation of chiasma frequency in meiosis. 11. Problems of genetics: - Mendel's law and its deviation. - Human genetics: Widow's peak, earlobe, index finger, straight and curly hair, rolling of tongue. 12. Testing of blood groups including Rh factors to observe the phenomenon of agglutination. 13. To study the various lymphoid glands (spleen and	Microbiological exercise have been more specified

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		analyze unknown samples successfully.		thymus). 14. To study different type of cells participating in non-specific immunity. 15. Immuno precipitation by double diffusion technique. **Suggested Books:** ➢ Aneja, K.R. (1996). *Experiments in Microbiology, Plant Pathology, Tissue Culture and Mushroom Cultivation* (2nd ed.). New Delhi: Wishwa Prakashan. ➢ Ghose, K., & Manna, B. (2016). *Practical Zoology* (4th ed.). Kolkata: New Central Book Agency. ➢ Kumar, V. (2011). *Laboratory Manual of Microbiology*. New Delhi: Scientific Publishers. ➢ Mahajan, R., Sharma, J., & Mahajan, R.K. (2010). *Practical Manual of Biotechnology* (1st ed.). New Delhi: Vayu Education of India.	
15.	**ZOO 202:** Comparative Anatomy and Embryology of Chordates	On completion of the course, students will be able to: • Understand the comparative anatomy of various organ systems with special reference to *Scoliodon, Rana, Uromastix, Columba* and *Oryctolagus*. • Gain the fundamental knowledge about the development of frog, Hen's egg and chick to understand the principles of	**Unit 1** • Comparative anatomy with special reference to *Scoliodon, Rana, Uromastix, Columba* and *Oryctolagus*: • Integumentary system: Skin and its derivatives. • Skeleton system: Development of chondrocranium and vertebra; jaw suspension. • Digestive system: Alimentary canal and associated glands. **Unit 2** • Comparative anatomy with special reference to *Scoliodon, Rana, Uromastix, Columba* and *Oryctolagus*: • Respiratory system: Respiratory organs. • Circulatory system: Evolution of heart and aortic arches. • Urinogenital system: Evolution of kidney and urinogential ducts. **Unit 3** • Comparative anatomy with special reference to	No change in the syllabus	

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<tr><th>S No.</th><th>Course List</th><th>Learning Outcomes</th><th>Existing Syllabus</th><th>Suggested Syllabus</th><th>Remarks</th></tr>
<tr><td></td><td></td><td>developmental biology.
• Gain an elementary idea about reproductive biology.</td><td>Scoliodon, Rana, Uromastix, Columba and Oryctolagus:
• Nervous System: Brain and spinal cord.
• Eye.
• Ear.
Unit 4
• Elementary idea about the formation of egg and sperm.
• Fertilization, parthenogenesis, induction and regeneration.
• Development of frog upto the end of neurulation, tadpole larva and its metamorphosis.
Unit 5
• Detailed structure of Hen's egg and its development upto 4th somite stage.
• Structure, development and functions of extraembryonic membranes in chick.
• Definition of placenta, types and functions of mammalian placenta.
Books Recommended:
➢ Chordates: R. L. Kotpal, Rastogi Publications, Meerut.
➢ A text book of Zoology: Chordates (Comparative anatomy): P.S. Dhami and J.K. Dhami, Pradeep's Publication.
➢ Vertebrates: Comparative Anatomy, fanctron Evolution 3rd Ed.: Kardong, TMH.
➢ A text book of Chordate Zoology: S.N. Prasad.
➢ A text book of Chordate Zoology: H.C. Nigam, Pub. Sohanlal Nagin Chand, 1995.
➢ Comparative anatomy of Chordates: Charles. J. Weichert.
➢ Development Biology: P.C. Jain.
➢ Development Biology: Balinsky.</td><td>Suggested Books:
➢ Balinsky, B.I. (2012). An Introduction to Embryology (5th ed.). New Delhi: Cengage Learning India.
➢ Chaki, K.K., Kundu, G., & Sarkar, S. (2016). Introduction to General Zoology Vol-II. Kolkata: New Central Book Agency.
➢ Dhami P.S., & Dhami, J.K. Chordate Zoology. New Delhi: R. Chand and Co.
➢ Jain, P.C. (2013). Elements of Developmental Biology (Chordate Embryology) (7th ed.). New Delhi: Vishal Publishing Co.
➢ Kardong, K.V. (2011). Vertebrates: Comparative Anatomy, Function, Evolution (6th ed.). McGraw-Hill Education.
➢ Kent, G.C., & Carr, R.K. (2000). Comparative Anatomy of the Vertebrates (9th ed.). Europe:</td><td></td></tr>
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S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				McGraw-Hill Science. ➢ Kotpal, R.L. (2018). *Modern Text book of Zoology: Vertebrates* (4^{th} ed.). Meerut: Rastogi Publications. ➢ Kotpal, R.L., Sastry, K.V., & Shukla, V. (2017). *Comparative Anatomy & Developmental Biology*. Meerut: Rastogi Publication. ➢ Lahiri, B.K. (2014). *College Zoology* Vol-II. Mumbai: Himalaya Publishing House. ➢ Prasad, S.N., & Kashyap, V. (2010). *A text book of* V*ertebrate Zoology* (XIV Ed.). New Delhi: New Age International (P) Limited. ➢ Sastry, K.V., & Shukla, V. (2017). *Developmental Biology*. Meerut: Rastogi Publications. ➢ Saxena, R.K. & Saxena, S. (2016). *Comparative Anatomy of Vertebrates* (2^{nd} ed.). Viva Books Private Limited. ➢ Srivastava, M.L. (1985). *An introduction to the Comparative Anatomy of Vertebrates*. Allahabad: Central Book Depot. ➢ Verma, P.S., & Agrawal, V.K. (2017). *Chordate Embryology: Developmental Biology*. New Delhi: S Chand. **Suggested e-Resources:** ➢ **Comparative anatomy** http://www.iaszoology.com/category/comparative-anatomy/ ➢ **Chick development** http://www.notesonzoology.com/vertebrates/chick/development-of-chick-with-diagram-vertebrates-chordata-zoology/8645 http://www.macollege.in/app/webroot/uploads/department_materials/doc_139.pdf ➢ **Developmental biology** https://www.shomusbiology.com/developmental-biology.html	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				➢ **Frog development** http://www.notesonzoology.com/frog/development-of-frog-with-diagram-vertebrates-chordata-zoology/8626	
16.	**ZOO 202L:** Comparative Anatomy and Embryology of Chordates Lab	On completion of the course, students will be able to: • Identify higher chordate animals based on the external features. • Identify and distinguish bones of *Rana*, *Varanus*, Fowl and *Oryctolagus*. • Understand histology of organs and endocrine glands through microscopic study of slides. • Understand the development of frog and chick through microscopic slides.	• Permanent mountings : i. Placoid and ctenoid scales. ii. Cartilage and striated muscle fibres of amphibian. iii. Filoplumes. iv. Blood film of mammal. • Osteology: A comparative study of articulated and disarticulated bones of *Rana*, *Varanus*, Fowl and *Oryctolagus*. • Study of Microscopic slides. (i) Comparative study of microscopic slides with special reference to ~~*Rana*, *Varanus*, bird~~ and Mammal: V.S. of skin, oesophagus, stomach, intestine, liver, pancreas, Lung, Kidney, Testis, Ovary, Spinal Cord. (ii) T.S. of endocrine glands of a mammal. • Study of Museum specimens : (i) Cyclostomata : *Amnocoete* larva, *Petromyzon*, *Myxine* and *Bdellostoma*. (ii) Pisces: *Sphyrna*, *Torpedo*, *Pristis*, *Stingray*, *Chimaera*, *Acipensor*, *Amia*, *Labeo*, *Wallago*, *Saccobranclus*, *Anguilla*, *Exocoetus*, *Belone*, *Hippocampus*, *Syngnathus*, *Echeries*, *Porcapine* and *Protopterus*. (iii) Amphibia: *Ichthyophis*, *Ambystoma*, Axolotal Larva, *Salamandra*, *Necturus*, *Siren*, *Alytes*, *Pipa*, *Hyla* and *Rhacophorus*. (iv) Reptilia: *Chelone*, *turtle*, *Testudo*, *Sphenodon*, *Phrynosoma*, *Chaemeleon*, *Calotes*, *Hemidactylus*, *Draco*, *Hydrophis*, *Eryx*, *Python*, *Naja*, *Viper*, *Bungarus* and *Crocodilus*. (v) Aves: *Archaeopteryx*, *Psittaculla*, *Passer*, *Columba* and *Pavo*.	1. Permanent mountings: (i) Placoid and ctenoid scales (ii) Cartilage and striated muscle fibres of amphibian. (iii) Filoplumes. (iv) Blood film of mammal. 2. Osteology: A comparative study of articulated and disarticulated bones of *Rana*, *Varanus*, Fowl and *Oryctolagus*. 3. Comparative study of microscopic slides with special reference to amphibian and mammal: (i) V.S. of skin, oesophagus, stomach, intestine, liver, pancreas, lung, kidney, testis, ovary, spinal cord. (ii) T.S. of endocrine glands of a mammal (pituitary, thyroid, parathyroid, adrenal). 4. Study of museum specimens: (i) Cyclostomata: Amnocoete larva, *Petromyzon*, *Myxine* and *Bdellostoma*. (ii) Pisces: *Sphyrna*, *Torpedo*, *Pristis*, Stingray, *Chimaera*, *Acipensor*, *Amia*, *Labeo*, *Wallago*, *Saccobranclus*, *Anguilla*, *Exocoetus*, *Belone*, *Hippocampus*, *Syngnathus*, *Echeries*, *Porcupine and Protopterus*. (iii) Amphibia: *Ichthyophis*, *Ambystoma*, Axolotal larva, *Salamandra*, *Necturus*, *Siren*, *Alytes*, *Pipa*, *Hyla* and *Rhacophorus*. (iv) Reptilia: *Chelone*, Turtle, *Testudo*, *Sphenodon*, *Phrynosoma*, *Chaemeleon*, *Calotes*, *Hemidactylus*, *Draco*, *Hydrophis*, *Eryx*, *Python*, *Naja*, *Viper*, *Bungarus* and *Crocodilus*. (v) Aves: *Archaeopteryx*, *Psittaculla*, *Passer*, *Columba* and *Pavo*. (vi) Mammalia: *Ornithorynchus*, *Tachyglossus*,	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			(vi) Mammalia: *Ornithorynchus*, *Tachyglossus*, *Pteropus*, *Funambulus*, Hedgehog, Mangoose and *Oryctolagus*. • Development of Chordates : (i) Study of the development and metamorphosis of Frog with the aid of permanent prepared slides. (ii) W.M. of Primitive steak, head folds, 18hrs, 24 hrs 33hrs and of chick embryo, T.S. of chick embryo through various regions upto 4th somite state with aid of permanent prepared slides.	*Pteropus, Funambulus, Hedgehog,* Mongoose and *Oryctolagus*. 5. Development of Chordates: (i) Study of the development and metamorphosis of frog with the aid of permanent prepared slides. (ii) W.M. of primitive steak, head folds, 18hrs, 24hrs and 33hrs of chick embryo, T.S. of chick embryo through various regions upto 4th somite state with aid of permanent prepared slides. **Suggested Books:** ➢ Ghose, K., & Manna, B. (2016). *Practical Zoology* (4th ed.). Kolkata: New Central Book Agency. ➢ Lal, S.S. (2015). *Practical Zoology: Vertebrates* (11th ed.). Meerut: Rastogi Publication. ➢ Poddar, T., Mukhopadhyay, S., & Das, S.K. (2003). *An advanced Laboratory Manual of Zoology*. Kolkata: Macmillan India Limited. ➢ Verma, P.S. (2010). *A Manual of Practical Zoology: Chordates* (11th ed.). New Delhi: S Chand Publishing.	
B.Sc. Biotechnology V & VI Semester					
Botany Discipline Electives-I & II					
1)	**Discipline Elective:** ~~**6.1:**~~ Introduction to Genetics and Genetic Engineering	On completion of the course, students will be able to: • Acquire knowledge of the structure and arrangement of the genome in living organisms. • Understand the biochemical nature of nucleic acids, their role in living systems. • Impart basic genetic	**Unit 1** • Organization of Eukaryotic Chromosomes. • Bacterial Genetics. • Cell cycle, Mitosis and Meiosis. • Eugenics and Genetic Counseling. **Unit 2** • Mendel's experiments: Laws of inheritance, interaction of factors (Modified dihybrid ratios). • Quantitative inheritance, Linkage, crossing over, multiple alleles, Sex determination, Sex Linked inheritance. • Extra chromosomal inheritance.	**Discipline Elective:** **BOT 302: Introduction to Genetics and Genetic Engineering** **Unit 1** • Organization of eukaryotic chromosomes. • Bacterial genetics. • Cell cycle, mitosis and meiosis. • Eugenics and genetic counseling. **Unit 2** • Genetic terminology, Mendel's experiments: Laws of inheritance, interaction of factors (Modified dihybrid ratios). • Quantitative inheritance, linkage, crossing over, multiple alleles.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		manipulation techniques and their application for human welfare. • Translate concepts in genetic engineering to their own research.	**Unit 3** • Chromosomal aberrations- structural and numerical • Mutations • Gene: Basic concept • Isolation of eukaryotic mRNA, cDNA synthesis and library • Genomic library **Unit 4** • Restriction enzymes • Vectors- plasmids, phages, cosmids • Construction of recombinant DNA • Screening and selection of recombinant clones **Unit 5** • Isolation of DNA- plasmid, plant genomic DNA, phage DNA • General idea of Patents and Bio safety Guidelines. • Biotechnology: Definition, Application of Biotechnology, Basic concept of Biotechnological processes • Edible vaccines **Books recommended:** ➢ Genetics: Stirckberger Prentice Hall of India. ➢ Principles of Genetics 9th Ed: Gardner, Simmons, Snustad, John Wiley & Sons. ➢ Genetics: P.K. Gupta, Rastogi Publications Meerut. ➢ Genetics –A molecular approach: T.A. Brown, Chapman and Hall. ➢ Concepts of Genetics 7th Ed.: William S. Klug, Pearson Education. ➢ Principles of Genetics: R.H. Tamarin, Tata McGraw Hill. ➢ Genetics-From Genes to Genomes: Hartwell, McGraw Hill. ➢ Genetics 5th Ed.: D.L. Hartl and E.W. Jones, Jones and	• Sex determination and sex linked inheritance. • Extra chromosomal inheritance. **Unit 3** • Chromosomal aberrations- structural and numerical. • Mutations. • Gene: Basic concept. • Isolation of eukaryotic mRNA, cDNA synthesis and library. • Genomic library. **Unit 4** • Restriction enzymes. • Vectors- plasmids, phages, cosmids. • Construction of recombinant DNA. • Screening and selection of recombinant clones. **Unit 5** • Isolation of DNA- plasmid, plant genomic DNA, phage DNA. • General idea of patents and bio safety guidelines. • Biotechnology: Definition, application of biotechnology, basic concept of biotechnological processes. • Edible vaccines. **Suggested Books:** ➢ Borem, A., Santos, F.R., & Bowen, D.E. (2003). *Understanding Biotechnology* (1st d.). USA: Prentice Hall. ➢ Brown, T. (2011). *Introduction to Genetics –A molecular approach* (1st ed.). USA: Garland Science. ➢ Brown, T.A. (2010). *Gene Cloning and DNA Analysis: An Introduction* (6th ed.). USA: Wiley-Blackwell. ➢ Gardner, E.J., Simmons, M.J., & Snustad, D.P. (2005). *Principles of Genetics* (8th ed.). New Jersey, USA: John Wiley & Sons Ltd.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			Barlett Publishers, Canada. ➢ An Introduction to Genetic Ananlysis: Suzuki, Griffith, Miller & Lewonith. ➢ Microbial Genetics: D. Friefelder, Narosa Publications, New Delhi ➢ Molecular Biology of Gene: J.D.Watson, Pearson Education. ➢ Gene VIII: Lewin, Pearson Education. ➢ Biotechnology by B.D. Singh. ➢ Plant Biotechnology by P.K. Gupta. ➢ Principles of Gene Manipulation: Old & Primrose, Blackwell Scientific Publications. ➢ Understanding Biotechnology: Aluizo Borem, Pearson Education. ➢ Molecular Biotechnology: B.R. Glick and J.J. Pasternak, ASM Press, Washington, USA. ➢ An Introduction to Gene Technology-From genes to clones: Winnacker, VCH.	➢ Glick, B.R., & Patten, C.L. (2017). *Molecular Biotechnology: Principles and Applications of Recombinant DNA* (5th ed.). USA: American Society for Microbiology Press. ➢ Griffiths, A.J.F., Miller, J.H., Suzuki, D.T., Lewonith, R.C. & Gelbert, W.M. (2000). *An Introduction to Genetic Ananlysis* (7th ed.). New York, U.S.: W. H. Freeman. ➢ Gupta, P.K. (2009). *Genetics*. Meerut: Rastogi Publications. ➢ Gupta, P.K. (2010). Plant biotechnology. Meerut: Rastogi Publications. ➢ Hartl, D.L. & Jones, E.W. (1997). *Genetics: Analysis of Genes and Genome* (9th ed.). Canada: Jones and Barlett Publishers. ➢ Hartwell, L., Hood., Goldberg, M., Reynolds, A.E., & Silver, L. (2010). *Genetics: From Genes to Genomes* (4th ed.). New York: McGraw-Hill Education. ➢ Klug, W.S., Cummings, M.R., Spencer, C.A., Palladino, M.A., Killian, D. (2018). *Concepts of Genetics* (12th ed.). USA: Pearson Education. ➢ Krebs, J.E., Goldstein, E.S., & Kilpatrick, S.T. (2012). *Lewin's Genes XI* (11th ed.). USA: Jones and Bartlett Publishers. ➢ Maloy, S.R., Cronan, J.E., & Friefelder, D. (1994). *Microbial Genetics* (2nd ed.). USA: Jones and Bartlett. ➢ Primrose, S.B., & Twyman, R. (2006). *Principles of Gene Manipulation and Genomics* (7th ed.) UK: Oxford University Press. ➢ Singh, B.D. (2015). Biotechnology. New Delhi: Kalyani Publishers. ➢ Strickberger, M.W. (1995). Genetics (3rd ed.). New Delhi: Prentice Hall India Learning Private Limited. ➢ Tamarin, R.H. (2004). *Principles of Genetics* (7th ed.). USA: McGraw-Hill Higher Education.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				➢ Watson, J.D., Tania, A.B., & Stephen, P.B. (2017). *Molecular Biology of the Gene* (7th ed.). USA: Pearson Education. ➢ Winnacker, E.L. (1987). *From Genes to Clones: Introduction to Gene Technology*. Germany: Wiley VCH. **Suggested e- Resources:** ➢ **Genetics** https://www.britannica.com/science/genetics ➢ **Recombinant-DNA-technology** https://www.britannica.com/science/recombinant-DNA-technology https://nptel.ac.in/courses/102103013/4 http://www.agbioworld.org/biotech-info/topics/dev-world/policies4.html ➢ **Principles & processes of recombinant-DNA-technology** https://www.toppr.com/guides/biology/biotechnology-principles-and-process/processes-of-recombinant-dna-technology/ ➢ **Vectors used in genetic engineering** http://www.biologydiscussion.com/genetic-engineering/vectors-used-in-genetic-engineering-biotechnology/61382 ➢ **Patent rights in India** https://www.hg.org/legal-articles/patent-rights-in-india-4995	
2)	**Discipline Elective:** ~~**6.2:**~~ Genetic and Genetic Engineering Lab	On completion of the course, students will be able to: • Develop skills and understanding about different techniques used in genetics and genetic engineering	1. Problems of Genetics 2. Models based on Mendel's law 3. Human Genetics: Tongue rolling, Widow's peak, Ear lobes, Little finger. 4. Estimation of standard DNA. 5. Determination of purity of standard DNA 6. Determination of λ_{max} of standard DNA. 7. Isolation of DNA from plant cells.	**Discipline Elective:** **BOT 302L: Genetic and Genetic Engineering Lab** 1. Problems of genetics. 1. Models based on Mendel's law. 2. Human genetics: Tongue rolling, widow's peak, ear lobes, little finger. 3. Estimation of standard DNA by DPA method. 4. Determination of purity of standard DNA.	

<table>
<tr><th>S No.</th><th>Course List</th><th>Learning Outcomes</th><th>Existing Syllabus</th><th>Suggested Syllabus</th><th>Remarks</th></tr>
<tr><td></td><td></td><td>• Critically analyze and interpret data generated from each practical
• Develop knowledge about genetic problems such as genetic mapping, test cross etc.</td><td></td><td>5. Determination of λ_{max} of standard DNA.
6. Isolation of DNA from plant cells.
7. Restriction digestion of DNA.
8. Agarose gel electrophoresis of DNA.
9. Basic biosafety guidelines in the laboratory.
Suggested Books:
➢ Purohit, S.D. (2007). *Molecular Biology and Biotechnology: A Practical Manual*. Udaipur: Apex Publishing House.
➢ Vats, S. (2015). *A Laboratory Textbook of Biochemistry, Molecular biology and Microbiology*. GRIN Verlag.</td><td></td></tr>
<tr><td>3)</td><td>**Discipline Elective**
~~**5.1:**~~ Plant Physiology and Ecology</td><td>On completion of the course, students will be able to:
• Comprehend about life processes happening inside plants and how they cope with varied biotic and abiotic factors.
• Understand maintenance of ecological balance and role of man in the degradation of the environment and to suggest remedies.
• Highlight the potential of these studies to become an entrepreneur.</td><td>**Unit 1**
• Plant water relations: Importance of water to plant life; movement of water across the membranes, ascent of sap; transpiration.
• Mineral nutrition: Methods to study the availability of macro and micro elements, uptake and roles of mineral elements.
• Translocation of organic substances: General principle and mechanism.
Unit 2
• Photosynthesis: Photosynthetic pigments, factors affecting photosynthesis, mechanism of photosynthesis, role of light, carbon fixation in plants, Photophosphorylation.
• Respiration: Significance and mechanism, factors affecting respiration, release and utilization of biochemical energy, ATP synthesis.
Unit 3
• Fat Metabolism: Mechanism of synthesis and break down of fats.
• Nitrogen metabolism: Nitrate assimilation, nitrogen fixation, amino acid synthesis and nitrogen cycle.
• Growth and Development: Physiology of dormancy and</td><td>**Discipline Elective**
BOT 303: Plant Physiology and Ecology
Unit 1
• Plant water relations: Importance of water to plant life; movement of water across the membranes, ascent of sap; transpiration.
• Mineral nutrition: Methods to study the availability of macro and micro elements, uptake and roles of mineral elements.
• Translocation of organic substances: General principle and mechanism.
Unit 2
• Photosynthesis: Photosynthetic pigments, factors affecting photosynthesis, mechanism of photosynthesis, role of light, carbon fixation in plants, Photophosphorylation.
• Respiration: Significance and mechanism, factors affecting respiration, release and utilization of biochemical energy, ATP synthesis.
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• Fat Metabolism: Mechanism of synthesis and break down of fats.
• Nitrogen metabolism: Nitrate assimilation, nitrogen fixation, amino acid synthesis and nitrogen cycle.</td><td></td></tr>
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S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			seed germination, vegetative and reproductive growth, Vernalization and Photoperiodism. • Growth regulators: Auxins, gibberellins, cytokinins, ethylene and abscissic acid, their physiological importance. **Unit 4** • Ecology. • Plant environment: Climatic, edaphic, topographic and biotic factors. • Ecosystem: Brief concept, food chains, ecological pyramids (Pyramids of number, mass and energy), energetics, biochemical cycling. **Unit 5** • Plant communities: Structure, classification, diversity, dynamics. • Applied ecology: Introduction to restoration ecology. • Environmental pollution (Air, Water and Radioactive), Conservation, Plant indicators. **Books Recommended:** ➢ Plant Physiology: Devlin & Witham, Van Narst, New Delhi: East West Press, 1974. ➢ Plant Physiology: Salisbury & Ross, Prentice Hall of India. ➢ Introductory Plant Physiology: Noggle & Fritz, Prentice Hall of India. ➢ Plant Physiology: Taiz and Zeiger. ➢ Introduction to Plant Physiology: W.G. Hopkins and Hunner John Wiley and Sons Inc. ➢ Plant Physiology: Pandey & Sinha. ➢ Ecology & Environment: P.D. Sharma, Rastogi Publications, Meerut. ➢ Fundamentals of Ecology: E.P. Odum, Natraj Publishers, Dehradun, India. ➢ Plant Physiology: H.N. Srivastava, Vikas Publishing House.	• Growth and development: Physiology of dormancy and seed germination, vegetative and reproductive growth, vernalization and photoperiodism. • Growth regulators: Auxins, gibberellins, cytokinins, ethylene and abscissic acid, their physiological importance. **Unit 4** • Ecology. • Plant environment: Climatic, edaphic, topographic and biotic factors. • Ecosystem: Brief concept, food chains, ecological pyramids (pyramids of number, mass and energy), energetics, biochemical cycling. **Unit 5** • Plant communities: Structure, classification, diversity, dynamics. • Applied ecology: Introduction to restoration ecology. • Environmental pollution (air, water, noise and radioactive), Conservation, plant indicators. **Suggested Books:** ➢ Ambhast, R.S. (2008). *Plant Ecology*. New Delhi: CBS. ➢ Dutta , S.C. (2012). *Plant Physiology*. New Delhi: New age International Publishers. ➢ Hopkins, W.G. & Huner, N.P.A. (2008). *Introduction to Plant Physiology*. New Jersey: John Wiley and Sons Inc. ➢ Narst, V., Devlin & Witham. (1974). *Plant Physiology*. New Delhi: East West Press. ➢ Noggle, G.R. & Fritz, G.J. (1992). *Introductory Plant Physiology*. New Delhi: Prentice Hall of India. ➢ Odum, E.P. (2004). *Fundamentals of Ecology*. Dehradun: Natraj Publishers. ➢ Pandey, S.N. & Sinha, B.K. (2015). *Plant Physiology*. New Delhi: Vikas Publishing House. ➢ Salisbury & Ross. (2012). *Plant Physiology*. New Delhi:	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Plant Physiology: S. C. Dutta. ➢ Plant Ecology: Ambhast and Ambhast.	Prentice Hall of India. ➢ Sharma, P.D. (2003). *Ecology & Environment*. Meerut: Rastogi Publications. ➢ Srivastava, H.S. (2005). *Plant Physiology*: Meerut: Rastogi Publications. ➢ Taiz, L., & Zeiger, E. (2010). *Plant Physiology*. London: Sinauer Associates. **Suggested e-Resources:** ➢ **Plant Physiology** https://www.udemy.com/plant-physiology/?siteID=zOCYiUhWwNM-1RExiYvhsJfnMd_rZR_ivg&LSNPUBID=zOCYiUhWwNM ➢ **Ecological communities** http://www-plb.ucdavis.edu/courses/bis/1c/text/Chapter27nf.pdf	
4)	**Discipline Elective** ~~**5.2:**~~ Plant Physiology and Ecology Lab	On completion of the course, students will be able to: • Understand the physiological details of photosynthesis and respiration. • Design experiments, collect and analyze data, critically evaluate and present the data produced in physiology or ecology. • Demonstrate skills related to	A. List of Physiology experiments 1. Osmosis a. Grapes and dried raisins. b. Potato osmoscope and semi permeable membrane. c. Plasmolysis and deplasmolysis. 2. Root pressure a. An experiment on root pressure. 3. Transpiration a. Ganong's potometer and Farmer's potometer b. Unequal transpiration from two surfaces of a leaf i. Cobalt chloride paper method. ii. Four leaf method with greased surface. c. Demonstration of water lifting power of transpiration (suction force). d. Ringing experiment. e. Study of stomata 4. Photosynthesis	**Discipline Elective** **BOT 303L: Plant Physiology and Ecology Lab** A. List of physiology experiments 1. Osmosis a. Grapes and dried raisins. b. Potato osmoscope and semi permeable membrane. c. Plasmolysis and deplasmolysis. 2. Root pressure a. An experiment on root pressure. 3. Transpiration a. Ganong's potometer and Farmer's photometer. b. Unequal transpiration from two surfaces of a leaf. i. Cobalt chloride paper method. ii. Four leaf method with greased surface. c. Demonstration of water lifting power of transpiration (suction force). d. Ringing experiment. e. Study of stomata. 4. Photosynthesis	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		laboratory as well as field based studies.	a. Oxygen is given off during photosynthesis (Wilmott's bubbler apparatus). b. Light is necessary for photosynthesis. c. Chlorophyll is necessary for photosynthesis. d. CO_2 is necessary for photosynthesis. ~~e. No oxygen liberation without CO_2.~~ f. RQ by Ganong's respirometer ~~of carbohydrate, fatty seeds and *Opuntia* phylloclade~~. 5. Respiration a. CO_2 is produced during respiration. b. Loss of dry weight in respiration. c. Anaerobic respiration. B. List of Ecological experiments 1. To determine the soil temperature by soil thermometer. 2. To measure relative humidity of the atmosphere by wet and dry–bulb thermometer or psychrometer. 3. To determine soil texture. 4. To test the presence of carbonate, nitrate, pH value and base deficiency in soil. 5. To measure the light intensity. 6. To study the structure of the plant community of an area by quadrat method and to determine the plant density, abundance and frequency ~~(the density, abundance and frequency can be calculated from a given data in laboratory during practical examination).~~ 7. To determine the water holding capacity of different soils. 8. ~~A record of the experiments done during the year is to be submitted by the candidates.~~	a. Oxygen is given off during photosynthesis (Wilmott's bubbler apparatus). b. Light is necessary for photosynthesis. c. Chlorophyll is necessary for photosynthesis. d. CO_2 is necessary for photosynthesis. e. RQ by Ganong's respirometer (demonstration). 5. Respiration a. CO_2 is produced during respiration. b. Loss of dry weight in respiration. c. Anaerobic respiration. B. List of ecological experiments 1. To determine the soil temperature by soil thermometer. 2. To measure relative humidity of the atmosphere by wet and dry–bulb thermometer or psychrometer. 3. To determine soil texture. 4. To test the presence of carbonate, nitrate, pH value and base deficiency in soil. 5. To measure the light intensity. 6. To study the structure of the plant community of an area by quadrat method and to determine the plant density, abundance and frequency. **7.** To determine the water holding capacity of different soils. **Suggested Books:** ➢ Bendre, A., & Kumar, A. (1984). *A Textbook of Practical Botany-II*. Meerut: Rastogi Publications.	
5)	**Discipline Elective: Ethnobotany**	**Learning outcomes:** On completion of		**Discipline Elective: Ethnobotany** **Unit 1: Ethnobotany** • Introduction, concept, scope and objectives;	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		the course, students will be able to: • Understand the science of ethnobotany, its concept, scope and objectives • Know the types, distribution and life style of ethnic groups in India. • Know the importance of tribals in present era. • Know the various uses of plants by the ethnic people in their daily life. • Know the miscellaneous uses of plants • Understand the methodology of ethnobotanical work • Know the medicinal uses of plants in crude ways. • Aware about the legal aspects associated with ethnobotany.		Ethnobotany as an interdisciplinary science. • The relevance of ethnobotany in the present context. • Major and minor ethnic groups or Tribals of India, and their life styles. **Unit 2: Ethnobotanical Uses** • Plants used by the tribals: a) Food plants b) Fodder c) intoxicants and beverages d) Resins and oils and miscellaneous uses. • Plants of mythological and religious. • Plants mentioned in Folklore and Folk songs. • Plants as totems, taboos and superstition. **Unit 3: Methodology of Ethnobotanical studies** • Field work b) Herbarium c) Ancient Literature d) Archaeological findings e) temples and sacred places. • Major centers of Ethnobotany in India. **Unit 4: Role of ethnobotany in modern Medicine** • Medico-ethnobotanical sources in India; Significance of the following plants in ethno botanical practices (along with their habitat and morphology):(a) *Azadiractha indica* (b) *Ocimum sanctum* (c) *Vitex negundo* (d) *Gloriosa superba* (e) *Tribulus terrestris* (f) *Pongamia pinnata* (g) *Cassia auriculata* (h) *Indigofera tinctoria*. • Role of ethnobotany in modern medicine with special example *Rauvolfia sepentina*, *Trichopus zeylanicus*, *Artemisia*,*Withania*. • Role of ethnic groups in conservation of plant genetic resources. • Endangered taxa and forest management (participatory forest management). **Unit 5: Ethnobotany and legal aspects** • Ethnobotany as a tool to protect interests of ethnic groups. Sharing of wealth concept with few examples from India. • Biopiracy, Intellectual Property Rights and Traditional	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				Knowledge. **Suggested Readings** ➢ Jain S.K. (1995). *Manual of Ethnobotany*, Scientific Publishers, Jodhpur, 1995. ➢ Jain S.K. (1995). *Glimpses of Indian. Ethnobotny*, Oxford and I B H, New Delhi – 1981 ➢ Lone et al. (1980). *Palaeoethnobotany*, Oxford and I B H, New Delhi – 1981 ➢ Jain S.K. (ed.) (1989). *Methods and approaches in ethnobotany*. Society of ethnobotanists, Lucknow, India. ➢ Jain S.K. (1990). Contributions of Indian ethnobotany. Scientific publishers, Jodhpur. ➢ Colton C.M. 1997. Ethnobotany – Principles and applications. John Wiley and sons, Chichester ➢ Rama Ro, N and Henry A.N. (1996). The Ethnobotany of Eastern Ghats in Andhra Pradesh, India.Botanical Survey of India. Howrah. ➢ Rajiv K. Sinha (1996). Ethnobotany The Renaissance of Traditional Herbal Medicine – INA –SHREE Publishers, Jaipur ➢ Ethnobotany: Vinay Sharma and Afroz Alam, Rastogi Publishing House, Meerut ➢ Faulks, P.J. 1958.An introduction to Ethnobotany, Moredale pub. Ltd. **Suggested e- Resources:** http://botanicaldimensions.org/what-is-ethnobotany/ https://www.plantsnap.com/blog/casual-ethnobotany/ https://trove.nla.gov.au/work/36470887?selectedversion=NBD44743330	
6)	**Discipline Elective: Ethnobotany Lab**			**Discipline Elective: Ethnobotany Lab** 1. Study of wild plants of different families at taxonomical level. 2. Collection of locally growing plants of ethnic importance.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				3. Herbarium preparation. 4. Study of ethnic groups through photographs and available literature. 5. Preparation of plants' extract. **6.** Analysis of phytochemicals.	
7)	**Disciple Elective: Horticulture**	After completion of the course students will be able to: • Understand the basic technique of plant propagation. • Perform cutting, grafting, budding, layering etc. • Grow plants in the absence of soil medium • Start bonsai creation • Know various aspects of Green House Technology • Start commercial cultivation of fruits and vegetables		**Disciple Elective: Horticulture** **Unit 1:** • Basic horticultural techniques (soil preparation, bed preparation, transplantation & pruning) • Vegetative propagation of plants (a) cutting (b) grafting (c) budding (d) layering (e) other special structures. **Unit 2:** • Soil less culture (hydroponic, Aeroponics). • Application of Coco peat, Perlite, Vermiculite and Peat moss in horticultural practices • Indoor and outdoor plants. • Bonsai: Types, forms, structure and styles. **Unit 3:** • Greenhouse Technology: Importance, types and operation techniques. • Commercial uses of Green House Technology. • Benefits and Risks associated with Green House Technology. **Unit 4:** • Commercial cultivation of cut flowers (Roses, Gerberas & Carnations). • Study of foliage plants (*Ficus*, Croton & Coleus). • Study of one locally available vegetables (root, leafy, cole crops). **Unit 5:** • Study of tropical fruits (Mango, Amla, Date palm). • Study of temperate fruits (Apple). • Commercial cultivation of exotic fruits.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				Suggested Readings ➢ Chalam, Venkateshwarlu, G.V.I. *Introduction to Agricultural Botany in India*. Asia Publishing House, New Delhi. ➢ Ankur: (Magazine). ➢ Jain, S.K. & Rao, R.R. *A Hand book of Field & Herbarium Methods*. Today & Tomorrow's Printers & Publications, New Delhi. ➢ Hartmann and Kester. Plant Propagation. ➢ Sandhu, M.K. Plant Propagation: ➢ Bajaj, Y.P.S. & Narosa. Biotechnology in agriculture and forestry. **Suggested e- Resources:** https://icar.org.in/content/horticultural_division http://tnhorticulture.tn.gov.in/horti/ https://www.onionseek.com/in/search/web/?pk=nQMhNzQd8g9IZLslSBEH6g&q=Online%20Horticulture%20Degree%20Program&id_event=5cc7d0693778ea7e85ea4bc6 https://www.longdom.org/horticulture.html	
8)	**Disciple Elective: Horticulture Lab**			**Disciple Elective: Horticulture Lab** 1. Layout of kitchen garden. 2. Vegetative propagation by cutting and grafting Herbarium preparation. 3. Vegetative propagation by budding and layering (Gootee). 4. To perform emasculation & hybridization. **5.** Preparation of compost.	
Biotechnology Discipline Elective-I & II					
1)	**Discipline elective** ~~**5.3:**~~ Genetic Engineering, rDNA Technology	On completion of the course, students will be able to: • Understand the various tools of recombinant DNA	**Unit 1** • Introduction and historical background of genetic engineering. • Isolation and purification of DNA from bacterial, plant	**Discipline elective** **BT 307: Genetic Engineering, rDNA Technology and Cell and Tissue Culture Technology** **Unit 1** • Introduction and historical background of genetic engineering.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
	and Cell and Tissue Culture Technology	technology and their applications in different fields. • Describe the principles, process of gene cloning and generation of recombinant libraries. • Learn theoretical aspects of different cell culture techniques and their uses in therapeutic applications. • Gain basic knowledge of patents and biosafety guidelines.	and animal cells. • Vectors: plasmids, cosmids and phages. • Restriction enzymes, Ligases, S1 nucleases, DNA polymerases, Reverse transcriptase. **Unit 2** • cDNA synthesis and cloning: mRNA enrichment, reverse transcription, • cDNA library. DNA primers • Linkers, Adaptors, Blunt end ligation, Homopolymer tailing. • Genomic library construction and screening. **Unit 3** • Molecular markers- RAPD, RFLP, AFLP, SNP. • Techniques used in identification of recombinant DNA clones. • Cloning and expression of foreign genes in prokaryotes (*E.coli*). • Cloning and expression of foreign genes in eukaryotes (e.g. Yeast) • Brief idea about gene cloning in plant and mammalian cells. • ~~Application of~~ transposons ~~in~~ gene tagging. **Unit 4** • Introduction, Historical background and terminology used in cell culture, Tissue culture lab: Basic requirements, Sterilization techniques. • Media: Types, preparation and composition. • Clonal propagation in plants. • Somatic embryogenesis, Protoplast isolation and culture, viability tests. **Unit 5** • Primary and established (including discontinuous and	• Isolation and purification of DNA from bacterial, plant and animal cells. • Vectors: plasmids, cosmids and phages. • Restriction enzymes, ligases, S1 nucleases, DNA polymerases, reverse transcriptase. **Unit 2** • DNA primers, cDNA synthesis and cloning: mRNA enrichment, reverse transcription. • cDNA library. • Linkers, adaptors, blunt end ligation, homopolymer tailing. • Genomic library construction and screening. **Unit 3** • Molecular markers- RAPD, RFLP, AFLP, SNP. • Techniques used in identification of recombinant DNA clones. • Cloning and expression of foreign genes in prokaryotes (*E. coli*). • Cloning and expression of foreign genes in eukaryotes (e.g. yeast). • Brief idea about gene cloning in plant and mammalian cells. • Transposon mediated gene tagging. **Unit 4** • Introduction, historical background and terminology used in cell culture, tissue culture lab: basic requirements, sterilization techniques. • Media: Types, preparation and composition. • Primary and established (including discontinuous and continuous) cell lines. • Cytotoxicity and transformation/transfection of cells. • Animal cell products. • Patents and biosafety guidelines. **Unit 5**	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			continuous) cell lines. • Cytotoxicity and transformation/transfection of cells. • Production of haploids and their applications. • Zygotic Embryo culture. • Animal cell products. • Somaclonal variations • Patents and Biosafety guidelines. **Books recommended:** ➢ Molecular Biology of Gene: J.D. Watson, Pearson Education. ➢ An introduction to Gene Technology-From genes to clones: Winnacker. ➢ Principles of Gene Manipulation: Old and Primrose. ➢ Molecular Biotechnology: B.R. Glick and J.J. Pasternak, ASM Press, Washington, USA. ➢ Plant Tissue Culture: S.S. Bhojwani and M.K. Razdan, Elsevier Science, The Netherlands. ➢ An Introduction to Plant Tissue Culture: M.K. Razdan. ➢ Genetic Engineering: Science and ethics on new frontier: Michael Boylan, Pearson Education. ➢ An Introduction to Genetic Engineering: S.T. Nicholl, Cambridge University Press. ➢ Principles of Gene Manipulations and Genomics, S. B. Primrose and R. M. Twyman. ➢ Biotechnology and Genomics: P. K. Gupta, Rastogi Publication. ➢ Introduction to plant Biotechnology: H.S. Chawla, Science Publishers. ➢ Gene Cloning and DNA analysis: T. A. Brown.	• Clonal propagation in plants. • Somatic embryogenesis, protoplast isolation and culture, viability tests. • Production of haploids and their applications. • Zygotic embryo culture. • Somaclonal variations. **Suggested Books:** ➢ Bhojwani, S.S., & Razdan, M.K. (1996). *Plant Tissue Culture: Theory and Practice*. Netherlands: Elsevier Science. ➢ Boylan, M., & Brown, K.E. *Genetic Engineering: Science And Ethics On The New Frontier*. ➢ Brown, T.A. (2010). *Gene Cloning and DNA Analysis: An Introduction* (6th ed.). USA: Wiley-Blackwell. ➢ Chawla, H.S. (2009). *Introduction to Plant Biotechnology* (3rd ed.). USA: CRC Press. ➢ Glick, B.R., & Patten, C.L. (2017). *Molecular Biotechnology: Principles and Applications of Recombinant DNA* (5th ed.). USA: American Society for Microbiology Press. ➢ Gupta, P.K. (2005). *Biotechnology and Genomics*. Meerut: Rastogi Publication. ➢ Gupta, P.K. (2017). *Animal Biotechnology*. Meerut: Rastogi Publication. ➢ Howe, C. (2007). *Gene Cloning & Manipulation* (2nd ed.). New Delhi: Cambridge University Press. ➢ Primrose, S.B., & Twyman, R. (2006). *Principles of Gene Manipulation and Genomics* (7th ed.) UK: Oxford University Press. ➢ Razdan, M.K. (2003). *Introduction to Plant Tissue Culture* (2nd ed.). USA: Science Pub Inc. ➢ Shrivastava, S. (2012). Molecular Techniques in Biochemistry & Biotechnology. Kolkata: New Central	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				Book Agency. ➢ Watson, J.D., Tania, A.B., & Stephen, P.B. (2017). *Molecular Biology of the Gene* (7^{th} ed.). USA: Pearson Education. ➢ Winnacker, E.L. (1987). *From Genes to Clones: Introduction to Gene Technology*. Germany: Wiley VCH. **Suggested e-Resources:** ➢ **Cloning** https://nptel.ac.in/courses/102103045/ ➢ **Molecular markers** http://www.biologydiscussion.com/plants/molecular-marker-study-notes/10883 ➢ **Plant biotechnology** https://nptel.ac.in/courses/102103016/12 ➢ **cDNA library** http://www.biotechnologynotes.com/dna-libraries/notes-on-cdna-library-dna-libraries/517 ➢ **Genetic engineering** https://nptel.ac.in/courses/102103013/ ➢ **Enzymes of genetic engineering** http://cec.nic.in/wpresources/module/Zoology/Paper-12/49/content/downloads/file1.pdf ➢ **Animal cell culture** https://nptel.ac.in/courses/102104059/	
2)	**Discipline Elective** ~~**5.4:**~~ Genetic Engineering, rDNA Technology and Cell and Tissue Culture Technology Lab	On completion of the course, students will be able to: • Learn all technicalities of setting up a plant tissue culture laboratory. • Learn the techniques of	1. Tissue culture, media preparation-MS/White media, Slant preparation ~~2. Sterilization techniques~~ 3. Excision of embryo/ovule/anther from the provided material and its inoculation. 4. Encapsulation of zygotic embryo. 5. Demonstration of column chromatography. 6. Extraction of proteins by phenol extraction. 7. Estimation of proteins by Popov's method. 8. To determine the melting curve ~~of DNA.~~	**Discipline Elective:** **BT 307L: Genetic Engineering, rDNA Technology and Cell and Tissue Culture Technology Lab** 1. Tissue culture, media preparation-MS/White media, slant preparation. 2. Aseptic techniques. 3. Excision of embryo/ovule/anther from the provided material and its inoculation. 4. Encapsulation of zygotic embryo. 5. Demonstration of column chromatography.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		isolation and estimation of nucleic acids. • Gain practical knowledge about chromatographic purification of proteins	9. ~~Determination of~~ base composition of DNA. 10. Estimation of RNA by orcinol method. 11. Isolation of plasmid. 12. Setting of a biotechnology laboratory e.g. Tissue culture, Fermentation, Molecular Biology, rDNA Technology, Biochemistry etc. (at least one).	6. Extraction of proteins by phenol extraction. 7. Estimation of proteins by Popov's method. 8. To determine the melting curve and base composition of DNA. 9. Estimation of RNA content by orcinol method. 10. Isolation of plasmid from bacterial cell and determination of purity. 11. Cell immobilization (yeast). 12. Setting of a biotechnology laboratory, viz., tissue culture, fermentation, molecular biology, rDNA technology, biochemistry etc. (at least one). **Suggested Books:** ➢ Saxena, J., Baunthiyal., & Ravi, I. (2015). *Laboratory Manual of Microbiology, Biochemistry and Molecular Biology*. Jodhpur: Scientific Publishers. ➢ Sharma, R.K., & Sangha, S.P.S. (2009). *Basic Techniques in Biochemistry & Molecular Biology*. New Delhi: I.K. International Publisher. ➢ Swamy, P.M. (2008). *Laboratory Manual on Biotechnology* (1^{st} ed.). Meerut: Rastogi Publication.	
3)	**Discipline Elective:** ~~6.1:~~ Advances in Biotechnology	On completion of the course, students will be able to: • Understand the different techniques of DNA sequencing, gene synthesis, gene silencing, PCR and blotting. • Describe the industrial production of biopesticides, biopolymer and	**Unit 1** • Techniques in Molecular Biology: Gene sequencing, solid phase automated synthesis of DNA, PCR, Northern, Southern and Western blotting, Hybridization. • Molecular probes and their applications, • Drug designing • Gene Therapy **Unit 2** • Fermentation processes, Batch, Fed batch and Continuous. • Bioreactor: components, types of bioreactor-CSTR, Loop reactor, Fluidized bed reactor	**Discipline Elective** **BT 301: Advances in Biotechnology** **Unit 1** • Techniques in molecular biology: Gene sequencing, solid phase automated synthesis of DNA. • PCR and its variants: nested, inverse, real time, touch down and hot start. • Northern, Southern and Western blotting, hybridization. • Molecular probes and their applications. • An overview of drug designing. • Gene therapy: An overview of its types and vectors used. **Unit 2** • Fermentation processes, batch, fed batch and continuous.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		biopolysaccharides using fermentation techniques. • Gain theoretical knowledge of cryopreservation, artificial insemination, IVF-ET technique, transgenic plants and transgenic animals.	• Biopesticides – (Bt genes) • Biopolymers (β-hydroxy butyrate) • Biopolysaccharide (Xanthum gum) **Unit 3** • Human genome project: History and salient features. • *Arabidopsis* as a model plant for genetic engineering. • Stem cells: current status. • Antisense RNA Technology, RNAi • Cassette vectors. • Edible Vaccines • DNA Chips **Unit 4** • Chloroplast Engineering • Proteomics and metabolomics. • Terminator seed technology. • Seed storage proteins. • Therapeutic proteins. • Biosensor. **Unit 5** • Cryopreservation, transport of germplasm (semen, ovum, embryo). • Artificial insemination, in vitro fertilization and embryo transfer. • Transgenic Plants: Resistance to herbicides, fungal and viral pathogens, environmental stress, Plants suitable for food processing, male sterility, molecular farming~~,~~ ~~to study regulated gene expression.~~ • Biotechnology of nitrogen fixation. • Transgenic animals **Books recommended:** ➢ Gene Cloning: TA Brown, Pearson Education. ➢ Human Molecular Genetics: Peter Sudbery, prentice Hall (Pearson Education).	• Bioreactor: Components, types of bioreactor-CSTR, loop reactor, fluidized bed reactor. • Biopesticides-(Bt genes). • Biopolymers (β-hydroxy butyrate). • Biopolysaccharide (xanthum gum). **Unit 3** • Human genome project: History and salient features. • *Arabidopsis* as a model plant for genetic engineering. • Stem cells: Current status. • Gene silencing: Antisense RNA technology and RNAi. • Cassette vectors. • Edible vaccines. • DNA chips. **Unit 4** • Chloroplast engineering. • A brief introduction of proteomics and metabolomics. • Terminator seed technology. • Seed storage proteins. • Therapeutic proteins. • Biosensor. **Unit 5** • Cryopreservation, transport of germplasm (semen, ovum, embryo). • Artificial insemination, *in vitro* fertilization and embryo transfer. • Transgenic plants: Resistance to herbicides, fungal and viral pathogens, environmental stress, male sterility, regulation of transgene expression, plants suitable for food processing, molecular farming. • Biological nitrogen fixation and its genetic engineering. • Transgenic animals. **Suggested Books:** ➢ Balasubramanian, D., Bryce, C.F.A., Dharmalingam, K., Green, J., & Jayaraman, K. (2004). *Concepts in*	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Understanding Biotechnology: Aluizo Borem, Pearson Education. ➢ Biotechnology and Genomics: P.K. Gupta, Rastogi Publications, Meerut. ➢ Modern Concepts of Biotechnology: H.D. Kumar, Vikas Publishing House, Pvt. Ltd., New Delhi. ➢ Concepts in Biotechnology: Balasubramanian et al. ➢ Immunology: Janis Kuby, John Wiley & Sons. ➢ Biotechnology: A handbook of Industrial Microbiology: Crueger and Crueger.	*Biotechnology*. Hyderabad: University Press. ➢ Borem, A., Santos, F.R., & Bowen, D.E. (2003). *Understanding Biotechnology* (1st ed.). USA: Prentice Hall. ➢ Brown, T.A. (2010). *Gene Cloning and DNA Analysis: An Introduction* (VI Ed.). USA: Wiley-Blackwell. ➢ Crueger, W., & Crueger, A. (2017). *Biotechnology: A Textbook of Industrial Microbiology* (3rd ed.). New York: Medtech. ➢ Gupta, P.K. (2005). *Biotechnology and Genomics*. Meerut: Rastogi Publication. ➢ Kumar, H.D. (1998). *Modern Concept of Biotechnology*. New Delhi: Vikas Publishing House. ➢ Owen, J., Punt, J., Stranford, S., & Jones, P. (2018). *Kuby Immunology* (8th ed.). USA: W. H. Freeman and Company. ➢ Shrivastava, S. (2012). *Molecular Techniques in Biochemistry & Biotechnology*. Kolkata: New Central Book Agency. ➢ Sudbery, P. (2010). *Human Molecular Genetics* (3rd ed.). USA: Pearson Education. **Suggested e-Resources:** ➢ **Gene therapy** https://nptel.ac.in/courses/102103041/ ➢ **Bioreactors** https://nptel.ac.in/courses/102106053/ ➢ **PCR, hybridization & blotting technique** http://www.tulane.edu/~wiser/methods/notes.pdf ➢ **IVF-ET** https://www.urmc.rochester.edu/MediaLibraries/URMCMedia/fertility-center/documents/In-Vito-Fertilization-4-29-15-updated.pdf ➢ **Transgenic plants** https://popups.uliege.be/1780-4507/index.php?id=11844	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				➢ **RNAi** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC309050/	
4)	**Discipline Elective:** ~~**6.2:**~~ Advances in Biotechnology Lab	On completion of the course, students will be able to: • Demonstrate the skills required for basic laboratory procedures and principles of reagent preparation. • Design, conduct experiments, analyze and interpret data for investigating problems in biotechnology and allied fields. • Understand the importance of the practical aspects of different techniques like electrophoresis, fermentation, and spectroscopy etc, currently used in biomedical research.	1. Isolation and estimation of genomic DNA from *E. coli*. 2. Agarose gel electrophoresis of DNA. 3. Seed germination under stress condition. ~~4. DO estimation~~ 5. To determine the hardness of water 6. To find out absorption spectrum of the oxidized and reduced form of a molecular species (NAD and NADH). 7. To determine the LD50 value of pesticide / weedicide. 8. Chlorophyll estimation from the given samples. 9. Extraction and estimation of ~~phenol based secondary metabolites~~. 2. Demonstration of fermenter. ~~3. Bioinformatics exercise -1.~~ ~~4. Bioinformatics exercise -2.~~ ~~5.~~ Submission of project report based on any topic related to Biotechnology.	**Discipline Elective:** **BT 301L: Advances in Biotechnology Lab** 1. Isolation and estimation of genomic DNA from *E. coli*. 2. Agarose gel electrophoresis of DNA. 3. Seed germination under stress condition. 4. To find out absorption spectrum of the oxidized and reduced form of a molecular species (NAD and NADH). 5. To determine the LD_{50} value of pesticide / weedicide. 6. Chlorophyll estimation from the given samples. 7. Extraction and estimation of total phenolic content using standard curve of gallic acid. 8. Isolation of protoplast and its culture using microchamber technique. 9. Demonstration of fermenter. 10. Determination of total hardness of water. 11. Submission of project report based on any topic related to Biotechnology. **Suggested Books:** ➢ Saxena, J., Baunthiyal., & Ravi, I. (2015). *Laboratory Manual of Microbiology, Biochemistry and Molecular Biology*. Jodhpur: Scientific Publishers. ➢ Sharma, R.K., & Sangha, S.P.S. (2009). *Basic Techniques in Biochemistry & Molecular Biology*. New Delhi: I.K. International Publisher. ➢ Swamy, P.M. (2008). *Laboratory Manual on Biotechnology* (1st ed.). Meerut: Rastogi Publication. ➢ Vats, S. (2015). *A laboratory Text book of Biochemistry, Molecular Biology and Microbiology*. Germany: GRIN Verlag.	
5)	**Discipline Elective:**	On completion of the course, students		**Discipline Elective:** **Animal and Plant Biotechnology**	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
	Animal and Plant Biotechnology	will be able to • Gain knowledge of assisted reproductive technology, transgenic animal production and applications. • Gain an understanding of current scenario of stem cells and their applications. • Explain applications of tissue engineering in bioartificial organs development and transplantation. • Explain various techniques used in plant biotechnology.		**Unit-I** • Animal propagation: Induction of superovulation, embryo collection and evaluation, embryo splitting, embryo sexing, artificial insemination (IUI, ICSI) and embryo transfer techniques in cattle. • Animal clones, nuclear transplantation, cloning for conservation of endangered species • *In vitro* fertilization and embryo transfer: Composition of IVF media, steps involved in IVF. **Unit-II** • Gene transfer methods in animals: Calcium phosphate, DEAE-dextran, lipofection, electroporation, microinjection, embryonic stem cell transfer, retrovirus. • Transgenic animals and their applications with reference to transgenic mice, cattle, sheep, goats, pigs, chicken and fish. • Stem cells: Definition, classification, characteristics and therapeutic applications. **Unit-III** • Recombinant protein vaccine production by cultured animal cells. • Basics of tissue engineering: Cell-ECM interaction, Biomaterials in tissue engineering. Bioartificial organs-sources of cells, scaffold material, mode of transplantation. • Shoot tip and meristem culture and production of virus-free plants. • Protoplast studies: Isolation, culture, fusion and selection of hybrid cells, somatic hybrids and cybrids and applications. **Unit-IV** • Artificial seeds: Production, applications and limitations. • Genetic transformation methods: Vector	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				(*Agrobacterium tumefaciens*) mediated genetic transformation. T-DNA transfer mechanism. Physical gene transfer methods: Particle bombardment, electroporation and microinjection. • Genetic engineering of crops for improved nutritional quality: Vitamin-A, iron, zinc, protein quality. **Unit-V** • Genetic engineering in plants: Selectable markers, reporter genes and promoters used in plant vectors. • Genetic engineering of plants for disease resistance, pest and herbicide resistance. • Molecular pharming: Concept of plants as biofactories, production of antibodies, viral antigens, peptide hormones and biodegradable plastics. **Suggested Books:** ➢ Chawla, H.S. (2009). *Plant Biotechnology* (3rd ed.). New Delhi, India: Oxford & IBH Publishing Co. Pvt. Ltd. ➢ Kumaresan, V. (2008). *Applied animal biotechnology*. Tamil Nadu, India: Saras Publication. ➢ Lanza, R., Gearhart, J., & Hogan, B. *Essentials of stem cell biology* (2nd ed.). London, UK: Academic Press. ➢ Lanza, R., Langer, R., & Vacanti, J. *Principles of tissue engineering* (4th ed.). London, UK: Academic Press. ➢ Peter, K.V., & Keshavachandran, R. (2008). Plant Biotechnology: Methods in Tissue Culture and Gene Transfer. India: Universities Press. ➢ Singh, B., Gautam, S.K., & Chauhan, M.S. (2015). *Textbook of animal biotechnology*. New Delhi, India:Teri Publication.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				➢ Singh, B.D. (2011). *Plant Biotechnology* (2nd ed.). New Delhi, India: Kalyani Publisher. ➢ Singh, B.S. (2007). *Fundamentals of Plant Biotechnology*. New Delhi, India: Satish Serial Publishing House. ➢ Slater, A. (2008). *Plant Biotechnology: The Genetic Manipulation of Plants* (2nd ed.). Oxford, UK: Oxford Publisher. **Suggested e- resources** **Plant Biotechnology** ➢ https://nptel.ac.in/courses/102103016/ **Tissue engineering** ➢ https://nptel.ac.in/courses/102106036/	
6)	**Discipline Elective: Animal and Plant Biotechnology Lab**	On completion of the course, students will be able to • Gain hands on training on plant & animal tissue culture and biotechnology. • Learn the technique of genomic DNA isolation, its electrophoresis and SDS-PAGE.		**Discipline Elective:** **Animal and Plant Biotechnology Lab** 1. Introduction to the laboratory and general safety practices for plant and animal cell culture. 2. Aseptic culture techniques for establishment and maintenance of cultures. 3. Prepare culture media with various supplements for plant and animal tissue culture. 4. To select, prune, sterilize and prepare an explant for culture. 5. Establishment of callus cultures. 6. Cell suspension cultures. 7. Isolation and culture of protoplast. 8. Isolation of plant genomic DNA by modified CTAB method. 9. Isolation of DNA from animal tissue. 10. Quantification of DNA by spectrophotometeric method. 11. Size analysis of DNA by agarose electrophoresis. 12. Effect of different light wavelengths and temperature on germinating embryos. 13. Separation of plant proteins by SDS-gel electrophoresis.	

<table>
<tr><th>S No.</th><th>Course List</th><th>Learning Outcomes</th><th>Existing Syllabus</th><th>Suggested Syllabus</th><th>Remarks</th></tr>
<tr><td></td><td></td><td></td><td></td><td>Suggested Books:
➢ Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
➢ Saxena, J., Baunthiyal., & Ravi, I. (2015). Laboratory Manual of Microbiology, Biochemistry and Molecular Biology. Jodhpur: Scientific Publishers.
➢ Swamy, P.M. (2008). Laboratory Manual on Biotechnology (1st ed.). Meerut: Rastogi Publication.</td><td></td></tr>
<tr><td>7)</td><td>Discipline Elective-I Environmental Biotechnology</td><td>On completion of the course, students will be able to:
• Understand the importance of microorganisms as pesticides.
• Understand the basic concept of bioleaching, biodesulphurization, bioplastics, biosurfactants and bioemulsifiers.
• Understand different waste management processes and generation of energy from waste.
• Describe various roles played by microbes in biodegradation,</td><td></td><td>Discipline Elective-I:
Environmental Biotechnology
Unit-I
• Solid waste management: Waste generation, handling, storage, processing, transport, bailing, composting-incineration, pyrolysis, land farming – waste disposal by sanitary land filling (aerobic and anaerobic degradation), recycling and product re-use.
• Microbial leaching and biomining: Types and methods of bioleaching, chemistry and microbiology of bioleaching, in situ and ex situ leaching process of copper and uranium, plasmids and genes in biomining.
Unit-II
• Bioremediation of soil and water contaminated with oil spills, heavy metals and detergents.
• Microbial degradation of pesticides and xenobiotic compounds, metabolism and mechanism of degradation, degradative plasmids, microbes and cloning strategies.
• Phyto-remediation: Basic concept, types (phytoaccumulation, phytovolatilization, rhizofiltration and phytostabilization) and applications.</td><td></td></tr>
</table>

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		bioremediation and plant growth promotion.		**Unit-III** • Bioinsecticides: *Bacillus thuringiensis*, baculoviruses, genetic modifications and aspects of safety in their use. Biofungicides: Mode of actions and mechanism (*Trichoderma*). • Biofertilizers: Algal fertilizers, nitrogen fixing bacteria, phosphate solubilising microbes, VAM, plant growth promoting rhizobacteria (PGPR). • Earthworm as biofertilizer. **Unit-IV** • Biodesulphurization of coal/petroleum/diesel: Bioprocessing of coal, mechanism of inorganic sulphur removal, organic sulphur removal by Kodama pathway and 4 S pathways. • Sewage treatment: Primary, secondary (Aerobic and anaerobic treatment) and tertiary. • An introduction of biodelignification. **Unit-V** • Bioindicators and biosensers for detection of environmental pollution. • Biofuels: Biogas, bioethanol, biodiesel, biohydrogen. • A brief introduction of bioplastics, biosurfactants and bioemulsifiers. **Suggested Books:** ➢ Allen, K. (2016). *Environmental Biotechnology*. New Delhi, India: CBS Publishers. ➢ Evans, G.M. & Furlong, J.C. (2003). *Environmental Biotechnology: Theory and Applications*. Wiley Publishers. ➢ Milton, W. (Ed.). (1999). *An Introduction to Environmental Biotechnology*. USA: Springer. ➢ Scragg A. (2005). *Environmental Biotechnology*. Pearson Education Limited.	
8)	**Discipline**	On completion of		**Discipline Elective:**	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
	Elective: Environmental Biotechnology Lab	the course, students will be able to: • Gain practical experience in quality determination of water with easy to run experiments such as dissolved oxygen, hardness and alkalinity. • Gain practical understanding in the role of biofertlizers and biopesticides in the cleaning of environment. • Gain practical experience in quality determination of water with easy to run experiments such as dissolved oxygen, hardness and alkalinity.		**Environmental Biotechnology Lab** 1. Isolation of biofertilizer microbes by biological enrichment method. 2. Estimation of BOD in water sample. 3. Estimation of COD in water sample. 4. Determination of total hardness of water. 5. Determination of total alkalinity of water. 6. Production of microbial biofertilizers. 7. Efficacy testing for biofertilizers. 8. Testing for microbiological quality of potable water (Coli form test). 9. Microbial degradation of heavy metals. 10. Effect of heavy metal toxicity on seed germination and plant growth. 11. Alcohol fermentation by using Baker's yeast and its quantification by dichromate method.	
Zoology Discipline Elective-I & II					
1)	**Discipline Elective** **~~6.3~~:** Animal Physiology	On completion of the course, students will be able to: • Gain basic understanding of structure and	**Unit 1** • Physiology of Digestion: Various kinds of digestive enzymes (Carbohydrases, Proteinases and Lipases) and their digestive action to corresponding food stuffs in the alimentary canal of mammals; Hormonal control of	**Discipline Elective** **ZOO 301: Animal Physiology** **Unit 1** • Physiology of digestion: Various kinds of digestive enzymes (carbohydrases, proteinases and lipases) and their digestive action to corresponding food stuffs in the	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		functions of each physiological system of human. • Describe principles and pathway of metabolism of carbohydrate, protein and lipids. • Develop an understanding about principles of human anatomy and physiology.	digestive functions; Mechanism of absorption of various end-products of digestion and other materials such as vitamins, minerals and trace elements. • Physiology of Respiration in mammals: Mechanism and control of breathing; Transport of oxygen and carbon dioxide; oxygen dissociation curves of Hemoglobin, Bohr's effect, Chloride shift, Respiration at cellular level. **Unit 2** • Metabolism: (Structure formula of metabolites not essential) Carbohydrate metabolism oxidation of glucose (glycolysis); The Embden–Meyerhof Parnas pathway, Tricarboxylic Acid Cycle (TCA) and Oxidative phosphorylation Glycogenolysis and Glycogenesis; Gluconeogenesis and the role of dicarboxylic acid Shuttle, role of insulin and glucagons on carbohydrate metabolism. • Protein metabolism: Essential and non-essential amino-acids, oxidative deamination, transamination and decarboxylation of amino acids, fate of glucogenic and ketogenic amino acids, Role of hormones in protein metabolism. • Fat metabolism: -oxidation of fatty acids, oxidation of glycerol and unsaturated fatty acids; fate of Acetyl CoA; Synthesis of lipids; Role of hormones in fat metabolism. **Unit 3** • Physiology of Excretion: Kinds of nitrogenous excretory products, Role of liver in the formation of urea; ~~Relationship between the nature of excretory products to the habitat (Fresh water, Marine water and Terrestrial);~~ Composition and formation of urine; Role of hormones. • Physiology of Vascular system: Composition and	alimentary canal of mammals; hormonal control of digestive functions; mechanism of absorption of various end-products of digestion and other materials such as vitamins, minerals and trace elements. • Physiology of respiration in mammals: Mechanism and control of breathing; transport of oxygen and carbon dioxide; oxygen dissociation curves of hemoglobin, Bohr effect, chloride shift, Haldane effect, lung volumes and capacities, regulation of respiration, respiration at cellular level. **Unit 2** • Metabolism: (structure formula of metabolites not essential) Carbohydrate metabolism oxidation of glucose (glycolysis); Embden–Meyerhof-Parnas pathway, tricarboxylic acid cycle and oxidative phosphorylation, shuttle mechanisms (malate-aspartate and glycerol-phosphate), glycogenolysis and glycogenesis; gluconeogenesis and the role of dicarboxylic acid shuttle, role of insulin and glucagons on carbohydrate metabolism. • Protein metabolism: Essential and non-essential amino-acids, oxidative deamination, transamination and decarboxylation of amino acids, fate of glucogenic and ketogenic amino acids, role of hormones in protein metabolism. • Fat metabolism: Oxidation of fatty acids (β-oxidation), glycerol, and unsaturated fatty acids; fate of Acetyl CoA; synthesis of fatty acids & lipids; role of hormones in fat metabolism. **Unit 3** • Physiology of excretion: Kinds of nitrogenous excretory products, structure of kidney, role of liver in the formation of urea; composition and formation of urine; role of hormones in urine formation; micturition. • Physiology of vascular system: Composition and	The topic "Relationship between the nature of excretory products to the habitat (Fresh water, Marine water and Terrestrial)"

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			functions of blood and lymph; Blood groups, Rh factor; Blood ~~Coagulation~~ (clotting) mechanism and its physiological significance; Structure and functions of Hemoglobin. Blood pressure; origin, conduction and regulation of heart beat; Nervous and hormonal regulation of heart beat; Cardiac cycle. **Unit 4** • Physiology of Muscle Contraction: Functional architecture of smooth, skeletal and cardiac muscles; mechanism of muscle contractions (skeletal muscle). Mechanical properties of muscle: simple muscle twitch; tetanus and muscle fatigue. • Physiology of nerve impulse and reflex action: Functional architecture of neuron, nature, origin and propagation of nerve impulse along a neuron, synapse; reflex arc, reflex action and its central control. **Unit 5** • Physiology of Endocrine Glands: Structure and functions of Hypothalamus; Pituitary; Thyroid; Parathyroid; Adrenal and Pancreas; • An elementary idea about neuro secretion. • Physiology of Reproduction: Structure and Physiology of human male and female reproductive system; reproductive cycles- Estrous and Menstrual cycle • Hormonal regulation of ovulation, fertilization, implantation, abortion, gestation, parturition and lactation **Books Recommended:** ➢ Text book of Medical Physiology: A.C. Guyton, Saunders College Publications. ➢ Text book of Animal Physiology: P.S. Verma.	functions of blood; lymph & lymphatic system; blood groups, Rh factor; platelet plug formation; blood clotting mechanism and its significance; structure and functions of hemoglobin. Blood pressure & its regulation; origin, conduction and regulation of heart beat; nervous and hormonal regulation of heart beat; cardiac cycle. **Unit 4** • Physiology of muscle contraction: Functional architecture of smooth, skeletal and cardiac muscles; mechanism of muscle contractions (skeletal muscle). Fuel for muscle contraction, mechanical properties of muscle: simple muscle twitch; wave summation, tetanus and muscle fatigue. • Physiology of nerve impulse and reflex action: Functional architecture and classification of neuron; nature, origin and propagation of nerve impulse along a neuron (myelinated and unmyelinated), synapse; reflex arc, reflex action and its central control. **Unit 5** • Physiology of endocrine glands: Structure and functions of hypothalamus; pituitary; thyroid; parathyroid; adrenal and pancreas. • An elementary idea about neuro-secretion. • Physiology of reproduction: Structure and physiology of human male and female reproductive system; spermatogenesis and oogenesis; reproductive cycles- estrous and menstrual cycle. • Hormonal regulation of ovulation, fertilization, implantation, abortion, gestation, parturition and lactation. **Suggested Books:** ➢ Chaterjee, C.C. (2005). *Human Physiology* Vol-II (11th ed.). ➢ Chaterjee, C.C. (2018). *Human Physiology* Vol-I (12th	is proposed to be remove from existing syllabus because it is usually covered in the another topic i.e. Kinds of nitrogenous excretory products. This is important for the students to learn about structure of kidney, therefore this topic is proposed to be part of modified syllabus. It is important to learn about the different fuels available for muscular contraction. It is important for the students to learn about the classification of neuron based on their functionality and number of process emerges from cell body.

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Text book of Human Physiology Vol. I & II: C.C. Chaterjee. ➢ A text book of Human Anatomy & Physiology: G.M. Tortora. ➢ Regulatory Mechanisms in Vertebrates: Pandey and Shukla Rastogi Publication, Meerut. ➢ Text book of Animal Physiology – Eckert.	ed.). New Delhi: CBS Publishers & Distributors. ➢ Guyton, A.C., & Hall, J.E. (2015). *Textbook of Medical Physiology* (13^{th} ed.). USA: Saunders. ➢ Jurd, R.D. (2003). *Instant notes in Animal Biology*. New Delhi: Viva Books Pvt. Ltd. ➢ Kumar, N. (2016). *Animal Physiology*. Jaipur: RSBA Publishers. ➢ Pandey, K., & Shukla, J.P. (2005). *Regulatory Mechanism in Vertebrates*. Meerut: Rastogi Publications. ➢ Randall, D., Burggren, W., & French, K. (2001). *Eckert Animal Physiology* (5^{th} ed.). W. H. Freeman. ➢ Roy, R.N. (2018). *Textbook of Physiology: with Biochemistry & Biophysics* Vol-I. Kolkata: New Central Book Agency. ➢ Tortora, G.J., & Grabowski. (2003). *Principles of Anatomy & Physiology* (10^{th} ed.). New Jersey, USA: John Wiley & Sons. ➢ Verma, P.S., Tyagi, B.S., & Agarwal, V.K. (2000). *Animal Physiology*. New Delhi: S. Chand Publisher. **Suggested e-Resources:** ➢ **Digestive system** https://www2.estrellamountain.edu/faculty/farabee/biobk/BioBookDIGEST.html ➢ **Unsaturated fatty acid oxidation** https://pharmaxchange.info/2013/10/oxidation-of-unsaturated-fatty-acids/ ➢ **Urine formation** http://medschool.slu.edu/gpbs/syllabus/2008/renal2/Kidney%20Lecture-2%20Core%202008.pdf ➢ **Muscles** http://www.onlinebiologynotes.com/muscular-tissue-skeletal-smooth-cardiac-muscle/ ➢ **Endocrine glands** http://what-when-how.com/nursing/the-endocrine-	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				system-structure-and-function-nursing-part-1/ ➢ **Physiological systems** https://nptel.ac.in/courses/102104042/ https://nptel.ac.in/courses/122103039/18	
2)	**Discipline Elective:** ~~6.4:~~Animal Physiology Lab	On completion of the course, students will be able to: • Gain hands on experience in hematological tests such as counting of RBCs, WBCs, preparation of haemin crystals, determination of blood haemoglobin, calcium, cholesterol, sugar, protein, cloting time. • Demonstrate the skills of pathological analysis of urine through the detection glucose and albumin.	1. Preparation of haemin crystals. 2. Estimation of haemoglobin percentage by haemometer. 3. Enumeration of the total number of red blood corpuscles (RBC). 4. Enumeration of the total number of white blood corpuscles (WBC). 5. Determination of ABO blood groups and Rh factor. 6. Study of effect of isotonic, hypotonic and hypertonic solutions on RBC. 7. Determination of the presence of sugar and albumin in the urine sample. 8. Determination of blood sugar content. 9. Estimation of total protein from blood. 10. Estimation of total calcium from blood. 11. Estimation of total cholesterol from blood. 12. Determination of the clotting time of blood.	**Discipline Elective:** **ZOO 301L:Animal Physiology Lab** No change in the syllabus, suggested Books added. **Suggested Books:** ➢ Poddar, T., Mukhopadhyay, S., & Das, S.K. (2003). *An advanced Laboratory Manual of Zoology*. Kolkata: Macmillan India Limited. ➢ Sharma, S. (2007). *Experiments and Techniques in Biochemistry* (1st ed.). New Delhi: Galgotia Publication. ➢ Sharma, S., & Sharma, R. (2016). *Practical Manual of Biochemistry* (2nd ed.). New Delhi: Medtech.	
3)	**Discipline Elective:** ~~5.1 Environmental Biology~~	On completion of the course, students will be able to: • Understand the physical and biological characters of the environment	~~**5.1 Environmental Biology**~~ **Unit 1 • Terminology and scope of ecology.** Environment : i. Biosphere – Lithosphere, Hydrosphere and Atmosphere. ii. Physical factors – with special reference to temperature, light and water.	**Discipline Elective:** **ZOO 302:Environmental Biology and Biostatistics** **Unit 1 •** • Terminology and scope of ecology. • Environment: i. Biosphere **-**Lithosphere, hydrosphere and atmosphere. ii. Physical factors**-**with special reference to temperature,	Title of the paper is renamed as Environmental Biology and Biostatistics

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		and the interrelationship between biotic and abiotic components of nature as well as relationship among the individuals of the biotic components. • Realize the importance of ecosystem and biodiversity for maintaining ecological balance. • Understand the basic principles of population and community ecology. • Understand the fundamental principles of biostatistics and its role in the data analysis generated by scientific research.	iii. Biotic factors – Intra and Inter specific relationship among animals. iv. Principles of limiting factors – Leibig's law of minimum, Shelford's Law of tolerance, combined concept of limiting factors. Biogeochemical Cycles: Carbon, Oxygen, Nitrogen and Phosphorus cycles. **Unit 2** **1.** Ecosystem Ecology: Structure and dynamics of the ecosystem including food chain, food webs trophic levels, productivity and energetics. 2. Fresh Water Ecosystem: Physiochemical factors, Biotic communities and lake eutrophication. 3. Marine Ecosystem: Zonation factors and biotic communities of deep sea only. 4. Terrestrial Ecosystem: Salient features of grass land, forest and desert ecosystem. **Unit 3** 5. *Population Ecology.* i. Definition and attributes of animal population: Population density and its measurement, natality, mortality, growth form, age distribution, age pyramids, Sex ratio, dispersal and dispersion. ii. Regulation of Population density: Population fluctuations and interactions. 6. Community Ecology : i. Definition of types of communities (micro and macro communities). ii. Community dominance and species diversity. iii. Ecotone, edge effect and ecological Niche. iv. Succession and Climax. **Unit 4** ~~7. *Pollution Ecology :*~~ ~~i. Pollution, Biodegradable and non-biodegradable pollutants.~~	light and water. iii. Biotic factors **-**Intra and inter specific relationship among animals. iv. Principles of limiting factors**-**Leibig's law of minimum, Shelford's law of tolerance, combined concept of limiting factors. • Biogeochemical cycles: Carbon, oxygen, nitrogen and phosphorus cycles. **Unit 2** • Ecosystem ecology: Structure and dynamics of the ecosystem including food chain, food webs trophic levels, productivity and energetics. • Fresh water ecosystem: Physiochemical factors, biotic communities and lake eutrophication. • Marine ecosystem: Zonation factors and biotic communities of deep sea only. • Terrestrial ecosystem: Salient features of grass land, forest and desert ecosystem. **Unit 3** • Population ecology: i. Definition and attributes of animal population: Population density and its measurement, natality, mortality, growth form, age distribution, age pyramids, sex ratio, dispersal and dispersion. ii. Regulation of population density: Population fluctuations and interactions. • Community ecology: i. Definition of types of communities (micro and macro communities). ii. Community dominance and species diversity. iii. Ecotone, edge effect and ecological niche. iv. Succession and climax. **Unit 4** • Applied ecology: i. Conservation of natural resources.	Unit-4 of this paper is already mentioned in

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			~~ii. Air pollution: Sources, nature, prevention and control.~~ ~~iii. Water pollution: Source, nature abatement.~~ ~~iv. Noise pollution~~ ~~v. Radioactive pollution and effects of radioactive substance on living organisms.~~ ~~vi. Environmental health and welfare.~~ **Unit 5** 8. *Applied Ecology :* i. Conservation of Natural resources. ii. Wild life management. iii. National parks and Wild life sanctuaries in India. iv. Extinction in animals. v. Zoogeographical regions of the world along with the boundaries and fauna **Recommended Books :** ➢ Elements of Ecology: Clarke. ➢ Ecology: E.P. Odum, New Delhi : Amerind Publishing, 1965. ➢ Environmental Analysis: M.M. Saxena, Bikaner Agro Botanical Pub., 1990. ➢ Ecology with special reference to animal and man : S. Charles Kendeigh. ➢ Principles of Animal Ecology: Allee, Emeroon, Park and Schmidt. ➢ Animal Ecology : S.P. Singh. ➢ Ecology and Environment: P.D. Sharma, Rastogi Publications. ➢ Ecology: C.V.S. Bahura. ➢ Ecology: C.J. Krebs. ➢ Ecology 2000: Edited by Edmand Hillary, London Michael Joseph, 1984.	ii. Wild life management. iii. National parks and wild life sanctuaries in India. iv. Extinction in animals. v. Zoogeographical regions of the world along with the boundaries and fauna. **Unit 5** • Biostatistics: i. Introduction, scope and applications. ii. Sampling, data collection and presentation. iii. Types of data, methods of collection of primary and secondary data, data presentation-Histogram, polygon, bar diagram, pie diagram. iv. Frequency distribution. Measures of central tendency-Mean, median, mode. v. Measures of variability-Standard deviation, standard error. **Suggested Books :** ➢ Alllee W.C., Emerson, A.E., Park, O., Parl, T., & Schmidt, K.P. (1967). *Principles of Animal Ecology*. USA: W.B. Saunders Company. ➢ Banerjee, P.K. (2007). *Introduction to Biostatistics* (3rd ed.). New Delhi: S Chand and company Pvt. Ltd. ➢ Bhuyan, K.C. (2017). *Advanced Biostatistics*. Kolkata: New Central Book Agency. ➢ Chaudhary, B.L., & Pandey, J. (2007). *Fundamentals of Ecology & Environment*. Jaipur: Apex Publishing House. ➢ Clarke, G.L. (1965). *Elements of Ecology*. New Jersey: John Wiley & Sons Inc. ➢ Datta, A.K. (2014). *Basic Biostatistics and Application*. Kolkata: New Central Book Agency. ➢ Hillary, E. (1984). *Ecology 2000: The Changing Face of Earth*. Michael Joseph Ltd.	plant physiology and ecology paper, therefore contents of unit-V has shifted to Unit-IV and Introduction to biostatistics is proposed to be include in the Unit-V

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				➢ Kendeigh, S.C. (1974). *Ecology with special reference to animal and man*. New Jersey: Prentice Hall. ➢ Krebs, C.J. (2001). *Ecology* (5th ed.). San Francisco, USA: Benjamin Cummings. ➢ Kumar, A. (2015). *Biodiversity & Conservation*. New Delhi: APH Publishing Corporation. ➢ Miller, G.T. (2004). *Environmental Science: Working with the Earth* (10th ed.). Singapore: Thomson Asia. ➢ Misra, S.P., & Pandey, S.N. (2016). *Essentials of Environmental Sciences* (4th ed.). New Delhi: Ane Books Pvt. Ltd. ➢ Odum, E.P. (1965). *Ecology*, New Delhi: Amerind Publishing. ➢ Pandey, M. (2015*). Biostatistics: Basic and Advanced*. New Delhi: MV Learning. ➢ Saxena, M.M. (1990). *Environmental Analysis*: Bikaner: Agro Botanical. ➢ Sharma, P.D. (2011). *Ecology and Environment*. Meerut: Rastogi Publication. ➢ Singh, S.P. (2005.). *Animal Ecology*. Meerut: Rastogi Publications. ➢ Tripathi, G. (2002). *Modern Trends in Environmental Biology*. New Delhi: CBS Publishers & Distributors. **Suggested e-Resources:** ➢ **Aquatic ecology** https://nptel.ac.in/courses/120108002/ ➢ **Ecosystem** https://nptel.ac.in/courses/122103039/38 ➢ **Biostatistics** https://nptel.ac.in/courses/102101056/ ➢ **Measures of central tendency** https://www.tutorialspoint.com/statistics/arithmetic_mean.htm ➢ **Population characteristics** http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.	

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<tr><th>S No.</th><th>Course List</th><th>Learning Outcomes</th><th>Existing Syllabus</th><th>Suggested Syllabus</th><th>Remarks</th></tr>
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<tr><td>4)</td><td>~~**5.2: Environmental Biology Lab**~~
Discipline Elective: ZOO 302L: Environmental Biology and Biostatistics Lab</td><td>On completion of the course, students will be able to:
• Demonstrate skills in the quality assessment of water through testing of water for CO_2, O_2, chloride and hardness.
• Gain an understanding of parasitic, aquatic, desert and aerial adaptations of animals with the help of charts and specimens.
• Describe symbiosis, commensalism and socialization among organisms with the help of charts and specimens.
• Understand analysis of data by solving biostatistical problems.</td><td>~~**5.2:Environmental Biology Lab**~~
1. To find the depth and visibility in a pond by Sachi disc method.
2. To determine the pH of water sample.
3. To determine the content of dissolved oxygen in the water sample.
4. To determine free CO2 content in the water sample.
5. To determine the Chloride content of the water sample.
6. To determine the total hardness of water.
7. To study the effect of environmental stimulation on *paramecium.*
8. To study parasitic, desert, aquatic and aerial adaptations in animals
i. Parasite : *Hirudinaria, Taenia, Ascaris, Schistosoma, Fasciola,* ~~Head louse.~~
ii. Desert : *Phrynosoma*, *Uromastix*, Camel, *Heloderma*, Rattle snake, Golden mole.
iii. Aquatic : *Pleuronectus*, *Exocoetus*, Turtle, *Hippocampus*, *Dolphin*, *Hydrophis*, *Duck*, Crocodile.
iv. Aerial: Any Bird, Draco, Bat.
9. To study different types of associations existing among living organisms.
i. Symbiosis: Chlorohydra, Termite and Aphid.
ii. Commensalism: Harmit-crab and Sea anemone and Gastropod shell, Euplectella and Shrimps.
iii. Socialization: Ants, Termites, Honey bees.
10. Draw a map of world and identify the Zoogeographical regions of the world along with their major fauna.
Report on any current topic related to Environmental Biology.</td><td>**Discipline Elective:**
ZOO 302L: Environmental Biology and Biostatistics Lab
1. To find the depth and visibility in a pond by Sachi disc method.
2. To determine the pH of water sample.
3. To determine the content of dissolved oxygen in the water sample.
4. To determine the chemical oxygen demand in the water sample.
5. To determine free CO_2 content in the water sample.
6. To determine the chloride content of the water sample.
7. To determine the total hardness of water.
8. To study the effect of environmental stimulation on *Paramecium*.
9. To study parasitic, desert, aquatic and aerial adaptations in animals:
i. Parasite: *Hirudinaria*, *Taenia*, *Ascaris*, *Schistosoma*, *Fasciola*, *Pediculus*.
ii. Desert: *Phrynosoma*, *Uromastix*, Camel, *Heloderma*, Rattle snake, Golden mole.
iii. Aquatic: *Pleuronectus*, *Exocoetus*, Turtle, *Hippocampus*, *Dolphin*, *Hydrophis*, Duck, Crocodile.
iv. Aerial: Any bird, *Draco*, bat.
10. To study different types of associations existing among living organisms.
i. Symbiosis: *Chlorohydra*, termite and aphid.
ii. Commensalism: Harmit-crab, sea anemone and gastropod shell, *Euplectella* and shrimps.
iii. Socialization: Ants, termites and honey bees.
11. Draw a map of world and identify the Zoogeographical regions of the world along with their major fauna.
12. Biostatistics exercise-mean, median, mode, standard deviation and standard error.
13. Report on any current topic related to environmental</td><td>Exercise on biostatistics is introduced in the revised laboratory syllabus</td></tr>
</table>

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				biology. **Suggested books:** ➢ Lal, S.S. (2015). *Practical Zoology: Invertebrates* (11th ed.). Meerut: Rastogi Publication. ➢ Lal, S.S. (2015). *Practical Zoology: Vertebrates* (11th ed.). Meerut: Rastogi Publication. ➢ Lal, S.S. (2016). *A Textbook of Practical Zoology* Vol-III (2nd ed.). Meerut: Rastogi Publication. ➢ Poddar, T., Mukhopadhyay, S., & Das, S.K. (2003). *An advanced Laboratory Manual of Zoology*. Kolkata: Macmillan India Limited. ➢ Verma, P.S. (2010). *A Manual of Practical Zoology: Chordates* (11th ed.). New Delhi: S Chand Publishing.	
5)	**Discipline Elective: Developmental Biology**	**Learning Outcomes:** On completion of the course, students will be able to • Gain expertise in explaining how a variety of interacting processes generate an organism's heterogeneous shapes, size and structural features that arise on the trajectory from embryo to adult or more generally throughout a life cycle. • Gain an understanding of		**Discipline Elective: Developmental Biology** **Unit 1: Introduction to developmental biology** • History, scope and applications of developmental biology. • Basic concepts: Phases of development, cell-cell interaction, pattern formation, differentiation and growth, differential gene expression, cytoplasmic determinants and asymmetric cell division. • Gametogenesis: spermatogenesis and oogenesis. Polarity and gradients. • Fertilization: Types, mechanism and theories. **Unit 2: Early embryonic development** • Cleavage: Definition, planes and patterns of cleavage, classification of cleavage based on distribution and amount of yolk. • Morulation, blastulation and gastrulation in ambhibia and birds. • Morphogenetic movements, embryonic induction and competence, primary organizers. **Unit 3: Late embryonic development** • Differentiation of germinal layers. • Method of organ formation: an overview of neural	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		systematic and organized learning about the knowledge and concepts of growth and development of organisms. • Demonstrate a rich array of material and conceptual practices that could be analysed to better understand the scientific reasoning exhibited in experimental life sciences.		tube formation, types of mesoderm, somite formation, endoderm and its derivatives in amphibians and birds. • Extra-embryonic membranes in birds, their development and functions. • Paedogenesis and neoteny in ambhibians. **Unit 4: Post embryonic development** • Metamorphic events and its hormonal regulations in amphibians. • Regeneration: types, regeneration of limbs in salamanders, regeneration of lost tail in lizard. • Introduction to senescence and apoptosis. **Unit 5: Implications of developmental biology** • Teratogenesis: Teratogenic agents and their effects on embryonic development. • Embryonic stem cells and their applications. • Cloning of animals: Nuclear transfer technique and embryo transfer technique. • *In vitro* fertilization, artificial insemination in cattle, amniocentesis. **Suggested Books** ➢ Balinsky, B.I. & Fabian, B.C. (1981). *An Introduction to Embryology* (5th ed.). International Thompson Computer Press. ➢ Carlson, B.M. (1999). *Patten's foundations in embryology*. (6th ed.). New York, USA: McGraw Hill. ➢ Chattopadhyay, S. (2017). *An introduction to developmental Biology*. Kolkata, India: Books and Allied. ➢ Gilbert, S.F. (2010). *Developmental Biology* (9th ed.). Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA. ➢ Kalthoff (2008). *Analysis of Biological Development* (2nd ed.). McGraw-Hill Publishers.	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				➢ Lewis, Wolpert (2002). *Principles of Development* (2nd ed.). Oxford University Press. ➢ Rastogi, V.B. & Jayaraj, M.S. (2005). Developmental Biology (A Text book of embryology). Kedar Nath Ram Nath Publisher, Meerut. **Suggested e-Resources:** **Developmental Biology** ➢ https://nptel.ac.in/courses/nptel_download.php?subjectid=102101068 ➢ http://cmb.i-learn.unito.it/mod/book/tool/print/index.php?id=3288	
6)	**Discipline Elective: Developmental Biology Lab**	On completion of the course, students will be able to • Understand the different stages of development of frog and chick through microscopic slides. • Understand the development and life cycle of *Drosophila* through microscopic slides.		**Discipline Elective: Developmental Biology Lab** 1. Study of whole mounts and sections of developmental stages of frog through permanent slides/charts/models: Eggs, cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpole (external and internal gill stages). 2. Study of whole mounts of developmental stages of chick through permanent slides/charts/models: Primitive streak (13 and 18 hours), 21, 24, 28, 33, 36, 48, 72, and 96 hours of incubation (Hamilton and Hamburger stages). 3. Study of the developmental stages and life cycle of *Drosophila* with the help of chart/specimen/models. **Suggested Books** ➢ Lal, S.S. (2015). *Practical Zoology: Vertebrates* (11th ed.). Meerut: Rastogi Publication. ➢ Verma, P.S. (2010). *A Manual of Practical Zoology: Chordates* (11th ed.). New Delhi: S Chand Publishing.	
7)	**Discipline Elective: Applied Zoology**	On completion of the course, students will be able to • Explore the important of		**Discipline Elective** **Unit-1** • **Parasitic protozoans:** Life history and pathogenicity of *Entamoeba histolytica*, *Plasmodium vivax*, *Giardia*, *Leishmania* and	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		earthworms in agro-ecosystems and utilize gained knowledge for production of vermicompost in small scale for garden/household plant. • Demonstrate their knowledge for setting up poultry farm, sericulture, apiculture, lacculture plant. • Understand biology, life cycle and control measures of crop pests, stored grain pests and insects serve as vectors for human diseases.		*Trypanosoma gambiense*. • **Parasitic Helminthes:** Life history and pathogenicity of *Ancylostoma duodenale* and *Wuchereria bancrofti*. **Unit-2** • **Insects of agriculture importance:** Biology, control and damage caused by crop pests (*Helicoverpa armigera, Pyrilla perpusilla, Papilio demoleus*) and stored grain pests (*Callosobruchus chinensis*, *Sitophilus oryzae* and *Tribolium castaneum*). • **Insects of medical importance and their control**: *Pediculus humanus corporis*, *Anopheles*, *Culex*, *Aedes*, *Xenopsylla cheopis*. **Unit 3** • **Apiculture:** Different species of honey bees, pollen calendar, bee keeping and management practices, honey extraction techniques, bee products, pests of honey bees and their control. • **Sericulture:** Different silkworm species and their host plants, silkworm rearing and management practices, pests of silkworms and their control. • **Lac culture:** Lac insect, culture practices, pests of lac insect and their control. **Unit 4** • **Aquaculture:** Types of fishery: Marine, inland. Composite fish culture, induced breeding and hybridization. Transportation of fish seed. Fish diseases and their control. • **Prawn culture:** Culture practices of giant fresh water prawn (*Macrobrachium rosenbergii*), biology and life history. • Pearl culture, pearl formation, composition, colour, size and quality of pearl. **Unit 5**	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				• **Vermiculture:** Definition, scope and importance, culture methods: indoors and out door, monoculture and polyculture, vermicomposting. • **Poultry farming:** Principles of poultry breeding, management of breeding stock and broilers, processing and preservation of eggs, diseases of poultry and their control. • **Animal Husbandry:** Preservation and artificial insemination in cattle, induction of early puberty and synchronization of estrus in cattle. **Suggested Books:** ➢ Arora, D.R & Arora, B. (2001). *Medical Parasitology* (2nd ed.). CBS Publications and Distributors. ➢ Atwal, A.S. (1986). *Agricultural Pests of India and South East Asia*, Kalyani Publishers. ➢ Dennis, H. (2009). *Agricultural Entomology*. Timber Press (OR). ➢ Dunham R.A. (2004). *Aquaculture and Fisheries Biotechnology Genetic Approaches*. CABI publications, U.K. ➢ Hafez, E.S.E. (1962). *Reproduction in Farm Animals*. Lea & Fabiger Publisher. ➢ Kumar and Corton. *Pathological Basis of Diseases*. ➢ Pedigo, L.P. (2002). *Entomology and Pest Management*, Prentice Hall. ➢ Sarkar, S., Kundu, G. & Chaki, K.K. (2014). *Introduction to Economic Zoology*. Kolkata: New Central Book Agency (P) Ltd. ➢ Shukla & Upadhyaya (1999-2000). *Economic Zoology*. Meerut: Rastogi Publishers. ➢ Venkitaraman (1983). *Economic Zoology*. Sudarsana Publishers. **Suggested e-Resources** **Sericulture**	

S No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				➢ https://swayam.gov.in/courses/152-silkworm-crop-protection	
8)	**Discipline Elective: Applied Zoology Lab**	On completion of the course, students will be able to • Understand the life cycle of protozoan and helminthes parasites through microscopic slides. • Explore the knowledge of life cycle of honey bees, silk moths and lac insects for setting up apiculture, sericulture and lac culture farm. • Gain an understanding of biology, life cycle and control of stored grain pests, crop pests and insect of medical importance.		**Discipline Elective:** **Applied Zoology Lab** 1. Study of life cycle of *Plasmodium vivax*, *Entamoeba histolytica*, *Giardia*, *Leishmania*, *Trypanosoma gambiense*, *Ancylostoma duodenale* and *Wuchereria bancrofti* through permanent slides/photomicrographs or specimens. 2. Study of different types of bees (Queens, drones and worker bees) permanent slides/photomicrographs or specimens. 3. Study of different types of silk moths (*Bombyx*, *Samia and Antheraea*) through permanent slides/photomicrographs or specimens. 4. Study of *Tachardia lacca* through permanent slides/photomicrographs or specimens. 5. Study of different types of pearls through photomicrographs or specimens. 6. Study of arthropod vectors associated with human diseases: *Pediculus*, *Culex*, *Anopheles*, *Aedes* and *Xenopsylla* through permanent slides/photomicrographs or specimens. 7. Study of some stored grains insect pests through damaged products/photographs. 8. Identifying feature and economic importance of *Helicoverpa (Heliothis) armigera*, *Papilio demoleus*, *Pyrilla perpusilla* and *Callosobruchus chinensis*. 9. Aquarium design and maintenance.	

[*] Matter in contrast (black background & white letters) is shifted to some other units, and material brought as a result of shift is also in contrast.
[#] Matter in square brackets, bold, italic and crossed is deleted.
[@] Proposed added materials are shaded in grey.

BANASTHALI VIDYAPITH

Department of Bioscience and Biotechnology

B. Tech BIOTECHNOLOGY PROGRAMME EDUCATIONAL OBJECTIVES

The B.Tech. Biotechnology programme aims at holistic development of the students through the unique and innovative five-fold Educational ideology of Banasthali Vidyapith.

Biotechnology is an applied discipline of biological science that makes use of living organisms, its components and biological processes to create products and other technology based systems for the welfare of mankind. Past few decades have witnessed a steady growth towards invention and innovation oriented research/startups using biotechnology. Thus, the B. Tech Biotechnology programme has been designed to provide fundamental knowledge of biotechnology and engineering, which can be applied by the students to pursue higher studies or in related industries, to find solutions related to process and product development. It will sensitize the students towards the societal, environmental and ethical issues being faced by a biotechnologist. The key objectives of the programme are:

- To provide fundamental theoretical and practical knowledge of biotechnology to pursue higher education and professional careers
- To help graduates to identify and analyze issues, which need biotechnological interventions and find solutions thereof
- To sensitizes students towards bioethics, IPR and biosafety issues
- To inculcate the habit of working in a team with interdisciplinary approach
- To develop scientific skills, temperament and communication skills, which will promote a lifelong learning
- To nurture overall growth and development of the students.

BANASTHALI VIDYAPITH
Department of Bioscience and Biotechnology
B. Tech. BIOTECHNOLOGY PROGRAMME OUTCOMES

PO1: Fundamental Knowledge: Acquire fundamental knowledge of engineering and biotechnology, which include Biochemistry, principles of chemical processes, data structures, biophysics and structural Biology, object oriented programming, recombinant DNA technology, basic bioinformatics, animal and plant biotechnology, genetics and foundations courses.

PO2: Planning ability: Demonstrate effective planning abilities including conceptual skills, interpersonal skills, decision making and problem solving skills, time and resource management and organizational skills.

PO3: Problem analysis: Identify, devise, review research literatures, and analyze biotechnological/engineering problems to find justifiable solutions.

PO4: Modern tool usage: Understand, select and apply suitable tools and techniques with proper methodology together with computational tools with an understanding of their limitations.

PO5: Leadership skills: Inculcate the habit of working in a team keeping individual identity and gradually develop leadership skills in a multidisciplinary setting.

PO6: Professional Identity: Apply logics gained through conceptual knowledge to carry out responsibilities relevant to the professional engineering practice.

PO7: Bioethics: Understand the ethical implications of biological research, honour personal values and apply in profession/research/society. Understand what is wrong and right, make decision and take responsibilities associated with the outcome.

PO8: Communication: Communicate effectively on intricate engineering/biotechnological issues with the engineering community and with society like, being able to interpret and write effective reports/ document, deliver effective presentations, and correspond through clear instructions.

PO9: The biotechnologist and society: Apply proper reasoning through fundamental concepts to assess societal, environmental, health, safety and legal issues and the consequent responsibilities relevant to the professional biotechnological practice.

PO10: Environment and sustainability: Understand the significance of ecosystem and its impact on living organisms and search for eco-friendly solutions for sustainable development.

PO11: Life- long learning: Recognize the necessity of independent and life-long learning, self assessment individual development through introspection and feedback from peers in the broadest context of technological change.

Department of Bioscience and Biotechnology, Banasthali Vidyapith
B. Tech. Biotechnology

Existing Courses					
B. Tech. Biotechnology I Sem.		**L**	**T**	**P**	**C**
BVF 002	Environmental Studies	2	0	0	2
	Or				
BVF 003	Indian Haritage	2	0	0	2
MATH 103	Calculus	3	1	0	4
	Or				
Math 107	Linear Algebra	3	1	0	4
PHY 101	Applied Optics	3	1	0	4
	Or				
PHY106	Modern Physics	3	1	0	4
CHEM 101	Chemistry	3	1	0	4
	Or				
BIO 101	Biology	3	1	0	4
CHEM 101	Thermodynamics	3	1	0	4
	Or				
PHY 105	Engineering Mechanics	4	0	0	4
CS 109	Computer Fundamentals and Programming	4	0	0	4
CS 109L	Computer Fundamentals and Programming Lab	0	0	4	2
	Or				
EEE 101	Electrical Engineering	4	0	0	4
EEE 101L	Electrical Engineering Lab	0	0	4	2
ENGG 101L	Engineering Drawing and Graphics Lab	0	0	6	3
	Or				
ENGG 102L	Measurement Techniques Lab	0	0	6	3
	Total	**19**	**4**	**10**	**27**

Proposed Courses					
B. Tech. Biotechnology I Sem.		**L**	**T**	**P**	**C**
	General English / General Hindi	2	0	0	2
	Core Foundation Course - I	2	0	0	2
MATH 103/107	Calculus/Linear Algebra	3	1	0	4
PHY 101/106	Applied Optics/Modern Physics	3	1	0	4
CHEM 101/ BIO 101	Chemistry/Biology	3	1	0	4
CHE 101/ PHY 105	Thermodynamics/Engineeering Mechanics	3	1	0	4
CS 109/EEE 101	Computer Fundamentals & Programming/Electrical Engineering	4	0	4	6
ENGG 101L/ENGG 102L	Engineering Drawing & Graphics/ Measurement Techniques Lab	0	0	6	3
	Semester Wise Total:	**20**	**4**	**10**	**29**

Existing Courses					
B. Tech. Biotechnology II Sem.		**L**	**T**	**P**	**C**
BVF 003	Indian Heritage	2	0	0	2
	Or				
BVF 002	Environmental Studies	2	0	0	2
Math 107	Linear Algebra	3	1	0	4
	Or				
MATH 103	Calculus	3	1	0	4
PHY106	Modern Physics	3	1	0	4
	Or				
PHY 101	Applied Optics	3	1	0	4
BIO 101	Biology	3	1	0	4
	Or				
CHEM 101	Chemistry	3	1	0	4
PHY 105	Engineering Mechanics	4	0	0	4
	Or				
CHEM 101	Thermodynamics	3	1	0	4
EEE 101	Electrical Engineering	4	0	0	4
EEE 101L	Electrical Engineering Lab	0	0	4	2
	Or				
CS 109	Computer Fundamentals and Programming	4	0	0	4
CS 109L	Computer Fundamentals and Programming Lab	0	0	4	2
ENGG 102L	Measurement Techniques Lab	0	0	6	3
	Or				
ENGG 101L	Engineering Drawing and Graphics Lab	0	0	6	3
	Total	**19**	**4**	**10**	**27**

Proposed Courses					
B. Tech. Biotechnology II Sem.		**L**	**T**	**P**	**C**
	General Hindi/General English	2	0	0	2
	Core Foundation Course - II	2	0	0	2
MATH 107/103	Linear Algebra/Calculus	3	1	0	4
PHY 106/101	Modern Physics/Applied Optics	3	1	0	4
BIO 101/ CHEM 101	Biology/Chemistry	3	1	0	4
PHY 105/ CHE 101	Engineeering Mechanics/Thermodynamics	3	1	0	4
EEE 101/CS 109	Electrical Engineering / Computer Fundamentals & Programming	4	0	4	6
ENGG 101L/ENGG 102L	Measurement Techniques Lab /Engineering Drawing & Graphics	0	0	6	3
	Semester Wise Total:	**20**	**4**	**10**	**29**

Existing Courses					
B. Tech. III Sem.		**L**	**T**	**P**	**C**
BVF 007R	Selected Writing for Self Study -I	2	0	0	2
	Course Choice - 1	3/4	0	0	3/4
	Course Choice - 2	4	0	0	4
	Course Choice - 3	3	0	0	3
CHEM 202	Principles of Chemical Processes	3	1	0	4
BT 201	Biochemistry	3	1	0	4
BT 204L	Biotechnology Lab-I	0	0	4	2
BT208S	Seminar	0	0	2	1
CS 209	Data Structure	4	0	0	4
CS 209L	Data Structure Lab	0	0	4	2
	Total	**22/23**	**2**	**10**	**29/30**

Proposed Courses					
B. Tech. III Sem.		**L**	**T**	**P**	**C**
	Core Foundation Course - III	2	0	0	2
	Elective Foundation Course - I	2	0	0	2
MATH 207/208	Complex Variables/Differential Equations	3	1	0	4
ENGG 201/202	Structure and Properties of Materials/Basic Electronics	4	0	0	4
CS 209	Data Structures	4	0	4	6
CHEM 202	Principles of Chemical Processes	3	1	0	4
BT 201	Biochemistry	3	1	0	4
BT 208S	Seminar	0	0	2	1
BT 204L	Biotechnology Lab-I	0	0	4	2
	Semester Wise Total:	**21**	**3**	**10**	**29**

Existing Courses					
B. Tech. IV Sem.		**L**	**T**	**P**	**C**
BVF 008R	Selected Writing for Self Study -I	2	0	0	2
	Course Choice - 1	4/3	0	0	4/3
	Course Choice - 2	4	0	0	4
	Course Choice - 3	3	0	0	3
BT 203	Biophysics and Structural Biology	3	1	0	4
BT 206	Cell and Molecular Biology-II	3	1	0	2
BT 205L	Biotechnology Lab-II	0	0	4	2
CS 214	Object Oriented Programming	4	0	0	4
CS 214L	Object Oriented Programming Lab	0	0	4	2
		23/22	**2**	**8**	**29/28**
	Course Choice - 1				
MATH 207	Complex Variables	3	0	0	3
Math 208	Differential Equations	4	0	0	4
	Course Choice - 2				

Proposed Courses					
B. Tech. IV Sem.		**L**	**T**	**P**	**C**
	Core Foundation Course - IV	2	0	0	2
	Elective Foundation Course - II	2	0	0	2
MATH 208/207	Differential Equations/Complex Variables	3	1	0	4
ENGG 202/201	Basic Electronics/Structure and Properties of Materials	4	0	0	4
CS 214	Object Oriented Programming	4	0	4	6
BT 203	Biophysics and Structural Biology	3	1	0	4
BT 206	Cell and Molecular Biology-II	3	1	0	4
BT 205L	Biotechnology Lab-II	0	0	4	2
	Semester Wise Total:	**21**	**3**	**8**	**28**

ENGG 201	Structure and Properties of Materials	4	0	0	4
ENGG 202	Basic Electronics	4	0	0	4
	Course Choice - 3				
MGMT 209	Entrepreneurship	3	0	0	3
TSKL 203	Technical Report Writing	3	0	0	3
	Course Choice - 1				
Math 208	Differential Equations	4	0	0	4
MATH 207	Complex Variables	3	0	0	3
	Course Choice - 2				
ENGG 202	Basic Electronics	4	0	0	4
ENGG 201	Structure and Properties of Materials	4	0	0	4
	Course Choice - 3				
TSKL 203	Technical Report Writing	3	0	0	3
MGMT 209	Entrepreneurship	3	0	0	3

Existing Courses					
B. Tech. V Sem.		**L**	**T**	**P**	**C**
FC 5.1	Course Choice -1	3	0	0	3
BT 5.1	Course Choice -2	3	0	0	3
BT 5.6	Microbiology & Immunology	3	1	0	4
BT 5.5	Metabolic Engineering	3	1	0	4
BT 5.4	Genetics & Genetic Engineering	3	1	0	4
BT 5.3	Enzyme Engineering & Technology	3	1	0	4
BT 5.7	Seminar	0	0	4	2
BT 5.2	Biotechnology Lab-III	0	0	8	4
	Total	**18**	**4**	**12**	**28**
	Course Choice - 1				
FC 5.1	Parenthood and Family Relation	3	0	0	3
FC 5.2	Women in Indian Society	3	0	0	3
	Course Choice - 2				
BT 5.8	Economics For Engineers	3	0	0	3
BT 5.9	Principles for Management	3	0	0	3

Proposed Courses					
B. Tech. V Sem.		**L**	**T**	**P**	**C**
	Vocational Course - I	2	0	0	2
	Core Foundation Course - V/Elective Foundation Course - III	2	0	0	2
	Economics/Principles of Management	3	0	0	3
	Probability and Statistical Methods	3	1	0	4
BT 310	Microbiology and Immunology	3	1	0	4
BT 309	Metabolic Engineering	3	1	0	4
BT 308	Genetics and Genetic Engineering	3	1	0	4
BT 303L	Biotechnology Lab-III	0	0	8	4
	Semester Wise Total:	**19**	**4**	**8**	**27**

Existing Courses					
B. Tech. VI Sem.		**L**	**T**	**P**	**C**
FC 6.1	Course Choice -3	3	0	0	3
BT 6.1	Course Choice -4	3	0	0	3
BT 6.2	Basic Bioinformatics	3	1	0	4
BT 6.3	Bioprocess Engineering	3	1	0	4
BT 6.5	Cell and Tissue Culture Technology	3	1	0	4
BT 6.6	Recombinant DNA Technology	3	1	0	4
BT 6.4	Biotechnology Lab-IV	0	0	8	4
BT 6.7	Analytical Techniques	3	1	0	4
BT 6.8	Analytical Techniques Lab	0	0	4	2
		21	**5**	**12**	**32**
	Course Choice - 3				
FC 5.2	Women in Indian Society	3	0	0	3
FC 5.1	Parenthood and Family Relation	3	0	0	3
	Course Choice - 4				
BT 5.9	Principles for Management	3	0	0	3
BT 5.8	Economics For Engineers	3	0	0	3

Proposed Courses					
B. Tech. VI Sem.		**L**	**T**	**P**	**C**
	Vocational Course - II	2	0	0	2
	Elective Foundation Course - III/Core Foundation Course - V	2	0	0	2
	Principles of Management/Economics	3	0	0	3
CHEM 301	Analytical Techniques	3	1	0	4
CHEM 301L	Analytical Techniques Lab	0	0	4	2
BIN 301	Basic Bioinformatics	3	1	0	4
BT 302	Bioprocess Engineering	3	1	0	4
BT 311	Recombinant DNA Technology	3	1	0	4
BT 304L	Biotechnology Lab-IV	0	0	8	4
	Semester Wise Total:	**19**	**4**	**12**	**29**

Existing Courses					
B. Tech. VII Sem.					
BT7.1	Reading Elective*	0	2	0	2
BT7.2	Project	0	0	50	25
	Total	**0**	**2**	**50**	**27**
	Reading Elective*				
BT 7.1 1.	Plant Genetic Engineering*	0	2	0	2
BT 7.1.2	Renewable Energy Resources*	0	2	0	2

Proposed Courses					
B. Tech. VII Sem.					
BT	Project	0	0	48	24
BT	Reading Elective	0	0	0	2
	Semester Wise Total:	**0**	**0**	**48**	**26**

Existing Courses					
B. Tech. VIII Sem.		**L**	**T**	**P**	**C**
BT 8.1	Animal Biotechnology	3	1	0	4
BT 8.2	Bioethics and Biosafety	3	1	0	4
BT 8.4	Environmental Biotechnology	3	1	0	4
BT 8.5	Plant Biotechnology	3	1	0	4
BT 8.6	Elective*	3	1	0	4
BT 8.3	Biotechnology Lab-V	0	0	8	4
	Total	**15**	**5**	**8**	**24**
	Elective*				
BT 8.6	1. Biomedicial Engineering*	3	1	0	4
BT 8.6	2. Food and Dairy Biotechnology*	3	1	0	4
BT 8.6	3. Genomics and Proteomics*	3	1	0	4
BT 8.6	4. Immuno - Technology*	3	1	0	4
BT 8.6	5. Microbial Technology*	3	1	0	4
BT 8.6	6. Molecular Modelling and Drug Designing*	3	1	0	4
BT 8.6	7. Nanotechnology*	3	1	0	4
BT 8.6	8. Plant Secondary Metabolites*	3	1	0	4

Proposed Courses					
B. Tech. VIII Sem.		**L**	**T**	**P**	**C**
BT	Animal Biotechnology	3	1	0	4
BT	Environmental Biotechnology	3	1	0	4
BT	Plant Biotechnology	3	1	0	4
	Biotechnology Lab-V	0	0	8	4
	Discipline Elective	4	0	0	4
	Open Elective	4	0	0	4
	Semester Wise Total:	**17**	**3**	**8**	**24**

(red)	Course discontinued
(yellow)	Course revised
(orange)	Course shifted to/ from different semester
(green)	New Course introduced
(light green)	Core course shifted to elective course

	Proposed List of Electives to be offered in the VIII Semester
BT	Biomedicial Engineering
BT	Food and Dairy Biotechnology
BT	Genomics and Proteomics
BT	Immunotechnology
BT	Microbial Technology
BT	Molecular Modelling and Drug Designing
BT	Nanotechnology
BT	Plant Secondary Metabolites
	Geoinformatics
BT	Bioethics and Biosafety
BT	Enzyme Engineering and Technology
	Bioreactor https://swayam.gov.in/course/1339-bioreactors
	Principles of Downstream techniques in Bioprocess http://nptel.ac.in/syllabus/102106048/
	Industrial Biotechnology https://www.coursera.org/learn/industrial-biotech

	Proposed List of Reading Electives to be offered in the VIII Semester
BT	Molecular Diagnostics
BT	Biodiversity and Conservation
BT	Emerging Trends in Biofuel Technology
BT	Drug Discovery https://www.coursera.org/learn/drug-discovery
BT	Proteins and Gel-Based Proteomics https://swayam.gov.in/course/1386-proteins-and-gel-based-proteomics
	Online course on IPR http://www.ili.ac.in/e-learnIPR.htm

Proposed List of Core Foundation Courses	**L**	**T**	**P**	**C**
Environment Studies	2	0	0	2
Indian Heritage/Indial Cultural Heritage	2	0	0	2
Selected Writings of Great Authors - I	2	0	0	2
Women in Indian Society	2	0	0	2
Parenthood and Family Relation	2	0	0	2

Proposed List of Elective Foundation Courses	**L**	**T**	**P**	**C**
Science of Happiness	2	0	0	2
Human Anatomy and Physiology	2	0	0	2
Design Thinking	2	0	0	2
Basic Human Values	2	0	0	2
Selected Writings of Great Authors - II	2	0	0	2

Proposed List of Vocational Course				
Basic Dress Making	0	0	4	2
Dress Designing	0	0	4	2
Entrepreneurship - I	2	0	0	2
Entrepreneurship - II	2	0	0	2
Radio Production - I	2	0	0	2
Radio Production - II	2	0	0	2
Web Designing & Internet Technology-I	1	0	2	2
Web Designing & Internet Technology-II	1	0	2	2
Library Science - I	1	0	2	2
Library Science - II	1	0	2	2
Photography - I	2	0	0	2
Photography - II	2	0	0	2

Comparative Table: B. Tech. Biotechnology: Existing and Modified syllabus, Suggested Books and Suggested e-Resources

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
	B. Tech. Biotechnology I/II Semester				
1)	**BIO 101** Biology	After successful completion of the course, students should be able to: • Understand the basic organization and classification of living organisms • Describe fundamental cellular functions • Learn the basic concept of molecular biology and recombinant DNA technology	**Section A** **Brief idea of origin of life:** ~~**Living Organisms:**~~ Classification, Five kingdoms, Viruses, (TMV, HIV, Bacteriophages), Prokaryote (Bacteria, cell structure, ~~nutrition~~); Protista, Plantae (~~Bryophyte, Pteridophyte Gymnosperm and Angiosperm~~) and Animalia. ~~**Structural Organization in Plants and Animals:**~~ Morphology, ~~anatomy~~ and functions of different parts of flowering plants: Root, stem, leaf, inflorescence, flower, fruit and seed. ~~Morphology, anatomy~~ and functions of different systems of humans. **Section B** ~~**Cell :**~~ The cell concept, prokaryotic and eukaryotic cell, plant and animal cell. Cell organelles and their functions ~~**Biomolecules :**~~ Brief introduction and significance of Carbohydrates, lipids, proteins and enzymes. ~~**Genetics:**~~ Mendelian inheritance. Chromosome theory of inheritance, deviations from mendelian ratio (~~gene gene interaction~~ Incomplete dominance, co-dominance, complementary genes, multiple alleles). Linkage and crossing over, Sex determination, Sex linked inheritance, genetic counseling. **Section C** ~~**Molecular Biology:**~~ Structure and replication of DNA, Structure of RNA. A brief concept of transcription and translation in prokaryotes and comparison with eukaryotes. Genetic code, ~~Genomics~~ and Human Genome Project. ~~DNA fingerprinting~~. Applications of Recombinant DNA Technology ~~in Health, Agriculture and Industries, Genetically modified (GM) organisms.~~ Biosafety issues. **Books Recommended:** ➢ Campbell, Biology, Pearson Education. ➢ J. W. Stroke, L. P. Renouf, Fundamental of Biology.	**Section A** • Brief idea of origin of life, Viruses (TMV, HIV, Bacteriophages), overview and brief introduction to five kingdom classification, characteristic features of Protista, Plantae and Animalia. • Morphology and functions of different parts of flowering plants: Root, stem, leaf, major inflorescence (Spike, Raceme, Corymb and Umbel), flower, fruit and seed. • Brief about the components and functions of different systems of humans. **Section B** • The cell concept, prokaryotic (Bacteria, cell structure) and eukaryotic cell (plant and animal cell). Cell organelles and their functions. • Brief introduction and significance of carbohydrates, lipids, proteins and enzymes. • Mendelian inheritance chromosome theory of inheritance, deviations from Mendelian ratio (Incomplete dominance, co-dominance, complementary genes, multiple alleles). Linkage and crossing over, sex determination, sex linked inheritance, genetic counseling. **Section C** • Structure and replication of DNA, structure of RNA and brief concept of transcription and translation in prokaryotes and comparison with eukaryotes, Genetic code, Basic concept of recombinant DNA Technology and its applications. Overview of Human Genome Project, Biosafety issues. **Suggested Books:** ➢ Green, N. P. O., Stout, G. W., Taylor, D. J. & Soper, R. (2005). *Biological Sciences*. Cambridge University	The content of the Section A has been streamlined because earlier it was quite lengthy. The topics have been sub-categorized. Topics shifted from Section A Contents have been rearranged properly.

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ N. B. Inamdar, P. J. Dyeash, Fundamental of Life Sciences	Press. ➢ Reece, J. B., Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V., & Jackson, R.B. (2013). *Campbell Biology*. Pearson Publisher, India. **Suggested e-Resources:** ➢ **Structural organization of plants and animals** https://www.emedicalprep.com/study-material/biology/structural-organization-in-plants-and-animals/ ➢ **Morphology, anatomy and functions of different systems of humans:** https://www.khanacademy.org/science/high-school-biology/hs-human-body-systems/hs-body-structure-and-homeostasis/a/tissues-organs-organ-systems ➢ **Basic concept of cell** https://biologydictionary.net/cell/ ➢ **Gene-gene interaction** http://www.biologydiscussion.com/genetics/gene-interactions/gene-interactions-allelic-and-non-allelic-cell-biology/38795 ➢ **Human genome project** https://www.genome.gov/12011238/an-overview-of-the-human-genome-project/ ➢ **Application of recombinant DNA technology:** https://medcraveonline.com/JABB/JABB-01-00013	
2)	**ENGG 102L:** Measurement Technique Lab	After successful completion of the course, students should be able to: • Demonstrate an understanding of different adulteration and qualitative analysis of biomolecules	**Biology** 1. To test for adulteration in turmeric, wheat flour, ghee and milk. 2. Qualitative analysis of nitrate, carbonate and replaceable base deficiency in soil samples. 3. Determination of soil pH. 4. Biochemical test for sugar, albumin and ketone bodies in urine samples. 5. ~~Tests for Proteins: Biuret's Test, Million's Test, Ninhydrin Test~~	**Biology** 1. To test for adulteration in turmeric, wheat flour, ghee and milk. 2. Qualitative analysis of nitrate, carbonate and replaceable base deficiency in soil samples. 3. Determination of soil pH. 4. Biochemical test for sugar, albumin and ketone bodies in urine samples. 5. Biochemical tests for lipids and cholesterol. 6. Detection of Vitamin A in the given sample.	

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		• Develop understanding working with microscope • Learn a basic concept of plant identification and vegetational analysis • Gain hands on training to check purity of biomolecules	6. Detection of Vitamin A in the given sample. 7. Study of typical prokaryotic and eukaryotic cells with the help of a microscope. 8. ~~Study of different cell organelles with the aid of prepared slides: nucleus, mitochondria, golgi bodies, endoplasmic reticulum, ribosomes, polytene and lampbrush chromosomes.~~ 9. Gram staining to identify gram positive and gram negative bacteria 10. Description of plant identification. 11. Vegetational analysis by Quadrat method. 12. ~~Determination of blood group and Rh factor.~~ 13. ~~Determination of total R.B.C. and W.B.C.~~ 14. ~~Haemoglobin estimation.~~	7. Study of typical prokaryotic and eukaryotic cells with the help of a microscope. 8. Gram staining to identify gram positive and gram negative bacteria 9. Description of plant identification (Neem, Babool, Peeli Kaner, Tulsi & Chandani, Aak/ Madar). 10. Vegetational analysis by Quadrat method. 11. Determination of concentration and purity of DNA 12. Determination of concentration and purity of RNA 13. Preparation of stained temporary mount of onion peel **Suggested Books:** ➢ Biradar, V.K., & Samshe, A. (2016). *Practical Biochemistry*. New Delhi: APH Publishing Corporation. ➢ Sharma, S., & Sharma, R. (2016). *Practical Manual of Biochemistry* (2^{nd} ed.). New Delhi: Medtech. ➢ Vats, S. (2015). A laboratory Text book of Biochemistry, Molecular Biology and Microbiology. Germany: GRIN Verlag. ➢ Yadav, V.K., & Yadav, N. (2018). *Biochemistry & Biotechnology: A Laboratory Manual*. Jaipur: Pointer Publisher.	More relevant experiments have been added.
	B. Tech. Biotechnology III Semester				
3)	**BT 201** Biochemistry	After successful completion of the course, students should be able to: • Learn about the biomolecules forming the cellular structure • Identify and compare the various biochemical pathways and their use	**Section A** Carbohydrates: Classification, structure and properties, glycolysis and fermentation and their regulations, gluconeogenesis and glycogenolysis, metabolism of galactose and galactosemia, pentosephosphate pathway. Citric Acid Cycle: Significance, reactions and energetics of the cycle, amphibolic role of the cycle. Glyoxylic acid cycle Enzymes: Nomenclature, classification, characteristics, enzyme kinetics and its mechanism of action, mechanism of inhibition, enzymes and iso-enzymes in clinical diagnosis. Co-enzymes and Cofactors: Role of Vitamins, metals ions,	**Section A** • Carbohydrates: Classification, structure and properties, glycolysis and fermentation and their regulations, gluconeogenesis and glycogenolysis, metabolism of galactose and galactosemia, pentosephosphate pathway. Citric Acid Cycle: Significance, reactions and energetics of the cycle, amphibolic role of the cycle, Glyoxylic acid cycle • Enzymes: Nomenclature, classification, characteristics, enzyme kinetics and its mechanism of action, mechanism of inhibition, enzymes and iso-enzymes in clinical diagnosis. Co-enzymes and Cofactors: Role of Vitamins, metals ions, significance.	Typographical corrections only

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		• Translate skills in research, quality control, production and diagnostics	significance. **Section B** Lipids: Classification, structure and properties of lipids. Oxidation of fatty acids, α-oxidation and its energetics, α-oxidation of fatty acids, α-oxidation. Biosynthesis of ketone bodies and their utilization, biosynthesis of saturated and unsaturated fatty acids, control of lipid metabolism, essential fatty acids and eicosanoids, phospholipids and sphingolipids. Proteins and Metabolism of Amino acids: Classification, structure and properties, Nitrogen balance, biosynthesis of amino acids, catabolism of amino acids, conversion of amino acids to specialized products. Biological Oxidation: Redox-potential, the respiratory chain, its role in energy capture and its control. Energetics of oxidative phosphorylation, inhibitors of respiratory chain and oxidative phosphorylation, Chemiosmotic coupling theory and mechanism of ATP production in oxidative phosphorylation. **Section C** Metabolism of Ammonia and Nitrogen containing Monomers: Assimilation of ammonia, urea cycle, metabolic disorders of urea cycle, porphyrin biosynthesis, formation of bile pigments, hyperbilirubinemia, purine biosynthesis, purine nucleotides interconversion, pyrimidine biosynthesis, formation of deoxyribonucleotides. Nucleic acids: Structure of DNA and RNA, Brief introduction of genetic organization of the mammalian genome, alteration and rearrangements of genetic material, Genetic code, transcription and translation, replication of DNA, mutation, physical and chemical mutagenesis / carcinogenesis, DNA repair mechanism, biosynthesis of tRNA and rRNA. **Books Recommended:** ➢ Principles of Biochemistry: A.L. Lehninger, Nelson and	**Section B** • Lipids: Classification, structure and properties of lipids. Oxidation of fatty acids, beta oxidation and its energetics, alpha oxidation of fatty acids, omega oxidation. Biosynthesis of ketone bodies and their utilization, biosynthesis of saturated and unsaturated fatty acids, control of lipid metabolism, essential fatty acids and eicosanoids, phospholipids and sphingolipids. • Proteins and Metabolism of Amino acids: Classification, structure and properties, Nitrogen balance, biosynthesis of amino acids, catabolism of amino acids, conversion of amino acids to specialized products. • Biological Oxidation: Redox-potential, the respiratory chain, its role in energy capture and its control. Energetics of oxidative phosphorylation, inhibitors of respiratory chain and oxidative phosphorylation, chemiosmotic coupling theory and mechanism of ATP production in oxidative phosphorylation. **Section C** • Metabolism of Ammonia and Nitrogen containing Monomers: Assimilation of ammonia, urea cycle, metabolic disorders of urea cycle, porphyrin biosynthesis, formation of bile pigments, hyperbilirubinemia, purine biosynthesis, purine nucleotides interconversion, pyrimidine biosynthesis, formation of deoxyribonucleotides. • Nucleic acids: Structure of DNA and RNA, brief introduction of genetic organization of the mammalian genome, alteration and rearrangements of genetic material, Genetic code, transcription and translation, replication of DNA, mutation, physical and chemical mutagenesis / carcinogenesis, DNA repair mechanism, biosynthesis of tRNA and rRNA. **Suggested Books:** ➢ Berg, J.M., Tymoczko, J.L., Gatto Jr., G.J & Stryer, L. (2015). *Biochemistry* (8^{th} ed.). W.H. Freeman and	

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			Cox, McMillan Worth Publishers. ➢ Biochemistry: Voet and Voet, John Wiley and Sons, Inc. USA. ➢ Biophysical Chemistry Vol. I, II & III: Cantor and Schimel, Freeman. ➢ Biochemistry: Zubey, WCB. ➢ Biochemistry: Garrett and Grisham, Harcourt. ➢ Biochemistry: Stryer, W. H. Freeman. ➢ Understanding Enzymes: T. Palmer, Horwood. ➢ Harper's review of Biochemistry: R.K. Murray et al., Prentice-Hall International Inc. ➢ Fundamentals of Biochemistry: Cohn and Stumf.	Company. ➢ Garrett, R. H. & Grisham, C. M. (2012). *Biochemistry* (5th ed.).Wadsworth Publishing Co Inc. ➢ Nelson, D. L. & Cox, M.M. (2012). *Lehninger Principles of Biochemistry* (6th ed.). W.H. Freeman. ➢ Palmer, T (2004). Enzymes: *Biochemistry, Biotechnology and Clinical Chemistry* (Horwood Chemical Science) Reprint Edition. Albion. ➢ Rodwell, V.W., Bender, D., Botham, K.M., Kenelly, P.J., & Weil., P.A. (2018). *Harper's illustrated Biochemistry* (31st ed.). McGraw-Hill Education / Medical. ➢ Voet, D. & Voet, J.G.(2010). *Biochemistry* (4th ed). Wiley. **Suggested e-Resources** ➢ **Metabolic pathways, Biomolecules** https://epgp.inflibnet.ac.in/ahl.php?csrno=2 ➢ **Glycolysis** https://www.khanacademy.org/science/biology/cellular-respiration-and-fermentation/glycolysis/a/glycolysis ➢ **Mechanism of enzyme action** http://www.biologydiscussion.com/enzymes/enzymes-properties-and-mechanism-of-enzyme-action/6145 ➢ **Enzyme action** http://chemistry.elmhurst.edu/vchembook/571lockkey.html	
4)	**CHEM 203** Principles of Chemical Processes	After successful completion of the course, students should be able to: • Understand basic concept of biochemical equation and material balance • Develop concept of energy balance,	**Section A** Basic Concepts, Units and Dimensions, Basic chemical calculations, Steady state and dynamic processes, Lumped and distributed processes, Single and multiphase systems. Types of Variables, Intensive and extensive variables, Specific properties, State Variables. Types of Equation: Mass and energy conservation, equilibrium relations. **Section B** Process Classification, material balances for steady state processes, properties of gases, liquids and solids, equations	**Section A** • Basic Concepts, Units and Dimensions, Basic chemical calculations, Steady state and dynamic processes, Lumped and distributed processes, Single and multiphase systems. • Types of Variables, Intensive and extensive variables, Specific properties, State Variables. Types of Equation: Mass and energy conservation, equilibrium relations. **Section B** • Process Classification, material balances for steady state processes, properties of gases, liquids and solids,	Typographical corrections only

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		thermodynamic approaches, unit operations • Apply the gained knowledge in bioprocess industries	of state, phase equilibria for ideal mixtures, Reactions and stoichiometry, Non-Reacting single phase systems; Single and multiple units without recycle, with recycle, bypass and purge, Non-Reacting multiphase systems. **Section C** Processes involving vaporization and condensation, reacting systems. Energy Balances for Steady State Processes: Specific heat capacity, Enthalpy, Heat of reaction, Thermo chemistry, Isothermal systems, Adiabatic Systems, Simultaneous material and energy balances. Unsteady State Material Balances, Reaction rate laws, Introduction to Modeling simulation for chemical processes: Basic idea about Model representation, types of modeling equations, types of mathematical models: Linear model vs nonlinear model, Static model vs dynamic model, Lumped parameter model vs Distributed model and Fundamental model vs empirical model, role of computer simulation in chemical processes. **Books Recommended:** ➢ Chemical Process Principles (Vol. 1): Hougan D. A., Watson K.M. and Ragatz R. A., Asia Publishing House. ➢ Basic Principles and Calculation in Chemical Engineering: Himmelblau, D.M, Prentice Hall ➢ Stoichimetry: Bhatt B.L.Vora, S.M, Tata McGraw Hill Publishing Co. Ltd., New Delhi ➢ Process Calculations for chemical engineers Chemical Engineering development Centre, Madras ➢ Elementary Principles of Chemical Processes, 2nd Ed.: Felder, R.M. Rousseau, R.W., John Wiley & Sons. ➢ Introduction to Material and energy balances: Reklaitis, G.V., John Wiley & sons ➢ Industrial Stoichimetry: Lewis, W.K. Radasch, A.H. Lewis, HC, McGraw Hil ➢ Chemical Process Analysis Mass and Energy Balance:	equations of state, phase equilibria for ideal mixtures. • Reactions and stoichiometry, Non-Reacting single phase systems; single and multiple units without recycle, with recycle, bypass and purge, Non-Reacting multiphase systems. **Section C** • Processes involving vaporization and condensation, reacting systems. • Energy Balances for Steady State Processes: specific heat capacity, enthalpy, heat of reaction, thermo chemistry, isothermal systems, adiabatic Systems, simultaneous material and energy balances. • Unsteady State Material Balances, reaction rate laws, Introduction to modeling and simulation for chemical processes: Basic idea about model representation, types of modeling equations, Types of mathematical models: linear model vs nonlinear model, static model vs dynamic model, lumped parameter model vs distributed model and fundamental model vs empirical model, role of computer simulation in chemical processes. **Suggested Books:** ➢ Bailey, J.E., & Ollis, D.F. (1944). *Biochemical Engineering Fundamentals* (2nd ed.). New York: McGraw-Hill Book company. ➢ Bhatt, B.I., & Vora, S.M. (2008). *Stoichiometry* (4th ed.). New Delhi: Tata McGraw-Hill Publishing Company Limited. ➢ Dutta, R. (2007). *Fundamentals of Biochemical Engineering*. Ane Books India. ➢ Felder, R.M., & Rousseau, R.W. (2000). *Elementary Principles of Chemical Processes* (3rd ed.). Wiley India. ➢ Jana, A.K. (2008). *Chemical process Modelling and computer Simulation*. New Delhi: Prentice Hall of India private Limited. **Suggested e-Resources:** ➢ **Energy Balance**	

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			Luben W.L. and Wenzel, L.A., Prentice Hall.	https://www.che.iitb.ac.in/faculty/madhu/CL152/Handouts/Handout%206.pdf ➢ **Lumped and Distributed model** http://web.engr.oregonstate.edu/~traylor/ece391/Andreas_slides/ECE391-S14-Lect1-web.pd	
5)	**BT 204L** Biotechnology Lab-I	After successful completion of the course, students should be able to: • Gain hand on training to quantitavely analyze biomolecules • Demonstrate an understanding analyze biomolecules spectrophotometrically • Hands on training on measuring techniques • Solve problems for mass balance and energy balance and equations numerically	**Biochemistry** 1. Estimation of proteins by Lowry's and TCA methods. 2. Estimation of carbohydrates : Total sugars by Anthrone method 3. Reducing sugars by Nelson Somogyi method 4. Estimation of serum cholesterol. 5. Preparation and purification of casein from buffalo milk. ~~6. Determination of Logic properties (pH value of blysine by titration).~~ 7. To find λmax for proteins. 8. To find λmax for nucleic acids. **Principles of Chemical Processes Lab** 9. Experiments based on measuring techniques – 10. Measurement of temperature by Thermocouple 11. Measurement of pressure by Manometer 12. Measurement of RPM 13. Determination of mass flow rate. 14. Calculation of TOC and ThOD of organic compounds present in the solution. 15. Mass balance problems. 16. Energy balance problems. ~~17. Computer aided programme based on~~ Newton-Raphson ~~method.~~	**Biochemistry** 1. Estimation of proteins by Lowry's and TCA methods. 2. Estimation of carbohydrates : Total sugars by Anthrone method 3. Reducing sugars by Nelson Somogyi method 4. Estimation of serum cholesterol. 5. Preparation and purification of casein from buffalo milk. 6. Determination of titrable acidity of milk. 7. To find λ_{max} for proteins. 8. To find λ_{max} for nucleic acids. **Principles of Chemical Processes** Experiments based on measuring techniques : 9. Measurement of temperature by Thermocouple. 10. Measurement of pressure by Manometer. 11. Measurement of RPM. 12. Determination of mass flow rate. 13. Calculation of TOC and ThOD of organic compounds present in the solution. 14. Mass balance problems. 15. Energy balance problems. 16. Newton Raphson (NR) optimization. **Suggested Books:** ➢ Biradar, V.K., & Samshe, A. (2016). *Practical Biochemistry*. New Delhi: APH Publishing Corporation. ➢ Kumar, A., Garg, S., & Garg, N. (2017). *Biochemical Tests: Principles & Protocols*. New Delhi: Viva Books.-all ➢ Saxena, J., Baunthiyal., & Ravi, I. (2015). *Laboratory Manual of Microbiology, Biochemistry and Molecular Biology*. Jodhpur: Scientific Publishers.	The practical is shifted to the IV Semester and new experiment has been added Experiment has been revised

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				➢ Sharma, S., & Sharma, R. (2016). *Practical Manual of Biochemistry* (II Ed.). New Delhi: Medtech. ➢ Shuler, M.L., & Kargi, F. (2002). *Bioprocess Engineering Basic Concepts* (2^{nd} ed,). Prentice Hall PTR Upper Saddle River, NJ, USA. ➢ Vats, S. (2015). *A laboratory Text book of Biochemistry, Molecular Biology and Microbiology*. Germany: GRIN Verlag. ➢ Yadav, V.K., & Yadav, N. (2018). *Biochemistry & Biotechnology: A Laboratory Manual*. Jaipur: Pointer Publisher.	
	B. Tech. Biotechnology IV Semester				
6)	**BT 203** Biophysics and Structural Biology	After successful completion of the course, students should be able to: • Develop a basic understanding of molecular and quantum mechanics in studying biomolecules • Solve questions of macromolecular folding and interactions. • Understand the molecular processes behind locomotion, neuronal signaling and vision.	**Section A** • Elements of Quantum Mechanics: Quantization of energy, Atomic structure wave equation, Quantum Mechanical Tunnelling. • Energies, Forces and Bonds: ~~Intraatomic~~ Potentials for strong and weak bonds, non central forces, Bond energies, spring constant. • Basic principle of protein structure: Ramachandran plot, motifs, folds, fibrous proteins, membrane proteins. **Section B** • Configuration of DNA, RNA, Glycosidic bond rotation and base stacking. • Zwitterionic properties of amino acids, peptide bonds, disulfide cross links, ~~Helix-coil transition.~~ • Basic principles of X-Ray diffraction studies, Calculation and interpretation of electron density map~~,~~ ~~Electron crystallography of proteins~~ • Protein secondary structure prediction methods: Chou and Fasman, Garnier-Osguthorpe-Robson. • Classification of three-dimensional structure of protein: HSSP, SCOP. **Section C** • Muscular movement: Molecular structure of skeletal muscle, Mechanical events of muscle contraction, Force	**Section A** • Elements of Quantum Mechanics: Quantization of energy, Atomic structure wave equation, Quantum Mechanical Tunnelling. • Energies, forces and Bonds: inter-atomic potentials for strong and weak bonds, non central forces, bond energies, spring constant. • Basic principle of protein structure: Ramachandran plot, motifs, folds, fibrous proteins, membrane proteins. **Section B** • Configuration of DNA, RNA, Glycosidic bond rotation and base stacking. • Zwitterionic properties of amino acids, peptide bonds, and disulfide cross links. • Basic principles of X-ray diffraction studies, calculation and interpretation of electron density map • Protein secondary structure prediction methods: Chou and Fasman, Garnier-Osguthorpe-Robson. • Classification of three-dimensional structure of protein: HSSP, SCOP. **Section C** • Muscular movement: molecular structure of skeletal muscle, mechanical events of muscle contraction, force velocity, power velocity and tension- length relationship	Interatomic is the correct term. Helix coil transition is part of statistical mechanics and cannot be introduced here without a background. Electron Crystallography is misleading terminology.

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			velocity, Power velocity and Tension- length relationship curves. • Neuronal Physics: Ion channels, Structure of Neurons, Synapse, Action potential and its propagation through nerve fiber. Post synaptic potential and Neural networking. • Photoreception: Structure of photoreceptors and photo chemical events of vision. • Molecular interaction: Protein-Protein interactions, Protein-DNA interactions. • Techniques for the studies of these interactions. **Books Recommended:** ➢ Principles of Biochemistry: A.L. Lehninger, Nelson and Cox, McMillan Worth Publishers. ➢ Biochemistry: Stryer. ➢ Biophysical Chemistry Vol. I, II & III: Cantor and Schimmel, Freeman. ➢ Practical Biochemistry: Wilson and Walker. ➢ Bioinformatics-Sequence and Genome analysis: David W. Mount. ➢ Structural Bioinformatics: Philip E.Bourne and Helge Weissig. ➢ Introduction to protein structure: C. Brandon and J. Tooze, International Garland. ➢ Proteins: Structure and molecular properties: Creighton, W.H. Freeman. ➢ Biophysics- An introduction: Kluwer, Dordrechrt ➢ Biophysical Chemistry Vol. I, II & III: Cantor and Schimmel, Freeman. ➢ Biophysics- An Introduction: Rodney Cotton II ➢ An introduction to Neural computing: Aleksander & Morten ➢ Biological membranes: architecture and function: Hand book of biological physics: Lipowsky & sackmann all volumes techniques & methods.	curves. • Neuronal physics: Ion channels, structure of Neurons, Synapse, Action potential and its propagation through nerve fiber. Post synaptic potential and Neural networking. • Photoreception: Structure of photoreceptors and photo chemical events of vision. • Molecular interaction: Protein-Protein interactions, Protein-DNA interactions. • Techniques for the studies of these interactions. **Suggested Books:** ➢ Atkins, P., & Paula, J.D. (2009). *Atkins Physical Chemistry* (9th ed.). OUP Oxford. ➢ Ber, J.M., Tymoczko, J.L., Gatto, G.J.. & Stryer, L. (2015). *Biochemistry* (8th ed.) WH Freeman &Co. ➢ Brenden, C., & Tooze, J. (1998). *Introduction to Protein Structure* (2nd ed.) Garland Science. ➢ Cotterill, R. (2002). *Biophysics: An Introduction*. Wiley Press. ➢ Creighton, T.E. (1992). *Proteins: Structures and Molecular Properties*. WH Freeman &Co. ➢ Hall, J.E. (2015). *Guyton and Hall Textbook of Medical Physiology* (13th ed.). Saunders Press. ➢ Nelson, D. L., & Cox, M.M. (2017). *Lehninger Principles of Biochemistry* (7th ed.) WH Freeman &Co. ➢ Voet, D., Voet, J.D., & Pratt, C.W. (2016). *Fundamentals of Biochemistry* (5th ed.). John Wiley. ➢ Wilson, K., & Walker, J. (2010). *Principles and Techniques of Biochemistry and Molecular Biology*. Cambridge University Press. **Suggested e-Resources:** ➢ **Muscular and Neuronal Physiology** https://www.khanacademy.org/science/biology/human-biology ➢ **Proteins** https://study.com/academy/lesson/proteins-	

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				structure-function-types.html ➢ **Nucleic Acids** https://chemistry.tutorvista.com/biochemistry/nucleic-acid-function.html	
7)	**BT 206** Cell and Molecular Biology – II	After successful completion of the course, students should be able to: • Understand functions of cell organelles and regulation of cellular processes • Explain the role and mechanism of cell signaling • Develop detailed understanding of fundamental processes viz., replication, transcription and translation	**Section A** • Cell: Prokaryotic and eukaryotic cell, a macromolecular assembly, cell compartmentalization, cytoskeleton. • Molecular structure and functional aspects of plasma membrane, carrier proteins and active membrane transport. • Endocytosis and Exocytosis. • ~~Cell signaling,~~ autocrine, paracrine and endocrine stimulation. • Cell Signaling: G-protein linked receptors, enzyme linked cell surface receptors (tyrosine kinases), structural features of trans membrane receptors, secondary messengers, role of Ca^{+2} ions, MAP Kinase cascade. • Cell cycle and division. **Section B** • The Nucleus, Nucleolus, structure of chromosomes, Nucleosomes, chromosomal DNA and its packaging. • Mitochondria and chloroplast organization, transport of proteins, genome of mitochondria and chloroplast. • Endoplasmic reticulum, golgi apparatus, role in protein processing and transport. • Lysosomes, intracellular digestion, sorting of lysosomal enzymes in golgi, lysosomal storage diseases. **Section C** • Central Dogma and genetic code. • DNA replication • Transcription: The transfer of DNA sequence information to RNA, exon, intron, tRNA and rRNA, mRNA processing. • Translation: mRNA translation in prokaryotes and	**Section A** • Cell: Prokaryotic and eukaryotic cell, cell compartmentalization, cytoskeleton. • Molecular structure and functional aspects of plasma membrane, carrier proteins and active membrane transport. • Endocytosis and exocytosis. • Autocrine, paracrine and endocrine stimulation. • Cell Signaling: G-protein linked receptors, enzyme linked cell surface receptors (tyrosine kinases), structural features of trans membrane receptors, secondary messengers, role of Ca^{2+} ions, MAP kinase cascade. • Cell cycle and division. **Section B** • The Nucleus, nucleolus, structure of chromosomes, nucleosomes, chromosomal DNA and its packaging. • Mitochondria and chloroplast organization transport of proteins, genome of mitochondria and chloroplast. • Endoplasmic reticulum, golgi apparatus, role in protein processing and transport. • Lysosomes, intracellular digestion, sorting of lysosomal enzymes in golgi, lysosomal storage diseases. **Section C** • Central dogma and genetic code. • DNA replication. • Transcription: The transfer of DNA sequence information to RNA, exon, intron, tRNA and rRNA, mRNA processing. • Translation: mRNA translation in prokaryotes and eukaryotes, notable features of the translation process.	Typographical corrections only

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			eukaryotes, notable features of the translation process. • Inhibitors of transcription and translation. • The fate of newly synthesized protein. **Books Recommended:** ➢ Cell and molecular Biology: De Robertis & De Roberties, B.I. Waverly Pvt. Ltd., New Delhi. ➢ The World of the Cell: W.M. Becker, Pearson Education. ➢ Cell and Molecular Biology: G. Karp, John Wiley & Sons. ➢ The Cell – A molecular Approach: Cooper, Sinauer. ➢ Cell and Molecular Biology: P.K. Gupta, Rastogi Publications. ➢ Molecular Cell Biology: Lodish, Baltimore, W.H. Freeman & Co. ➢ Molecular Biology of the Cell: Bruce Albert, Garlend Publication, NY. ➢ Essential of Cytology: C.B. Powar, Himalaya Publications. ➢ Principles of Genetics 4th Ed: Snustad and Simmons, John Wiley & Sons. ➢ Gene VIII: Lewin, Pearson Education. ➢ Molecular Biology of Gene: J.D. Watson, Pearson Education. ➢ Molecular Biology: David Freifelder, Narosa Publishing House, New Delhi. ➢ Molecular Biology: R. Weaver, WCB Mc Graw Hill.	• Inhibitors of transcription and translation. • The fate of newly synthesized protein. **Suggested Books:** ➢ Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008). *Molecular Biology of the Cell* (5th ed.). New York: Garland Science. ➢ Cooper, G. M., & Hausman, R. E. (2013). *The Cell: a Molecular Approach* (6th ed.). Washington: ASM; Sunderland. ➢ Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2012). *Becker's World of the Cell. Boston* (8th ed.). Benjamin Cummings. ➢ Karp, G. (2008). *Cell and molecular biology: Concepts and experiments*. John New Jersey: Wiley and Sons ➢ Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014). *Lewin's Genes XI. Burlington*, MA: Jones & Bartlett Learning. ➢ Lodish, H. F. (2016). *Molecular Cell Biology* (8th ed.). New York: W.H. Freeman. ➢ Watson, J. D. (2008). *Molecular Biology of the Gene* (5th ed.). Menlo Park, CA: Benjamin/Cummings. **Suggested e-Resources:** ➢ **Macromolecular assembly** https://www.sciencedirect.com/science/article/pii/B9780323341264000050 ➢ **Cell division** https://www2.le.ac.uk/projects/vgec/highereducation/topics/cellcycle-mitosis-meiosis ➢ **Lysosomal storage disorders** https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1365-2141.2004.05293.x	
8)	**BT 205L** Biotechnology Lab-II	After successful completion of the course, students should be able to: • Learn techniques	**Cell and Molecular Biology** ~~1. Study of cell organelles by permanent slides~~ ~~2.~~ Study of cell division (mitotic and meiotic) ~~in plants and animals.~~ 3. Separation of different organelles/molecules by sucrose	**Cell and Molecular Biology** 1. Estimation of DNA by DPA method. 2. Determination of Logic properties (pH value of glycine by titration). 3. Study of the stages of mitotic and meiotic cell division.	More practical exercises have been added, which are more relevant

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		related to histochemical localization of biomolecules • Gain hand on training to analyze stages of cell division • Predict structure of biomolecules using bioinformatics tools	density gradient/differential gradient. 4. Histochemical localization of biomolecules (protein, carbohydrate or any other). **Biophysics** 5. Download PDB files for protein complexes with proteins (Haemoglobin, Myoglobin, Insulin), nucleic acid and do various exercises using : Rasmol SPDBV	4. Separation of different organelles/molecules by sucrose density gradient/differential gradient. 5. Histochemical localization of biomolecules (protein, carbohydrate or any other). **Biophysics** 6. Download PDB files for protein complexes with proteins (haemoglobin, myoglobin, insulin), nucleic acid and do various exercises using : - Rasmol - SPDBV **Suggested Books:** ➢ Saxena, J., Baunthiyal, M. & Ravi, I. (2015). *Laboratory Manual of Microbiology, Biochemistry and Molecular Biology*. Jodhpur: Scientific Publishers. ➢ Sharma, R.K., Sangha, S.P.S. (2009). *Basic Techniques in Biochemistry & Molecular Biology*. New Delhi: I.K. International Publisher. ➢ Swamy, P.M. *Laboratory Manual on Biotechnology* (1st ed.). Meerut: Rastogi Publication.	
	B. Tech. Biotechnology V Semester				
9)	~~**BT 5.3:**~~ ~~Enzyme Engineering and Technology~~				This course is proposed to be shifted in VIII semester and offered as an elective course.
10)	**BT 308** Genetics and Genetic Engineering	After successful completion of the course, students should be able to: • Explain the theoretical and experimental foundation of classical and molecular genetics • Develop	**BT 5.4** **Section-A** • Mendel's laws of inheritance • Gene-Gene interaction, Multiple alleles, Lethal alleles • Linkage and crossing over, Linkage maps, three point testcross, Interference, Calculating recombinant frequencies. • Sex-determination: Chromosomes theory, Genic balance theory and hormone theory, other factors affecting sex determination, Lyon's Hypothesis, Dosage compensation, Sex-linked inheritance.	**Section-A** • Mendel's laws of inheritance. • Gene-Gene interaction, multiple alleles, methal alleles • Linkage and crossing over, linkage maps, three point testcross, Interference, calculating recombinant frequencies. • Sex-determination: Chromosomes theory, Genic balance theory and hormone theory, other factors affecting sex determination, Lyon's hypothesis, dosage compensation, sex-linked inheritance.	Typographical corrections only

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		comprehensive concept of genetic engineering including vectors and techniques • Identify various application of genetics and genetic engineering	• Chromosomal aberrations: Structural and Numerical Mutation: Spontaneous and Induced, Chemical and Physical mutagens, Induced mutations in plants, animals and microbes for economic benefit of man **Section-B** • Vector systems: *E. coli*-the host cells plasmids structural and functional organization replication, classification, incompatibility groups, construction of an ideal plasmid vector pBR322 • Phage-biology, construction of vector other phages and cosmids. • Direct gene delivery methods-Biolistics, Electroporation, Liposome mediated, Microinjection. • Construction, cloning and selection inserts ligation, infection, transfection and cloning • Synthesis and cloning of cDNA, cDNA library. • Enzymes used in molecular cloning: Nucleases, Restriction Endonucleases, phosphodiesterase polynucleotide kinase, DNA ligase, DNA polymerase, reverse transcriptase, terminal deoxynucleotidyl transferase. • Isolation of DNA, RNA: bacteriophage, prokaryotic and eukaryotic. **Section-C** • Inborn errors of metabolism, autosomal and sex linked diseases. • One gene-one enzyme, one gene-one protein, one gene-one polypeptide hypothesis, • Heredity and Environment with special reference to the study of twins. • Human Genome Project: Genetic diseases in humans, Genetics and society. • Current techniques of genetic analysis. • Important discoveries of genetic engineering. • Identification and analysis of recombinant clones. **Books Recommended:**	• Chromosomal aberrations: Structural and numerical mutation: spontaneous and induced, chemical and physical mutagens, induced mutations in plants, animals and microbes for economic benefit of man. **Section-B** • Vector systems: *E. coli*-the host cell plasmids structural and functional organization replication, classification, incompatibility groups, construction of an ideal plasmid vector pBR322. • Phage biology, construction of vector other phages and cosmids. • Direct gene delivery methods- Biolistics, electroporation, iposome mediated, microinjection. • Construction, cloning and selection inserts ligation, infection, transfection and cloning. • Synthesis and cloning of cDNA, cDNA library. • Enzymes used in molecular cloning: Nucleases, restriction Endonucleases, phosphodiesterase polynucleotide kinase, DNA ligase, DNA polymerase, reverse transcriptase, terminal deoxynucleotidyl transferase. • Isolation of DNA, RNA: bacteriophage, prokaryotic and eukaryotic. **Section-C** • Inborn errors of metabolism, autosomal and sex linked diseases. • One gene-one enzyme, one gene-one protein, one gene-one polypeptide hypothesis. • Heredity and environment with special reference to the study of twins. • Human Genome Project: Genetic diseases in humans, genetics and society. • Current techniques of genetic analysis. • Important discoveries of genetic engineering. • Identification and analysis of recombinant clones. **Suggested Books:**	

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Principles of Genetics 4th Ed: Snustad and Simmons, John Wiley & Sons. ➢ Genetics: P.K. Gupta, Rastogi Publications. ➢ Genetics - A molecular approach: T.A. Brown, Chapman and Hall. ➢ Concepts of Genetics 7th Ed.: William S. Klug, Pearson Education. ➢ Molecular Cloning Vol. 1, 2 and 3: Sambrook and Russell, Cold Spring Harber laboratory, 2001. ➢ Molecular Biology of Gene: J.D. Watson, Pearson Education. ➢ An Introduction to Gene Technology-From genes to clones: Winnacker, VCH. ➢ Principles of Gene Manipulation: Old and Primrose. ➢ Molecular Biotechnology: B.R. Glick and J.J. Pasternak, ASM Press, Washington, USA.	➢ Brown, T. A. (1990). *Genetics: A molecular approach* (3rd ed.). UK: Chapman and Hall. ➢ Gupta, P. K. (2005). *Biotechnology and Genomics*. India: Rastogi Publications. ➢ Primrose, S. B., Twyman, R., & Old, B. (2001). *Principles of Gene Manipulation* (6th ed.). USA: Wiley-Blackwell. ➢ Russel, P. J. (1996). *Genetics*. USA: Addison-Wesley. ➢ Sambrook, J. F., & Russell, D. W. (2001). *Molecular Cloning: A Laboratory Manual* (3rd ed.). USA: Cold Spring Harbor Laboratory Press.**:** ➢ Singh, B. D. (2015). *Biotechnology*. Kolkata, India: Kalyani Publishers. ➢ Snustad, D. P., & Simmons, M. J. (2008). *Principles of Genetics* (5th ed.). USA: John Wiley & Sons. **Suggested e-Resources:** ➢ **Linkage and crossing over** http://classpages.warnerpacific.edu/bdupriest/BIO%20250/Lecture%207%20Linkage%20&%20Mapping.pdf ➢ **Sex determination theory** http://www.biologydiscussion.com/genetics/modern-theories-of-sex-determination-with-diagrams/5257 ➢ **Plasmid vector** https://nptel.ac.in/courses/102103045/module3/lec17/3.html ➢ **Direct gene delivery methods** https://www.slideshare.net/saugatbhatt/methods-27443684 ➢ **cDNA library** https://nptel.ac.in/courses/102103013/19 ➢ **Enzymes used in molecular cloning** http://www.biologydiscussion.com/enzymes/types-of-enzymes-involved-in-dna-synthesis-and-cloning-7-types/12075 ➢ **One gene one enzyme hypothesis** http://www.biologydiscussion.com/genetics/one-gene-	

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				one-enzyme-hypothesis-genetics/59768 ➢ **Techniques of genetic analysis** http://psych.colorado.edu/~carey/hgss/hgsschapters/HGSS_Chapter07.pdf ➢ **Important discoveries of genetic engineering** https://www.genome.gov/pages/education/genetictimeline.pdf	
11)	**BT 309** Metabolic Engineering	After successful completion of the course, students should be able to: • Provide basic concept about cellular metabolism, pathway design and bioenergetics • Understand regulatory mechanisms and metabolic modeling • Develop analytical skills to address metabolic engineering problems	**BT 5.5** **Section – A** • Basic concepts of Metabolic Engineering- Overview of cellular metabolism. Introduction to various pathways. • Primary and Secondary metabolites. • Medical and agricultural importance of secondary metabolites. • Different models for cellular reactions. Flexible and rigid in metabolic pathways. • Metabolic regulation network at enzyme level and whole cell level- Examples of metabolic pathway manipulations. **Section – B** • Metabolic pathway synthesis algorithms. • Metabolic flux analysis and its applications. • Mathematical calculation for the flow of carbon and nitrogen fluxes. • Methods for experimental determination of metabolic fluxes by isotope labeling. • Stereochemistry of regulatory molecules. • Concepts of regulatory analogs. **Section – C** • Genetic regulation of metabolic fluxes. • Gene expression in response to environmental stimuli. • Regulation of gene expression. • Analysis of metabolic control and the structure of metabolic networks. • Thermodynamics of cellular processes – New concepts	**Section – A** • Basic concepts of metabolic engineering, overview of cellular metabolism. Introduction to various pathways. • Primary and secondary metabolites. • Medical and agricultural importance of secondary metabolites. • Different models for cellular reactions, flexible and rigid in metabolic pathways. • Metabolic regulation network at enzyme level and whole cell level, examples of metabolic pathway manipulations. **Section – B** • Metabolic pathway synthesis algorithms. • Metabolic flux analysis and its applications. • Mathematical calculation for the flow of carbon and nitrogen fluxes. • Methods for experimental determination of metabolic fluxes by isotope labeling. • Stereochemistry of regulatory molecules. • Concepts of regulatory analogs. **Section – C** • Genetic regulation of metabolic fluxes. • Gene expression in response to environmental stimuli. • Regulation of gene expression. • Analysis of metabolic control and the structure of metabolic networks. • Thermodynamics of cellular processes – New concepts	Typographical corrections only

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			for quantitative bioprocess research and development. **Books Recommended:** ➢ Computational Modeling of Genetic and Biochemical Networks: James M. Bower & Hamid Bolouri. ➢ Metabolic Flux Analysi: Valino. ➢ Comprehensive Biotechnology (Vol. 3): Moo & Young. ➢ Fundamentals of Biochemical Engineering: Bailey and Olis	for quantitative bioprocess research and development. **Suggested Books:** ➢ Bailey, J.E., & Ollis, D.F. (1986). *Biochemical Engineering fundamentals* (2nd ed). McGraw-Hill. ➢ Bower, J.M., & Bolouri, H., (2001). Computational Modeling of Genetic and Biochemical Networks (1st ed.). MIT Press. ➢ Stephanopoulos, G.N., Aristidou, A.A., & Nilsen, J., (1998). *Metabolic Engineering-Principles and Methodologies*. Academic Press. **Suggested e-Resources:** ➢ **Metabolites** http://lifeofplant.blogspot.in/2011/03/metabolites-primary-vs-secondary.html http://www.bio21.bas.bg/ipp/gapbfiles/v-34_pisa-08/08_pisa_1-2_67-78.pdf ➢ **Metabolic engineering file** https://biotechnologyforbiofuels.biomedcentral.com/track/pdf/10.1186/s13068-017-0791-3	
12)	**BT 310** Microbiology and Immunology	After successful completion of the course, students should be able to: • Explain bacterial and fungal classification and ultra structure • Discuss different techniques related to isolation, staining and maintenance of microbes • Understand fundamental concept of immunology	**BT 5.6** **Section – A** • Discovery of microorganisms and their significance. • Bacteria: Classification, structural organization, composition of cell wall, cell membrane, capsule, nutrition, respiration, methods of recombination and asexual reproduction. • Fungi- classification, ultra structure and characteristics, nutrition and reproduction. • Viruses: Plant, Animal and Bacteriophages, nature, organization, replication classification. **Section – B** • Sterlization techniques: Physical and Chemical methods. • Techniques in Microbiology: Media preparation, isolation and pure culture techniques, staining techniques, preservation and maintenance of culture.	**Section – A** • Discovery of microorganisms and their significance. • Bacteria: classification, structural organization, composition of cell wall, cell membrane, capsule, nutrition, respiration, methods of recombination and asexual reproduction. • Fungi: classification, ultra structure and characteristics, nutrition and reproduction. • Nature, organization, classification and replication of Plant and animal viruses and bacteriophages. **Section – B** • Sterilization techniques: physical and chemical methods. • Techniques in Microbiology: media preparation, isolation and pure culture techniques, staining techniques, preservation and maintenance of culture. • Industrial applications of microorganisms in food and	Typographical corrections only

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			• Industrial applications of microorganisms in food and medicines. • Introduction to Immunology: Innate and Acquired immunity, Active and Passive immunity, Organs and Cells of Immune system • Antigen and Antigenicity: Concept of Immunogens, Antigens, Haptens, Characteristic properties of Antigens. **Section-C** • Immunoglobulins: Molecular structure, properties, classification and significance of Immunoglobulin. Immunoglobulin as Antigens – Isotypes, Allotypes and Idiotypes. • Cell mediated and Humoral immune response. • General idea of Major Histocompatibility Complex, Complement System • Hypersensitive reactions: (Type I, II, III and delayed type IV). • Monoclonal antibody (Production and their applications.) **Books Recommended:** ➢ Introductory Microbiology: F.C. Ross, Columbus Charles E. Mehrill. ➢ Microbiology – Fundamentals and Applications: S.S. Purohit, Agro Botanical Publishers, Bikaner. ➢ Modern Concepts of Microbiology: H.D. Kumar and S. Kumar, Vikas Publishing House, New Delhi. ➢ Microbiology: M.J. Pelczar, C.E. Sun and N.R. Krieg, Tata Mc Graw Hill, New Delhi. ➢ A Textbook of Microbiology: R.C. Dubey and D.K. Maheshwari, S. Chand and Company. ➢ Principal of Fermentation Technology: P.F. Stanbury and A. Whittaker, Pegamon Press. ➢ Fundamental Principles of Bacteriology: A.J. Salle, Tata McGraw Hill. ➢ T.D. Book's World of Microbiology: Madigan	medicines. • Introduction to Immunology: Innate and acquired immunity, active and passive immunity, organs and cells of immune system • Antigen and antigenicity: concept of immunogens, antigens, haptens, characteristic properties of antigens. **Section-C** • Immunoglobulins: molecular structure, properties, classification and significance of immunoglobulin. immunoglobulin as antigens– isotypes, allotypes and idiotypes. • Cell mediated and humoral immune response. • General idea of Major Histocompatibility Complex, complement system • Hypersensitive reactions: (Type I, II, III and delayed type IV). • Monoclonal antibody (production and their applications). **Suggested Books:** ➢ Goldsby, R. A., Kindt, T.J., & Osborne, B. A. (2006). *Kuby Immunology* (6th ed.). New York: W.H. Freeman & Co. Ltd. ➢ *Madigan, M., Martinko, J., Stahl, D. & Clark, D.* (2010). *Brock Biology of Microorganisms* (13th ed.). Pearson ➢ Paul, W.E. (1999). Fundamental Immunology (14th ed.). Lippincott-Raven. ➢ Pelczar, M.J., Sun, C.E., & Krieg, N.R. (2002). *Microbiology* (5th ed.). New Delhi: Tata Mc Graw Hill. ➢ Willey, J. M., Sherwood, L.M. & Woolverton, C.J. (2014). *Prescott's Microbiology* (9th ed.). McGraw-Hill Education. **Suggested e-Resources:** ➢ **Bacteria structure** http://www.biologydiscussion.com/bacteria/cell-structure-of-bacteria-with-diagram/47058 ➢ **Bacterial growth & nutrition**	

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Microbiology: Prescott. ➢ Essential of Immunology: W.H. Hildemann, Elservier Scientific Publishing Co. Inc. ➢ Immunology 5th Ed: Richard A. Goldsby et al., W.H. Freeman and Co., NY 2003. ➢ Immunology-Understanding of Immune System: Klans D.Elgret, Wiley-Liss.NY ➢ Fundamentals of Immunology: Paul W.E. (Eds.) Raven Press, New York. ➢ Antibodies- A laboratory Manual: Harlow and David Lane, Cold Spring Harbor Laboratory.	➢ http://www.biologydiscussion.com/bacteria/nutrition-and-growth-in-bacteria/47001 ➢ **Basic Immunology** ➢ http://pdffavor.info/the-tao-of-immunology-a-revolutionary-new-understanding-of-our-body-s-defenses-openlibra-free-books-marc-lapp.pdf	
13)	**BT 303L** Biotechnology Lab-III	After successful completion of the course, students should be able to: • Demonstrate microbial and immunological techniques • Understand chromosome structure and solve genetic problems • Learn various techniques of genetic Engineering • Gain hands on training for experiments related to properties of enzyme	**BT 5.2** **Microbiology** 1. Preparation of media for fungal and bacterial culture and their sterilization, slant preparation. 2. Streak ~~plate~~ technique, ~~pour plate technique and surface plate technique~~ 3. Isolation and enumeration of microbes from air/soil by serial dilution/agar plating method. 4. Antibiotic sensitivity test. ~~5. Lactic acid production and estimation~~ **Immunology** 6. Blood film preparation and identification of leucocytes. ~~7. Lymphoid organs (Thymus and Spleen) and their microscopic examination.~~ 8. ~~Aseptic collection of serum for immunological assays.~~ 9. Double diffusion and immuno-electrophoresis. 10. ELISA: Determination of antibody titre. **Genetics** 11. ~~Preparation of metaphase chromosomes~~. ~~12. Study of ADH activity in tissue/cells by cytochemical staining using Drosophila.~~ 13. ~~Study of~~ Giant chromosomes. 14. Genetic problem and Genetic traits. **Genetic Engineering** 15. ~~Isolation of plasmid DNA from E. coli~~ and its	**Microbiology** 1. Preparation of media for fungal and bacterial culture and their sterilization, slant preparation. 2. Streaking technique, spread plate technique. 3. Isolation and enumeration of microbes from air/soil by serial dilution/agar plating method. 4. Antibiotic sensitivity test. **Immunology** 5. Blood film preparation and identification of leucocytes. 6. Ouchterlony double diffusion and immuno-electrophoresis. 7. ELISA: Determination of antibody titre. **Genetics** 8. Microscopic examination of Giant chromosomes. 9. Genetic problem and Genetic traits. **Genetic Engineering** 10. Isolation of genomic DNA and its electrophoretic	Practical shifted to B.Tech VI Sem Practical shifted to Sem VIII

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			electrophoretic separation. 16. Extraction of RNA and its estimation by orcinol method. ~~17. Estimation of DNA by DPA method.~~ ~~18. To determine the melting curve and base composition of DNA.~~ 19. Amplification of a gene fragment using PCR. **Enzyme Engineering and Technology** 20. To obtain standard curve of p-nitrophenol solution. 21. To determine activity of acid phosphatase from peas/moong seedlings. 22. Purification of an enzymatic protein by salt precipitation. 23. Determination of kinetic properties (Km and Vmax values) of an enzyme. 24. To check time and protein linearity of an enzymatic reaction. 25. Immobilization of an enzyme	separation. 11. Extraction of RNA and its estimation by orcinol method. 12. Amplification of a gene fragment using PCR. **Enzymology** 13. To obtain standard curve of p-nitrophenol solution. 14. To determine activity of acid phosphatase from mung bean seeds. 15. Purification of an enzymatic protein by salt precipitation. 16. Determination of kinetic properties (K_m and V_{max} values) of an enzyme. 17. To check time and protein linearity of an enzymatic reaction. 18. Immobilization of an enzyme. **Suggested Books:** ➢ Cappuccino, J. G., & Welsh, C. (2016). *Microbiology: a Laboratory Manual*.Benjamin-Cummings Publishing Company. ➢ Kumar, V. (2011). *Laboratory Manual of Microbiology*. New Delhi: Scientific Publishers. ➢ Mahajan, R., Sharma, J., & Mahajan, R.K. (2010). *Practical Manual of Biotechnology* (1st ed.). New Delhi: Vayu Education of India. ➢ Saxena, J., Baunthiyal., & Ravi, I. (2015). *Laboratory Manual of Microbiology, Biochemistry and Molecular Biology*. Jodhpur: Scientific Publishers. ➢ Vats, S. (2015). *A laboratory Text book of Biochemistry, Molecular Biology and Microbiology*. Germany: GRIN Verlag.	The practical is there in the B.Tech IV Semester
	B. Tech. Biotechnology VI Semester				
14)	**BIN 301** Basic	After successful completion of the	**BT 6.2** **Section-A**	**Section-A**	

<table>
<tr><th>S. No.</th><th>Course List</th><th>Learning outcomes</th><th>Existing Syllabus</th><th>Suggested Syllabus</th><th>Remarks</th></tr>
<tr><td></td><td>Bioinformatics</td><td>course, students should be able to:
• Demonstrate basic skills in information retrieval, programming languages and operating systems
• Identify various biological databases and develop data mining methods
• Predict 3D structure of proteins and their regular structural elements for the integrity of the structure.</td><td>• Bioinformatics: Introduction and Historical background.
• Information Retrieval: LAN, WAN, Introduction to Internet, WWW, NICNET, ERNET, VSNL, ISDN,. Introduction to FTP, login and other network services, Publication on worldwide web, on-line publishing ventures e.g. Biomed, online international database access.
• ~~Introduction and applications of programming languages, C++, Perl.~~
• Conceptual understanding of assemblers, Operating Systems (DOS, Windows, UNIX, LINUX).
Section-B
• Concept of CD-ROM, e-mail, Websites, Internet, Networking, Databases.
• Biological Databases: Primary Sequence databases (Protein and DNA databases), Secondary databases, Composite databases.
• Sequence format i.e. genbank and FASTA format
• Sequence Alignment and Databases searching: Evolutionary basis of sequence alignment, Optimal alignment methods, Substitution Scores and Gap penalties.
Section-C
• Statistical significance of alignment, Similarity searching tools: FASTA, BLAST.
• Pair wise database searching: EMBOSS, Multiple Sequence alignment: CLUSTAL W.
• Protein structure prediction method- Homology modeling, ab-initio method and threading method
• Scope of Bioinformatics, BTIS Network in India, Centers for Bioinformatics (DICs and sub DICs) in India.
Books Recommended:
➢ Fundamental of computer: P.K. Sinha
➢ Introduction to Bioinformatics: Parrysmith and</td><td>• Bioinformatics: Introduction and historical background.
• Information retrieval: LAN, WAN, introduction to internet, WWW, NICNET, ERNET, VSNL, ISDN, introduction to FTP, login and other network services, publication on worldwide web, on-line publishing ventures e.g. biomed, online international database access.
• Conceptual understanding of assemblers, operating systems (DOS, Windows, UNIX, LINUX).
Section-B
• Concept of CD-ROM, e-mail, websites, internet, networking, databases.
• Biological databases: Primary sequence databases (Protein and DNA databases), secondary databases, composite databases.
• Sequence format i.e. genbank and FASTA format.
• Sequence alignment and databases searching: Evolutionary basis of sequence alignment, optimal alignment methods, substitution scores and gap penalties.
Section-C
• Statistical significance of alignment, similarity searching tools: FASTA, BLAST.
• Pair wise database searching: EMBOSS, multiple Sequence alignment: CLUSTAL W.
• Protein structure prediction method: Homology modeling, ab-initio method and threading method.
• Scope of bioinformatics, BTIS Network in India, centers. for bioinformatics (DICs and sub DICs) in India.
Suggested Books:
➢ Baxevanis, A.D. & Ouellette, B.F.F. (2004). *Bioinformatics: A Practical Guide to the Analysis of*</td><td>Programming languages have been removed as the content cannot be justified for a introductory course.</td></tr>
</table>

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			Attwood ➢ Introduction to Bioinformatics: Baxevenis and Oulette ➢ Internet for Molecular Biologist: Swindell ➢ Molecular Databases for Protein Sequences and Structure Studies - An Introduction Silence: J., Sillince M., Springerberlagd, Berlin 1972 ➢ Leaping from Basic to C++ : Robert J. Traister, A.P. Professional Cambridge ➢ Perl 5 Unleashed: Kamran Husain & Robert F Breedlore SAMS Publishing. ➢ Bioinformatics: David Mount. ➢ Text book of Bioinformatics: Vinay Sharma, Ashok Munjal and Asheesh Shanker, Rastogi publications	*Genes and Proteins* (3rd ed.). Wiley. ➢ Bosu, O. & Thukral, S.K. (2007). *Bioinformatics: database, tools and algorithms* (1st ed.). Oxford University Press. ➢ Sharma, V., Munjal, A., & Shanker, A. (2017). *A Text Book of Bioinformatics* (2nd ed.). Meerut: Rastogi Publications. ➢ Sinha, P.K & Sinha, P. (2016). *Computer Fundamentals* (6th ed.). New Delhi: BPB publication. **Suggested e-Resources:** ➢ **Chou-Fasman Method for protein secondary structure prediction** https://pdfs.semanticscholar.org/fd8c/c95aec2d7af19ed28eea3688b3c231d0e745.pdf ➢ **Homology modeling** https://proteinstructures.com/Modeling/homology-modeling.html ➢ **ExPASy** https://www.expasy.org/	
15)	**BT 302** Bioprocess Engineering	After successful completion of the course, students should be able to: • Develop comprehensive concepts on various processes in bioreactors mediated microbial process • Apply engineering principles to address issues in bioprocesses and delineate problems associated with production of	**BT 6.3** **Section – A** • Growth kinetics and death kinetics • Microbial growth: structured and unstructured • Kinetics of Batch, Fed-batch and Continuous processes • Mass balance, energy balance • Maintenance coefficient and yield concept • Mass transfer, Volumetric mass transfer coefficient, aeration and agitation • Media sterilization and medium rheology **Section – B** • Bioreactors: components and control of process parameters • Types of bioreactors: CSTR, Airlift, Fluidized bed, Plug flow reactor, Photobioreactor, Bubble column, advances in bioreactor designing. • Down stream processing : recovery and purification of	**Section – A** • Growth kinetics and death kinetics. • Microbial growth: structured and unstructured. • Kinetics of batch, fed-batch and continuous processes. • Mass balance, energy balance. • Maintenance coefficient and yield concept. • Mass transfer, volumetric mass transfer coefficient, aeration and agitation. • Media sterilization and medium rheology. **Section – B** • Bioreactors: components and control of process parameters . • Types of bioreactors: CSTR, airlift, fluidized bed, plug flow reactor, photobioreactor, bubble column, advances in bioreactor designing. • Down stream processing: recovery and purification of	Typographical corrections only

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		biomolecules in bioreactor. • Plan a career in research field in the biotechnology industry.	fermentation products • Upscaling of bioprocess **Section – C** ~~**Fermentative production of:**~~ • Organic solvents: acetone, ethanol, butanol • Organic acids: lactic acid, citric acid and acetic acid • Enzymes: Proteases, Lipases and alpha-amylase • Antibiotics: Penicillin, Streptomycin and Tetracycline • Amino acids: L-glutamic acid, phenylalamine and L-lysine **Books Recommended:** ➢ Biochemical Engineering: J.M. Lee, Prentice Hall. ➢ Bioprocess Engineering: M. Shuler and F. Kargi, Pretice Hall. ➢ Comprehensive Biotechnology: M. MooYoung, Editor. ➢ Biotechnology: H.J. Rehm and G. Reed, VCH.	fermentation products. • Upscaling of bioprocess. **Section – C** Fermentative production of: • Organic solvents: acetone, ethanol, butanol. • Organic acids: lactic acid, citric acid and acetic acid. • Enzymes: proteases, lipases and alpha-amylase. • Antibiotics: penicillin, streptomycin and tetracycline. • Amino acids: L-glutamic acid, phenylalamine and L-lysine. **Suggested Books:** ➢ Bailey, J.E., & Ollis, D.F. (1986). *Biochemical Engineering fundamentals* (2nd ed). McGraw-Hill College. ➢ Clark,D.S., & Blanch, H.W. (1997). *Biochemical Engineering*. CRC Press. ➢ Crueger, W., & Crueger, A. (1990). *Biotechnology, A Text Book of Industrial Microbiology* (2nd ed.). USA: Sinauer Associates Inc., ➢ Shuler, M.L., & Kargi, F. (2002). *Bioprocess Engineering Basic Concepts* (2nd ed,). USA: Prentice Hall PTR Upper Saddle River. ➢ Stanbury, P.F., Whitaker, A., & Hall S.J. (1995).*Principles of Fermentation Technology* (2nd & 3rd ed.). Elsevier Science Ltd. **Suggested e-Resources:** ➢ **Application of microbial enzymes** ➢ https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5387804/pdf/BMRI2017-2195808.pdf ➢ **Acetone-Butanol-Ethanol fermentation** ➢ https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4894279/pdf/fnw134.pdf ➢ **Microbial culture fermentation** ➢ https://pdfs.semanticscholar.org/b4d3/7ed66ef2e37ce22ff7a3be09e3df7568fe49.pdf	
~~16)~~	BT 305		~~BT 6.5~~		This course is

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
	~~Cell and Tissue Culture Technology~~		**~~Section – A~~** • ~~Historical background and terminology used in cell and tissue culture.~~ • ~~Basic techniques, surface sterilization, aseptic tissue transfer, concept of totipotency.~~ • ~~Nutritional requirement of cells in vitro, various types of nutrient media.~~ • ~~Somatic embryogenesis and organogenesis in plants.~~ • ~~Variability in tissue cultures, somaclonal and other variations.~~ • ~~Isolation of cells, single cell cultures and cloning.~~ **~~Section – B~~** • ~~Production of disease free plants by tissue culture methods.~~ • ~~Protoplast isolation and culture, viability test, techniques of protoplast fusion.~~ • ~~Somatic hybrids, selection methods, gene expression in somatic hybrids.~~ • ~~Haploid Production: Introduction, Techniques, plant regeneration from pollen embryo.~~ • ~~Plant cell culture products: Secondary Metabolites.~~ **~~Section- C~~** • ~~Maintenance and propagation of animal cell and tissue culture: Disaggreagation techniques and primary culture.~~ • ~~Preservation of cell lines: cryopreservation, cell banks, transporting cells.~~ • ~~Somatic Hybridization: Fusogens, basis of somatic hybridization technology, storage of hybridoma cells, Productions of monoclonal antibodies.~~ • ~~Animal cell culture products.~~ **~~Books Recommended:~~** ➢ ~~Plant Tissue Culture: S.S. Bhojwani and M.K. Razdan, Elsevier Science, The Netherlands.~~ ➢ ~~An Introduction to Plant Tissue Culture: M.K. Razdan.~~ ➢ ~~Biotechnology in Agriculture and Forestry: Y.P.S.~~		proposed to be discontinued and relevant contents incorporated in the Papers of B. Tech VIII Semester (Animal Biotechnology & Plant Biotechnology)

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			~~Bajaj, Narosa.~~ ➢ ~~Plant Cell and Tissue Culture: Butenko.~~ ➢ ~~Plant Tissue Culture Methods and Application in Agriculture: T.A. Thorpe, Academic Press Inc.~~ ➢ ~~Cell and Tissue Culture: Lab Procedures in Biotechnology, Alan Doyal (ed) J.Bryan Griffth (ed.)~~ ➢ ~~Micropropagation Tech. and Applications: P.C. Dobergh & R.H. Zimmerman, Kluwer Academic Pub. Dordrecht.~~ ➢ ~~Introduction to Cell and Tissue Culture: Jennie P. Methew and Penelpoe E. Rohes.~~ ➢ ~~Animal Cell Culture: John R.W. Masters.~~ ➢ ~~Cell and Tissue Culture: Lab procedure in biotechnology Alan Doxal (ed) J. Bryan 6th ed.~~ ➢ ~~Animal Cell Culture- a Practical Approach: R.I. Freshney, wiley-Liss.~~		
17)	**BT 311** Recombinant DNA Technology	After successful completion of the course, students should be able to: • Understand the concept of DNA synthesis, amplification and sequencing • Apply strategies of cloning in both prokaryotes and eukaryotes • Explain use of molecular probes and DNA finger printing for relevant applications.	**BT 6.6** **Section – A** • Chemical synthesis of DNA: Phosphodiester, triester approaches, phosphoramidite method, solid phase automated synthesis of DNA. • Sequencing of DNA: Chemical and dideoxy methods, random and directed approaches, automated DNA sequencing, improved gel-based sequencers, mass spectrometry based sequencing, pyrosequencing. • Polymerase chain reaction (PCR) – Basic principles, modifications and applications. • Site directed mutagenesis; ~~various approaches~~. **Section – B** • ~~Direct gene transfer methods~~	**Section A** • Chemical synthesis of DNA: Phosphodiester, triester approaches, phosphoramidite method, solid phase automated synthesis of DNA. • Sequencing of DNA: Chemical and dideoxy method, random and directed approaches, automated DNA sequencing, improved gel based sequencers, mass spectrometry based sequencing, pyrosequencing. • Polymerase chain reaction (PCR): Basic principle, modifications: multiplex, nested, hot start, reverse transcriptase, real time, inverse, anchored, touch down and applications. • Site directed mutagenesis: Oligonucleotide directed mutagenesis using M13 DNA, oligonucleotide directed mutagenesis using plasmid DNA, PCR based oligonucleotide directed mutagenesis, deletion mutagenesis. **Section – B** • Gene expression analysis: Northern blot, primer	Subtopics have been introduced to make the content precise.

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			• Cloning in plants. • Cloning in Bacillus subtilis and yeast. • Artificial chromosomes (YACs, ~~BACs, MACs~~). • Cloning in mammalian cells using SV-40 vectors.	extension, SI mapping, RNase protection assays, reporter assays. • Cloning in *Bacillus subtilis*. • Cloning in yeast: YEPs, YIPs, YRP, YAC. • Cloning in plants-*Agrobacterium tumefaciens* mediated gene transfer: Binary vector, cointegrate vector; viral vector mediated gene transfer, direct gene transfer methods. • Cloning in mammalian cell using SV-40 vector- Early replacement and late replacement vector.	Gene transfer methods already covered in Genetics and Genetic engineering syllabus. Thus, new and relevant topics have been introduced.
			Section – C • Molecular probes – DNA, RNA probes, Applications, radioactive and non-radioactive labeling of probes. • Eukaryotic selectable markers. • DNA fingerprinting; Various molecular markers: RAPD, AFLP, SNP's, SSR, ARDRA • Antisense RNA Technology, RNAi. • Gene Therapy. • Detection of genetic disorders.	**Section – C** • Molecular probes- DNA, RNA probes, application, radioactive and non-radioactive labeling of probes. • Eukaryotic selectable markers. • Various molecular markers: RAPD, AFLP, SNPs, SSR, ARDRA. • DNA fingerprinting- Principle of technique, Basic DNA fingerprinting procedure. • Antisense RNA technology, RNAi, siRNA. • Gene therapy. • Methods of detection of genetic disorders: Cytogenetic testing, biochemical testing, molecular testing.	Subtopics have been introduced to make the content precise.
			Books Recommended: ➢ Molecular Cloning Vol. 1, 2 and 3: Sambrook and Russell, Cold Spring Harber laboratory, 2001. ➢ Molecular Biology of Gene: J.D. Watson, Pearson Education. ➢ An Introduction to Gene Technology-From genes to clones: Winnacker, VCH. ➢ Principles of Gene Manipulation: Old and Primrose. ➢ Molecular Biotechnology: B.R. Glick and J.J. Pasternak, ASM Press, Washington, USA. ➢ Genetic Engineering: Science and ethics on new frontier: Michael Boylan, Pearson Education. ➢ An Introduction to Genetic Engineering: S.T. Nicholl, Cambridge University Press.	**Suggested Books:** ➢ Glick, B.R., Pasternak, J.J. & Patten, C.L. (2010). *Molecular Biotechnology: Principles and Applications of Recombinant DNA* (4th ed.). American Society for Microbiology. ➢ Kumar, H.D. (1990). *Nucleic acid and biotechnology*. Vikas Publication. ➢ Primrose, S. B., & Old, R.W. (2001). *Principles of Gene Manipulation* (6th ed.).Wiley-Blackwell. ➢ Sambrook, J.F. & Russell, D.W. (2001). *Molecular Cloning: A Laboratory Manual* (3rd ed.) Vol. 1, 2 and 3. Cold Spring Harbor laboratory. ➢ Winnacker, E.L. (1987). *From genes to clones: Introduction to gene technology*. Wiley VCH.	

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Recombinant DNA Methodology: Grossman and Noldave, Academic Press. ➢ Recombinant DNA: J.D. Watson, W.H. Freeman. ➢ Nucleic acid and Biotechnology: H.D. Kumar. ➢ Understanding DNA and Gene Cloning : Darlica, John Wiley and Sons.	**Suggested e-Resources:** ➢ **Solid phase oligonucleotide synthesis** https://www.atdbio.com/content/17/Solid-phase-oligonucleotide-synthesis ➢ **Antisense Technology** https://www.ukessays.com/essays/sciences/antisense-technology-applications-7151.php ➢ **SV40 vector** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC322153/pdf/nar00317-0279.pdf	
18)	**BT 304L** Biotechnology Lab-IV	After successful completion of the course, students should be able to: • Demonstrate an understanding of production and estimation of commercially important molecules • Hands on training related to genetic manipulation techniques • Learn sequence alignment of biomolecules using bioinformatic tools	**BT 6.4** **Bioprocess Engineering** 1. Demonstration of Bioreactor. ~~2. Estimation of Biomass.~~ 3. Estimation of growth and product yield in a Bioconversion process. 4. Comparison between aerobic and anaerobic process. **Plant cell and tissue culture** ~~5. Tissue culture media preparation MS/White media, Slant preparation~~ ~~6. Sterilization techniques~~ ~~7. Culture of axillary meristems for clonal multiplication.~~ ~~8. Embryo culture.~~ **Animal Cell and Tissue Culture** ~~9. Peripheral Blood culture preparation of metaphase chromosomes.~~ ~~10. Cell separation by enzymatic and mechanical methods.~~ ~~11. Counting and cell viability tests.~~ **Recombinant DNA Technology** ~~12. Isolation of genomic DNA and its electrophoretic separation.~~ 13. Restriction digestion of plasmid DNA. ~~14. To obtain transposon Tn5 insertion into the genome of AK 631 strain of Rhizobium meliloti using suicide plasmid vector pGS 9.~~ 15. To transfer plasmid pJB3JI from J53 strain of E. coli to	**Bioprocess Engineering** 1. Determination of growth kinetics of *E. coli* 2. Demonstration of Bioreactor. 3. Estimation of growth and product yield in a Bioconversion process. 4. Comparison between aerobic and anaerobic process. 5. Lactic acid production and estimation by titration. **Recombinant DNA Technology** 19. Isolation of plasmid DNA from *E. coli*. 20. Restriction digestion of plasmid DNA and its electrophoretic separation. 6. To transfer plasmid pJB3JI from J53 strain of *E. coli* to HB101 strain of *E. coli*.	The theory paper Cell and Tissue Culture Technology has been merged with Plant & Animal Biotechnology paper. Thus, the practicals are Shifted to the VIII Semester which coincides with the theory paper Relevant practical introduced

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			HB101 strain of E. coli. **Bioinformatics** 16. To check similarity between DNA and Protein sequence using DOT PLOT method. 17. To check sequence alignment of DNA and Protein sequence using dynamic ~~sequencing~~. 18. Various exercises of in silico functional and comparative genomics in downloaded DNA and Protein sequences using: a. BLAST b. FASTA ~~c. ClustalW~~	**Bioinformatics** 7. To check similarity between DNA and Protein sequence using DOT PLOT method. 8. To check sequence alignment of DNA and Protein sequence using dynamic programming. 9. Various exercises of *in silico* functional and comparative genomics in downloaded DNA and Protein sequences using: a. BLAST b. FASTA c. ClustalX **Suggested Books:** ➢ Green, M. R., & Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual.*Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. ➢ Mahajan, R., Sharma, J., & Mahajan, R.K. (2010). *Practical Manual of Biotechnology* (I Ed.). New Delhi: Vayu Education of India. ➢ Swamy, P.M. *Laboratory Manual on Biotechnology* (I Ed.). Meerut: Rastogi Publication. ➢ Vats, S. (2015). *A Laboratory Text book of Biochemistry, Molecular Biology and Microbiology*. Germany: GRIN Verlag.	
	B. Tech. Biotechnology VII Semester				
	Reading Electives to be offered in VII Semester				
~~1)~~	~~**Reading Elective**~~ ~~**BT 7.1**~~ ~~**1. Plant Genetic Engineering**~~	~~After successful completion of the course, students will be able to:~~ • ~~Understand the various gene delivery system and vectors~~ • ~~Develop concept of gene cloning in~~	~~**Section – A**~~ • ~~Direct gene delivery systems – Biolistics, electroporation, microinjection and liposome mediated gene transfer.~~ • ~~Vectors used for gene transfer in plants: Ti and Ri plasmid based vectors.~~ • ~~Gemini virus, cauliflower mosaic virus.~~ • ~~Cloning vectors for plant genes: pUC vectors.~~ • ~~Other possible vectors – maize mitochondrial elements, nuclear genomic components, RNA viruses.~~		This course is proposed to be discontinued.

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		~~plants.~~ • ~~Learn application of genetic modified plants~~	~~**Section – B**~~ • ~~Gene cloning strategies in plants – cloning plastid and mitochondrial genes.~~ • ~~Molecular markers for plants.~~ • ~~Plant gene expression signals and genetic markers.~~ • ~~Study of structure and function of representative plant genomes viz. Chloroplast, mitochondrial and nuclear.~~ ~~**Section – C**~~ • ~~Antisense RNA technology, use of RNAi.~~ • ~~Arabidopsis as a model plant for genetic engineering.~~ • ~~Gene tagging.~~ • ~~Improvement of seed storage proteins.~~ • ~~Transgenic plants with resistance against herbicide, pesticide and disease resistance, stress tolerance.~~ • ~~Manipulation of photosynthetic carbon metabolism (Rubisco) in transgenic plants.~~ ~~**Books Recommended:**~~ ➢ ~~Transgenic plants: Promise or danger by B.L. Kakralya and Ishita Ahuja (Agrobios, India).~~ ➢ ~~Plant Biotechnology by Ignacimuthu, S.J. (Oxford and IBH publishing Co. PVT. Ltd.).~~ ➢ ~~Applied Plant Biotechnology by S. Ignacimuthu S.J. (Tata Mc Graw Hill Publishing Co. Ltd. New Delhi).~~		
2)	**Reading Elective** ~~**BT 7.1**~~ ~~**2. Renewable Energy Resources**~~	~~After successful completion of the course, students will be able to:~~ • ~~Understand the various forms of conventional and non conventional energy resources~~ • ~~Environmental aspects of these energy sources~~ • ~~Learn the present~~	**Section -A** ~~Energy and power, conventional energy sources. Renewable energy sources, solar energy alternatives, optimal tilt for solar equipments. Solar photovoltaic technologies, solar photovoltaic systems and their components. Wind energy, wind flow, power in the wind, types of wind turbines, wind turbine sizing and systems design.~~ **Section -B** Biomass energy, introduction, types of biomass and their ~~applications, energy content of biomass, biomass as a source of energy, biomass-based fuels, structure of a biogas plant, design of a biogas plant, costing and payback period.~~		This course is proposed to be discontinued.

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		~~energy scenario and the need for energy conservation~~	~~Chemical energy sources, hydrogen energy technology, production storage transportation alternate fuel for motor vehicles, safety and management.~~ **Section -C** ~~Magneto hydro dynamic power, thermo electric power, thermionic generation, thermonuclear fusion energy, Energy storage and distribution Energy conservation concept, principles technologies involved. Co-generation, waste heat utilization heat recuperators, regenerators, heat pipes & pumps. Renewable energy sources and devices and their instrumentation and control.~~ **Books Recommended:** **Text Book:** ➢ G. D. Rai, "Non conventional energy sources", Khanna Publishers, New Delhi 2007. **Reference Books:** ➢ Singhal R. K. "Non conventional energy sources" Katson publishers. New Delhi 2009. ➢ M. Chiogioji, "Industrial Energy Conservation", McGraw Hill, New York, 1979. ➢ Chetan Singh Solanki, "Renewable energy technologies" PHI, New Delhi, 2009.		
3)	**Molecular Diagnostics**	After successful completion of the course the students will be able to: • Comprehend techniques used to diagnose diseases • Use the gained knowledge in pursuing career in diagnostic labs and related research areas.		The successful treatment of diseases essentially depends on the early and accurate detection of pathogens. Conventional methods are available for detection of infectious agents but often they are time consuming and costly. Over the last decade, molecular diagnostics has become the gold standard to detect genetic disorders and infectious disease. These techniques are sensitive and allow detection of even lower amounts of infectious agents, thus, allowing early detection of infections. Molecular diagnostic methods include: immunological (ELISA), Monoclonal Antibodies, biofluorescent and bioluminescent systems (Colored fluorescent proteins, luciferase and microbial biosensors), nucleic acid diagnostic systems (hybridization probes, molecular beacons, DNA fingerprinting, RAPD, Real-Time	New course proposed to be introduced

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				PCR, Immunoquantitative Real-Time PCR and automated DNA analysis). Further, for the detection of genetic disorders like cystic fibrosis and sickle-cell anemia methods viz., PCR/OLA, padlock probes, genotyping with fluorescence labelled PCR primers and TaqMan assay and mutation detection (PCR-Single strand conformation polymorphism, PCR-denaturing gradient gel electrophoresis and mismatch chemical cleavage) are generally employed. **Suggested Books:** ➢ Glick B.R., Pasternak J.J., & Patten C.L. (2010). *Molecular Biotechnology: Principles and applications of recombinant DNA* (4th ed). American Society for Microbiology. ➢ Primrose, S.B., Twyman R.H., & Old R.W. (2001). *Principles of Gene Manipulation* (6th ed). Wiley-Blackwell. **Suggested e-resources** ➢ **PCR-Denatured gradient gel electrophoresis** https://www.scq.ubc.ca/denaturing-gradient-gel-electrophoresis-dgge-an-overview/ ➢ **PCR-Single strand conformation polymorphism** https://genome.cshlp.org/content/1/1/34.long ➢ **Mismatch chemical cleavage** http://www.livingnaturally.com/ns/DisplayMonograph.asp?StoreID=3ED1FF6A18BD42979FFF73C8E8CD4512&DocID=genomic-ccm	
4)	**Biodiversity and Conservation**	After completing this course, students will be able to: • Understand the importance and gain knowledge of various aspects of ecosystems • Describe the physiological and		India is considered as a mega diversity zone and falls among the major biodiversity hot spots of the world. It is necessary to understand distribution and types of biodiversity seen in India especially with respect to ecological diversity, species diversity and genetic diversity. However, due to several reasons, there has been severe biodiversity loss not only in India but globally. Thus, study of species extinction (local, ecological, biological, background extinction, anthropogenic extinction) based on IUCN status categories and Red Data Book is necessary to plan biodiversity preservation and	New course proposed to be introduced

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		ecological adaptations of different organisms for survival and growth in various types of natural and engineered ecosystems		conservation strategies. The knowledge of endangered species in India and various conservation strategies both *in situ* (biosphere reserve, national park, wildlife sanctuaries, sacred forests) and *ex situ* (Cryo-preservation, Gene banks, DNA banks) are important aspects to maintain biodiversity. **Books Recommended:** ➢ Krishnamurthy, K.V. (2003). *Textbook of Biodiversity* (1st ed). USA:CRC Press publisher. ➢ Wilson, E.O., Peter, F.M. (1988). *Biodiversity*. Washington, D.C., USA: National Academy press. ➢ Sharma, A.K., Ray, D., Ghosh, S.N. (2012). *Biological Diversity: Origin, Evolution and Conservation*, New Delhi: Viva Books publisher. **Suggested e-Resources:** ➢ **Biodiversity conservation** https://link.springer.com/content/pdf/10.1007%2Fs10531-015-0860-5.pdf ➢ **Biodiversity** http://ncert.nic.in/ncerts/l/lebo115.pdf ➢ **Conservation** http://download.nos.org/333courseE/15.pdf http://www.rgmcet.edu.in/wp-content/uploads/2017/03/IV.BIODIVERSITY-AND-ITS-CONSERVATION.pdf	
5)	**Emerging Trends in Biofuel Technology**	After successful completion of the course, students will be able to: • Understand the production of different types of biofuel • Describe the environmental and social sustainability aspects of biofuel		Globally, fuel from biomass has immense potential as a commercially viable renewable energy source. Three generations of biomass identified for energy use have been described (crop plants, lingo-cellulosic material and microbial systems). Biomass can be converted to fuels, electricity, and process heat. The study of different methodologies for biomass extraction (anaerobic digestion, gasification, fermentation, liquefaction) and their conversion to various fuels like biodiesel, bio-hydrogen, bio-ethanol and biogas is important. Considering the environmental ramifications, the study of biomass based energy is important for achieving environmental and social	New course proposed to be introduced

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		• Learn the present energy scenario and the need for energy conservation		sustainability. **Suggested Books:** ➢ Chiogioji, M. (1979). *Industrial Energy Conservation*. New York, USA: McGraw Hill. ➢ Singhal, R. K. (2013). *Non -conventional energy sources*. New Delhi: S.K. Kataria & Sons publishers. ➢ Gude, V. G. (2018). *Green chemistry for sustainable biofuel production*. Oakville, ON Waretown, NJ AAP, Apple Academic Press [Boca Raton] CRC Press, Taylor & Francis Group. ➢ In Gikonyo, B. (2015). *Efficiency and sustainability in biofuel production: Environmental and land-use research*. Oakville, ON Canada ; Waretown, NJ, USA : Apple Academic Press **Suggested e-Resources:** ➢ **Technology for biofuel** https://nptel.ac.in/courses/108108078/7 ➢ **Biofuel** http://www.teriin.org/policybrief/docs/biofuel.pdf ➢ **Biogas plant** http://cdn.intechopen.com/pdfs/31334/InTech-Biogas_plant_constructions.pdf	
	B. Tech. Biotechnology VIII Semester				
18.	**BT 8.1** Animal Biotechnology	After successful completion of the course, students should be able to: • Develop comprehensive concepts of cell and tissue culture techniques and methodology • Gain fundamental concepts of in vitro fertilization and	**Section - A** • ~~Gene transfer techniques.~~ • In vitro fertilization and Embryo ~~Transfer: Composition of IVF media, steps involved in IVF, Fertilization by means of Micro insemination, PZD, ICSI, SUZI and MESA.~~ • ~~Cryopreservation: Need of cryopreservation, nature of assay~~, viability of assay, survival assay, ~~microtitration assay~~ and transformation assay. **Section - B** • Animal cell culture products ~~and their applications.~~ • ~~Transgenic animal: Methodology, Embryonic stem cell method, Microinjection and Retroviral vector method.~~	**Section - A** • Animal cell culture: brief history of animal cell culture, cell culture media and reagents, animal cell growth characteristics. • Disaggregation techniques, primary cell cultures, secondary culture, continuous cell lines, suspension cultures, establishment and maintenance of cell cultures. • Cell viability assays, cytotoxicity assays, survival assay and transformation assay. **Section - B** • Animal reproductive biotechnology: structure of sperms and ovum; cryopreservation of sperms and ova of livestock; artificial insemination; super ovulation,	Contents of 'Cell and Tissue Culture Technology' in the VII Sem has been incorporated with addition of some latest topics. Contents have been replaced with latest topics

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		animal cloning • Explain applications of cell and tissue culture in pharmaceutical industry	• Applications of transgenic animal. **Section - C** • ~~Gene therapy: Ex- vivo gene therapy, in vivo gene therapy, viral gene delivery system, Retrovirus vector system, Adenovirus vector system, Adeno-associated virus vector system, herpes simplex virus vector system, Non viral gene delivery system, Prodrug activation therapy, Nucleic acid as therapeutic agents.~~ **Books Recommended:** ➢ Molecular Biotechnology: Primrose ➢ Animal Cell Biotechnology: R.E. Spies and J.B. Griffiths (1988), Academic Press. ➢ Stem Cell Biology by Marshak (2001), Cold Spring Harbor symposium publication. ➢ Animal Cell Culture by John R.W. Masters	embryo recovery and *in vitro* fertilization • Culture of embryos; cryopreservation of embryos; embryo transfer technology; transgenic manipulation of animal embryos. • Animal cloning: Basic concept; cloning for conservation of endangered species. **Section - C** • Vaccinology: History of development of vaccines, introduction to the concept of vaccines, conventional methods of animal vaccine production, recombinant approaches to vaccine production, modern vaccines. • Somatic Hybridization: Fusogens, basis of somatic hybridization technology, storage of hybridoma cells, productions of monoclonal antibodies. • General overview of applications of transgenic animal technology and animal cell culture products. **Suggested Books:** ➢ Bernard, R., Glick, Jack, J., Pasternak, Cheryl, L, &. Patten. (2009). Molecular Biotechnology Principles and Applications of Recombinant DNA (4th ed.). ASM press. ➢ Butler, M. (2004). *Animal Cell Culture & Technology* (2nd ed.). UK: Taylor & Francis. ➢ Davis, J. M. (2011). *Animal Cell Culture: Essential Methods*. USA: John Wiley & Sons Ltd. ➢ Freshney, R. I. (2011). *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications* (6th ed.). USA: Wiley-Blackwell. ➢ Gordon, I. (2005). *Reproductive Techniques in Farm Animals.* Oxford: CAB International. ➢ John, R. W. (2000). *Animal Cell Culture: a Practical Approach* (3rd ed.). UK: Oxford Unievrsity Press. ➢ Levine, M. M. (2004). *New Generation Vaccines*. New York: M. Dekker. ➢ Pörtner, R. (2007). *Animal Cell Biotechnology: Methods and Protocols*. Totowa, NJ: Humana Press.	'Gene therapy' is taught in VI Semester. Thus, it has been replaced with relevant topics

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				Suggested e-Resources: ➢ **Animal cell culture products** http://www.biologydiscussion.com/biotechnology/animal-biotechnology/applications-of-animal-cell-cultures/10457 ➢ **Artificial Insemination** https://fertilityfirst.com.au/wp-content/uploads/2017/02/intrauterine-insemination-iui.pdf ➢ **Intracytoplasmic Sperm Injection (ICSI)** https://www.intechopen.com/books/advances-in-embryo-transfer/new-advances-in-intracytoplasmic-sperm-injection-icsi-	
19.	~~BT 8.2 Bioethics and Biosafety~~				This course is proposed to be shifted in VIII semester and offered as an elective course.
20.	**BT 8.4** Environmental Biotechnology	After successful completion of the course, students should be able to: • Understand the biological process for sewage and wastewater management • Discuss role of biology in sustainable technology development • Explain the role of microbes in environmental remediation	**Section – A** • Biological processing of sewage and wastewater treatment: Anaerobic and aerobic, conventional, advanced and new emerging technology, methanogensis, methanogenic, acetogenic and fermentative bacteria – technical process and conditions. • Solid waste management: Waste monitoring, treatment and disposal of non-hazardous solid waste, general remedial measures for medical waste management and Hazardous waste. **Section – B** • Bioenergy and Biofuel**:** Advantages of Biofuels, plant derived fuels, energy crops, Biogas, Bioethanol and Biohydrogen. • Biopolymers and Bioplastics: Types of Bio-polymers, Preparation of Bio polymers and Bio-plastics, properties and practical applications of PHB,	**Section – A** • Biological processing of sewage and wastewater treatment: anaerobic and aerobic, conventional, advanced and new emerging technology, methanogensis, methanogenic, acetogenic and fermentative bacteria – technical process and conditions. • Solid waste management: waste monitoring, treatment and disposal of non-hazardous solid waste, general remedial measures for medical waste management and hazardous waste. **Section – B** • Bioenergy and biofuel**:** advantages of biofuels, plant derived fuels, energy crops, biogas, bioethanol and biohydrogen. • Biopolymers and bioplastics: types of bio-polymers, preparation of bio polymers and bioplastics, properties and practical applications of PHB, advantages and	Typographical corrections only

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			advantages and disadvantages of Bioplastics. • Biosensors: Principle and application, BOD, Ammonium, Nitrate and Sulphate. **Section – C** • Biodegradation of Xenobiotics**:** Organisms involved in degradation of chlorinated hydrocarbons, polyaromatic hydrocarbons, pesticides. • Surfactants and microbial treatment of oil pollution. • Biofertilizers and Biopesticides • Bioremediation and Biorestoration: General approaches, Reforestation through micropropagation, use of microbes for improving soil fertility, germplasm conservation (gene banks), conservation of Biodiversity (*in situ* and *ex situ*). **Books Recommended:** ➢ An Introduction to Environmental Biotechnology: Milton Wainwright, Kluwer Academic Press. ➢ Environmental Biotechnology: Alen Scragg, Longman. ➢ Encyclopedia of Pollution and its Control Vol. I-VI. ➢ Environmental Impact Assenment: Clark, Bissel & Watham. ➢ J. Winter, Environmental Processes I-III 2nd Ed. ➢ Metcalf Eddy – Waste water Biotechnology, Wiley Pub. ➢ Ted Munn, Encyclopedia of Global Environmental changes, 5 Vol. Set Wiley Pub. ➢ Metcalf Eddy – Waste water Engineering – 3 Ed.; THM Pub. ➢ Introduction to waste water treatment: R.S. Ramalho. ➢ Environmental Chemistry: Dr. A. K. ➢ Environmental Science: Miller T. G. ➢ Applications of Biotechnology: Eds. B N Tripathi, G S Shekhawat and Vinay Sharma, Aavishkar publishers	disadvantages of bioplastics. • Biosensors: principle and application, BOD, ammonium, nitrate and sulphate. **Section – C** • Biodegradation of xenobiotics**:** organisms involved in degradation of chlorinated hydrocarbons, polyaromatic hydrocarbons, pesticides. • Surfactants and microbial treatment of oil pollution. • Biofertilizers and biopesticides • Bioremediation and biorestoration: general approaches, reforestation through micropropagation, use of microbes for improving soil fertility, germplasm conservation (gene banks), conservation of Biodiversity (*in situ* and *ex situ*). **Suggested Books:** ➢ Jogdand, S. N. (2010). *Environmental Biotechnology (Industrial pollution management)* (3rd ed.). Mumbai, India: Himalaya Publishing House. ➢ Milton, W. (Ed.). (1999). *An Introduction to Environmental Biotechnology*. USA: Springer. ➢ Modi, P. N. (2015). *Sewage treatment & disposal and waste water engineering*. New Delhi, India: Rajsons Publications Pvt. Ltd. ➢ Srinivasan, D. (2009). *Environmental Engineering*. New Delhi, India: PHI Learning Pvt. Ltd. ➢ Thakur, I. S. (2012). *Enviromental Biotechnology: Basic concepts and Application* (2nd ed.). New Delhi: I K International Publishing House. ➢ Tripathi, B. N., Shekhawat, G. S., & Sharma, V. (Ed.). (2009). *Applications of Biotechnology*. Jaipur, India: Aavishkar Publishers. **Suggested e-Resources:** ➢ **Biological treatment of wastewater** http://www.neoakruthi.com/blog/biological-treatment-of-wastewater.html ➢ **Biogas**	

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				http://www.biologydiscussion.com/biomass/production-of-biogas-from-biomass/10436 ➢ **Biofuel** http://uru.ac.in/uruonlinelibrary/BioFuels/Biomass%20and%20biofuels.pdf ➢ **Biosensor** https://www.edgefx.in/biosensors-types-its-working-and-applications/ ➢ **Xenobiotic compound biodegradation** http://www.biologydiscussion.com/microbiology-2/bioremediation/xenobiotic-compounds-meaning-hazards-and-biodegradation/55625	
21.	**BT 8.5** Plant Biotechnology	After successful completion of the course, students should be able to: • Develop comprehensive concepts of cell and tissue culture techniques and methodology • Understand the basic concepts of transgenic plants and molecular pharming • Comprehend the basic knowledge of chloroplast engineering and edible vaccines	**Section – A** • ~~Introduction, scope and future outlook~~. • Transgenic plants - basic concept ~~and essential steps for producing transgenic plants, Examples,~~ use of suitable promoters. • ~~Development of plants for improved seed quality.~~ • Development of plants resistant to environmental stress and herbicides. • Development of pathogen resistant plants (Virus and insect resistance). **Section – B** • Artificial seeds. • Plant gene banks, germplasm collection, Cryobanks. • Plant secondary metabolites, metabolic engineering, strategies for enhancement of their production in cell and tissue culture. • Plants as Biofactories – concept, ~~production of chemicals, pigments, perfumes, flavors, insecticides, anticancer agents etc.~~ **Section – C** • Chloroplast engineering: techniques, advantages and application of chloroplast transgenics in production of	**Section – A** • Plant tissue culture: historical perspective, totipotency, media preparation ,nutrients and plant hormones. • sterilization techniques, establishment of cultures :callus culture, cell suspension culture, organogenesis, somatic embryogenesis; artificial seeds • Micropropagation, somaclonal variation, somatic hybridization, cybrids. • Protoplast isolation and culture, viability test, techniques of protoplast fusion, haploid production and applications. **Section – B** • Transgenic plants - basic concept and use of suitable promoters. • Development of plants resistant to environmental stress and herbicides. • Development of pathogen resistant plants (Virus and insect resistance). • Overview of plant secondary metabolites, metabolic engineering, strategies for enhancement of their production in cell and tissue culture. • Concept of plants as biofactories, molecular pharming. **Section – C** • Chloroplast engineering: techniques, advantages and	Contents of 'Cell and Tissue Culture Technology' in the VII Sem has been incorporated with addition of some latest topics.

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			biopharmaceuticals, introduction of agronomic traits, ~~viz. disease resistance, herbicide resistance, salt and drought resistance, phytoremediation etc~~. • Edible Vaccines. • ~~Radiobiology of cultured plant cells.~~ • Biotechnology of biological nitrogen fixation: *nif* genes. **Books Recommended:** ➢ Biotechnology - A laboratory Course: J. M. Becker, G.A. Cold well and E.A. Zachgo, Academic Press, New York. ➢ Genetic Engineering Technology in Industrial Pharmacy: Ed.- J.M. Tabor. ➢ Tissue Culture, Methods and Applications: P.F. Kruse. ➢ Applications of biotechnology: Eds. B N Tripathi, G S Shekhawat and Vinay Sharma, Aavishkar publishers.	application of chloroplast transgenics in production of biopharmaceuticals and introduction of agronomic traits • Edible Vaccines. • Plant gene banks, germplasm collection, cryobanks. • Biotechnology of biological nitrogen fixation: *nif* genes. **Suggested Books:** ➢ Bhojwani, S. S., & Razdan, M K. (1996). *Plant Tissue Culture: Theory and Practice*. Nederland: Elsevier Science. ➢ Chawla, H. S. (2000). *Introduction to Plant Biotechnology*. USA: Science Publishers. ➢ Gupta, P. K. (2005). *Elements of Biotechnology*. India: Rastogi Publications. ➢ Singh, B. D. (2015). *Biotechnology*. Kolkata, India: Kalyani Publishers. ➢ Slater, A., Scott, N., & Fowler, M. (2008). *Plant Biotechnology: The Genetic Manipulation of Plants* (2^{nd} edition). UK: Oxford University Press. **Suggested e-Resources:** ➢ **Background of Tissue Culture Technology** http://www.biologydiscussion.com/botany/tissue-culture/tissue-culture-definition-history-and-importance/42944 ➢ **Embryogenesis and organogenesis** https://nptel.ac.in/courses/102103016/module1/lec8/3.html ➢ **Single Cell Cultures and Cloning**: http://www.biologydiscussion.com/botany/tissue-culture/methods-for-obtaining-single-cell-clones-from-callus-culture-plant-tissue-culture/43004 ➢ **Protoplasm isolation and regeneration** https://nptel.ac.in/courses/102103016/12 ➢ **Haploid plant production** http://www.biologydiscussion.com/plants/haploid-plants/production-of-haploid-plants-with-diagram/10700 ➢ **Preservation of cell lines**	

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				https://www.ukessays.com/essays/biology/techniques-for-cell-preservation-biology-essay.php ➢ **Somatic hybridization** http://www.biologydiscussion.com/somatic-hybridization/somatic-hybridization-aspects-applications-and-limitations/10686	
22.	**BT 8.3** Biotechnology Lab - V	After successful completion of the course, students should be able to: • Understand various techniques of plant and animal biotechnology • Learn analytical techniques to estimate toxicity of hazardous component • Demonstrate an understanding to assess water pollution • Demonstrate animal cell culture techniques	**Plant Biotechnology** 1. ~~Extraction and~~ estimation of ~~phenol based secondary metabolites.~~ ~~2. Isolation of chloroplast genome.~~ ~~3. Restriction analysis of chloroplast genome.~~ 4. Isolation of plant genomic DNA. 5. Artificial seeds. 6. Shoot tip culture. 7. Isolation of protoplasts. **Environmental Biotechnology** 8. Degradation of pesticide in soil and estimation of its residue. 9. Determination of fluoride in water/soil/biosamples. 10. Determination of LD50 of common pesticides/weedicides. 11. Bacteriological Analysis of wastewater. 12. Demonstration of Biosensors, Principle and Application, eg. BOD, Nitrite, sulfite on the basis of availability. **Animal Biotechnology** ~~13. Initiation of primary cell culture and maintenance~~ ~~14. Isolation of hepatocytes~~	**Plant Biotechnology** 1. Preparation of MS medium 2. Sterilization techniques 3. Embryo culture. 4. Shoot tip culture 5. Encapsulation of embryo using sodium alginate 6. Isolation of protoplasts. 7. Estimation of total phenolic content from plant leaves **Environmental Biotechnology** 8. Degradation of pesticide in soil and estimation of its residue. 9. Determination of fluoride in water/soil/biosamples. 10. Determination of LD_{50} of common pesticides/weedicides. 11. Bacteriological Analysis of wastewater. 12. Estimation of BOD from water samples. **Animal Biotechnology** 13. Cell counting and determination of cell viability 14. Preparation of metaphase chromosomes **Suggested Books:** ➢ Kumar, V. (2011). *Laboratory Manual of Microbiology*. New Delhi: Scientific Publishers. ➢ Mahajan, R., Sharma, J., & Mahajan, R.K. (2010). *Practical Manual of Biotechnology* (1st ed.). New Delhi: Vayu Education of India. ➢ Saxena, J., Baunthiyal., & Ravi, I. (2015). *Laboratory Manual of Microbiology, Biochemistry and Molecular*	Practical exercises of the Paper Cell & Tissue Culture Technology, which were removed from VI Semester, are proposed to be incorporated. Feasible experiments have been included.

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				Biology. Jodhpur: Scientific Publishers. ➢ Sharma, R.K., Sangha, S.P.S. (2009). *Basic Techniques in Biochemistry & Molecular Biology*. New Delhi: I.K. International Publisher. ➢ Swamy, P.M. *Laboratory Manual on Biotechnology* (1st ed.). Meerut: Rastogi Publication. ➢ Trivedi, R. (2016). *Practical Manual in Microbial Physiology and Industrial Microbiology* (1[st] ed.). New Delhi: S. K. Book Agency.	
	Electives to be offered in VIII Semester				
1)	**BT 8.6 1** Biomedical Engineering	After successful completion of the course, students will be able to: • Understand different human systems and associated physiological disorders • Explain the role of recent medical advances in diagnostics and treatment • Develop high employability as a biomedical scientist	**Section – A** • An introduction to Biomedical Engineering • Applications and scope of Engineering in Medical Science • Respiratory System: Anatomy and physiology, Disorders and diagnostics. • Digestive System: Anatomy and physiology, Disorders and diagnostics. • Excretory System: renal anatomy and physiology, disorders and diagnostics **Section – B** • Electrical potentials in the human body. • Cardio Vascular System: Anatomy of heart, Cardiac Cycle and ECG or EKG, pacemaker, Heart disorders, diagnostics. • Haemodynamics: Blood flow, velocity, circulation time, Blood pressure, Resistance, blood and vascular modeling. • Muscular System: Anatomy, physiology and electrical properties of muscles. Clinical consideration and diagnostics. • Nervous System: Synapse, electrical properties of neurons, neuromuscular functions, Disorders and diagnostics. **Section - C** • Biomaterials and Implentable sensors.	**Section – A** • An introduction to biomedical engineering. • Applications and scope of engineering in medical science. • Respiratory system: anatomy and physiology, disorders and diagnostics. • Digestive system: anatomy and physiology, disorders and diagnostics. • Excretory System: renal anatomy and physiology, disorders and diagnostics. **Section – B** • Electrical potentials in the human body. • Cardio vascular system: anatomy of heart, cardiac cycle and ECG or EKG, pacemaker, heart disorders, diagnostics. • Haemodynamics: blood flow, velocity, circulation time, blood pressure, resistance, blood and vascular modeling. • Muscular system: anatomy, physiology and electrical properties of muscles. clinical consideration and diagnostics. • Nervous system: Synapse, electrical properties of neurons, neuromuscular functions, disorders and diagnostics. **Section - C** • Biomaterials and implantable sensors.	Typographical Corrections only

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			• Testings of biomaterials *In vitro* and *In vivo.* • Artificial heart. • Dialysis Machine. • Medical Imaging: X- ray, design of X-ray tube. • Medical imaging processes and projections, 3D, 2D slice identification, CAT, MMR, MRI, PET / SPECT. **Books Recommended:** ➢ Principles of Anatomy and Physiology: G.M. Tortora. ➢ Human physiology Vol. I and Vol. II : C.C. Chatterjee. ➢ Introduction to Biomedical Engineering - Enderle, Blanclrard & Bronzine. ➢ Medical Instrumentation – Application & Design: John G. Webster ➢ Biomechanics: Y. C. Fung. ➢ The Essentials of Physics of Medical Imaging: J.J. Bushberg et. al.	• Testing of biomaterials *in vitro* and *in vivo.* • Artificial heart. • Dialysis machine. • Medical imaging: X- ray, design of X-ray tube. • Medical imaging processes and projections, 3D, 2D slice identification, CAT, MMR, MRI, PET / SPECT. **Suggested Books:** ➢ Bushberg, J. T. (2012). *The Essential Physics of Medical Imaging*. Philadelphia, PA: Wolters Kluwer / Lippincott Williams & Wilkins. ➢ Chatterjee, C.C. (1992). *Human Physiology* (11th ed.). Kolkata: Medical Allied Agency. ➢ Enderle, J. D., Bronzino, J. D., & Blanchard, S. M. (2005). *Introduction to Biomedical Engineering*. Amsterdam: Elsevier Academic Press. ➢ Fung, Y. C. (1993). *Biomechanics: Mechanical Properties of Living Tissues*. New York: Springer-Verlag. ➢ Tortora, G. J., & Derrickson, B. (2017). *Principles of Anatomy & Physiology* John Wiley & Sons. ➢ Webster, J. G., & Clark, J. W. (1998). *Medical instrumentation: Application and Design*. New York: Wiley. **Suggested e-Resources:** ➢ **Cardiocascular and hemodynamics** https://pdfs.semanticscholar.org/a102/b25a8c6b74b97b4bfc8e6d5391aa95308925.pdf ➢ **Medical image processing** http://www.bme.teiath.gr/medisp/downloads/education/en_NOTES_IMAGE_PROCESSING_CAVOURAS.pdf ➢ **Artificial heart** https://www.heartfoundation.org.au/images/uploads/publications/Artifical-hearts-information-sheet.pdf	
2)	**BT 8.6 2** Food and Dairy	After successful completion of the course, students will	**Section – A** • History of microorganisms in food. • Intrinsic and extrinsic parameters that affect microbial	**Section – A** • Introduction and history of microorganisms in food. • Intrinsic and extrinsic parameters that affect microbial	

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
	Biotechnology	be able to: • Identify parameters affecting microbial growth and its effect on food • Demonstrate an understanding of various food processing and preservation methods • Describe contemporary food related policies and their implications	growth. • Microbiological examination of food, enumeration and detection of food borne microorganisms. • Bioassay and related methods. • ~~Methods of~~ food preservation. **Section – B** • ~~Brewing~~: Beer, wine and distilled spirits. • ~~Micro organisms in~~ meat, ~~poultry, baked products, fermented vegetables.~~ • ~~Contemporary food related policy issues and their implications~~. • Genetically modified foods. **Section – C** • Emerging processing and preservation technologies for milk and dairy products. • Fermented Dairy products: Cheese, yogurt, ~~whey~~ and butter. • Lactose metabolism production of aroma compounds. • ~~Xanthum gum, Pullulan, Rennin, Amylase~~ **Books Recommended:** ➢ Food Microbiology: W.C. Frazier, D.C. Westhoff, 3rd ed. Tata McGraw Hill ➢ Food Microbiology: M.R. Adams, M.O. Moss New Age international (p) Ltd. ➢ Stanbury, PF., Whitekar, A. and Hall, S.J. (1995) Principles of fermentation technology 2nd ed.	growth. • Microbiological examination of food. Enumeration and detection of food borne microorganisms (conventional, immunological, molecular, biosensor). • Bioassay and related methods. • Food preservation by controlling growth of microorganisms (asepsis, low temperature, high temperature, non-thermal processes, hurdle concept). **Section – B** • Alcoholic beverages: Beer, wine and distilled spirits. • Fermented meat products: sausages, salami. • Fermented vegetables products: Sauerkraut, miso, tempeh, kimchi, gundruk, khalpi. • Protein foods: Single cell proteins (SCP), mushroom, algal proteins. • Overview of the International and National guidelines for safety assessment of genetically modified (GM) foods. **Section – C** • Emerging processing and preservation technologies for milk and dairy products. • Fermented dairy products: Cheese, yogurt, kefir, butter. • Lactose metabolism production of aroma compounds. • Food safety acts (Indian act-Food Safety and Standards Act, 2006, Various food acts-PFA, FPO, AGMARK, MMPO, MFPO, edible oil acts, standard weight acts) and regulatory agencies monitoring safety of foods. **Suggested Books:** ➢ Adams, M. R., & Moss, M. O. (2007). *Food Microbiology*. Royal Society of Chemistry. ➢ Banwart, G.J. (1989*). Basic Food Microbiology*. CBS Publishers and Distributors, Delhi ➢ Frazier, W.C., & Westhoff, D.C. (2003). *Food Microbiology*. Tata McGraw Hill, Inc., New York. ➢ Joshi, V. K., &Pandey, A. (1999). *Biotechnology: Food*	Subtopics have been introduced to make the content precise with addition of relevant topics. Subtopics have been introduced to make the content precise with addition of relevant topics Whey is replaced by Kefir as whey is a byproduct of cheese production thus already covered there More important and relevant topics are introduced.

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			Pergamon Press. ➢ Banwart, G.J. (1989) Basic Food Microbiology. CBS Publishers and Distributors, Delhi ➢ Robinson R.K. (1990) Dairy Microbiology, Elsevier Applied Sciences, London	*Fermentation*. Asiatech Publishers Inc. ➢ Robinson, R.K. (1990). *Dairy Microbiology*. Elsevier Applied Sciences, London. ➢ Stanbury, P.F., Hall, S. J.,& Whitaker, A. (1999). *Principles of Fermentation Technology*. Butterworth-Heinemann, Elsevier Science Ltd. **Suggested e-Resources:** ➢ **History of microorganisms in food** https://faculty.weber.edu/coberg/class/3853/3853%20HistoryofFood.htm ➢ **Quality control of food detection system** https://www.engineersgarage.com/Contribution/Arduino-based-Smart-IoT-Food-Quality-Monitoring-System ➢ **Food Preservation** https://sciencesamhita.com/methods-of-food-preservation/ ➢ **Genetically modified food** http://anrcatalog.ucdavis.edu/pdf/8180.pdf	
3)	**BT 8.6 3** Genomics and Proteomics	After successful completion of the course, students will be able to: • Understand the scope of genomics with special emphasis on functional and structural genomics • Describe role of proteomics and various techniques associated • Demonstrate practical insight of techniques and tools applied in Proteomic	**Section – A** • Introduction to Genomics and Proteomics. • Gene Prediction and Counting. • Genome Similarity: SNPs and comparative genomics. • Functional Genomics: Microarray technique, Fluorescence in situ hybridization, Comparative genomic hybridization, microarray • Mapping genome modifications for crop improvement, Gene mining by transposons. **Section – B** • Proteomics and Proteome: Proteomics and the new biology, the proteome method for measurement of gene (mRNA) expression. • Analytical protein and peptide separations: Two-dimensional gel electrophoresis for proteome analysis, Image analysis of two dimensional gels, Detection of proteins in polyacrylamide gels and on electroblot membranes.	**Section – A** • Introduction to genomics and proteomics. • Gene prediction and counting. • Genome similarity: SNPs and comparative genomics. • Functional genomics: Microarray technique, fluorescence *in situ* hybridization, comparative genomic hybridization, microarray. • Mapping genome modifications for crop improvement, gene mining by transposons. **Section – B** • Proteomics and proteome: proteomics and the new biology, the proteome method for measurement of gene (mRNA) expression. • Analytical protein and peptide separations: two-dimensional gel electrophoresis for proteome analysis, Image analysis of two dimensional gels, detection of proteins in polyacrylamide gels and on electroblot membranes.	Typographical Corrections only

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		and genomic research	• Mass-spectrometry based method for protein identification and phosphorylation site analysis. **Section – C** • Application of proteomics: Drug development and toxicology, mixing proteome, protein expression profile, identifying protein-protein interaction and protein complexes, mapping protein modifications, as tool for plant genetics and breeding. • Novel approaches to protein expression analysis. • ~~Bridging genomics and proteomics.~~ • Protein arrays: Generation of cDNA expression Libraries, use of automated technologies to generate protein arrays and chips, application of protein arrays in proteomics. • Characterization of protein complement of a specific cell type or tissue or a certain time by high-resolution 2DE. • Bridging the current proteomics and genomic approaches by mass spectrometry, Future perspective and developments. **Books Recommended:** ➢ Proteomics: from protein sequence to function. Edited by S.R. Pennington & M.J. Dunn. Published by viva books. (2002). ➢ Introduction to proteomics: Tools for the new biology by Daniel C. Liebler published by Humana Press (2002).	• Mass-spectrometry based method for protein identification and phosphorylation site analysis. **Section – C** • Application of proteomics: drug development and toxicology, mixing proteome, protein expression profile, identifying protein-protein interaction and protein complexes, mapping protein modifications, as tool for plant genetics and breeding. • Novel approaches to protein expression analysis. • Protein arrays: Generation of cDNA expression Libraries, use of automated technologies to generate protein arrays and chips, application of protein arrays in proteomics. • Characterization of protein complement of a specific cell type or tissue or a certain time by high-resolution 2DE. • Bridging the current proteomics and genomic approaches by mass spectrometry, Future perspective and developments. **Suggested Books:** ➢ Brown, S.M. (2015). *Next-generation DNA sequencing Informatics* (2nd ed.). Cold Spring Harbor Press. ➢ Lesk, A.M. (2015). *Introduction to Genomics* (2nd ed.). Oxford University Press. ➢ Liebler, D. C. (2001). *Introduction to proteomics tools for the new biology*. Humana Press. ➢ Pennington, S. R., Dunn, M. J., & Ebrary, Inc. (2001). *Proteomics: From protein sequence to function*. Oxford: BIOS. ➢ Pevsner, J. (2017). *Bioinformatics and Functional Genomics* (3rd ed.). John Wiley. ➢ Thangadurai, D. & Sangeetha, J. (2015). *Genomics and Proteomics: Principles, Technologies, and Applications*. CRC Press. ➢ Twyman, R.M. (2004). *Principles of Proteomics*. CBS Publishers. **Suggested e-Resources:**	**Repetition**

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				➢ **Protein array** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3680110/pdf/nihms465562.pdf ➢ **Gene mining by transposon** http://transposonpsi.sourceforge.net/ ➢ **Applications of proteomics in drug development** https://onlinelibrary.wiley.com/doi/full/10.1002/jcb.10576	
4)	**BT 8.6 4** Immunotechnology	After successful completion of the course, students will be able to: • Explain structure and function of the immune systeme at cellular and molecular level • Describe immunization/vaccination, immunological disease and immunotherapy • Develop approaches for the immune intervention of diseases	**Section – A** • General organization, expression and regulation of major Histocompatibility complex. Structural organization and expression of immunoglobulin genes and Generation of antibody diversity. • Genomic organization, structure and isolation of TCR. • Immune regulation, positive and negative selection in Thymus, Apoptosis. **Section – B** • Autoimmune diseases (Organspecific and Systemic autoimmune disease). • Immune response to infectious diseases (Viral, Bacterial Protozoan and Parasitic infections). • Immunodeficiency diseases (Phagocytic, Humoral, Cell mediated, Combined cell mediated Humoral deficiencies and Complement deficiencies). • Immune System in AIDS. **Section – C** • Tumor Biology. • Transplantation Immunology. • Synthetic Vaccines. • Cloning techniques and engineered antibody production and application, T cell cloning. **Books Recommended:** ➢ Essential of Immunology: W.H. Hildemann, Elservier Scientific Publishing Co. Inc. ➢ Understanding Immunology: A.J. Connigham, Academic Press.	**Section – A** • General organization, expression and regulation of major histocompatibility complex. Structural organization and expression of immunoglobulin genes and generation of antibody diversity. • Genomic organization, structure and isolation of TCR. • Immune regulation, positive and negative selection in thymus, apoptosis. **Section – B** • Autoimmune diseases (organspecific and systemic autoimmune disease). • Immune response to infectious diseases (viral, bacterial, protozoan and parasitic infections). • Immunodeficiency diseases (phagocytic, humoral, cell mediated, combined cell mediated humoral deficiencies and complement deficiencies). • Immune System in AIDS. **Section – C** • Tumor Biology • Transplantation immunology. • Synthetic vaccines. • Cloning techniques and engineered antibody production and application, T cell cloning. **Suggested Books:** ➢ Abbas, A. K., Lichtman, A. H. & Pillai, S. (2017). *Cellular and Molecular Immunology* (9th ed.). Elsevier. ➢ Delves, P. J., Martin, S. J., Burton, D. R., & Roitt, I. M. (2006). *Roitt's Essential Immunology* (11th ed.). Wiley-	Typographical corrections only

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Immunochemistry in Practice: A Johnstone and R. Thrope Blackwell Scientific Publications. ➢ Benjamin E and Leskowitz S. Immunology a short course. Wiley Liss NY to 1991. ➢ Richard A. Goldshy et al. Immunology 5th Ed. W.H. Freeman and Co., NY 2003. ➢ Pravesh C.Sen Gupta, Clinical Imunology, Oxford India. 2003 (2vol.) ➢ Klans D.Elgret (1996) Immunology-understanding of immune system.Wiley-Liss.NY ➢ Topley and Wilson's (1995) Text Book on Principles of Bacteriology, Virology and Immunology IX Ed. Edward Arnold, London. ➢ Fundamentals of Immunology: Paul W.E. (Eds.) Raven Press, New York, 1988. ➢ Antibodies a laboratory Manual: Harlow and David Lane (1988), Cold spring harbor laboratory. ➢ Cellular Interactions and Immunobiology – BIOTOL series ➢ Cellular and molecular Immunology – Abbas A.K., Lichtman A.H. and Pober, J.S. ➢ Immunobiology 3rd ed. – Janeway Travers	Blackwell. ➢ Punt, J., Stranford, S., Jones, P., & Owen, J. (2018). *Kuby Immunology* (8th ed.). W. H. Freeman and Company. ➢ Tizard, I. R. (1995). *Immunology: Introduction* (4th ed.). Philadelphia: Saunders College Publishing. **Suggested e-Resources:** ➢ **Cellular and Molecular Immunology** https://ocw.mit.edu/courses/health-sciences-and-technology/hst-176-cellular-and-molecular-immunology-fall-2005/lecture-notes/ ➢ **Immunology** https://study.com/academy/topic/immunology.html	
5)	**BT 8.6 5** Microbial Technology	After successful completion of the course, students will be able to: • Utilize various strategies for isolation, strain improvement, maintenance and containment of microbes • Describe strategies used for large scale production from	**Section – A** • Biotechnological innovation in pharmaceutical health, agricultural and industrial sectors. • Strategies for selection and improvement of industrial strains. • Measurement and control of bioprocess parameters. • Metabolic pathways and metabolic control mechanism. **Section – B** • Industrial production of biofuel, steroids and single cell protein. • Biofertilizres (Rhizobium and BGA) and Biopesticides (Bt toxin) • Biosensors (NH_4, Sulphide) and Biofilms. • Biopolymers (PHB), Xanthum gum).	**Section – A** • Biotechnological innovation in pharmaceutical health, agricultural and industrial sectors. • Strategies for selection and improvement of industrial strains. • Measurement and control of bioprocess parameters. • Metabolic pathways and metabolic control mechanism. **Section – B** • Industrial production of biofuel, steroids and single cell protein. • Biofertilizers (*Rhizobium* and BGA) and biopesticides (Bt toxin). • Biosensors (NH_4, Sulphide) and biofilms. • Biopolymers: PHB, Xanthum gum.	Typographical corrections only

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		microorganisms including overexpression • Understand advances in field of microbial technology for societal benefit	**Section - C** • Microbial overproduction of recombinant molecules: Selection of suitable promoter sequences, ribosome binding sites, transcription terminator, fusion protein tags, protease cleavage sites and enzymes, plasmid copy number, inducible expression systems. • Large scale production using recombinant microorganisms. **Books Recommended:** ➢ Biotechnological innovations in chemical synthesis, BIOTOL Publisher: butterworth-Heinemann. ➢ Industrial Microbiology, G. Reed (editor), CBS Publishers (AVI Publishing Company) ➢ Genetics and biotechnology of industrial microorganisms. C.L. Hershnergev, S. W. Queener and Q. Hegeman. Publisher: American Society of Microbiology, Ewesis. Et at., 1998. Bioremediation principles. McGraw Hill. ➢ Protein Expression: A Practical Approach edited by S.J. Higgins and B.D. Hames (OUP).	**Section - C** • Microbial overproduction of recombinant molecules: selection of suitable promoter sequences, ribosome binding sites, transcription terminator, fusion protein tags, protease cleavage sites and enzymes, plasmid copy number, inducible expression systems. • Large scale production using recombinant microorganisms. **Suggested Books:** ➢ Braun,V. & Gotz, F. (Eds.). (2002). *Microbial Fundamentals of Biotechnology*. Wiley-Vch. ➢ Crueger, W., & Crueger, A. (1990). *Biotechnology, A Text Book of Industrial Microbiology* (2^{nd} ed.). U.S: Sinauer Associates Inc ➢ Glazer, A.N. Nikaido, H. (2008). *Microbial Biotechnology*. Cambridge University Press. ➢ Kun, L.Y. (Ed.) (2003). *Microbial Biotechnology: Principles and Applications.* World Scientific Publication Co. Ptv. Ltd. **Suggested e-Resources:** ➢ **Microbial Biotechnology** http://www.biologydiscussion.com/microbial-biotechnology-2/microbial-biotechnology-biotechnology-2/71609 ➢ **Biosensor** https://www.edgefx.in/biosensors-types-its-working-and-applications/ ➢ **Biofertilizer** www.krishisewa.com/articles/organic-agriculture/115-biofertilizers.html ➢ **Biopesticide** www.agriinfo.in/default.aspx?page=topic&superid=3&topicid=1950	
6)	**BT 8.6 6** Molecular Modeling and	After successful completion of the course, students will	**Section – A** • Protein conformations, folding and mutation through modeling. The multi drug resistance proteins, drug	**Section – A** • Protein conformations, folding and mutation through modeling. The multi drug resistance proteins, drug	Typographical corrections only

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
	Drug Designing	be able to: • Understand the scope of pharmacokinetics and computer aided drug designing. • Identify and search potential drug leads using various tools of computational biology. • Understand methodologies used for drug designing	carrier affecting drug response, Pharmacokinetic basis of individual difference in response to drugs, pharmacokinetic properties, influence of structural modifications on pharmacokinetic properties, Pharmacodynamics studies. **Section – B** • Introduction to semi-empirical, molecular mechanics and ab intio techniques, potential energy surfaces, docking and modeling substrate receptor interactions, Software tools for modeling bimolecular, molecular electrostatic potentials, charge analysis. Different docking methodologies, success stories in docking. **Section – C** • A brief introduction to drug design methodologies, Structure based drug designing, Ligand based drug designing. Quantitative Structure Activity Relationship (QSAR), present and future aids to drug design, structure and confirmation of drugs and receptors, drug receptor binding forces, structural aspects of drug-nucleic acid interactions. • Pharmacopore identification, Pharmacophore modeling, Pharmacophore mapping, Pharmacophore generation, Hiphop and hypogen theories. **Books Recommended:** ➢ Molecular modeling: principles and applications 2nd Ed.: Andrew R. Leech ➢ Molecular Modeling for Beginners: Alan Hinchliffe ➢ Modeling Molecular Structures, 2nd Edition: Alan Hinchliffe ➢ Nucleic Acid Targeted Drug Design: Catherin Propst ➢ Computer-Aided Drug Design: Methods and Applications: Thomas J. Perun, Catherine Lamb Propst ➢ Structure-Based Drug Design: Pandi (EDT) Veerapandian ➢ Textbook of Drug Design and Discovery 3rd Edition: Povl Krogsgaard-Larsen, Tommy Liljefors, Ulf	carrier affecting drug response, pharmacokinetic basis of individual difference in response to drugs, pharmacokinetic properties, influence of structural modifications on pharmacokinetic properties, pharmacodynamics studies. **Section – B** • Introduction to semi-empirical, molecular mechanics and ab intio techniques, potential energy surfaces, docking and modeling substrate receptor interactions, software tools for modeling bimolecular, molecular electrostatic potentials, charge analysis. different docking methodologies, success stories in docking. **Section – C** • A brief introduction to drug design methodologies, structure based drug designing, ligand based drug designing. quantitative structure activity relationship (QSAR), present and future aids to drug design, structure and confirmation of drugs and receptors, drug receptor binding forces, structural aspects of drug-nucleic acid interactions. • Pharmacophore identification, pharmacophore modeling, pharmacophore mapping, pharmacophore generation, hiphop and hypogen theories. **Suggested Books:** ➢ Hinchliffe, A. (1998). *Modelling molecular structures*. Biochemical Education ➢ Leech, A.R. (2001). *Molecular modeling: principles and applications* (2nd ed.). USA: Pearson. ➢ Perun, T. J., & Propst, C. L. (1989). *Computer-aided drug design: Methods and applications*. New York: Marcel Dekker. ➢ Tommy, L., Larsen, P.K., & Madsen, U. (2002). *Textbook of Drug Design and Discovery* (3rd ed.). USA: CRC Press. **Suggested e-Resources:** ➢ **Drug design and Discovery**	

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			Madsen, U. Madse.	https://nptel.ac.in/courses/104103071/pdf/mod15.pdf ➢ **Bioinformatic tools** https://nptel.ac.in/courses/102103044/pdf/mod6.pdf ➢ **Pharmacophore modeling** https://www.dovepress.com/pharmacophore-modeling-advances-limitations-and-current-utility-in-dru-peer-reviewed-fulltext-article-JRLCR	
7)	**BT 8.6 7** Nanotechnology	After successful completion of the course, students will be able to: • Understand the basic concepts of nanobiotechnology • Apply engineering concepts to the nano-scale domain and design processing conditions • Comprehend the legal issues in nanotechnology and environmental risk assessment	**Section – A** • Introduction to Nanotechnology. • Current and future market applications: Semiconductor manufacturing, Advanced composites, Advanced ceramics, Catalytic and photocatalytic applications, Gas sensors and other analytical devices, consumer products, drug delivery mechanisms and medical therapeutics, Micro electronic applications. • Legal considerations for nanotechnology. • Environmental risk assessment, Health risk assessment, Hazards risk assessment. **Section – B** • Prime Materials: Metals, Iron, Aluminum, Nickel, Silver, Gold, Copper and their oxides, Silica products. • Nonmaterial Types: Nanowires, Nanotubes and their synthesis, properties, applications. • Fullerenes, quantum dots, Dendrimers, Properties. • Method of preparation: Top down, bottom up, plasma orcing, chemical vapour deposition, sol – gel methods. **Section – C** • Self assembled monolayers, Bio molecular motors and their functions. • Proteins and applications, • Drug delivery systems - Nanofluidic, fluids at micro and nanometer scale, fabrication of nanoporous and nanofluidic devices, applications. **Books Recommended:** ➢ Introduction to Nanoscale science and technology. Ed. By Mosimilano Di ventra I Edition, Kluwer Academic	**Section – A** • Introduction to nanotechnology. • Current and future market applications: semiconductor manufacturing, advanced composites, advanced ceramics, catalytic and photocatalytic applications, gas sensors and other analytical devices, consumer products, drug delivery mechanisms and medical therapeutics, micro electronic applications. • Legal considerations for nanotechnology. • Environmental risk assessment, health risk assessment, hazards risk assessment. **Section – B** • Prime Materials: metals, iron, aluminum, nickel, silver, gold, copper and their oxides, silica products. • Nonmaterial Types: nanowires, nanotubes and their synthesis, properties, applications. • Fullerenes, quantum dots, dendrimers, Properties. • Method of preparation: top down, bottom up, plasma orcing, chemical vapour deposition, sol – gel methods. **Section – C** • Self assembled monolayers, bio molecular motors and their functions. • Proteins and applications. • Drug delivery systems - nanofluidic, fluids at micro and nanometer scale, fabrication of nanoporous and nanofluidic devices, applications. **Suggested Books:** ➢ Bhattacharya, S. (2013). *Introduction to Nanotechnology*. New Delhi: Wisdom Press.	Typographical corrections only

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			– 2004. ➢ Nanotechnology, Grejory Timp –I Edition, Springer International – 2005. ➢ Nanotechnology. Michel Kohler – I Edition, Wiley VCH-2004. ➢ Nanotechnology: Environmental implications and solutions by Lous Theodove & Robert A. Kung. ➢ Introduction to Nanotechnology- C.P. Poole & F.S. Owens. ➢ Nanotechnology: Basic science and emerging technologies- M.Wilsin, K. Kannaranga, G. Smith, M. Simmons & B. Raguse. ➢ An introduction to materials engineering and science for chemical and material engineers – B.S. Mitchell. ➢ Essay: The coming technological revolutions, from the websites of the center for responsible nanotechnology; www.crnano.org/magic.htm.	➢ Bhushan, B. (2017). *Springer Handbook of Nanotechnology*. Berlin, Heidelberg: Springer Berlin Heidelberg. ➢ Di, V. M. (2008). *Introduction to Nanoscale Science and technology*. New York, NY: Springer. ➢ Wilson, M. (2004). *Nanotechnology: Basic Science and Emerging Technologies*. Boca Raton: Chapman & Hall/CRC. **Suggested e-Resources:** ➢ **Nanofluidic devices** https://aip.scitation.org/doi/pdf/10.1063/1.4794973?class=pdf ➢ **Preparation of Nanomaterial** https://nptel.ac.in/courses/103103033/module9/lecture2.pdf	
8)	**BT 8.6 8** Plant Secondary Metabolites	After successful completion of the course, students will be able to: • Understand isolation techniques for plant secondary metabolites and their biosynthetic pathway. • Demonstrate production of various secondary metabolites and factors affecting it • Explain large scale production of various secondary metabolites	**Section – A** • Introduction to secondary metabolites. • Plant products in nature. • Occurrence, types and uses of plant products. • Basic tools and techniques used in isolation & separations of plant secondary metabolites. • Biosynthesis of secondary metabolites- Shikimate, Acetate-malonate and acetate-mevalonate pathways. **Section – B** • Production, *In vitro* optimization. • Secondary metabolite selection, effect of metabolism on secondary metabolite production. • Production of secondary metabolites under stress factors. • Production of alkaloids, steroids & saponins. • Mechanism & control by different factors. • Detoxification of secondary metabolites. **Section – C** • Production of secondary metabolites by Bioconversion.	**Section – A** • Introduction to secondary metabolites. • Plant products in nature. • Occurrence, types and uses of plant products. • Basic tools and techniques used in isolation & separations of plant secondary metabolites. • Biosynthesis of secondary metabolites: Shikimate, Acetate-malonate and acetate-mevalonate pathways. **Section – B** • Secondary metabolite selection, effect of metabolism on secondary metabolite production. • Production of secondary metabolites under stress factors. • Production of alkaloids, steroids & saponins. • Mechanism & control by different factors. • Detoxification of secondary metabolites. **Section – C** • Production of secondary metabolites by bioconversion.	Typographical corrections only

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			• Genetic transformation for production of secondary metabolites. • Large scale production in Bioreactors. • Sources & types of antitumour compounds. • Food additives and insecticides. **Books Recommended:** ➢ Secondary metabolites by K.C. Ramavat- Oxford Press (2000) ➢ Plant Physiology: Devlin and Witham, Van Narst. ➢ Plant Physiology: Salisburry and Ross, Prentice Hall of India. ➢ Introductory plant physiology: Noggle and Fritz, Prentice Hall of Pvt. Ltd. ➢ Plant Physiology: Taiz and Zeiger, Introduction to Plant physiology: W.G. Hopkins, John Wiley and Sons Inc. ➢ Plant Physiology: Pandey and Sinha ➢ Biochemistry and Molecular Biology of Plants: Buchanan, Gressum and Jons, I K International Publications.	• Genetic transformation for production of secondary metabolites. • Large scale production in bioreactors. • Sources & types of antitumour compounds. • Food additives and insecticides. **Suggested Books:** ➢ Buchanan, B. B., Gruissem, W., & Jones, R. L. (2000). *Biochemistry & molecular biology of plants.* Rockville, Md.: American Society of Plant Physiologists. ➢ Noggle, G.R. and Fritz, C.J. (1986). *Introductory Plant Physiology*. (2nd ed.). New Delhi: Prentice Hall *of India* Pvt. Ltd., ➢ Pandey, S.N. and Sinha, B.K. (1996). *Plant Physiology* (3rd revised ed.). New Delhi: Vikas Publishing House Pvt. Ltd.. ➢ Ramavat, K.C. (2000). *Secondary Metabolites.* Oxford Press. ➢ Ross, C.W. (1974). *Plant Physiology Laboratory Manual*. California: Wadsworth Publishing Company. ➢ Salisbury, F.B. & Ross, C.W. (1991). *Plant Physiology* (4th ed.) Wadsworth Publishing Company. ➢ Taiz, L., & Zeiger, E. (2010). *Plant Physiology* (5th ed.). USA: Sinauer Associates lnc., ➢ Witham, F.H., Devlin, R. M., & Blaydes, D. F. (1971). *Experiments in Plant Physiology*. New York: Van Nostrand Reinhold Co. **Suggested e-Resources:** ➢ **Secondary metabolites** https://nptel.ac.in/courses/102103016/module4/lec32/3.html ➢ **Tools for production of secondary metabolites** https://nptel.ac.in/courses/102103016/38 ➢ **Industrial application** http://www.biologydiscussion.com/biotechnology/plant-biotechnology/secondary-metabolites-in-plant-cultures-	

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				applications-and-production/10646	
9)	**BT 8.2** Bioethics and Biosafety	After successful completion of the course, students should be able to: • Explain role of biotechnology in sustainable research and various ethical implications • Understand biosafety –objective, implementation, necessity and legislations • Develop preliminary understanding of Intellectual Property with emphasis on patents	**Section - A** 1. (i) Introduction to science, technology and society, (ii) Socio-economic impacts of biotechnology. 2. (i) Global biotech issues; major categories and impact (ii) Biodiversity: concept and importance, main features of Indian Biodiversity Act. (iii) Traditional knowledge. (iv) Access and benefit sharing (ABS): concept, convention on biological diversity and its impact on ABS, regulation of ABS and impact on developed and developing countries. (v) Environmental sustainability: concept of sustainable development types and factors, significance for developed and developing countries. 3. (i) Globalization : concept, impact in biotechnology. (ii) Development divide. 4. (i) Concept of legality, morality and ethics. (ii) Concept and Principles of bioethics: expanding scope of ethics from biomedical practice to biotechnology. (iii) Ethical conflicts in biotechnology: interference with nature, fear of the unknown, unequal distribution of risks and benefits of biotechnology; bioethics vs. business ethics. (iv) Case studies of relevance - ethical aspects of human genome project prenatal diagnosis and xenotransplantation. **Section - B** 5. (i) Biosafelty: concept definition of risks, hazards and various terminologies asssociated with hazard assessment and managment. (ii) Public acceptance in biotechnology (based on rationalsvs subjective perception of riks and	**Section – A** • Introduction to science, technology and society, socio-economic impacts of biotechnology, global biotech issues, major categories and impact. • Biodiversity: concept and importance, main features of Indian Biodiversity Act. Traditional knowledge. Access and benefit sharing (ABS): concept, convention on biological diversity and its impact on ABS, regulation of ABS and impact on developed and developing countries. • Environmental sustainability: concept of sustainable development types and factors, significance for developed and developing countries. Globalization: concept, impact in biotechnology, development divide. • Concept of legality, morality and ethics. Concept and Principles of bioethics: expanding scope of ethics from biomedical practice to biotechnology. Ethical conflicts in biotechnology: interference with nature, fear of the unknown, unequal distribution of risks and benefits of biotechnology; bioethics vs. business ethics. Case studies of relevance - ethical aspects of human genome project prenatal diagnosis and xenotransplantation. **Section – B** • Biosafelty: concept definition of risks, hazards and various terminologies asssociated with hazard assessment and management. Public acceptance in biotechnology (based on rationals vs subjective perception of risks and benefits.	Typographical Corrections only

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			benefits.) 6. (i) Biotechnology and biosafety concerns at the level of individuals, institutions and country. (ii) Cartagena Protocol: history conception and implementation of the protocal, impact on nations, main areas covered. 7. (i) Levels of Biosafety: concept, levels and their description (plants, animals and microbes). (ii) General .concepts: Good Lab Practices, Good Manufacturing Practices, Good Clinical Practices, Good Large Scale Practices. (iii) Chemical and biological hazards: disposal and safeguards. 8. (i) Biosafety regulations in the handling of recombinant DNA processes and products in institutions and industries- India America, European Union, China and Japan. (ii) Biosafety assessment: A general perspective. **Section - C** 9. (i) Biotechnology and food safety: The GM food debate and biosafety assessment procedures for biotech foods and related products, including transgenic food crops. (ii) Ecological safety assessment of recombinant organisms and transgenic crops, Case studies-golden rice, Bt cotton, flavr savr tomatoes, transgenic soybean. 10. International dimensions in biosafety: (i) Bioterrorism and convention on biological weapons. (ii) Biosafety assessment of biotech pharmaceutical products such as drugs/ vaccines. 11. Patents: brief description, types, basic idea of patent application and procedure, farmers rights Plant breeder's rights, international union for the protection of new varieties of plants (UPOV)	• Biotechnology and biosafety concerns at the level of individuals, institutions and country. Cartagena Protocol: history conception and implementation of the protocol, impact on nations, main areas covered. • Levels of Biosafety: concept, levels and their description (plants, animals and microbes). General .concepts: Good Lab Practices, Good Manufacturing Practices, Good Clinical Practices, Good Large Scale Practices. Chemical and biological hazards: disposal and safeguards. • Biosafety regulations in the handling of recombinant DNA processes and products in institutions and industries- India America, European Union, China and Japan. Biosafety assessment: A general perspective. **Section - C** • Biotechnology and food safety: The GM food debate and biosafety assessment procedures for biotech foods and related products, including transgenic food crops. • Ecological safety assessment of recombinant organisms and transgenic crops, Case studies-golden rice, Bt cotton, flavr savr tomatoes, transgenic soybean. • International dimensions in biosafety: Bioterrorism and convention on biological weapons. Biosafety assessment of biotech pharmaceutical products such as drugs/ vaccines. • Intellectual Property rights: definition, origin, types, Role of GATT, WTO, WIPO and TRIPS in 1PR, ethical impacts of IPR, technology transfer (concept and significance) ownership and monopoly Patents: brief description, types, basic idea of patent application and procedure, farmers rights Plant breeder's rights, international union for the protection of new varieties of	

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			12. Intellectual Property rights: definition, origin, types, Role of GATT, WTO, WIPO and TRIPS in 1PR, ethical impacts of IPR, technology transfer (concept and significance) ownership and monopoly. **Books Recommended:** ➢ Biotechnology and Safety Assessment 3rd Ed: Thomas, J.A., Fuch, R.L. Academic Press. ➢ Biological Safety Principles and Practices 3rd Ed: Fleming, D.A., Hunt, D.L., ASM Press, Washington. ➢ Biotechnology - A Comprehensive Treatise (Vol. 12). Legal Economic and Ethical Dimensions: H.J. Rehm and G. Reed, VCH. ➢ Encyclopedia of Bioethics.	plants (UPOV). **Suggested Books:** ➢ Fleming D. O. & Hunt D. L (Eds.). (2006). *Biological Safety: Principles & Practices* (4th ed.). ASM Press ➢ Goel D. & Parashar S. (2013). *IPR, Biosafety and Bioethics* (1st ed.) Pearson Education India. ➢ Ignacimuthu, S. (2008). *Bioethics*. Alpha Science International Ltd. ➢ Pandey, N. & Dharni, K. (2014). *Intellectual Property Rights.* PHI Learning. ➢ Ramakrishna, B. & Kumar, A. (2017). *Fundamentals of Intellectual Property Rights: For Students, Industrialist and Patent Lawyers* (1st ed.). Notion Press. ➢ Rehm, H.J & Reed, G. (1995). *Biotechnology – A Comprehensive Treatise Legal, Economic and Ethical Dimensions.* Vch Verlagsgesellschaft Mbh. ➢ Sateesh, M.K. (2008). *Bioethics and Biosafet*y. New Delhi: I.K. International Publishing House. **Suggested e-Resources:** ➢ **Access and Benefit sharing, Convention of Biological Diversity, Cartegena Protocol** https://www.cbd.int/convention ➢ **Bioethics** http://www.unesco-chair-bioethics.org/?page_id=43 **Biosafety** https://www.nih.gov/research-training/safety-regulation-guidance http://www.dbtindia.nic.in/ https://www.who.int/csr/resources/publications/biosafety/Biosafety7.pdf ➢ **Biosafety, Risk assessment and management** http://www.fao.org/docrep/014/i1905e/i1905e02.pdf ➢ **IPR** https://www.wipo.int/portal/en/index.html	
10)	**BT 306** Enzyme	After successful completion of the	**BT 5.3** **Section – A**	**Section – A**	Typographical

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
	Engineering and Technology	course, students should be able to: • Describe structure, functions and the mechanisms of action of enzymes • Develop concept of regulation of enzyme activity • Identify industrially relevant enzymes and describe their application	• Brief history of enzymes, nomenclature and classification of enzymes. • Specificity of Enzymes: Types of specificity, the Koshland "induced fit" hypothesis. • Strain or transition – state stabilization hypothesis. • Mechanism of enzyme action: Chymotrypsin and Carboxypeptidase A. • Enzyme Catalysis and Kinetics: Factors affecting the rate of chemical reactions, kinetics of enzyme-catalyzed reaction, Michaelis-Menten laws, importance and determination of Vmax and Km values, Hofstee's plot, L & B plots, Methods for investigating the kinetics of enzyme-catalyzed reactions (single and bisubstrate), nature of enzyme catalysis. • Enzyme inhibition: types and their Kinetics. **Section – B** • Extraction of soluble and membrane bound enzymes. • Purification of enzymes: salt precipitation, gel filtration, ion exchange and affinity chromatography. • Regulation of enzyme activity, various controls (metabolic compartmentation, covalent modifications and others), feedback regulation, allosteric enzymes. • The Investigation of Active Site Structure and Chemical nature of Enzyme Catalysis: The identification of binding sites and catalytic site, three dimensional structure of active site, mechanism of catalysis, mechanism of reaction catalyzed by enzyme without cofactors, metal-activated enzyme and metalloenzyme, coenzymes in enzyme catalyzed reactions. • The impact of genetic engineering on enzyme production, Modification of structural and catalytic properties by chemical methods and genetic engineering, enzymes from extremophiles, enzymes in organic solvent. **Section – C** • Immobilization of Enzymes: Concept, methods of	• Brief history of enzymes, nomenclature and classification of enzymes. • Specificity of enzymes: Types of specificity, the Koshland "induced fit" hypothesis. • Strain or transition – state stabilization hypothesis. • Mechanism of enzyme action: Chymotrypsin and carboxypeptidase A. • Enzyme catalysis and kinetics: Factors affecting the rate of chemical reactions, kinetics of enzyme-catalyzed reaction, Michaelis-Menten laws, importance and determination of V_{max} and K_m values, Hofstee's plot, L & B plots, Methods for investigating the kinetics of enzyme-catalyzed reactions (single and bisubstrate), nature of enzyme catalysis. • Enzyme inhibition: types and their kinetics. **Section – B** • Extraction of soluble and membrane bound enzymes. • Purification of enzymes: salt precipitation, gel filtration, ion exchange and affinity chromatography. • Regulation of enzyme activity, various controls (metabolic compartmentation, covalent modifications and others), feedback regulation, allosteric enzymes. • The investigation of active site structure and chemical nature of enzyme catalysis: The identification of binding sites and catalytic site, three dimensional structure of active site, mechanism of catalysis, mechanism of reaction catalyzed by enzyme without cofactors, metal-activated enzyme and metalloenzyme, coenzymes in enzyme catalyzed reactions. • The impact of genetic engineering on enzyme production, modification of structural and catalytic properties by chemical methods and genetic engineering, enzymes from extremophiles, enzymes in organic solvent. **Section – C** • Immobilization of enzymes: concept, methods of	corrections only

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			immobilization, Kinetics of immobilized enzymes, effect of solute partition and diffusion on kinetics of immobilized enzymes, bioreactors using immobilized enzyme. • Industrial enzymes: traditional (non-recombinant) sources of industrial enzymes, • Proteases and carbohydrases: Proteolytic enzymes, Carbohydrases, Lignocellulose degrading enzymes, Pectin and pectic enzymes. • Additional industrial enzymes: Lipases, Penicillin acylase, Amino acylase and amino acid production, cyclodextrins and cyclodextrin glycosyl transferase, enzymes in animal nutrition, Oxidoreductases. • Enzymes in molecular biology and clinical diagnostics. **Books Recommended:** ➢ Enzymes: Palmer, Horwood Publishing Series. ➢ Fundamentals of Enzymology: Price and Stevens, Oxford University Press. ➢ Enzyme Technology: Helmut Uhling, John Wiley ➢ Introduction to Proteins Structure: Branden and Tooze, Garland Publishing Group.	immobilization, kinetics of immobilized enzymes, effect of solute partition and diffusion on kinetics of immobilized enzymes, bioreactors using immobilized enzyme. • Industrial enzymes: traditional (non-recombinant) sources of industrial enzymes. • Proteases and carbohydrases: proteolytic enzymes, carbohydrases, lignocellulose degrading enzymes, pectin and pectic enzymes. • Additional industrial enzymes: lipases, penicillin acylase, amino acylase and amino acid production, cyclodextrins and cyclodextrin glycosyl transferase, enzymes in animal nutrition, oxidoreductases. • Enzymes in molecular biology and clinical diagnostics. **Suggested Books:** ➢ Bhaskar, A., Vidhya, V. G. (2014). *Enzyme Technology*. India: Mjp Publishers. ➢ Copeland, R. A. (2000). *Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis*. USA: John Wiley & Sons. ➢ Devasena, T. (2010). *Enzymology* (3rd ed.). UK: Oxford University Press. ➢ Meena, M., & Chauhan, D. (2009). *Fundamentals of Enzymology*. Jaipur, India: Aavishkar publishers. ➢ Palmer, T., & Bonner, P. (2008). *Enzymes: Biochemistry, Biotechnology, Clinical Chemistry* (2nd ed.). India: East West Publications. ➢ Scopes, R. K. (2013). *Protein Purification: Principles and Practice* (3rd ed.). USA: Springer. ➢ Segel, I. H. (2010). *Biochemical Calculations* (Second Edition). India: Wiley India Pvt. Ltd. **Suggested e-Resources:** ➢ **Mechanism of chymotrypsin** https://slideplayer.com/slide/5116894/ ➢ **Factors affecting rate of chemical reaction** https://www.adichemistry.com/physical/kinetics/factors/	

S. No.	Course List	Learning outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				factors-affecting-rate-reaction.html ➢ **Extraction and purification of enzyme** http://chemsites.chem.rutgers.edu/~kyc/Teaching/Files/543-05/09%20544-10%20ppt.pdf	

* Matter in contrast (black background & white letters) is shifted to some other units, and material brought as a result of shift is also in contrast.
# Matter in square brackets, bold, italic and crossed is deleted.
@ Proposed added materials are shaded in grey.

List of online courses in B.Tech Biotechnology Programme

S. No.	Portal	Name of course	Duration	Core/Elective/ Reading elective (Additional/ Alternate)	Credit point(s)	URL	Paid/ Free	Fee (course/ examination)	Remarks
	VII Semester Online Reading Elective Courses								
1	**COURSERA** University of California, San Diego	Drug Discovery	3 weeks 30 lectures	Reading Elective course	2	https://www.coursera.org/learn/drug-discovery	Paid	Rs. 2,508 only	-
2	**SWAYAM, Created by** Sanjeeva Srivastava IIT Madras	Proteins and Gel-Based Proteomics	8 weeks 20 lectures	Reading Elective course	2	https://swayam.gov.in/course/1386-proteins-and-gel-based-proteomics	Free	-	-
3	**Indian law university**	Online course on IPR	3 months	Reading Elective course	2	http://www.ili.ac.in/e-learnIPR.htm	-	Rs. 7500	-
	VIII Semester Online Elective Courses								
1	**SWAYAM,** Created by GK Suraishkumar, IIT Madras	Bioreactor	8 weeks , 27 lectures	Elective course	2	https://swayam.gov.in/course/1339-bioreactors	Free		Course 1 and 2 need to be taken together for fulfillment of 4 credit requirement.
2	**SWAYAM** Prof. Mukesh Doble, Institute of Technology, Madras	Principles of Downstream techniques in Bioprocess	8 weeks , 20 lectures	Elective course	2	http://nptel.ac.in/syllabus/102106048/	Paid	Certification exam fee	
3	**COURSERA** University of Manchester	Industrial Biotechnology	6 weeks 6-8 h/week	Elective course	4	https://www.coursera.org/learn/industrial-biotech	Free		

BANASTHALI VIDYAPITH
Department of Bioscience and Biotechnology
M.Sc. BIOSCIENCE- ANIMAL SCIENCE
PROGRAMME EDUCATIONAL OBJECTIVES

The M.Sc Bioscience Animal Science programme aims for the holistic development of the students through the unique and innovative five fold educational ideology of Banasthali Vidyapith.

Animal science is the study of nature of each kind of animal that helps the zoologist to learn evolution of animal species on earth and their processes and behaviour. The programme focuses on specific knowledge about animal biology and the associated academic disciplines including physiology, ecology, diversity, embryonic development, evolution, immunology, animal tissue culture, entomology, fish biology and animal biotechnology. The program fulfills the requirement of the students to become familiar with basic and advanced concepts of the subject thus providing them the scientific background they need to find career opportunities in any related field of zoology. On completion of the Programme, the student will be able to:

- develop aptitude for learning about the biology and significance of fauna ranging from single cell to multicellular system
- compare and contrast the characteristics of animals that differentiate them from other forms of life
- explain theory of evolution and how descent with modification has shaped animal morphology, physiology, life history, and behavior
- explain how organisms function at the level of the gene, genome, cell, tissue, organ and organ-system
- apply zoological science in aquaculture, agriculture and modern medicine
- gain the ability to work as taxonomist, paleontologist and evolutionary biologist
- access the primary literature, recognize relevant works for a particular topic, and evaluate the scientific content of these works
- demonstrate ability in the experimental techniques and methods of analysis appropriate for their area of specialization within zoology.

BANASTHALI VIDYAPITH
Department of Bioscience and Biotechnology
M.Sc. BIOSCIENCE-ANIMAL SCIENCE PROGRAMME OUTCOMES

PO1: Knowledge: Students will be equipped with an in-depth knowledge in the area of basic and applied zoology including evolution, taxonomy, physiology, molecular biology, genetics, cell biology, and environment.

PO2: Planning abilities: Develop efficient planning abilities with time management, analytical and decisive skills to reach achievable goals.

PO3: Problem analysis: Devise and sustain logical thinking to tackle detailed problem-solving and analytical tasks associated with questions in core and applied zoology.

PO4: Modern tool usage: Learn, select, and apply traditional taxonomy, practical field skills and modern molecular laboratory expertise. Develop competence in the handling of research facilities and operate safely in a laboratory environment, both individually and as a team member.

PO5: Leadership skill: Develop leadership skills to work in a team and take initiative for fulfillment of professional and societal responsibilities.

PO6: Professional Identity: Understand, analyze and communicate the value of their professional roles in different analytical and forensic laboratory, Zoological Survey of India, archeology, wild life management, aquaculture and food processing etc.

PO7: Animal Ethics: Develop empathy and love towards the animals. Apply principles of animal ethics and commit to professional and social responsibilities.

PO8: Communication: Develop skills used in reasoning and communication with scientific community and society. To synthesize information from literature and its communication in form of scientific papers, reports, poster and oral presentations.

PO9: The Zoologist and society: Contribute to society, in the realms of the environment, agriculture, natural resource management, human and animal health well being.

PO10: Environment and sustainability: Utilization of zoological research to enhance sustainable development of programs for conservation and preservation of biodiversity.

PO11: Life-long learning: Develop independent, critical and creative thinker who has a self-motivated passion for life-long learning.

Department of Bioscience and Biotechnology, Banasthali Vidyapith
M.Sc. Bioscience (Animal Science) Programme

Existing Courses					
M.Sc. Bioscience (Animal Science) Sem. I		**L**	**T**	**P**	**C**
BIO 407	Cell & Molecular Biology	4	0	0	4
BIO 403	Biochemistry & Biophysics	4	0	0	4
BIO 416	Microbiology	4	0	0	4
BIN 401	Bioinformatics	4	0	0	4
BIO 401	Analytical Techniques-I	4	0	0	4
BIO 404L	Bioscience Lab-I	0	0	12	6
	Total	**20**	**0**	**12**	**26**

Proposed Courses					
M.Sc. Bioscience (Animal Science) Sem. I		**L**	**T**	**P**	**C**
BIO	Cell and Molecular Biology	4	0	0	4
BIO	Biochemistry	4	0	0	4
BIO	Microbiology	4	0	0	4
BIN	Bioinformatics	4	0	0	4
BIO	Analytical Techniques-I	4	0	0	4
BIO	Bioscience Lab-I	0	0	12	6
	Total	**20**	**0**	**12**	**26**

Existing Courses					
M.Sc. Bioscience (Animal Science) Sem. II		**L**	**T**	**P**	**C**
BIO 406	Biostatistics and Research Methodology	4	0	0	4
BIO 410	Genetics	4	0	0	4
BIO 411	Immunology	4	0	0	4
BT 406	Enzymology and Enzyme Technology	4	0	0	4
BT 408	Genetic Engineering	4	0	0	4
BIO 405L	Bioscience Lab-II	0	0	12	6
	Total	**20**	**0**	**12**	**26**

Proposed Courses					
M.Sc. Bioscience (Animal Science) Sem. II		**L**	**T**	**P**	**C**
BIO 406	Biostatistics and Research Methodology	4	0	0	4
BIO	Genetics	4	0	0	4
BIO 411	Immunology	4	0	0	4
BIO	Environmental Biology and Biotechnology	4	0	0	4
BT	Genetic Engineering	4	0	0	4
BIO	Bioscience Lab-II	0	0	12	6
	Total	**20**	**0**	**12**	**26**

Red	Course proposed to be discontinued
Yellow	Course content modified
Orange	Course shifted to/ from different semester
Green	New course proposed
Purple	Course shifted to/from different programme

Appendix-IVC

Existing Courses					
M.Sc. Bioscience (Animal Science) Sem. III		**L**	**T**	**P**	**C**
BIO 408	Environmental Biology & Toxicology	4	0	0	4
ZOO 503	Animal Diversity -I	4	0	0	4
ZOO 507	Ethology & Neurobiology	4	0	0	4
ZOO 508	Histology	4	0	0	4
ZOO 509D	Literature Dissertation	0	0	8	4
ZOO 505L	Animal Science Lab-I	0	0	12	6
	Total	**16**	**0**	**20**	**26**

Proposed Courses					
M.Sc. Bioscience (Animal Science) Sem. III		**L**	**T**	**P**	**C**
ZOO	Biosystematics, Taxonomy and Evolution	4	0	0	4
ZOO	Biology of Non-Chordates	4	0	0	4
BT 507	Cell and Tissue Culture Technology	4	0	0	4
ZOO 509D	Literature Dissertation	0	0	8	4
ZOO L	Animal Science Lab-I	0	0	12	6
ZOO	Discipline Elective	4	0	0	4
	Total	**16**	**0**	**20**	**26**

Existing Courses					
M.Sc. Bioscience (Animal Science) Sem. IV		**L**	**T**	**P**	**C**
ZOO 501	Advance Animal Physiology	4	0	0	4
ZOO 502	Animal Cell and Tissue Culture Techniques	4	0	0	4
ZOO 504	Animal Diversity-II	4	0	0	4
ZOO 510	Medical Pathology	4	0	0	4
ZOO 511	Reproduction Biology and Endocrinology	4	0	0	4
ZOO 506L	Animal Science Lab-II	0	0	12	6
	Total	**20**	**0**	**12**	**26**

Proposed Courses					
M.Sc. Bioscience (Animal Science) Sem. IV		**L**	**T**	**P**	**C**
ZOO	Biology of Chordates and Histology	4	0	0	4
ZOO	Animal Physiology and Endocrinology	4	0	0	4
ZOO	Reproduction and Developmental Biology	4	0	0	4
ZOO	Neurobiology and Animal Behavior	4	0	0	4
ZOO	Open Elective	4	0	0	4
ZOO L	Animal Science Lab-II	0	0	12	6
	Reading Elective -I & II	0	0	0	2
	Total	**20**	**0**	**12**	**28**

Appendix-IVC

	Proposed List of Elective courses to be offered in III & IV Semester
ZOO	Insect Diversity, Morphology, Physiology and Ecology
ZOO	Fish Biology
ZOO	Animal Biotechnology-I
ZOO	Immunotechnology
	Biophysics-I
ENVS 402	Ecology and Environment
BIO	Fundamentals of Ecology for Sustainable Ecosystem
	https://www.extension.harvard.edu/academics/courses/fundamentals-ecology/12779
ZOO	Applied Entomology and Insect Pest Management
ZOO	Capture Fishery
ZOO	Animal Biotechnology-II
ZOO	Immunotechnology-I
	Biophysics-II
ENVS 502	Biodiversity and Conservation

	Proposed Reading Elective-I & II to be offered in IV Semester
BT	Drug Discovery
BT	Human Genetics and Diseases
	Intellectual Property Rights
BT	Medical Microbiology
BT	Molecular Plant Breeding
BT	Protein Engineering
BIO	Bio- organic Chemistry: http://nptel.ac.in/courses/104103018/#
BT	Enzyme Science and Engineering
	http://freevideolectures.com/Course/85/Enzyme-Science-and-Engineering/1
BT	Biocatalysis in organic synthesis: http://nptel.ac.in/courses/104105032/
BT	Comprehensive Disaster Risk Management Framework
	www.nidm.gov.in/online.asp
BT	General Course on Intellectual Property: https://welc.wipo.int/acc/index.jsf?page=courseCatalog.xhtml
BT	Environmental Management - An Introduction: www.algonquincollege.com/ ccol/courses/environmental-management-an-introduction/

Comparative Table: M.Sc. Bioscience (Animal Science): Existing and Modified syllabus, Suggested Books and Suggested E-Resources

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
M.Sc. Bioscience (Animal Science) I Semester					
1.	**BIN 401:** Bioinformatics	After successful completion of the course, students should be able to: • Describe and identify various databases and tools used for phylogenetic analysis. • Apply protein structure prediction • Demonstrate and apply different tools for data-mining .	**Section-A** • ~~Introduction of computers: Basic components and their functions, hardware and software, Input-Output devices.~~ • ~~Basic concepts about data and information, Representation of data in computers in binary, bits and bytes~~. ~~Computer words coding (ASCII and EBCDIC), Number System Conversion.~~ • ~~Conceptual understanding of assemblers, Compilers, Operating System.~~ • ~~Introduction to Programming languages, C++, Perl~~. **Section-B** • ~~Information Retrieval: LAN, WAN, Introduction to Internet, WWW, NICNET, ERNET, On line publishing ventures eg. Biomed Central,~~ BTIS Network in India. • ~~Introduction to Microarray Technology and its applications.~~ • Biological Databases: Primary Sequence databases (Protein and DNA databases), Secondary databases, Composite databases. Online international database access. **Section-C** • Sequence Alignment and Databases searching: ~~Evolutionary basis of sequence alignment~~, Optimal alignment methods; Dot Plot, ~~Dynamic Programming~~. • ~~Databases similarity searching: Algorithms of FASTA~~ BLAST.	**Section A** • Introduction and scope of bioinformatics, Introduction to biological databases: primary, composite, secondary databases and structural database. Description of specific databases: UniGene,UniProt, and RCSB – PDB). Introduction to genomics, proteomics and phylogenetics resources available at ExPassy. • Introduction to sequence analysis: Dot Plot, scoring matrices (PAM matrix) and gap penalty. **Section B** • Description and application of global and local sequence alignment. Sequence based database searching working algorithms of BLAST, variations of BLAST. Multiple Sequence alignment. Evolutionary significance of sequence alignment. • Evolutionary models: Jukes – Cantor and Kimura two parameter. • Phylogenetic Analysis: distance based (UPGMA, N-J Methods) and character based (Maximum Parsimony). **Section C** • Protein 2D structure prediction: Chou – Fasman algorithm • Protein 3D structure prediction: homology modeling, its advantage and limits. • Concept of structure optimization and energy minimization. • Forces stabilizing biomolecular interaction.	The components were very basic and mostly covered in undergraduate programs in almost every stream of science as compulsory computer knowledge. Learning languages such as C++ and Perl are extremely tedious; syntax of these two languages is very different to each other and not of use without hands-on sessions. More computer science information instead of bioinformatics. Further, the proposed syllabus is comprehensive for introductory course of bioinformatics. ClustalW is obsolete, progressive methods will include all the concept and methodology of programs like ClustalW. Protein structure prediction is the new introduction in the content to satisfy the need and requirement of a complete bioinformatics course.

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• ~~Statistical significance of alignment, Substitution Scores and Gap penalties.~~ • Multiple Sequence alignment: ~~CLUSTAL W~~. [redacted]. ~~EMBOSS~~. **Books Recommended :** ➢ A textbook of Bioinformatics : Sharma, Munjal&Shanker, Rastogi Publication, Meerut ➢ Fundamental of computer : P.K. Sinha ➢ Introduction to Bioinformatics : Parrysmith and Attwood ➢ Introduction to Bioinformatics : Baxevenis and Oulette ➢ Internet for Molecular Biologist : Swindell ➢ Molecular databases for protein sequences and structure studies - An Introduction Silence : J., Sillince M., Springerberlagd, Berlin 1972 ➢ Leaping from Basic to C++ : Robert J. Traister, A.P. Professional Cambridge ➢ Perl 5 Unleashed : Kamran Husain & Robert F Breedlore SAMS Publishing. ➢ Bioinformatics : David, Mount.	• Principle of Molecular Docking. Types of molecular docking, its advantage and limits. **Suggested Books:** ➢ Rastogi, S.C. & Rastogi, P. (2013). *Bioinformatics Methods and Applications* (4th ed.). New Delhi: PHI Learning Private Limited. ➢ Lesk, A.M. (2008). *Introduction to Bioinformatics.* UK: Oxford University Press. ➢ Krane, D.E. & Reymer, M.L. (2003). *Fundamental Concepts of Bioinformatics*. UK: Pearson Education. ➢ Attwood, T.K., Parry-Smith, D.J. & Phukam, S.(2009). *Introduction to Bioinformatics* (4th ed.). UK: Pearson Education. ➢ Sharma, V., Munjal, A. & Shanker, A. (2017). *A Text Book of Bioinformatics* (2nd ed.). Meerut: Rastogi Publications. **Suggested e- Resources:** ➢ **Chou-Fasman Method for protein secondary structure prediction** https://pdfs.semanticscholar.org/fd8c/c95aec2d7af19ed28eea3688b3c231d0e745.pdf ➢ **Homology modeling** https://proteinstructures.com/Modeling/homology-modeling.html ➢ **ExPASy** https://www.expasy.org/	
2.	**BIO 401:** Analytical Techniques-I	After successful completion of the course, students should be able to: Comprehend the principles of various instrumentation	**Section-A** • Chromatographic methods for macromolecule separation- TLC and Paper chromatography, gel permeation; ion exchange; hydrophobic, Reverse-phase and Affinity chromatography; HPLC, FPLC	**Section-A** • Chromatographic methods for macromolecule separation: TLC and Paper chromatography, Gel permeation, Ion exchange, Hydrophobic,	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		techniques: • Identify suitable and relevant tools for use in research problems • Utilize the scope of the content for designing and performing future experiments	and GLC. • Electrophoretic techniques : • Theory and application of polyacrylamide and agarose gel electrophoresis, capillary electrophoresis; 2D electrophoresis; Disc gel electrophoresis; Gradient electrophoresis; Pulse field gel electrophoresis, Isoelectric focusing. **Section-B** • Microscopy- Microscope and its modifications- Light, Phase contrast and interference, Fluorescence, Confocal, Electron (TEM & SEM), Electron tunneling and Atomic Force Microscopy • Centrifugation -Basic principle & theory, Types of centrifuges- Micro centrifuge, High speed & Ultracentrifuges; Preparative centrifugation, differential & density gradient centrifugation. Analytical centrifugation & its applications. **Section-C** • Spectroscopy-Principle, instrumentation applications in biological sciences: UV-visible spectrophotometry Florometry& Atomic absorption Spectrophotometer (AAS). Principle and application of NMR, X-ray crystallography, ~~API electrospray~~, mass spectroscopy and MALDI-TOF, Circular Dichroism • Radioactivity : • Radioactive and stable isotopes; Pattern and rate of radioactive decay; Measurement of radioactivity; Geiger-Muller counter; solid and liquid scintillation counters (Basic principal, instrumentation and technique); brief idea of radiation dosimetry; Cerenkov radiation; autoradiography.	Reverse-phase & Affinity chromatography; HPLC, FPLC & GLC. • Electrophoretic techniques: Theory and applications of polyacrylamide and agarose gel electrophoresis, capillary electrophoresis, 2D electrophoresis, Disc gel electrophoresis, Gradient electrophoresis, Pulse field gel electrophoresis & Isoelectric focusing. **Section-B** • Microscopy: Microscope and its modifications- Light, Phase contrast and interference, Fluorescence, Confocal, Electron (TEM & SEM), Electron tunneling & Atomic Force Microscopy • Centrifugation: Basic principle & theory, types of centrifuges- Micro centrifuge, High speed & Ultracentrifuges. Preparative centrifugation: differential & density gradient centrifugation. Analytical centrifugation & its applications. **Section-C** • Spectroscopy: Principle, instrumentation applications in biological sciences. UV-visible spectrophotometry, Florometry & Atomic absorption spectrophotometer (AAS). Principle & applications of NMR, X-ray crystallography, Mass spectroscopy and MALDI-TOF, Circular Dichroism. • Radioactivity: Radioactive and stable isotopes, Pattern and rate of radioactive decay, Measurement of radioactivity, Geiger-Muller counter, solid and liquid scintillation counters (Basic principle, instrumentation and technique), brief idea of	Typographical errors have been rectified.

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Books Recommended : ➢ Practical Biochemistry: Keith Wilson and John Walker, Cambridge University Press. ➢ Physical Biochemistry : David Friefelder. ➢ Instrumental methods of chemical analysis :Chatwal and Anand, Himalaya Publishing House. ➢ Instrumental methods of chemical analysis : B.K. Sharma, Goel Publishing House. ➢ X-Ray Methods : C. Whiston. ➢ The Electron Microscope in Biology : A. V. Grimstone. ➢ Tertiary level biology - Methods in Experimental biology : R. Ralph Blackie. ➢ Animal Tissue Technique : G.L. Humason. ➢ NMR and Chemistry : J.W. Akitt, Chapman and Hall.	radiation dosimetry, Cerenkov radiation & autoradiography. **Suggested Books:** ➢ Wilson, K. & Walker, J. (2010). *Principles and Techniques of Biochemistry and Molecular Biology*. Cambridge, UK: Cambridge University Press. ➢ Friefelder, D. (1982). *Physical Biochemistry: Applications to Biochemistry and Molecular Biology*. New York, USA: W.H. Freeman and Company. ➢ Chatwal, G.R. & Anand, S.K. (2018). *Instrumental Methods of Chemical Analysis*. New Delhi, India: Himalaya Publishing House. ➢ Sharma,B.K. (2004). *Instrumental methods of Chemical Analysis, In: Introduction to Analytical Chemistry*. New Delhi, India: Goel Publishing House. ➢ Talluri, S. (2012). *Bioanalytical techniques*. New Delhi, India: I.K. International Publishing House Pvt. Ltd. ➢ Chatanta, D.K. & Mehra, P.S. (2012). *Instrumental Methods of Analysis in Biotechnology*. New Delhi, India: I.K. International Publishing House Pvt. Ltd. **Suggested e- Resources:** ➢ **Chromatographic Techniques** https://nptel.ac.in/courses/103108100/module7/module7.pdf ➢ **Spectroscopic techniques** https://nptel.ac.in/courses/102103044/pdf/mod2.pdf ➢ **Microscopic techniques** www.nptel.ac.in/courses/102103015/pdf/mod3.pdf	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
3.	**BIO 403:** Biochemistry &Biophysics	After successful completion of the course, students should be able to: • Understand the structure and role of various biomolecules • Identify, assess and explain various biochemical pathways • Develop understanding of enzymes and their mechanism of action	**Biochemistry & Biophysics** **Section-A** • ~~Hydrogen bonding and structure of water molecule, Ionization of water, pH and colligative properties of water~~. • Bioenergetics: First & second law of thermodynamics, concept of free energy, change in standard free energy, ~~ATP and its hydrolysis.~~ • Carbohydrates: general classification, Polysaccharides: ~~&proteoglycans~~: Starch, glycogen, cellulose, chitin ~~&bacterial cell wall~~. ~~Glycosaminoglycans& proteoglycans in extracellular matrix.~~ **Section-B** • Electron transport system in mitochondria & chloroplasts. Oxidative phosphorylation, P/O ratio, Uncouplers. • Lipids - Glycerophospholipids, sphingolipids, gangliosides, Eicosanoids & prostaglandins~~.~~ ~~Cholesterol & its biosynthesis~~. • Proteins & amino acids - Zwitterionic properties of amino acids & titration curves. Peptide bonds, disulphide cross links, various levels of structural organization of proteins. • Ramachandran plot, Alpha-helix, Beta sheet, ~~Helix-coil transitions.~~ **Section-C** • Structure function relationship in model proteins like ribonuclease A, haemoglobin, chymotrypsin. • Biosynthesis of purines and pyrimidines, *de novo* and salvage pathway, ~~various confirmations of nucleotides,~~ glycosidic bond rotation, base-stacking. • ~~Mechano-Chemical Process: Molecular structure of~~	**Biochemistry** **Section-A** • Bioenergetics: First and Second law of thermodynamics, concept of free energy, change in standard free energy. • Carbohydrates: general classification, Polysaccharides: Starch, glycogen, cellulose & chitin. • Glycolysis, Citric acid cycle. Electron transport system in mitochondria & chloroplasts. Oxidative phosphorylation, Photosynthetic phosphorylation, P/O ratio, Uncouplers. **Section-B** • Lipids - glycerophospholipids, sphingolipids, gangliosides, eicosanoids & prostaglandins. • Proteins & amino acids – Zwitterionic properties of amino acids & titration curves. Peptide bonds, disulphide crosslinks, various levels of structural organization of proteins. • Ramachandran plot, Alpha-helix, Beta sheet, • Structure function relationship in model proteins like ribonuclease A, haemoglobin and chymotrypsin. • Biosynthesis of purines and pyrimidines, *de novo* and salvage pathway, **Section-C** • Introduction to enzymes: Classification of enzymes Nomenclature of enzymes, E.C. Number • Enzyme kinetics (Michaelis – Menten kinetics), importance and determination of Vmax and Km values, L & B plots. • Enzyme inhibition: competitive, non-	The title is changed as Biophysics component has been removed as it does not fit in two year M.Sc. Biotechnology programme. Section B: Relevant topics, which were earlier not part of the syllabus, have been added. These topics are essential part of the carbohydrate metabolism, a key component of the living organisms. Section C: Biophysics topics have been deleted. Reshuffling done in order to coherently organize various topics of the syllabus.

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			~~muscle-Actin, myosin, troponin, tropomyosin, Muscle Contraction.~~ • ~~Action Potential and propagation of neuronal computation through nerve fibre.~~ **Books Recommended :** ➢ Principles of Biochemistry : A.L. Lehninger, Nelson and Cox, McMillan Worth Publishers. ➢ Biochemistry :Voet and Voet, John Wiley and Sons, Inc. USA. ➢ Biophysical Chemistry Vol. I, II &III : Cantor and Schimmel, Freeman. ➢ Biochemistry :Zubey, WCB. ➢ Biochemistry : Garrett and Grisham, Harcourt. ➢ Biochemistry :Stryer, W. H. Freeman. ➢ Understanding Enzymes : T. Palmer, Horwood. ➢ Harper's review of Biochemistry : R.K. Murray et al., Prentice-Hall International Inc. ➢ Fundamentals of Biochemistry : Cohn and Stumf. ➢ Molecular Biophysics-Structure in Motion :Michel Daune, Oxford University Press.	competitive and un-competitive. • Coenzymes and Isozymes. **Suggested Books:** ➢ Nelson, D. L. & Cox, M.M. (2012). *Lehninger Principles of Biochemistry* (6thed.). New York, USA: W. H. Freeman and Company. ➢ Rodwell, V.W., Bender, D., Botham, K.M., Kenelly, P.J. & Weil., P.A. (2018). *Harper's Illustrated Biochemistry* (31sted.). New York, USA: McGraw-Hill Education. ➢ Voet, D. & Voet, J.G. (2010). *Biochemistry* (4thed.). New Jersey, USA: Wiley. ➢ Berg, J.M., Tymoczko, J.L., Gatto Jr., G.J. & Stryer, L. (2015). *Biochemistry* (8thed.). New York, USA: W. H. Freeman and Company. ➢ Garrett, R. H. & Grisham, C. M. (2012). *Biochemistry* (5thed.). Belmont, USA: Wadsworth Publishing Co Inc. ➢ Palmer, T.& Bonner, P. (2014). *Enzymes: Biochemistry, Biotechnology and Clinical Chemistry*. UK: Woodhead Publishing Limited. ➢ Cantor, C.R. & Schimmel, P.R. (1980). *Biophysical Chemistry Part I, II & III*. New York, USA: W. H. Freeman and Company. ➢ Ferdinand, W. (1976). *The Enzyme Molecule*. New Jersey, USA: John Wiley & Sons Ltd. **Suggested e- Resources:** ➢ **Metabolic pathways, Biomolecules** https://epgp.inflibnet.ac.in/ahl.php?csrno=2 ➢ **Mechanism of enzyme action** http://www.biologydiscussion.com/enzymes/enzymes-properties-and-mechanism-of-enzyme-action/6145	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				➢ **E-book for Garrett and Grisham** https://bit.ly/2TbDWWR	
4.	**BIO 404L:** Bioscience Lab-I	After successful completion of the course, students should be able to: • Demonstrate use of various tools and techniques for detection and quantification of biomolecules. • Perform various biochemical assays for fats, carbohydrate, protein and enzymes • Demonstrate microbiological techniques • Access, retrieve, and analyze nucleotide and protein sequences using bioinformatics tools	1. Demonstration, principle and use of lab equipments: Centrifuges (~~Table top~~ and high speed), ~~Balances (electrical and digital).~~ ~~2. Demonstration, principle and use of lab equipments: Spectrophotometer, pH meter.~~ 3. Estimation of proteins by Lowry's ~~and TCA methods.~~ 5. Estimation of carbohydrates (reducing and non-reducing sugar). 6. Estimation of fats (cholesterol). 7. ~~Preparation and purification of casein from buffalo milk.~~ 8. Separation of amino acids by TLC and paper chromatography. 9. ~~Determination of Logic properties (pH value of Lysine by titration).~~ 10. ~~To find λmax for proteins.~~ 11. ~~Use of selective and diagnostic media for cultivation, isolation, enumeration and purification of microorganisms.~~ ~~12.~~ Measurement of bacterial ~~and fungal~~ growth. 13. Isolation and enumeration of microbes from air/soil by serial dilution/agar plating method. 14. Antibiotic sensitivity test. 15. ~~Microbiological examination of food~~. 16. Citric acid production by A. niger. ~~17.~~ Study of cell division in plants and animals,~~Giant chromosomes.~~ 18. Separation of different organelles/molecules by sucrose density gradient/differential gradient. 19. Separation and identification of serum proteins/plant proteins by gel electrophoresis. 20. ~~Histochemical localization of biomolecules~~	**Analytical Techniques-I** 1. Demonstration: Working principle & applications of - Centrifuges (high speed refrigerated centrifuge & ultracentrifuge), - Fluorescence microscope. - Atomic absorption spectrophotometer, HPLC, FPLC, GC-MS 2. Separation of amino acids by TLC and Paper Chromatography. **Cell and Molecular Biology** 3. Study of different stages of mitosis (onion root tip) and meiosis (onion buds/grasshopper testis) and determine the mitotic index. 4. Separation of chloroplast by sucrose density gradient centrifugation **Biochemistry** 5. To prepare sodium acetate buffer and validate the Henderson-Hasselbach equation. 6. Extraction of crude enzyme from germinating mung bean seeds. 7. Estimation of total protein content by Lowry's method 8. Separation of protein by SDS PAGE. 9. Estimation of acid phosphatase activity using standard curve of p-nitrophenol. 10. Purification of the crude enzyme extract (from Expt. 6) using ammonium sulphate precipitation and ion exchange/ affinity chromatography (demonstration). 11. Determination of kinetic properties (K_m and V_{max} values) of acid phosphatase. 12. Estimation of total carbohydrates using	The experiments have been reframed and modified keeping in consideration, the suggested syllabus.

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			~~(protein, carbohydrate or any other).~~ ~~21. Bioinformatics exercise 1~~ 22. ~~Bioinformatics exercise 2.~~	Anthrone method. 13. Estimation of reducing sugar by Nelson-Somogyi method. 14. Estimation of fats (cholesterol). **Microbiology** 15. Isolation and enumeration of microbes from soil and water. 16. Staining of selected bacterial and fungal strains. 17. Estimation of bacterial growth by turbidometric method. 18. Antibiotic sensitivity test. 19. Estimation of infectivity titre of a virus sample using Plaque assay **Bioinformatics** 20. Database Search: Use and analysis of BLAST tool for protein and DNA sequences. 21. Molecular Evolution: Multiple sequence alignment and phylogenetic analysis. (Clustal X/ Mega/ Tree-View) 22. Structure Prediction: Protein secondary and tertiary structure prediction using online tools. 23. Molecular Visualization: Structural analysis of PDB entries for active and inactive states of protein(Pymol). **Suggested Books:** ➢ Aneja, K. R. (2001). *Experiments in Microbiology, Plant Pathology, Tissue Culture and Mushroom Production Technology*. New Delhi, India: New Age International Ltd. ➢ Cappuccino, J. G. & Welsh, C. (2019). *Microbiology: A Laboratory Manual*. New York, USA: Pearson. ➢ Sadasivam, S., & Manickam, A. (1996). *Biochemical Methods* (2nd ed.). New Delhi:	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				New Age International Publishers. ➢ Saxena, J., Baunthiyal., & Ravi, I. (2015). *Laboratory Manual of Microbiology, Biochemistry and Molecular Biology*. Jodhpur: Scientific Publishers. **Suggested e- Resources:** ➢ **Harisha, S. Biotechnology procedures and experiments handbook** http://site.iugaza.edu.ps/mwhindi/files/BIOTECHNOLOGY-PROCEDURES-AND-EXPERIMENTS-HANDBOOK.pdf ➢ **Introduction to biotechnology** http://www.austincc.edu/awheeler/Files/BIOL%201414%20Fall%202011/BIOL1414_Lab%20Manual_Fall%202011.pdf	
5.	**BIO 407:** Cell and Molecular Biology	After successful completion of the course, students should be able to: • Understand membrane transport and cell signalling mechanisms. • Develop comprehensive understanding of endo-membrane system • Understand molecular mechanisms of prokaryotes and eukaryotes	**Section-A** • Molecular structure and function: ~~Structural models,Composition and dynamics;~~ Transport of ions and macromolecules; Pumps, carriers and channels; Membrane carbohydrates and their significance in cellular recognition; cellular junctions and adhesions; ~~structure and functional significance of plasmodesmata~~. • Endocytosis and exocytosis, clathrin~~&coatomer~~ coated vesicles, SNARE proteins. • Cell to cell signaling :autocrine, paracrine and endocrine stimulation. • Signaling via G-protein linked cell-surface receptors, adenylatecyclase system, inositol phosphate pathway, role of Ca^{2+} -ions. • Signallingvia enzyme-linked surface receptors, tyrosine kinases. • Steroid receptors. **Section-B** • ~~Mitochondrial membrane organization,~~transport of	**Section-A** • Molecular structure and function of plasma membrane; Transport of ions & macromolecules; Pumps, carriers and channels; Membrane carbohydrates & their significance in cellular recognition; Cellular junctions & adhesions. • Endocytosis & exocytosis, clathrin coated vesicles, SNARE proteins. • Cell to cell signalling: autocrine, paracrine and endocrine stimulation. • Signaling via G-protein linked cell surface receptors, adenylate cyclase system, inositol phosphate pathway, role of Ca^{2+} ions. • Signaling via enzyme-linked surface receptors, tyrosine kinases. • Steroid receptors. **Section-B** • Protein sorting and targeting:Signal hypothesis,	Plasmodesmata already covered in 'cell junctions'

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			proteins into mitochondria and chloroplasts. ~~Genome of mitochondria and cholorplasts.~~ • Concept of signal peptide, SRP, SRP Receptor, ~~transport of soluble and membrane bound proteins in Endoplasmic Reticulum,~~ ER Resident proteins, ER chaperone proteins and their functions, glycosylation of proteins in ER. • Golgi apparatus, role in protein glycosylation and transport. • Lysosomes, intracellular digestion, sorting of lysosomal enzymes in Golgi, lysosomal storage diseases. **Section-C** • Replication of genetic material in prokaryotes and eukaryotes: initiation, elongation and termination; Replication of single stranded circular DNA. • Prokaryotic transcription: Transcription units; RNA polymerase structure and assembly; Promotors; Rho-dependent and Rho-independent termination; Anti-termination. • Eukaryotic transcription: RNA polymerase structure and assembly; RNA polymerase I, II, III; eukaryotic promoters and enhancers; general transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF). • Post transcriptional modifications: processing of hnRNA, tRNA and rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; Splicing; RNA editing; Nuclear export of mRNA; ~~mRNA stability;~~ Catalytic RNA. • Translation: Translation machinery; ~~Ribosomes: composition and assembly;~~ Genetic code~~: degeneracy of codons, initiation and termination codons, wobble hypothesis,genetic code in mitochondria;~~IsoacceptingtRNA; ~~Mechanism of~~	SRP, SRP Receptor, ER Resident proteins, ER chaperone proteins & their functions, glycosylation of proteins in ER. • Golgi apparatus, role in protein glycosylation and transport. • Lysosomes, intracellular digestion, sorting of lysosomal enzymes in Golgi, lysosomal storage diseases. • Transport of proteins into mitochondria & chloroplasts. • Cell Cycle & its regulation, apoptosis. **Section-C** • Replication of genetic material in prokaryotes & eukaryotes: initiation, elongation & termination; Replication of single stranded circular DNA. • Prokaryotic transcription: Transcription units; RNA polymerase structure & assembly; Promotors, Rho-dependent & Rho-independent termination; Anti-termination. • Eukaryotic transcription: RNA polymerase structure and assembly; RNA polymerase I, II, III; eukaryotic promoters & enhancers; general transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF). • Post transcriptional modifications: processing of hnRNA, tRNA and rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; splicing; RNA editing; nuclear export of mRNA; catalytic RNA. • Genetic code, Isoaccepting t-RNA; Translation: Translation machinery: initiation, elongation and termination; Co- and post-translational modifications.	The deleted portion has been replaced with more relevant topic Cell Cycle and its regulation and division.

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			initiation, elongation and termination; Co- and post-translational modifications. **Books recommended :** ➢ Cell and Molecular Biology : De Robertis& De Robertis, B.I. Waverly Pvt. Ltd., New Delhi. ➢ The world of the cell : W.M. Becker, Pearson Education. ➢ Cell and Molecular Biology : G. Karp, John Wiley & Sons. ➢ The Cell - A Molecular Approach : Cooper, Sinauer. ➢ Cell and Molecular Biology : P.K. Gupta, Rastogi Publications. ➢ Molecular Cell Biology :Lodish, Baltimore, W. H. Freeman & Co. ➢ Molecular Biology of the Cell : Bruce Albert, Garland Publication, NY. ➢ Essentials of Cytology : C.B. Powar, Himalaya Publications. ➢ Principles of Genetics : Gardner, Simmons, Snustad, John Wiley & Sons. ➢ Gene VIII :Lewin, Pearson Education. ➢ Molecular Biology of Gene : J.D. Watson, Pearson Education. ➢ Molecular Biology : David Freifelder, Narosa Publishing House, New Delhi. ➢ Molecular Biology : R. Weaver, WCB McGraw Hill.	**Suggested Books:** ➢ De Robertis, E.D.R. & De Robertis, E.M.F. (2017). *Cell and Molecular Biology*. New York, USA: Lippincott Williams & Wilkins. ➢ Hardin, J., Bertoni, G. & Lewis, K.J. (2011). *Becker's World of the Cell*. Essex, UK: Pearson Education Limited. ➢ Karp, G., Lwasa, J. & Larshall, W. (2015). *Cell and Molecular Biology: Concepts and Experiments*. New Jersey, USA: John Wiley & Sons Ltd. ➢ Cooper, G., M. & Hausman, R. E. (2004). *The Cell: A Molecular Approach*. Washington, D.C.: ASM Press. ➢ Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretsher, A., Ploegh, H., Amon, A. & Martin, K. C. (2007). *Molecular Cell Biology*. New York, USA: W. H. Freeman and Company. ➢ Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K.& Walter, P. (2007). *Molecular Biology of the Cell*. UK: Garland Science. ➢ Freifelder, D. M. (1986). Molecular Biology. USA: Jones & Bartlett Publishers. **Suggested e- Resources:** ➢ **Cell Biology resources** https://www.nature.com/scitable ➢ **Sorting and trafficking of proteins** http://www.vcell.science/project/proteintrafficking ➢ **RNA editing** study.com/academy/lesson/rna-editing-definition-processes.html	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
6.	**BIO 416:** Microbiology	After successful completion of the course, students should be able to: • Describe different methodologies for classification of microbes. • Understand structural, functional and metabolic diversity of bacteria • Explain viral structure, properties, replication and cultivation	**Section-A** ~~- Discovery of Micro-organisms.~~ • Criteria for classification; molecular approaches • Bacteria: General features, Structural organisation, Nutrition, ~~Growth~~, ~~Respiration and Reproduction~~. • ~~Methanogens~~ and ~~Methylotrophs~~, Chemolithotrophs, Phototrophs, Sulphur reducing bacteria. • Archaebacteria **Section-B** • Nature of viruses, Organisation of virion, Animal, Plant and Bacterial Viruses. • Virus replication, Cultivation of viruses & Virulence factor. • Isolation and screening of industrially important microbes. • Improvement of strains. **Section-C** Biofertilizer and Compost. - Biopesticide~~s, Biopolymers and Biosurfactants~~ ~~- Industrial production of various metabolites with special example of antibiotics, organic acids and alcohol~~ ~~Microbes in the disposal of sewage: sewage treatment processes, sewage water and~~	**Section-A** • History and scope of microbiology. • Bacteria: Structural organization. • Archaea: Structural organization and brief overview of major physiological groups (Halophiles, Methanogens, Thermophiles). • Growth of bacteria- bacterial growth curve, factors affecting growth, • Nutrition in bacteria- nutritional classes, modes of nutritional uptake, media (types) and culture methods. • Modes of bacterial reproduction. • Regulation in bacteria-operon concept-lac, trp and ara **Section-B** • Classification of bacteria and approaches used (conventional and modern) • Metabolic diversity in bacteria- aerobic and anaerobic respiration (suphate, nitrate), fermentation (lactic, mixed, acetone-butanol, stickland fermentations and acetogenesis), chemolithotrophy(hydrogen, sulphur, nitrate and iron oxidizers), phototrophy (oxygenic and anoxygenic). • Unculturable microbes. • Bacterial quorum sensing. **Section-C** • General properties, structure, taxonomy (ICTV & Baltimore classification)of virus • General features of viral replication, sub-viral particles – satellite virus, viroids& prions. • Bacteriophages: one step growth curve, structure & life cycle of T_4 and lambda phages, molecular control of lytic & lysogenic cycle.	The current syllabus is too bulky and inadequately distributed in the three sections. Contents of section C will be taken up by biotechnology students in bioprocess engineering and environmental biotechnology papers. Also, the last two points of section B are more suited to bioprocess. In the proposed syllabus, the syllabus is more evenly distributed and pertinent content has been added for a more cohesive syllabus.

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			~~transmission of diseases, indicator organisms.~~ **Books Recommended :** ➢ Introductory Microbiology : F.C. Ross, Columbus Charles E. Mehrill. ➢ Microbiology - Fundamentals and Applications : S.S. Purohit, Agro Botanical Publishers, Bikaner. ➢ Modern Concepts of Microbiology : H.D. Kumar and S. Kumar, Vikas Publishing House, New Delhi. ➢ Microbiology : M.J. Pelczar,C.E.C. Sun and N.R. Krieg, Tata McGraw Hill, New Delhi. ➢ A Text book of Microbiology : R.C. Dubey and D.K. Maheshwari, S. Chand and Company. ➢ Microbiology : K.L. Burdon and R.P. Williams, Mcmillan Worth Publishers. ➢ Microbiology : B.D. Davis et al. : Harper and Row Publishers. ➢ Microbiology : E.W. Nester et al., Saunders international edition. ➢ Principle of Fermentation Technology : P.F. Stanbury and A. Whittaker, Pegamon Press. ➢ Fundamental principles of Bacteriology : A.J. Salle, Tata McGraw Hill. ➢ T.D. Boock's World of Microbiology : Madigan ➢ Microbiology :Presscott.	Animal virus: structure and life cycle of- herpes simplex virus, papovavirus, reovirus & retroviruses. Plant virus: structure & life cycle of - geminivirus, caulimovirus & tobacco mosaic virus; virus-vector relationship. Virus assay: Plaque, pock, hemagglutination & transformation assays and concept of ID50. Cultivation of viruses. **Suggested Books:** ➢ Willey, J. M., Sherwood, L.M. & Woolverton, C.J. (2014). *Prescott's Microbiology* (9^{th} ed.). New York, USA: McGraw-Hill Education. ➢ Madigan, M., Martinko, J., Stahl, D. & Clark, D. (2010). *Brock Biology of Microorganisms* (13thed.). UK: Pearson Education. ➢ Pelczar Jr., M.J., Chan, E.C.S.& Krieg, N.R. (2011). *Microbiology*. New York, USA: Tata McGraw-Hill. ➢ Kungo, R. (Ed.). (2017). Nanthnarayanand Paniker's *Textbook of Microbiology* (10th ed.). New Delhi, India: Universities Press. ➢ Moat, A. G., Foster, J.W. & Spector, M.P. (2003). *Microbial Physiology* (4^{th} ed.). US: WileyLiss Inc. ➢ Atlas, R.M.& Bartha, R. (1998), *Microbial Ecology: Fundamentals and Applications* (4thed.). UK: Pearson Education. ➢ Dimmock, N.J., Easton, A.J. & Leppard, K.N. (2016). *Introduction to Modern Virology* (8^{th} ed.). Hoboken, NJ: Wiley Blackwell. ➢ Cann, A.J. (2015). Principles of Molecular Virology (6^{th} ed.). Massachusetts, USA: Academic Press. **Suggested e- Resources:**	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				➢ **Bacteria structure** http://www.biologydiscussion.com/bacteria/cell-structure-of-bacteria-with-diagram/47058 ➢ **Bacterial growth & nutrition** http://www.biologydiscussion.com/bacteria/nutrition-and-growth-in-bacteria/47001 ➢ **Bacterial quorum sensing** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3543102/ ➢ **Chemolithotrophy** https://courses.lumenlearning.com/boundless-microbiology/chapter/chemolithotrophy/ ➢ **Bacterial metabolism** https://www.ncbi.nlm.nih.gov/books/NBK7919/ ➢ **Structure and classification of Viruses** https://www.ncbi.nlm.nih.gov/books/NBK8174/ https://www.pnas.org/content/101/44/15556 ➢ **Virus replication** https://bit.ly/2BQLTa5	
M.Sc. Bioscience (Animal Science) II Semester					
7.	**BIO 405L:** Bioscience Lab-II	After successful completion of the course, students should be able to: • Demonstrate techniques used in immunology and genetic engineering • Perform key experiments for water quality analysis and other contaminants • Solve problems based on gene mapping and population genetics	1. To obtain standard curve of p-nitrophenol solution. 2. To prepare a sample of enzyme extract. 3. To determine activity of acid phosphatase from peas/moong seedlings. 4. Purification of an enzymatic protein by salt precipitation. 1. Determination of kinetic properties (Km and Vmax values) of an enzyme. 2. To check time and protein linearity of an enzymatic reaction. ~~3.~~ Immobilization of an enzyme. ~~4. Blood film preparation and identification of~~	**Environmental Biology and Biotechnology** 1. Determination of total hardness of water. 2. Determination of fluoride content in water. 3. Determination of BOD values. 4. Determination of LD_{50} for common pesticides/weedicides. 5. Bacteriological analysis of waste water. **Immunology** 6. To perform differential leucocytes count. 7. Lymphoid organs and their microscopic organization 8. To perform immune diffusion by ouchterlony double diffusion method.	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			~~leucocytes.~~ 5. Lymphoid organs and their microscopic organization. 6. ~~Immunization, collection of serum~~. 7. Double diffusion and immuno-electrophoresis. 8. ELISA : Determination of antibody titre. 9. Immunodiagnostics (Demonstration using commercial kits). 10. Extraction and estimation of RNA. 11. Extraction and estimation of DNA. ~~12. To find □ max for nucleic acids~~. ~~13. Preparation of metaphase chromosomes.~~ ~~14. Detection of ADH activity in tissue/cells by cytochemical staining using Drosophila.~~ ~~15. Statistical problem.~~ 16. Genetic problem - (chromosome mapping).	9. To perform immunoelectrophoresis. 10. ELISA: Determination of antibody titre. 11. Immunodiagnostics (Demonstration using commercial kits). **Genetic Engineering** 12. Extraction of genomic DNA by CTAB method and determination of its purity. 13. Estimation of DNA content by diphenyl amine (DPA) method. 14. PCR amplification of 'n' number of genotypes of a species using random primers (Demonstration). 15. Extraction of RNA by Phenol-Chloroform method and estimation by orcinol method. **Genetics** 16. Study of sex chromatin from buccal epithelial/ hair bud cells. 17. Genetic exercise: - Chromosome mapping, two and three point cross. - Quantitative genetics/ population genetics. **Biostatistics and Research Methodology** 18. Biostatistics problems based on following: - Measures of dispersion (variance). - Correlation analysis. - Probability and probability distribution. - Testing hypothesis by student t- test, Fisher's test, chi-square test and one way analysis of variance. **Suggested Books:** ➢ Aneja, K.R. (1996). *Experiments in Microbiology, Plant Pathology, Tissue Culture and Mushroom Cultivation* (2nd ed.). New Delhi: Wishwa Prakashan.	

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				➢ Green, M. R., & Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual.* Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. ➢ Gupta S.P. (2000). *Statistical Methods.* S. Chand Publications. **Suggested e- Resources:** ➢ **Harisha, S. Biotechnology procedures and experiments handbook** http://site.iugaza.edu.ps/mwhindi/files/BIOTECHNOLOGY-PROCEDURES-AND-EXPERIMENTS-HANDBOOK.pdf ➢ **Introduction to biotechnology** https://bit.ly/2IICkzE	
8.	**BIO 406:** Biostatistics and Research Methodology	After successful completion of the course, students should be able to: • Apply statistical analysis to biological data • Identify ethics in scientific research and associated methodologies • Develop skills in scientific writing.	**Section-A** • Scope of Biostatistics, variables in biology, collection, classification, tabulation of data. • Frequency distribution, diagrammatic and graphical presentation of statistical data, sampling techniques. • Measures of central location and dispersion, simple measure of skewness and kurtosis. • Probability, conditional probability. **Section-B** • Binomial, Poisson and Normal Distribution. • Correlation and Regression: Least Square method of fitting, Standard error of estimate, Correlation and regression coefficient. • Basic idea of significance testing, level of significance, students 't' test, □ 2 (chi-square) test and F-test, Analysis of variance. **Section-C** • Introduction of Research Methodology: meaning and importance, nature and areas of research in Biological Sciences.	No change in the syllabus	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• Formulation of a research problem (Hypothesis). • Elements in Research Methodology; Research Designs (CRD, RBD, LSD). • Ethical, legal and social issues in Biological Research. • Writing of Research Report/Research Paper: various components and their organization. **Recommended Books:** ➢ Singh S. (1988). Statistical methods for Research. Central publishing, Ludhiana. ➢ Gupta S.P. (2000). Statistical Methods. S. Chand Publications. ➢ Khan and Khanum (2012). Fundamentals of Biostatistics.Ukaz Publications. ➢ Zerold J. (2009). BiostatisticalAnalysis. UK: Pearson Education. ➢ Marcello P. and Kimberlee G. (2000). Principles of Biostatistics. Duxbury. ➢ Prasad S. (2012). Elements of Biostatistics.Rastogi Publications. ➢ Rastogi V. B. (2015). Biostatistics. Medtec publications. ➢ Basotia, G.R. and Sharma K.K. (1999). Research Methodology.Mangal Deep Publications. ➢ Chaudhary C.M. (1991). Research Methodology. RBSA Publications. ➢ Dorendro A. (2016). Research Methodology in Zoology.Pearlbooks . ➢ Kadam R.M. and Allapure R. B. (2016). Research Methodology in Botany.Gaurav Books	**Suggested Books:** ➢ Singh S. (1988). *Statistical methods for Research.* Central publishing, Ludhiana. ➢ Gupta S.P. (2000). *Statistical Methods.* S. Chand Publications. ➢ Khan and Khanum (2012). *Fundamentals of Biostatistics.* Ukaz Publications. ➢ Zerold J. (2009). *BiostatisticalAnalysis.*UK: Pearson Education. ➢ Marcello P. and Kimberlee G. (2000). *Principles of Biostatistics.* Duxbury. ➢ Prasad S. (2012). *Elements of Biostatistics.*Rastogi Publications. ➢ Rastogi V. B. (2015). *Biostatistics*. Medtec publications. ➢ Basotia, G.R. & Sharma K.K. (1999). *Research Methodology*. Mangal Deep Publications. ➢ Chaudhary C.M. (1991). *Research Methodology*. RBSA Publications. ➢ Dorendro A. (2016). *Research Methodology in Zoology*. Pearlbooks. ➢ Kadam R.M. & Allapure R. B. (2016). *Research Methodology in Botany*. Gaurav Books **Suggested e- Resources:** ➢ **ANOVA** https://www.analyticsvidhya.com/blog/2018/01/anova-analysis-of-variance/	

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				➢ **Regression Analysis** https://bit.ly/2s9vHdM ➢ **Student’s t Test- Interactive tutorial** https://www.ruf.rice.edu/~bioslabs/Stats_tutorial/index.html	
9.	**BIO 410:** Genetics	After successful completion of the course, students should be able to: • Understand the theoretical and experimental foundations of classical and molecular genetics. • Describe the basics of genetic mapping in bacteria, virus and eukaryotes • Understand the scope of cytogenetics and its applications.	**Section-A** • Definition of gene: genetic & biochemical view; Gene: unit of structure & function, complementation test. • Mendelian Genetics: Mendel’s experimental design; Mendelian Genetics in humans: Pedigree analysis. • Extensions of Mendelian Genetics Principles: Modification of dominance relationships, Gene interactions and modified Mendelian ratios, Multiple alleles, Essential and lethal genes. • Non Mendelian inheritance: Extrachromosomal inheritance; Genomic imprinting; isodisomy; Complex inheritance-genetic and environmental variation; Heritability; Twin studies; Behavioral traits; Analysis of quantitative traits. • Linkage & Crossing over: Tetrad analysis, mapping of gene order and centromere location in fungi **Section-B** • Genome organization: Organization of bacterial genome; Structure of eukaryotic chromosomes, organization of DNA into chromosomes; Heterochromatin and euchromatin. • ~~Regulation of gene expression in prokaryotes: transcriptional regulation-Positive and negative; Operon concept- lac, trp and ara operons; transcriptional control in phage.~~ • ~~Regulation of gene expression in eukaryotes~~. • Mutations: Nonsense, missense and point mutations; Intragenic and intergenicsuppression;	**Section A** • Definition of gene: genetic & biochemical view; Gene: unit of structure & function, complementation test. • Mendelian Genetics: Mendel’s experimental design; Mendelian Genetics in humans: Pedigree analysis. • Extensions of Mendelian Genetics: Modification of dominance relationships, gene interactions and modified Mendelian ratios, multiple alleles, essential and lethal genes. • Non Mendelian inheritance: Extrachromosomal inheritance. • Genomic imprinting. • Complex inheritance-genetic and environmental variation; Heritability; Twin studies; Behavioral traits; Analysis of quantitative traits. **Section-B** • Linkage & crossing over, models of genetic recombination, gene conversion, Tetrad analysis, mapping of gene order & centromere location in fungi. • Genome organization: Organization of bacterial genome. • Structure of eukaryotic chromosomes, organization of DNA into chromosomes; Heterochromatin and euchromatin • Mutations: Nonsense, missense & point mutations; Frameshift mutations; Mutagens;	Genetic recombination models is important to be discussed to understand result of crossing over, gene conversion is important consequence of recombination. Gene regulation can be deleted because this content is covered in Cell and Molecular Biology After modification students will have basic understanding of cytogenetics and its application

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Frameshift mutations; Mutagens; Molecular mechanism of mutations. • ~~Transposable genetic elements in prokaryotes and eukaryotes: Insertion sequences, composite and complex transposons, replicative and non-replicative transposons; Mechanism of transposition; Role of transposons in mutation; Genetic analysis using transposons.~~ **Section-C** • Cytogenetics: Cell division and errors in cell division; Non disjunction; Structural and numerical chromosomal abnormalities-deletion; duplication; translocation; Sex determination; Lyon hypothesis; Role of Y chromosome; Genetic recombination; Disorders of sex chromosomes and autosomes; • Molecular cytogenetics-Fluorescence In Situ Hybridization (FISH); Comparative Genomic Hybridization (CGH). • Genetics of bacteria and bacteriophages: Genetic analysis of Bacteria; Genetic mapping in bacteria by conjugation, transformation and transduction; Mapping of bacteriophage gene. • Population genetics: the Hardy-Weinberg law; Genetic variation in natural populations; Forces that change gene frequency in populations; Genetic basis of speciation. **Books Recommended :** ➢ Principles of Genetics 4th Ed:Snustad& Simmons, John Wiley & Sons. ➢ i-Genetics : P.J. Russel, Pearson Education. ➢ Principles of Genetics 8th Ed: Gardner,	Molecular mechanism of mutations; Suppressor mutation. • Transposon mutagenesis, transposons as genetic tools: signature tagging mutagenesis, insertional inactivation, P- elements as genetic tool. **Section-C** • Cytogenetics: Cytogenetics introduction, karyotype analysis, chromosome banding techniques • Cell division & errors in cell division; Non disjunction. • Structural and numerical chromosomal abnormalities- deletion, duplication, translocation; Sex determination; Lyon hypothesis; Role of Y chromosome; Disorders of sex chromosomes & autosomes. • Molecular cytogenetics-Fluorescence in Situ Hybridization (FISH); Comparative Genomic Hybridization (CGH). • Genetics of bacteria and bacteriophages; Genetic mapping in bacteria by conjugation, transformation and transduction • Mapping of bacteriophage gene. • Population genetics: Hardy-Weinberg law; Genetic variation in natural populations; Forces that change gene frequency in populations; Genetic basis of speciation. **Suggested Books:** ➢ Klug, W. S., Cummings, M.R., Spencer, C.A. & Palladine, M.A. (2015). *Concepts of Genetics* (11^{th}ed.). UK: Pearson Education. ➢ Gardner, E.J., Simmons, M.J., & Snustad, D.P.	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Simmons, Snustad, John Wiley & Sons. ➢ Genetics : P.K. Gupta, Rastogi Publications. ➢ Genetics - A molecular approach : T.A. Brown, Chapman and Hall. ➢ Concepts of Genetics 7th Ed. : William S. Klug, Pearson Education. ➢ Principles of Genetics : R.H. Tamarin, Tata McGraw Hill. ➢ Genetics-From Genes to Genomes : Hartwell, McGraw Hill. ➢ Genetics 5th Eds. : D.L. Hartl and E.W. Jones, Jones and Barlett Publishers, Canada. ➢ An Introduction to Genetic Ananlysis : Suzuki, Griffith, Miller &Lewonith. ➢ Molecular Biology : Weaver, WCB McGraw Hill.	(2005). *Principles of Genetics* (8thed.). New Jersey, USA: John Wiley & Sons Ltd. ➢ Benjamin, A.P. (2003). *Genetics: A conceptual approach*. New York, USA: W. H. Freeman and Company. ➢ Russel, P.J. (2010). *iGenetics* (3rd ed.). UK: Pearson Education. ➢ Brown, T.A. (1992). *Genetics- A Molecular Approach*. London, UK: Chapman & Hall. ➢ Gupta, P.K. (2010).*Genetics*. Meerut, India: Rastogi Publications. **Suggested e- Resources:** ➢ **Cytogenetic methods and Disease** www.nature.com/scitable/topicpage/cytogenetic-methods-and-disease-flow-cytometry-cgh-772 ➢ **CGH Analysis** www.cs.cmu.edu/~epxing/Class/10810-05/Lecture11.pdf ➢ **Population Genetics** https://biomed.brown.edu/Courses/BIO48/6.PopGen1.HW.drift.HTML	
10.	**BIO 411:** Immunology	After successful completion of the course, students should be able to: • Evaluate and compare the role of various components and mechanisms of the immune system. • Describe various immune response mechanisms • Develop concept of antibody generation and various immunological techniques	**Section-A** • Basic concepts of immunology: specific and nonspecific defense mechanisms (innate and acquired immunity), organs and cells of immune system. • Antigen and Antigenicity: concept of immunogens, antigens, heptans, mitogens and superantigens. Properties of antigens, ~~cross reactivity~~, special group of antigens: bacterial antigens, viral antigens, cell surface antigens (MHC), autoantigens, isoantigens and frossman antigens (Heterophilic antigens). • Immunoglobulins: structure and properties of immunoglobulins, immunoglobulin isotypes and	**Section-A** • Basic concepts of immunology: Historical background of immunology, specific and nonspecific defense mechanisms (innate and acquired immunity), cells and organs of immune system. • Antigen and Antigenicity: Concept of immunogens, antigens, haptens, mitogens and superantigens. Properties of antigens, special group of antigens: bacterial antigens, viral antigens, cell surface antigens (MHC), autoantigens, isoantigens and frossman antigens (Heterophilic antigens). • Immunoglobulins: Structure and properties of	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			their significance.Immunoglobulins as antigens: isotypes, allotypes and idiotypes. • Complement System. **Section-B** • Cell - mediated immune responses : origin, maturation and characterization of T-Lymphocytes, monocytes and macrophages, characteristics of antigen presentation and its significance, concepts of memory cell, mode of action and functioning of TH, TC, CTLS and NK cells, lymphokines, the product of T cell activation. • Humoral immune responses: Origin, maturation and characterisation of B Lymphocytes, activation and proliferation of B and T cells, antibody generation in vivo. • Immunological tolerance ~~and Autoimmunity~~: characteristics and mechanism of immunologic tolerance, factors affecting immunologic tolerance and ~~mechanisms of autoimmunity~~. • Hypersensitivity: Type I, II, III and IV. **Section-C** • Hybrid and Chimeric monoclonal antibodies, catalytic antibodies • Surface plasmon resonance, Biosensor assay for assessing ligand-receptor interaction. • ~~Measurement of low molecular weight non-immunogenic compounds (such as secondary metabolites); phytohormones immunoassays.~~ • Advanced immunological techniques:	immunoglobulins, immunoglobulin isotypes and their significance. Immunoglobulins as antigens: isotypes, allotypes and idiotypes, brief idea about instructive, selective & clonal selection theory of antibody formation. • Complement system. **Section-B** • Cell - mediated immune responses: origin, maturation and characterization of T-Lymphocytes, monocytes and macrophages, characteristics of antigen presentation and its significance, concepts of memory cell, mode of action and functioning of TH, TC, CTLS and NK cells, lymphokines, the product of T-cell activation. • Humoral immune responses: Origin, maturation and characterization of B-Lymphocytes, activation and proliferation of B and T cells, antibody generation *in vivo*. • Immunological tolerance and characteristics and mechanism of immunologic tolerance, factors affecting immunologic tolerance of autoimmunity. Immune regulation, positive, negative selection, apoptosis. **Section-C** • Hypersensitivity: Type I, II, III and IV. • Hybrid and Chimeric monoclonal antibodies, catalytic antibodies. • Surface plasmon resonance, biosensor assay for assessing ligand-receptor interaction. • Advanced immunological techniques: Immunofluorescent and immunogold labelling.	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Immunofluorescent and Immunogoldlabelling **Books Recommended:** ➢ Abbas, A.K.,&Lichtman, A.H. (2001). *Basic immunology: Functions and Disorders of Immune System*. US: W.B. Saunders. ➢ Delves, P.J., Martin, S.J., Burton, D.R.,&Roitt, I.M (2011). *Roitt's Essential Immunology* (12th ed.). New Jersey, USA: John Wiley & Sons Ltd. ➢ Goldsby, R. A., Kindt, T.J., & Osborne, B. A. (2006). *Kuby Immunology* (6th ed.). New York, USA: W.H. Freeman & Co. Ltd. ➢ Paul, W.E. (1999). *Fundamental Immunology* (14th ed.). USA: Lippincott-Raven. ➢ Peakman, M.,&Vergani, D. (2009). *Basic and Clinical Immunology* (2nd ed.). US: Elsevier Health Sciences. ➢ Tizard, I.R. (2017). *Veterinary Immunology* (10th ed.). US: Elsevier Health Sciences.	**Suggested Books:** ➢ Abbas, A.K. & Lichtman, A.H. (2001). *Basic Immunology: Functions and Disorders of Immune System*. US: W.B. Saunders. ➢ Delves, P.J., Martin, S.J., Burton, D.R., & Roitt, I.M (2011). *Roitt's Essential Immunology* (12th ed.). New Jersey, USA: John Wiley & Sons Ltd. ➢ Goldsby, R. A., Kindt, T.J. & Osborne, B. A. (2006). *Kuby Immunology* (6th ed.). New York, USA: W.H. Freeman & Co. Ltd. ➢ Paul, W.E. (1999). *Fundamental Immunology* (14th ed.). USA: Lippincott-Raven. ➢ Peakman, M. & Vergani, D. (2009). *Basic and Clinical Immunology* (2nd ed.). US: Elsevier Health Sciences. ➢ Tizard, I.R. (2017). *Veterinary Immunology* (10th ed.). US: Elsevier Health Sciences. **Suggested e- Resources:** ➢ **Basic Immunology** https://bit. y/2E6Zz16l ➢ **Monoclonal Antibodies** https://www.genscript.com/how-to-make-monoclonal-antibodies.html ➢ **Complement system** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3956958/	
11.	**BT 406:** Enzymology and Enzyme Technology	At the end of this course, the students will have fundamental knowledge of enzymes and varioustechniques involved in their production and purification. They would also learn about theirapplication in different fields such as	**Section-A** • History and introduction to enzymes: Classification of enzymes. IUPAC system, nomenclature, E.C. numbers. • Enzyme kinetics (Michaelis - Menten laws), importance and determination of Vmax and Km values, Hofstee's plot, L & B plots. • Bisubstrate reactions-ordered & random sequential	Course proposed to be discontinued	Some part of the syllabus is integrated with I Semester course "Biochemistry".

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		medical, textile, chemical processes, etc. They can applythis knowledge for better understanding of other basic and advanced courses in biologicalsciences as well as to solve research based problems.	mechanism. Theorell chance mechanism, ping pong mechanism, products of inhibition in bisubstrate reactions. • Enzyme inhibition: competitive, non-competitive and other types. **Section-B** • Extraction of soluble and membrane bound enzymes from microbial, plant and animal tissues. • Purification of enzymes: salt precipitation, gel filtration, ion exchange and affinity chromatography. • Regulation of enzyme activity, various controls (metabolic compartmentation, covalent modifications and others), feedback regulation, allosteric enzymes. • Coenzymes, Isozymes and Multienzyme complexes. • Methods of storing enzymes. **Section-C** • Large scale production of enzymes including genetic engineering approaches for their over production. • Enzyme engineering; identification of active sites, approaches for modification of catalytic properties. • Techniques of enzyme immobilization and their applications in: a. Food industry- High fructose syrup, cheese making and beer industry. b. Antibiotics and other Pharamaceuticals c. Medical applications d. Analysis of substances, enzyme electrodes, enzyme thermistors. • Basic idea of proteomics **Suggested Books:** ➢ Understanding Enzymes : T. Palmer.		

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Fundamentals of Enzymology : Price and Stevenson. ➢ The Enzyme : Dixon and Webb, Academic Press, London. ➢ Methods in Enzymology : Academic Press. ➢ The Enzyme Molecule: W. Ferdinan, John Wiley and sons. ➢ Protein Methods: D.M. Bollag and S.J. Edelstein, Wiley-Liss. ➢ The Nature of Enzymology : F.L. Foster, John Wiley and sons. ➢ Enzyme technology, biotechnology Vol7 : John Wiley and sons. ➢ Enzyme, Biomass, Food and Feed Biotechnology Vol. 9 : John Wiley and Sons.		
12.	**Environmental Biology and Biotechnology**	After successful completion of the course, students should be able to: • Identify key factors responsible for ecosystem balance and explain different efforts which can be undertaken for restoration and environmental remediation. • Comprehend the toxicity of various environmental pollutants and their influence on ecosystem. • Understand different waste management processes and generation of energy from waste. • Describe various roles played by microbes in	**M.Sc. III Semester Bioscience core course** **BIO 408: Environmental Biology and Toxicology** **Section-A** - ~~Concept of energy, conventional & non-conventional energy sources. Fossil fuels, hydro, wind and nuclear power, geothermal, solar and bioenergy.~~ - Energy flow in organisms, energy pathways & models, energy efficiencies, ~~conservation of energy.~~ - ~~Classification & characteristics of resources~~: water, soil, forest, wild life, ~~land use.~~ - Conservation of natural resources: water, soil, forest and wild life. **Section-B** - ~~Origin of pollutants : industrial, agricultural, domestic and vehicular sources.~~	**Environmental Biology and Biotechnology** **Section A** ➢ Structure and functions of ecosystem. ➢ Energy flow in organisms, energy pathways & models, energy efficiencies. ➢ Basic concept of Population Ecology – Inter & intra-specific interactions among populations. ➢ Community structure & dynamics: Ecological succession. ➢ Natural resources & conservation: water, soil, forest, wild life. ➢ Environmental challenges & sustainable development; Environmental Laws & Acts. **Section B** ➢ Heavy metal toxicity, agrochemical pollutants. ➢ Bioremediation of heavy metal pollution and oil spills, phytoremediation. ➢ Radiations—as environmental pollutants.	"Environmental Biology and Biotechnology" is proposed to be included as a new core course in the second semester instead of the existing core course "Enzymology and Enzyme Technology". The syllabus of "Environmental Biology and Biotechnology" is designed by updating and merging the contents of existing courses BIO 408 "Environmental Biology and Toxicology" which is running as a core course in third semester of M.Sc. Bioscience programme and another course BT 509 "Environmental Biotechnology" which is

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		biodegradation, bioremediation and plant growth promotion.	- ~~Pollutant & their toxicology :~~ Heavy metals ~~and trace elements~~. Agrochemicals ~~(Pesticides, herbicides, rodenticides & fungicides, detergents) & particulate matter.~~ - ~~Types of radiations including ionizing & non-ionizing radiations & their interaction with matter.~~ - Radiations as environmental pollutants. - Effects of radiations at cellular, molecular & genetic level. **Section-C** - ~~Mutagenecity, carcinogenecity~~. - ~~Green house effect, acid rains~~. - ~~Ozone layer depletion, photochemical smog~~. - Types of solid wastes, transport, reuse & recycling. **M.Sc. III Semester Biotechnology core course** **BT 509: Environmental Biotechnology** **Section-A** - ~~Current status of biotechnology in environmental protection.~~ - ~~Sewage &~~ waste water treatment: ~~Physical, Chemical and biological treaments; Aerobic processes & anaerobic processes,~~ Primary, secondary and tertiary treatments; ~~Sludge dewatering & its disposal;~~ Water reclamation. - Solid waste management: Methods & disposal ~~of non hazardous and hazardous~~	Effects of radiations at cellular, molecular & genetic level. Disposal of radioactive waste. ➢ Waste water treatment- sources of waste water, strategies used in primary, secondary & tertiary treatments, water reclamation. **Section C** ➢ Biofertilizers, biopesticides, compost & vermicompost. ➢ Biofuels: Biogas, bioethanol, biodiesel, biohydrogen. Biodegradable plastics. ➢ Biodegradation of xenobiotic compounds: Simple aromatics, chlorinated polyaromatic petroleum products & pesticides; role of degradative plasmids. ➢ Solid waste management: types, treatment & disposal strategies. ➢ Bioleaching of metals, microbially enhanced oil recovery. Bioindicators. **Suggested Books** ➢ Allen, K. (2016). *Environmental Biotechnology*. New Delhi, India: CBS Publishers. ➢ Miller, G.T. (2004). *Environmental Science: Working With The Earth* (10th ed.). Singapore: Thomson Asia. ➢ Milton, W. (Ed.). (1999). *An Introduction to Environmental Biotechnology*. USA: Springer. ➢ Milton, W. (Ed.). (1999). *An Introduction to Environmental Biotechnology*. USA: Springer. ➢ Modi, P. N. (2015). *Sewage treatment & disposal and waste water engineering*.	running as a core course in the third semester of M.Sc. Biotechnology programme.

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			~~solid wastes, recycling,~~ methods of disposal of radioactive waste. - ~~Conservation of Biodiversity: *Ex situ* & *in situ* methods.~~ **Section-B** - ~~Environmental Biotechnology in Agriculture~~: Biofertilizers ~~and microbial inoculants~~, Biopesticides. - Biodegradation of xenobiotic compounds: Simple aromatics, chlorinated polyaromatic petroleum products, Pesticides ~~and surfactants.~~ - Bioremediation ~~& Biorestoration: Reforestation through micro-propagation, development of stress tolerant plants, and use of mycorrhiza in reforestation of soil contaminated with heavy metals.~~ **Section-C** - Biofuels: ~~Energy crops, Conventional sources of biofuel, Second and third generation of biofuel,~~ Biogas, Bioethanol, Biohydrogen. Biodegradable plastics. - Bioindicators ~~and Biosensers for detection of environmental pollution.~~ - Environmental genetics: Degradative plasmids, ~~release of GE microbes in environment.~~	New Delhi, India: Rajsons Publications Pvt. Ltd. ➢ Odum E. P. (2006). *Fundamentals of Ecology* (5th ed.). Boston, US: Cengage. ➢ Sharma, P.D. (2008). *Environmental Biology and Toxicology*. Meerut, India: Rastogi Publications. ➢ Sodhi, G.S. (2002*). Fundamental Concepts of Environmental Chemistry*. New Delhi, India: Narosa Publishing House. ➢ Tripathi, B. N., Shekhawat, G. S., & Sharma, V. (Ed.). (2009). *Applications of Biotechnology*. Jaipur, India: Aavishkar Publishers. ➢ Vallero, D.A. (2016*). Environmental Biotechnology: Abiosystems approach***.** US**:** Elsevier. ➢ Wright, R. T. (2015). *Environmental Science: Toward a Sustainable Future.* UK: Pearson Education. **Suggested e-Resources** ➢ **Ecosystem structure** http://www.biologydiscussion.com/ecosystem/ecosystem-its-structure-and-functions-with-diagram/6666 ➢ **Radioactive waste treatment** https://ehs.unc.edu › Manuals › Radiation Safety Manual ➢ **Environmental Remediation** https://www.iaea.org/sites/default/files/18/05/environmental_remediation.pdf ➢ **Biological treatment of wastewater** http://www.neoakruthi.com/blog/biological-treatment-of-wastewater.html ➢ **Biogas**	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				http://www.biologydiscussion.com/biomass/production-of-biogas-from-biomass/10436 ➢ **Biofuel** http://uru.ac.in/uruonlinelibrary/BioFuels/Biomass%20and%20biofuels.pdf ➢ **Biological treatment of wastewater** http://www.neoakruthi.com/blog/biological-treatment-of-wastewater.html ➢ **Xenobiotic compound biodegradation** https://bit.ly/2GHRoMj	
13.	**BT 408:** Genetic Engineering	After successful completion of the course, students should be able to: • Develop comprehensive understanding of gene manipulation techniques • Describe various cloning and expression vectors • Develop skills for primer designing, gene amplification and expression	**Section-A** • Basic concepts of DNA structure and properties, restriction enzymes, DNA ligase, Klenow enzyme, T4 DNA polymerase, Polynucleotide kinase, Alkaline phosphatase, Cohesive and blunt end ligation, Linkers, Adapters, Homopolymeric tailing, Labeling of DNA, Nick translation, Random priming, Radioactive and non-radioactive probes, Hybridization techniques, Northern, Southern and Colony Hybridization, ~~Fluorescence in situ hybridization~~, Chromatin immunoprecipitation, DNA-Protein Interaction-Electromobility shift assay, DNaseIfootprinting, Methyl interference assay, Isolation of genomic DNA from prokaryotes and eukaryotes, Isolation of Plasmid DNA and Bacteriophage DNA. Isolation of total RNA and mRNA. **Section-B**	**Section-A** • Basic concepts of DNA structure and properties, restriction enzymes, DNA ligase, Klenow enzyme, T_4 DNA polymerase, polynucleotide kinase, alkaline phosphatase. • Cohesive & blunt end ligation, linkers, adapters, homopolymeric tailing, labeling of DNA, nick translation, random priming, radioactive & non-radioactive probes. • Hybridization techniques: Colony hybridization, Northern, Southern, South-Western & far-western blotting. • DNA-Protein Interaction: Chromatin immunoprecipitation, electromobility shift assay, DNaseI footprinting, methyl interference assay. • Protein-protein interaction: Yeast two hybrid system, split ubiquitin system, co-immunoprecipitation, Forster Resonance Energy Transfer, phage display. • Isolation of genomic DNA from prokaryotes and eukaryotes, isolation of Plasmid DNA and Bacteriophage DNA. Isolation of total RNA and mRNA. **Section-B**	Already covered in the Genetics course Yeast vectors have been covered in **Recombinant DNA Technology** paper. Relevant vectors have been added.

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• Plasmids, Bacteriophages, pBR322 and pUC series of vectors, M13 and P2 phage based vectors, High capacity vectors: Cosmids, phagemid, ~~phasemid, YAC~~, BAC, Animal and Plant virus based cloning vectors, Shuttle vectors, Expression vectors, pMal, GST, pET-based vectors, ~~Insertion of foreign DNA into Host Cells, Transformation~~, Constructions of libraries, cDNA and genomic libraries, cDNA and genomic cloning, Expression cloning, Jumping and hopping libraries, South-western and Far-western cloning, Protein-protein interactive cloning and Yeast two hybrid system, Phage display. **Section-C** • Primer designing, Fidelity of thermostable enzymes, ~~DNA polymerase~~, Types of PCR- multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, in situ PCR, cloning of PCR products, T-vectors, ~~Proof reading enzymes~~, Principles in maximizing gene expression, Gene expression analyses, differential gene expression methods, Introduction of DNA into mammalian cells, ~~transfection techniques.~~ **Books Recommended :** ➢ Molecular Cloning Vol. 1, 2 and 3 :Sambrook, Russell and Maniatis, Cold Spring Harber laboratory, 2001. ➢ Molecular Biology of Gene : J.D. Watson, Pearson Education. ➢ An Introduction to Gene Technology-From genes to clones :Winnacker, VCH. ➢ Principles of Gene Manipulation : Old and Primrose. ➢ MoleculerBiotechnology : B.R. Glick and J.J. Pasternak, ASM Press Washington, USA.	• Plasmids, Bacteriophages, pBR322 & pUC series of vectors, M13 based vectors. • High capacity vectors: cosmids, phagemids, BAC, animal & plant virus based cloning vectors, shuttle vectors; expression vectors: pMal, GST, pET-based vectors; *Baculovirus* and *Pichia* vectors. • Introduction of DNA into mammalian cells. • cDNA & genomic libraries, expression, cloning, jumping & hopping libraries. **Section-C** • Primer designing, fidelity of thermostable enzymes. • Types of PCR- multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, *in situ* PCR, T-vectors. • Principles in maximizing gene expression, gene expression analyses, differential gene expression methods. **Suggested Books:** ➢ Old, R. W., Primrose, S. B. & Twyman, R. M. (2001). *Principles of Gene Manipulation: an Introduction to Genetic Engineering*. Oxford: Blackwell Scientific Publications. ➢ Brown, T. A. (2006). *Genomes* (3rd ed.). New York: Garland Science. ➢ Glick, B.R. & Pasternak, J.J. (1998). *Molecular Biotech: Principles and Application of Recombinant DNA*. US: ASM Press. ➢ Richard J. R. (2004). *Analysis of Genes and Genome*. New Jersey, USA: John Wiley & Sons Ltd.	Repeating topics have been removed Repeating topics have been removed

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Genetic Engineering : Science and ethics on new frontier : Michael Boylan, Pearson Education. ➢ An Introduction to Genetic Engineering : S.T. Nicholl, Cambridge University Press. ➢ Recombinant DNA Methodology : Grossman and Noldave, Academic Press.	➢ Green, M. R. & Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. **Suggested e- Resources:** ➢ **Genetic engineering-Basics, New Applications and Responsibilities** http://library.umac.mo/ebooks/b28055287.pdf ➢ **Construction of genomic libraries** https://nptel.ac.in/courses/102103013/20 ➢ **Enzymes in genetic engineering** https://nptel.ac.in/courses/102103013/7	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
M.Sc. Bioscience (Animal Science) III Semester					
14.	**BIO 408: Environmental Biology and Toxicology**		**Environmental Biology and Toxicology** **Section-A** - ~~Concept of energy, conventional & non-conventional energy sources. Fossil fuels, hydro, wind and nuclear power, geothermal, solar and bioenergy.~~ - Energy flow in organisms, energy pathways & models, energy efficiencies, ~~conservation of energy.~~ - ~~Classification & characteristics of resources~~: water, soil, forest, wild life, ~~land use.~~ - Conservation of natural resources: water, soil, forest and wild life. **Section-B** - ~~Origin of pollutants : industrial, agricultural, domestic and vehicular sources.~~ - ~~Pollutant & their toxicology :~~ Heavy metals ~~and trace elements~~. Agrochemicals ~~(Pesticides, herbicides, rodenticides &~~	This course is discontinued in the present form from Semester III. With some modification and merging with another course it is proposed to be shifted in the II Semester as a new core course "Environmental Biology and Biotechnology"	The course contents are proposed to be modified and merged with M.Sc. Biotechnology III Semester core course "Environmental Biotechnology" to propose new core course named as "Environmental Biology and Biotechnology" in the II Semester.

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
			~~fungicides, detergents) & particulate matter.~~ - ~~Types of radiations including ionizing & non-ionizing radiations & their interaction with matter.~~ - Radiations as environmental pollutants. - Effects of radiations at cellular, molecular & genetic level. **Section-C** - ~~Mutagenecity, carcinogencity~~. - ~~Green house effect, acid rains~~. - ~~Ozone layer depletion, photochemical smog~~. - Types of solid wastes, transport, reuse & recycling.		
15.	**ZOO 503** ~~Animal Diversity – I~~		~~**ZOO 503** Animal Diversity – I **4 0 0 4**~~ ~~**Section-A**~~ Basic concept of taxonomy ~~and systematics,~~ terms & definition, ~~contribution and role of systematics~~ Current trends in taxonomy: Morphological, embryological, ecological, behavioural, cytological, biochemical & numerical taxonomy. Zoological classification: International code of zoological nomenclature, principles of nomenclature, Kinds of classification, Linnaean hierarchy. ~~**Section-B**~~ ~~Diagnostic features and phylogeny of Protozoa, Porifera, Coelentrata & Ctenophora.~~ ~~Diagnostic features and phylogeny of Platyhelminthes, Nematoda, Acanthocephala & Rotifera.~~ ~~Diagnostic features and phylogeny of Annelida & Mollusca.~~ ~~**Section-C**~~ ~~Diagnostic features and phylogeny of Arthropoda,~~	**Discontinued in present form**	We intend to introduce two separate papers for Taxonomy and Non Chordates ZOO- Biosystematics, Taxonomy and Evolution ZOO-2: Biology of Non-Chordates

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
			~~Onychophora & Echinodermata.~~ ~~Diagnostic features and phylogeny of Ectoprocta, Brachiopoda & Chaetognatha.~~ ~~Diagnostic features and phylogeny of Hemichordata & Protochordata.~~ ~~**Books Recommended :**~~ ➢ Principles of systematics : Ernest Mayr. ➢ Theory and practice of Animal Taxonomy : V. C. Kapoor. ~~➢ Animal diversity : Fingermann.~~ ~~➢ Text book of invertebrate Zoology : J.A. Young.~~ ~~➢ Text book of invertebrate Zoology : S.N. Prasad.~~ ➢ The invertebrates : Hyman Series. ~~➢ Cambridge Natural History series.~~ ➢ Invertebrate Zoology: Parker & Haswell. ➢ Invertebrate Zoology: P.A. Maglitsch, F.R. Sehram, Oxford univ. Press.		
16.	**ZOO: Biosystematics, Taxonomy and Evolution**	After successful completion of course students will be able to: • Understand the principles, methods of taxonomy and systematics • Explain key concepts in evolutionary biology • Develop an understanding of the geological time scale and paleontology		**ZOO: Biosystematics, Taxonomy and Evolution** **Section-A** • Basic concept of taxonomy. • Definition, history, basic concepts and application of biosystematics. • Current trends in taxonomy: Morphological, embryological, ecological, behavioural, cytological, biochemical and numerical taxonomy. • Zoological classification: International code of zoological nomenclature, principles of nomenclature, kinds of classification, Linnaean hierarchy. **Section-B** • Theories of origin of life, concept of organic evolution during pre and post Darwin era. • Concepts of evolution: Micro and macro evolution.	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				• Mechanism of evolution: Species & speciation, variation, mutation, isolation, natural selection, adaptations. • Hardy-Weinberg law, molecular tools in phylogeny. **Section-C** • The evolutionary time scale: Eras, periods and epochs, distribution of animals in time and space. • An introduction to the science of Paleontology, fossil record, dating and significance. • Evolution of Horse and Man. **Suggested Books:** ➢ Mayr, E. (1991). *Principles of systematic* (2nd ed.). New York, USA: McGraw-Hill Inc. ➢ Kapoor, V.C. (2017). *Theory and practice of animal taxonomy* (8^{th} ed.). New Delhi, India: Oxford & Ibh. ➢ Barton, N.H., Briggs, D.E.G., Eisen, J.A., Goldstein, A.E., & Patel, N.H. (2007). *Evolution*. New York, USA: Cold Spring Harbor Laboratory Press. ➢ Futuyma, D.J. (2013). *Evolution* (3^{rd} ed.). Sunderland, USA: Sinauer Associates, Inc. ➢ Strikberger M.W. (2005). *Evolution* (3^{rd} ed.). Boston, London: Jones and Bartett Publishers. ➢ Wilson E.O. (1961). *Principal of animal taxonomy*. New Delhi, India: Oxford, IBH Publishing Company. **Suggested e-Resources:** ➢ **Zoological Nomenclature** http://bio.slu.edu/mayden/systematics/bsc4205 20lect2.html ➢ **Origin of life, Theories of origin of life** http://www.evolution-textbook.org	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				➢ **Evolution of Man** https://www.britannica.com/science/human-evolution ➢ **Evolution of Horse** https://www.britannica.com/animal/horse/Evolution-of-the-horse	
17.	**ZOO- Biology of Non Chordates**	After successful completion of course students will be able to: • Identify and classify the major groups of organisms belonging to different non chordate phyla • To compare and contrast different systems evolved in non-chordates • Understand general organization and affinities of minor phyla		**ZOO- Biology of Non-Chordates** **Section A** • Protozoa: Classification and characteristic features up to order, osmoregulation, locomotory organelles, locomotion and reproduction • Porifera: Classification and characteristic features up to order, cell types, canal system, reproduction in sponges • Origin of metazoa • Coelenterata: Classification and characteristic features up to order, nematocysts and feeding mechanisms, locomotion, polymorphism, corals and coral reefs. • Platyhelminthes: Classification and characteristic features up to order, general organization and larval stages of trematodes and cestodes, parasitic adaptations and economic importance. • Aschelminthes: Classification and characteristic features up to order, general organization of nematodes, parasitic adaptations and economic importance. **Section B** • Annelida: Classification and characteristic features up to order, metamerism and coelom, adaptive radiation in polychaetes, economic importance. • Trochophore larva: Structure and significance.	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				• Arthropoda: Classification and characteristic features up to order, exoskeleton, sense organs in arthropoda, crustacean larvae and their significance, general organization of tradigrada, pycogonida and trilobitomorpha. • Mollusca: Classification and characteristic features up to order, shell diversity, filter feeding mechanism, respiration, nervous system, modifications of foot, larval forms. **Section C** • Echinodermata: Classification and characteristic features up to order, water vascular system, hemal and perihemal system, larval forms and their significance. • General organization and affinities of minor phyla: Mesozoa, ctenophora, entoprocta, phoronida, bryozoa, barachiopoda, chaetognatha. • General organization and affinities of hemichordata. **Suggested Books:** ➢ Ruppert, E.E., Fox, R. & Barnes R.D. (2003). *Invertebrate Zoology: A functional evolutionary approach*. (7^{th} ed.). CA, USA: Brooks Cole. ➢ Meglitsch, P.A. & Schram, F.R. (1991). *Invertebrate Zoology*. Oxford, UK: Oxford University Press. ➢ Barrington, E.J.W. *Invertebrate structure and function* (2^{nd} ed.). London, UK: Thomas Nelson and Sons Ltd. ➢ Hymen, L.H. (1940-1967). *The invertebrates* (all volumes). Philadelphia, USA: McGraw Hill. ➢ Barnes, R.D. *Invertebrate Zoology* (3^{rd} ed.).	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				Philadelphia, USA: W.B. Saunders Co. ➢ Parker, T.J. & Haswell, W.A (1972). *Text book of zoology*, *Vol I.*, *Invertebrates* (7th ed.). London, UK: Macmillan co. **Suggested e-Resources:** ➢ **Porifera** www.ucmp.berkeley.edu/porifera/porifera.html ➢ **Coelenterata** www.ucmp.berkeley.edu/cnidaria/cnidaria.html ➢ **Corals and coral reef** www.reefbase.org/ ➢ **Bryozoa** http://bryozoa.net/ ➢ **Mollusca** www.ucmp.berkeley.edu/taxa/inverts/mollusca/mollusca.php ➢ **Echinodermata** www.ucmp.berkeley.edu/echinodermata/echinodermata.html	
18.	**BT 507** Cell and Tissue Culture Technology	On completion of this course, students should be able to: • Virtually develop an idea of cell culture laboratory. • To learn different techniques/methods of cell culture like primary cell culture,subculturing, cryopreservation, thawing etc. along with their applications. • Basics of animal and plant cell culture knowledge will help them to join any of the cellculture based research institution and industry of repute besides the	**Section-A** • Historical background and terminologies used in cell & tissue culture. • Basic techniques of cell and tissue culture, sterilization, aseptic tissue transfer, concept of totipotency. • Nutritional requirement of cell in vitro, various types of nutrient media. • Contamination and cytotoxicity • Cryopreservation and cell storage. • Isolation of plant cells, single cell cultures and cloning. **Section-B** • Organogenesis and somatic embryogenesis, applications in agriculture, horticulture & forestry. • Haploid production: androgenesis, gynogenesis	**Section-A** • Historical background and terminologies used in cell & tissue culture. • Basic techniques of cell and tissue culture, sterilization, aseptic tissue transfer, concept of totipotency. • Nutritional requirement of cell in vitro, various types of nutrient media. • Contamination and cytotoxicity • Cryopreservation and cell storage. • Isolation of plant cells, single cell cultures and cloning. **Section-B** • Organogenesis and somatic embryogenesis, applications in agriculture, horticulture & forestry.	No modification

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
		academicsemployability • The students can establish their own cell culture laboratory as an entrepreneur.	various techniques, applications. • Production of disease free plants by tissue culture methods. • Protoplast isolation and culture, fusion of protoplasts. • Somatic hybrids, selection methods, gene expression in somatic hybrids. **Section-C** • Disaggregation of animal tissue, isolation of cells, single cell culture, routine maintenance of animal cell lines. • Cloning & selection of specific animal cell types. • Transfection: gene transfer methods for adherent and non-adherent cell culture. • Cell fusion: fusogen, animal somatic cell fusion and selection of cybrids. • Animal organ culture. • Elementary idea about animal cell culture products. **Books Recommended :** ➢ Plant Tissue Culture : S.S. Bhojwani and M.K. Razdan, Elsevier Science, The Netherlands. ➢ ~~An Introduction to Plant Tissue Culture : M.K. Razdan.~~ ➢ ~~Cell Culture Methods and Cell biology Vol. 4 : D.W. Barens.~~ ➢ ~~Cell and Tissue Culture - laboratory procedure : A. Doyle.~~ ➢ ~~Plant Tissue Culture - A Practical Approach : R.A. Dixon, IRL Press.~~ ➢ ~~Biotechnology in Agriculture and Forestry : Y.P.S. Bajaj, Narosa.~~ ➢ ~~Plant cell and Tissue Culture : Rienert and Yeoman.~~ ➢ ~~Plant Cell Culture : Butenko.~~ ➢ ~~Plant Tissue Culture Methods and Applications in Agriculture : T.A. Thorpe, Academic Press Inc.~~	• Haploid production: androgenesis, gynogenesis various techniques, applications. • Production of disease free plants by tissue culture methods. • Protoplast isolation and culture, fusion of protoplasts. • Somatic hybrids, selection methods, gene expression in somatic hybrids. **Section-C** • Disaggregation of animal tissue, isolation of cells, single cell culture, routine maintenance of animal cell lines. • Cloning & selection of specific animal cell types. • Transfection: gene transfer methods for adherent and non-adherent cell culture. • Cell fusion: fusogen, animal somatic cell fusion and selection of cybrids. • Animal organ culture. • Elementary idea about animal cell culture products. **Suggested Books:** ➢ Bhojwani, S.S. & Razdan, M.K. (1996). *Plant Tissue Culture*. USA: Elsevier Science. ➢ Chawla, H.S. (2000). *Introduction to Plant Biotechnology*. US: Science Publishers. ➢ Razdan, M.K. (2006). *Introduction to Plant Tissue Culture*. New Delhi, India: Oxford and IBH Pub. ➢ Smith, R.H (Ed.). (2013). *Plant tissue culture: Techniques and experiments*. Amsterdam: Academic Press. ➢ Buler, M. (2003). *Animal Cell Culture and Technology* (2^{nd} ed.). UK: Taylor & Francis. ➢ Mathur, S. (2006). *Animal Cell and Tissue*	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				Culture. India: Agrobios. ➢ Clynes, M. (Ed.) (1998). *Animal Cell Culture Techniques*. Germany: Springer-Verlag Berlin Heidelberg. ➢ Pollard, J.W. &Walker, J.M. (Eds.) (1990). *Animal Cell Culture*. USA: Humana Press ➢ John, R.W. (2000). *Animal Cell Culture: A Practical Approach* (3rd ed.). UK: Oxford University Press. ➢ Freshney, R.I. (2011). *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications* (6thed.). USA: Wiley-Blackwell. ➢ Davis, J.M. (2011). *Animal Cell Culture: Essential Methods*. New Jersey, USA: John Wiley & Sons Ltd. **Suggested e- Resources:** ➢ **Background of Tissue Culture Technology** http://www.biologydiscussion.com/botany/tissue-culture/tissue-culture-definition-history-and-importance/42944 ➢ **Embryogenesis and organogenesis** https://nptel.ac.in/courses/102103016/module1/lec8/3.html ➢ **Single cell cultures and cloning** http://www.biologydiscussion.com/botany/tissue-culture/methods-for-obtaining-single-cell-clones-from-callus-culture-plant-tissue-culture/43004 ➢ **Protoplasm isolation and regeneration** https://nptel.ac.in/courses/102103016/12 ➢ **Haploid plant production** http://www.biologydiscussion.com/plants/haploid-plants/production-of-haploid-plants-with-diagram/10700	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				➢ **Preservation of cell lines** https://www.ukessays.com/essays/biology/techniques-for-cell-preservation-biology-essay.php ➢ **Somatic hybridization** http://www.biologydiscussion.com/somatic-hybridization/somatic-hybridization-aspects-applications-and-limitations/10686 ➢ **Animal cell culture products** http://www.biologydiscussion.com/biotechnology/animal-biotechnology/applications-of-animal-cell-cultures/10457 ➢ **Cell Culture Technology** https://onlinecourses.nptel.ac.in/noc17_bt21/preview	
19.	**ZOO 507:** Ethology & Neurobiology			Renamed as **ZOO-Neurobiology and Animal Behavior** with modifications shifted to IV semester	
20.	~~ZOO 508: Histology~~		~~ZOO 508: Histology~~ **Section-A** Introduction to Histology, methods for the study of histology and observation of living and killed tissue. Epithelial tissue : Classification, special structural features, and specialization of free surface epithelia. Connective tissue : General types and special properties of connective tissue with special reference to cartilage and bone. **Section-B** ~~Liquid connective tissue : blood, bone marrow and lymphoid tissue.~~ Muscular tissue : Structure of different types of muscular tissue (Skeletal, Cardiac & Smooth muscles)	**Discontinued in present form**	Contents merged as Biology of Chordates and Histology in IV semester

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
			~~Nervous tissue : Structure of the elements of nerves tissue, neurons, nerve fibers. neuralgia, synapse and meninges.~~ **Section-C** His~~tological study of the organs with special reference to mammal : Skin, Oesophagus, Stomach, Intestine, Rectum, Liver, Pancreas, Trachea, Lung, Blood vessels, Kidney, Testis, Ovary, Uterus, Retina, Chochlea and Vestibule.~~ **Books Recommended :** - Histology : Bloom. - ~~A Textbook of Histology : Naranyan.~~ - ~~Basic Histochemistry : Summner, John Wiley & Sons~~. - ~~A Textbook of Histology : Leeson and Leeson.~~ - Histology : Janquera		
21.	**ZOO:** Animal Science Lab-I	After successful completion of course students will be able to • Identify and classify museum specimens belonging to non-chordate phyla. • Explain various adaptations evolved in some representative non chordate animals. • Demonstrate practical application of tissue culture techniques.	**ZOO 505L:** Animal Science Lab-I • Study of protista on the basis of Locomotory organs. • Study of Parazoans on the basis of Skeletal, Canal and Reproductive systems. • Study of metazoans on the morphological, germ layer and coelom basis taking the examples of each class or order as necessary. • Study of the salient features of non-chordate connecting links with the help of specimens or models available in the lab. • Study of some representative of non-chordate showing protective, feeding and parasitic adaptation. • Study of microscpic slides of (i) Mouthparts of House fly/*Apis* and Mosquito	**ZOO:** Animal Science Lab-I • Study of protista on the basis of locomotory organs. • Study of parazoans on the basis of skeletal, canal and reproductive systems. • Study of metazoans on the basis of morphology, germ layer and coelom taking the examples of each class or order as necessary. • Study of the salient features of non-chordate connecting links with the help of specimens or models available in the lab. • Study of some representative of non-chordate showing protective, feeding and parasitic adaptations. • Study and preparation of mouthparts of house fly/honey bee/cockroach and mosquito. • Study the life cycles of honey bee, silk moth	Practicals are revised based on theory papers in this semester

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
			(ii) Hisological Slides - Skin, Stomach, intestine, pancrease, liver, kidney, lungs, ear, testes, ovary. (iii) Preparation of permanent slides: Microtomy. (iv) ~~Quality analysis of drinking water :~~ (v) ~~Estimation of Total hardness.~~ (vi) ~~Estimation of Calcium content.~~ (vii) ~~Estimation of Magnesium content.~~ (viii) ~~Estimation of Chloride content.~~ (ix) ~~Estimation of Sulphate content.~~ (x) ~~Estimation of Alkalinity.~~ (xi) ~~Estimation of Dissolved Oxygen.~~ (xii) ~~Estimation of Fluoride~~ (xiii) ~~Study of life cycle of insects of economic importance~~. (xiv) ~~Lac insect, silkmoth, honeybee and some stored grain pests with the help of specimens/chart/models/CD.~~	and lac insect through models • Study the evidences of evolution (analogy, homology, and embryology) through charts/ models. • Preparation and sterilization of complete media from powdered medium for animal cell culture. • Preparation and sterilization of serum from the given blood sample for animal cell culture. • Disaggregation and initiation of primary cell culture. • Cell viability count using Trypan blue stain • Preparation of freezing media for preservation of the animal cells. • Short term culture of whole blood and preparation of metaphase chromosome. • Preparation of G and C banding in chromosome **Suggested Books**: ➢ Ghose, K., & Manna, B. (2016). *Practical Zoology* (4th ed.). Kolkata, India: New Central Book Agency. ➢ Verma, P.S. (2010). *A Manual of Practical Zoology: Invertebrates* (11th ed.). New Delhi, India: S Chand Publishing. ➢ Lal, S.S. (2015). *Practical Zoology: Invertebrates* (11th ed.). Meerut, India: Rastogi Publication.	
22.	**Z00 509D:** Literature dissertation	After successful completion of course students will be able to: • Access the primary literature, understand the scientific reports and extract the useful information from it.	Z00 509D: Literature dissertation	**No modifications**	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
		• Write a scientific document highlighting introduction of the research problem, review of literature, conclusions, future prospects and literature cited. • Communicate significant findings in the form of scientific papers, reports, poster and oral presentations.			
M.Sc. Bioscience (Animal Science) IV Semester					
23.	**ZOO-** Biology of Chordates and Histology	After successful completion of course students will be able to: • Identify and classify the major groups of organisms belonging to chordate phylum • Compare and contrast the characteristics of fishes, amphibians, reptiles, birds, and mammals • Describe the histological techniques and basic structure of different tissues		**ZOO- Biology of Chordates and Histology** **Section A** • Modern interpretation of origin of early chordates. • Characteristic features and affinities of urochordata and cephalochordata. • Transition from agnatha to gnathostomes. • Fish: Origin and classification up to order, general organization and affinities of ostracoderms and placoderms, general organization of elasmobranchii, holocephali, crossopterygii, dipnoi. • Amphibia: Origin and classification up to order, general organization of amphibia, adaptive radiation, parental care. **Section B** • Reptiles: Origin and classification up to order; general organization and affinities of chelonia, rhynocooephalia, squamata, crocodalia, dinosaurs, venom in ophidians. • Birds: Origin and classification up to order,	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				origin of flight, flight adaptations, flightless birds. • Mammals: Origin and classification up to order, characteristic features of prototheria and metatheria, adaptive radiation. **Section C** • Introduction to histology, methods for the study of histology and observation of living and killed tissue. • Epithelial tissue: Classification, special structural features, and specialization of free surface epithelia. • Connective tissue: General types and special, properties of connective tissue with special reference to cartilage and bone. • Muscular tissue: Structure of different types of muscular tissue (Skeletal, Cardiac & Smooth muscles). **Suggested Books:** ➢ Hildebrand, (1995). *Analysis of vertebrate structure* (4th ed.). New Jersey, USA: John Wiley. ➢ Pugh, F.H., Heiser, J.B., McFarland, W.N. (1979). *Vertebrate life* (4th ed.). London, UK: Macmillan Publishing. ➢ Parker, T.J. & Haswell, W.A (1978). *Text book of zoology*, Vol II., *Vertebrates*. London, UK: Macmillan co. ➢ Young, (1981). *The life of vertebrates* (3rd ed.). Oxford, UK: Oxford University Press. ➢ Bloom, W. & Fawcett, D.W. *A Textbook of histology* (10th ed.). Philadelphia, USA: W.B. Saunders Company. ➢ Junqueira, L.C. & Carneiro, J. (2005). *Basic histology*: *Text and Atlas* (11th ed.). New York,	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				USA: McGraw Hill Medical. ➢ Rej, S.K. (2015). *General concepts of histology & endocrinology*. Kolkata, India: New Central Book Agency. **Suggested e-Resources:** ➢ **Origin of early chordates** https://manoa.hawaii.edu/exploringourfluidearth/biological/.../phylum-chordata ➢ **Mammals** https://courses.lumenlearning.com/boundless-biology/chapter/mammals/ ➢ **Birds** https://courses.lumenlearning.com/boundless-biology/chapter/birds/ ➢ **Methods for the study of histology** https://www.microscopemaster.com/histochemistry.html ➢ **Epithelial tissue and Connective tissue** www.academia.edu/25115428/Histology_of_animal_tissue ➢ **Muscular tissue** http://medcell.med.yale.edu/histology/muscle_lab.php	
24.	ZOO-5: Animal Physiology and Endocrinology	After successful completion of course students will be able to: • Understand the process of nutrition and respiration in mammals • Comprehend the physiology of mammalian circulatory, respiratory and excretory systems • Explain the role of hormones and their endocrine and neural control.	~~ZOO501: Advance Animal Physiology~~ **Section-A** ~~A general idea, about the functions of exoskeleton in animals,~~ thermoregulation in ectotherms and endotherms, ~~occurrence of bioluminescence among animals.~~ ~~An idea about~~ mechanoreception, equilibrium reception phonoreception, chemoreception electroreception and photoreception~~.~~ Nutritional pattern in animals, mechanism of digestion absorption and assimilation of different food materials, digestive enzymes and the regulation of	ZOO-5: Animal Physiology and Endocrinology **Section A** • Thermoregulation in ectotherms and endotherms • Nutritional pattern in animals, mechanism of digestion absorption and assimilation of different food materials, digestive enzymes and the regulation of their secretion in mammals, physiology of defecation. • Mechanism of respiration and its regulation in mammals, mechanism of exchange of CO_2 and O_2 at cellular level, respiratory pigments in	A general idea, about the functions of exoskeleton in animals, different types of respiratory organs in animals, different types of hearts on physiological basis (these contents will be covered in courses Biology of Non-Chordates and Biology of Chordates and Histology)

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
			their secretion in mammals, physiology of defecation. **Section-B** ~~Different types of respiratory organs in animals,~~ mechanism of respiration and its regulation in mammals, mechanism of exchange of CO2 and O2 at cellular level, respiratory pigments in animals, respiratory quotient, oxygen equilibrium curves, Bohr's effect. An idea about types of circulating systems in animals, ~~different types of hearts on physiological basis~~, cardiac cycle, cardiac output and its regulation in mammals. Composition and functions of mammalian blood, blood volume, blood pressure, mechanism of blood coagulation, blood group system. **Section-C** ~~An idea about the various types of excreting organs and excreting products in animals~~, functional structure of nephron, ornithine cycle, production of urine and its regulation, counter current mechanism, micturition and its control. Fluid, electrolytes and acid base balance, homeostasis in mammals. Mechanism of muscle contraction of different types of vertebrate muscles, energy supply and heat production, mechanical properties of muscles, invertebrate muscles and mechanism of their	animals, respiratory quotient, oxygen equilibrium curves, Bohr's effect, Haldane effect. **Section B** • An idea about types of circulating systems in animals, cardiac cycle, cardiac output and its nervous and hormonal regulation in mammals. • Composition and functions of mammalian blood, blood volume, blood pressure, mechanism of blood coagulation, blood group system. • Concept of excretion and nitrogenous wastes, functional structure of nephron, ornithine cycle, production of urine and its regulation, counter current mechanism, micturition and its control. • Fluid, electrolytes and acid base balance, homeostasis in mammals. • Mechanism of muscle contraction of different types of vertebrate muscles, energy supply and heat production, mechanical properties of muscles, invertebrate muscles and mechanism of their contraction. **Section C** • Introduction and scope of endocrinology, classes of hormones, biosynthesis of hormones. • Hormonal receptors and mechanism of hormonal action. • General survey of endocrine glands in vertebrates, structure and functions of pituitary, hypophysial- hypothalamus complex, pineal thyroid, parathyroid, adrenal and pancreas. **Suggested Books:** ➢ Prosser, L.C., & Brown, F.A. (1973). *Comparative animal physiology*. Philadelphia, USA: W. B. Saunders Co.	An idea about mechanoreception, equilibrium reception phonoreception, chemoreception electroreception and photoreception(moved to Neurobiology and Animal Behavior) Section C includes Endocrinology

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
			contraction. **Books Recommended :** ➢ Comparative animal physiology: Prosser and Brown. ➢ Function of Human body : A.C. Guyton. ➢ Eckert Animal physiology-Mechanism and adaptation: Randall and Burggren. ➢ Human Anatomy & Physiology: E.N. Mereib, Pearron Education. ➢ Human physiology Vol. I and Vol. II : C.C. Chatterjee. ➢ Human physiology Vol. I and Vol. II : E. Babsky, B. Khodorov, G. Kositsky and A. Zubkov. ➢ Principles of anatomy and physiology : G.M. Tortora ➢ ~~Animal physiology : Goodman.~~ ➢ Animal physiology : Laural Sherwood, Thompson Learning.	➢ Guyton, A.C. (2006). *Textbook of medical physiology* (11th ed.). Philadelphia, USA: W.B. Saunders Co. ➢ Mereib, E.N., & Hoehn, K. (2016). *Human anatomy & physiology* (10th ed.). London, UK: Pearson Education. ➢ Chatterjee, C.C. (2005). *Human physiology*, Vol. I and Vol. II. New Delhi, India: CBS Publishers & Distributors. ➢ Babsky, E., Khodorov, B., Kositsky, G. & Zubkov, A. (1970). *Human physiology*, Vol. I and Vol. II. Moscow: MIR Publishers. ➢ Tortora, G.M., & Derrickson, B. (2009). *Principles of anatomy and physiology* (12th ed.). NJ, USA: John Wiley and Sons. ➢ Sherwood, L. (2007). *Human physiology: From cells to systems* (6th ed.). CA, USA: Thomson Brooks/Cole. ➢ Roy, R.N. (2018). *Textbook of physiology: with biochemistry & biophysics* Vol-I. Kolkata: New Central Book Agency. ➢ Turner, C.D. *General Endocrinology* (6th ed.). New Delhi, India: Affiliated East-West Press Pvt. Ltd. ➢ Hadley, M.E. (2007). *Endocrinology* (6th ed.). New Delhi, India: Pearson Education. ➢ Bentley, P.J. (1998). *Comparative vertebrate endocrinology* (3rd ed.). Cambridge, UK: Cambridge University Press. . **Suggested e-Resources:** ➢ **Thermoregulation** https://www.nature.com/scitable/knowledge/library/homeostatic-processes-for-thermoregulation-23592046 https://www.shmoop.com/animal-	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				movement/temperature-regulation.html ➢ **Circulatory System** https://en.wikibooks.org/wiki/Human_Physiology/The_cardiovascular_system https://courses.lumenlearning.com/boundless-ap/chapter/physiology-of-circulation ➢ **Muscular System** http://www.lamission.edu/lifesciences/lecturenote/aliphysio1/muscles.pdf https://genius.com/Human-physiology-introduction-to-the-muscular-system-annotated https://opentextbc.ca/anatomyandphysiology/chapter/10-3-muscle-fiber-contraction-and-relaxation ➢ **Urinary System** https://www.innerbody.com/image/urinov.html ➢ **Endocrine System** https://www.endocrineweb.com/endocrinology/about-endocrine-system https://www.britannica.com/science/human-endocrine-system.	
25.	~~ZOO 502: Animal Cell and Tissue Culture Techniques~~			Discontinued	
26.	~~ZOO 504: Animal Diversity-II~~		~~**ANIMAL DIVERSITY-II**~~ ~~**Note:** The paper is divided into three sections. Students are required to attempt five questions in all, selecting not more than two questions from each section.~~ ~~**Section-A**~~ • ~~Diagnostic features and phylogeny of Fishes & Amphibia.~~	Discontinued	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
			• ~~Diagnostic features and phylogeny of Reptilia & Birds.~~ • ~~Diagnostic features and phylogeny of Mammals.~~ ~~**Section-B**~~ • ~~Basic idea about origin of life.~~ • Mechanism of evolution (a) Species & Speciation (b) Variation (c) Mutation (d) Isolation (e) Natural Selection (f) Hardy-Weinberg law (g) Adaptations (h) Concept of Modern Synthetic theory. ~~**Section-C**~~ • Distribution of animals in time and space. • An introduction to the science of Palaentology, Fossil record, Dating & significance. • Evolution of Horse and *Homo sapiens*. ~~**Books Recommended :**~~ ▫ ~~Text book of Vertebrate Zoology : S.N. Prasad.~~ ▫ Vertebrate Zoology: Parker & Haswell. ▫ ~~Vertebrate Biology: R.T. Orr.~~ ▫ Anatomy & Physiology: C.C. Chaterjee.		
27.	~~ZOO 510: Medical Pathology~~		~~ZOO 510: Medical Pathology~~	**To be discontinued**	
28.	~~ZOO 511: Reproductive Biology and Endocrinology~~		~~ZOO 511: Reproductive Biology and Endocrinology~~ **Section-A** Introduction and scope of endocrinology and reproduction biology. General survey of endocrine gland in vertebrates, study of structure and functions of pituitary, hypophysial - hypothalamus complex, thyroid, parathyroid, adrenal and pancreas. ~~Neuroendocrine system in invertebrates with special reference to insects and crustaceans.~~ **Section-B**	**To be discontinued**	Reproductive Biology part is merged with Developmental Biology and Endocrinology part is shifted to Animal Physiology

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
			~~Synthesis, secretion, transport and mechanism of action of hormones.~~ Origin of primordial germ cells, spermatogenesis and spermeiogenesis, ogenesis and fertilization. Breeding seasons, reproductive cycles and their hormonal regulation in animals. **Section-C** Endocrine control of gestation, lactation and parturition in mammals. Hormonal control of growth and metamorphosis in insects, Pheromones. Hormonal control of migration in birds and fishes. **Books Recommended :** ➢Endocrinology : Turner. ➢Endocrinology : Hadley, Pearson Education. ➢Comparative endocrinology : P.S. Bentley. ➢~~Comparative endocrinology : Gorbman.~~ ➢~~Reproduction : Cohen.~~ ➢~~Reproductive physiology : B. Nalabandhov.~~ ➢~~Physiology of reproductions : Marshall.~~ ➢~~Reproduction in Domestic animals : H.H. Cole and P.T. Ceeps.~~ ➢~~Comparative spermatology : Baccio Daccet.~~ ➢Textbook of Medical Physiology : A.C. Guyton.		
29.	ZOO: -Animal Science Lab-II	After successful completion of course students will be able to • Identify and classify museum specimens belonging chordate class • Observe and describe ecological adaptations in chordates • Perform clinical procedures for blood and urine analysis • Develop skill in tissue	ZOO 506L: Animal Science Lab-II • Evolution of chordates on the basis of skeletal and integumentary systems. • Study of connecting links of chordates with the help of specimens or models available in the lab. • Study of some representatives of chordates shawing following adaptations : ▫ Aquatic ▫ Desert ▫ Fossorial and curssorial ▫ Aerial and arboreal	ZOO: -Animal Science Lab-II • Evolution of chordates on the basis of skeletal and integumentary systems. • Study of connecting links of chordates with the help of specimens or models available in the lab. • Study of types of scales in fish • Study of some representatives of chordates showing following adaptations : ▫ Aquatic ▫ Desert	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
		preservation, microtomy and preparation of permanent microscopic slides.	• Haemtoalogical determinations : ▫ Estimation of blood sugar ▫ Estimation of serum total proteins ▫ Estimation of serum cholesterol ▫ Estimation of blood calcium ▫ SGPT and SGOT ▫ Estimation of Hemoglobin by light absorbance method ▫ TLC, DLC ▫ ~~Neutrophil phagocytic index~~ ▫ ESR • Examination of abnormal or pathological constituents of urine ▫ Reducing sugars ▫ Proteins ▫ Blood ▫ Bile pigment and salts • Experiments based on reproduction biology ▫ Study of vaginal smear of rat or mice to detect various stages of estrous cycle. ▫ Pregnancy Test • Prepartion of report on local/wild fauna. • ~~Prepartion of phylogenic tree of animal kingdom~~ • Microscopic study : ▫ Microscopic study of different developmental stages of blastula and gastrula. ▫ Identification of stages of oogenesis and spermatogenesis. ▫ Microscopic study of endocrine glands: Pituitary, Parathyroid Adrenal, Thymus, Hypothalamus.	▫ Fossorial and curssorial ▫ Aerial and arboreal • Haematological determinations: ▫ Estimation of blood sugar ▫ Estimation of serum total proteins ▫ Estimation of serum cholesterol ▫ Estimation of blood calcium ▫ SGPT and SGOT ▫ Estimation of haemoglobin by light absorbance method ▫ Complete Blood Count (CBC) using hematoanalyzer ▫ TLC (WBC count), DLC ▫ ESR • Examination of abnormal or pathological constituents of urine ▫ Reducing sugars ▫ Proteins ▫ Blood ▫ Bile pigment and salts • Experiments based on reproduction biology ▫ Study of vaginal smear of rat or mice to detect various stages of estrous cycle. ▫ Pregnancy test • Microscopic study of different developmental stages of blastula and gastrula. • Identification of stages of oogenesis and spermatogenesis. • Microscopic study of endocrine glands: pituitary, parathyroid adrenal, thymus, hypothalamus. • Preparation of histological slides of different tissues. • Study of permanent histological slides of skin, stomach, intestine, pancreas, liver, kidney,	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				lungs, ear, testes, and ovary. • Preparation of report on local/wild fauna. **Suggested Books:** ➢ Ghose, K., & Manna, B. (2016). *Practical Zoology* (4th ed.). Kolkata, India: New Central Book Agency. ➢ Lal, S.S. (2015). *Practical Zoology: Vertebrates* (11th ed.). Meerut, India: Rastogi Publication. ➢ Verma, P.S. (2010). *A Manual of Practical Zoology: Chordates* (11th ed.). New Delhi, India: S Chand Publishing.	
30.	**ZOO:** Reproduction and Developmental Biology	After successful completion of course students will be able to: • Understand events that lead up to the process of fertilization, differentiation and organogenesis in animals. • Describe reproductive organs and their functions. • Develop an understanding of methods for assisted reproductive technologies.		**ZOO: Reproduction and Developmental Biology** **Section-A** • History and scope of reproduction and developmental biology. • General concept of potency, commitment, specification, induction, competence and determination • Gametogenesis: Spermatogenesis, oogenesis, hormonal regulation of gametogenesis • Fertilization: Hormonal control of gamete interaction, recognition of gametes and acrosomal reaction, prevention of polyspermy and gamete fusion, activation of egg metabolism. • Cleavage patterns and formation of blastula in amphibians and birds. • Gastrulation: fate maps, cell movement and formation of germ layers in amphibians and birds. **Section B** • Differentiation and Pattern formation: Stalk and fruiting body formation in *Dictyostellium*, origin of anterior-posterior and dorsal-ventral	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				polarity in drosophila (role of maternal, segmentation and homeotic genes). • Axis formation in amphibians (Nieuwkoop centre and primary organizer), axis formation in birds and mammals: role of pattern forming genes. • Neurogenesis and neural tube in vertebrates, development of limb in vertebrates: role of HOX and other pattern forming genes. **Section C** • Ovary: Anatomy, histological structure, female accessory sex organs in mammals (oviduct, uterus, vagina, mammary gland). • Testes: Anatomy, histological structure, structural organization and endocrine regulation of prostate, functions of male accessory sex glands in mammals. • Regulation of reproduction processes: breeding seasons, menstrual cycle/estrous cycle, endocrine control of implantation, gestation, lactation and parturition in mammals • Assisted reproductive techniques: principles, methods and types of ART, cryopreservation of gametes, modern contraceptive technologies. **Suggested Books:** ➢ Carlson, B.M. (1999). *Patten's foundations in embryology*. (6th ed.). New York, USA: McGraw Hill. ➢ Gillbert, S.F. (2006). *Developmental biology* (8th ed.). Sunderland, USA: Sinauer Associates. ➢ Kalthoff, K. (2001). *Analysis of biological development* (2nd ed.). New York, USA: McGraw Hill. ➢ Wolpert, L., & Tickle, C. (2007). *Principles*	

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				of development (3rd ed.). Oxford, London: Oxford University Press. ➢ Chattopadhyay, S. (2017). *An introduction to developmental Biology*. Kolkata, India: Books and Allied ➢ Plant, T.M., & Zeleznik, A.J. (2014). *Knobil and Neill's Physiology of reproduction Vol. I & II* (4th ed.). London, UK: Academic Press ➢ Lamming**,** G.E. (1992). *Marshall's physiology of reproduction*. Volume 2: *Reproduction in the male* (4th ed.). London, Churchill Livingstone ➢ Findlay, J.K. (Ed.). (1994). *Molecular biology of the female reproductive system*. London, UK: Academic Press **Suggested e-Resources:** ➢ **Origin of anterior-posterior and dorsal-ventral polarity in *Drosophila*** https://people.ucalgary.ca/~browder/D_m_segment_I.html ➢ **Nieuwkoop centre** http://life.bio.sunysb.edu/biochem/holdener/ho16_s99.html ➢ **Ovary** https://courses.lumenlearning.com/boundless-ap/chapter/the-female-reproductive-system/ ➢ **Testes** https://courses.lumenlearning.com/boundless-ap/chapter/the-male-reproductive-system/ ➢ **Assisted reproductive techniques** https://www.varta.org.au/information-support/assisted-reproductive-treatment	
31.	**ZOO-7:** Neurobiology and Animal	After successful completion of course students will be able to: • Understand nervous system	**ZOO 507:** Ethology & Neurobiology **Section-A** • An introduction to the field of neurobiology.	**ZOO-7: Neurobiology and Animal Behavior** **Section-A** • An introduction to the field of neurobiology.	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
	Behavior	anatomy and physiology • Describe neural and genetic control of animal behaviour • Explain learning, sexual, social behavior and animal communication.	• Introduction to nervous system. • Anatomy of brain, spinal cord and nerve. • ~~Neuroglia and Blood brain barrier~~. • Physiology of nerve impulse conduction, synapse and neuromuscular junction. • Classification & anatomy of receptors ~~and sense organs.~~ • An idea about the physiology of sleep and pain. **Section-B** • Definition of Ethology, ethological approach to the study of behaviour, a brief outline of classical and modern theories of ethology. • Development of behaviour-Instinct, learning, imprinting and motivation. • Neural mechanism of learning. • Genes and behaviour. **Section-C** • Biological communication. • Biological clocks and rhythms. • Social behaviour - The advantages of grouping, sociology, social insects, social organisation of vertebrates, primates • ~~Applied Ethology Ways in which an ethological research can be applied to practical problems~~ **Books recommended** ➢ Human physiology : C.C. Chatterjee ➢ Text book of medical physiology : Guyton. ➢ ~~The Study of Animal Behaviour : Fellicity Hunt Ingford.~~ ➢ ~~An Introduction to Animal behaviour : A. Manning, Cambridge Univ. Press.~~ ➢ Ethology : R. Mathur, Rastogi Publications. ➢ ~~The oxford companion to Animal Behaviour :~~	• Introduction to nervous system: Anatomy of brain, spinal cord and nerve, physiology of nerve impulse conduction, synapse and neuromuscular junction. • Classification & anatomy of receptors, mechanism of reception: mechanoreception, equilibrium reception phonoreception, chemoreception, electroreception and photoreception. • An idea about the physiology of sleep and pain. **Section-B** • Definition of ethology, ethological approach to the study of behaviour, a brief outline of classical and modern theories of ethology. • Development of behaviour-Instinct, learning, imprinting and motivation. • Neural mechanism of learning. • Genes and behaviour. **Section-C** • Biological communication, biological clocks and rhythms, migration in birds and fishes. • Social behaviour: The advantages of grouping, sociology, social insects, social organisation of vertebrates; primates. **Suggested Books:** ➢ Tortora, G.M., & Derrickson, B. (2009). *Principles of Anatomy and Physiology* (12th ed.). New Jersey, USA: John Wiley and Sons ➢ Mathur, R. (2014). *Animal behaviour* (5th ed.). Meerut, India: Rastogi publications ➢ Shukla, J. P. (2010). *Fundamentals of Animal Behaviour* (1st ed.). New Delhi, India: Atlantic Publishers & Distributors	

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			~~M.C. David~~ ➢ ~~Animal Behaviour : M.P. Arora.~~ ➢ ~~An Introduction to Ethology : P.J.B. Slaters, Cambridge Univ. Press.~~ ➢ Principles of Anatomy & Physiology - GM Tortora.	➢ Alcock, J. (2009). *Animal Behavior: An evolutionary approach* (9^{th} ed.). Sunderland, USA: Sinauer Associates ➢ Hall, J. E. (2011). *Guyton and Hall Textbook of Medical Physiology* (6^{th} ed.). Philadelphia, USA: Saunders Elsevier. **Suggested e-Resources:** ➢ **Anatomy of Brain and Spinal cord** https://www.seattlecca.org/diseases/brain-spinal-cord-cancers/brain-spinal-cord-cancers-facts/anatomy-brain-and-spinal-cord ➢ **Neuroglia and Blood brain barrier** https://www.wikilectures.eu/w/Glial_cells,_brain_barrier_systems ➢ **Physiology of sleep and pain** https://www.myvmc.com/anatomy/sleep-physiology/ ➢ **Neural mechanism of learning** https://kundoc.com/pdf-neural-mechanisms-of-learning-and-memory-.html ➢ **Biological clock** http://www.exactlywhatistime.com/psychology-of-time/biological-clock/	
Proposed List of Elective courses to be offered in the III & IV Semester					
1)	Insect Diversity, Morphology, Physiology and Ecology	After successful completion of course students will be able to: • Identify, classify and describe insect morphology and physiology. • Understand insect life cycle and development • Describe incest social behavior and effect of various biotic and abiotic factors on insect population.		**Section-A** • Insect diversity-Origin and evolution of insects; historical aspects of entomology in India, classification of phylum arthropoda; cassification of insects up to orders. • Characteristic features of economically important families of insect orders (orthoptera, hemiptera isoptera; diptera; coleoptera; lepidoptera; hymenoptera); collection and preservation of insects. • Insect morphology: Segmentation and tagmosis;	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				integument; head; thorax; abdomen; appendages; mouth parts; antennae; types of wings; wing coupling apparatus. **Section-B** • Insect anatomy-Structure and functions of insect cuticle and molting, • Circulatory system; respiratory system; digestive system; excretory system and waste disposal; reproductive system; nervous system and co-ordination; endocrine system and function of hormones; sensory systems-mechanical stimuli; • Thermoregulation; chemical stimuli; insect vision; sound and light producing organs. **Section-C** • Insect development and life history- Types of larvae and pupae; types of reproduction; metamorphosis and diapause in insects; polymorphism and polyphenism. • Social life of insects: Termite and honey bee. • Insect ecology: Effect of abiotic factors (temperature, moisture, humidity, rainfall, light, atmospheric pressure and air currents) and biotic factors (food competition, natural and environmental resistance). **Suggested Books** ➢ Chapman, R.F. (2013). *The insects structure and function* (5th ed.). Cambridge, UK: Cambridge Univ. Press. ➢ Imms, A.D. (1992). *A general text book of entomology*. Vol. I and II. London, UK: Chapman & Hall. ➢ Snodgrass, R.E. (1935). *Principles of insect morphology*. New York, USA: Mc Graw Hill. ➢ Blum, M.S. (1985). *Fundamentals of insect*	

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				physiology. New York, USA: John Willey & Sons. ➢ Wigglesworth, V.B. (1982). *Principles of insect physiology* (7th ed.). Netherland: Springer, ELBS edition. ➢ Klowden, M. (2007). *Physiological systems in insects* (2nd ed.). London, UK: Academic Press. ➢ Singh, R. (2018). *Elements of entomology* (2nd ed.). Meerut, India: Rastogi publication. **Suggested e- Resources** ➢ **Origin and Evolution of Insects** https://www.sciencedirect.com/science/article/pii/S0960982215009276 ➢ **General Characters of Insect Orders** https://texasinsects.tamu.edu/insect-orders ➢ **Identification of Insects** https://www.insectidentification.org/orders_insect.asp ➢ **Insect Anatomy and Physiology** http://krishikosh.egranth.ac.in/handle/1/2049010?mode=full http://www.agrimoon.com/insect-morphology-and-systematics-pdf-book/ https://www.researchgate.net/publication/276175248_Insect_Morphology_and_Systematics_Ento-131_-_Notes	
2)	Applied Entomology and Insect Pest Management	After successful completion of course students will be able to: • Comprehend role of insects in agriculture • Describe types of insecticides and evaluate their toxicity • Develop skill in insect pest management		**Section-A** • Distribution, habitat, appearance, life history, importance and control measures of house hold insects- Cockroaches and house fly. Polyphagous insects (locust; termites; white grub and red hairy caterpillar). • Characteristic features, life cycle, nature of damage and control measures of- important	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				insect pests of cotton; sugarcane; paddy; wheat; cereals & pulses; maize; vegetables; oil seeds; fruit trees; stores grains pest and their management. **Section-B** • Classification of insecticides; Structure and mode of action of various chemical insecticides-Organochlorides; organophosphates; carbamates; pyrethroides; neonicotinoids. Insect growth regulators; Concepts of I, II and III generation of insecticides. • Evaluation of toxicity of insecticides; toxicity parameters- LD_{50}, LC_{50}, LT_{50}, KD_{50}, ED_{50}/EC_{50}, formulation of insecticides; insect resistance, insecticidal act-1968. Insecticide poisoning- symptoms first aid and antidotes. **Section-C** • Methods of Insect Pest Management (IPM): Concepts, scope and limitations of IPM, different IPM strategies (physical; mechanical; cultural; genetic; botanical; legal/regulatory control and chemical control). • Methods of biological control- Parasitoids; parasitic nematodes; microbial agents-baculoviruses; bacteria; fungi and protozoans. insect attractants, repellents and antifeedants. • Industrial entomology- Apiculture, sericulture, lac culture. **Suggested Books:** ➢ Srivastava, K.P., & Dhaliwal, G.S. (2010). *A Text Book of Applied Entomology* Vol I & II. New Delhi, India: Kalyani Publishers. ➢ Singh, R. (2018). *Elements of Entomology* (2nd	

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				d.). Meerut, India: Rastogi publication. ➢ Atwal, A.S. (1986). *Agricultural Pests of INDIA and South East ASIA* (2nd ed.). New Delhi, India: Kalyani Publishers. ➢ Awasthi, V.B. (2009). *Introduction to General and Applied Entomology* (3rd ed.). New Delhi, India: Scientific Publishers. ➢ Eldridge, B. (2004) *Medical Entomology* (2nd ed.). Netherland: Springer. ➢ Fenemore, P.G., & Prakash, A. (2009). *Applied Entomology* (2nd ed.). New Delhi, India: New Age Publishers. ➢ Pedigo, L.P. (2004). *Entomology and pest management* (6th ed.). New Jersey, US: Prentice Hall Inc. **Suggested e-Resources:** ➢ **Insect Ecology and Integrated Pest Management** http://www.agrimoon.com/insect-ecology-integrated-pest-management-pdf-book/ ➢ **Applied Entomology** https://www.researchgate.net/publication/327282644_A_Text-book_of_Economic_Entomology_M_Dayib ➢ **Chemical Insecticides** https://www.britannica.com/technology/insecticide http://npic.orst.edu/ingred/ptype/index.html https://www.slideshare.net/gill0094/insecticide-classification-of-insecticide-insecticidal-act-and-spraying-techniques-davinder-gill-135021014	
3)	**Fish Biology**	After successful completion of course students will be able to • Understand aquatic adaptations		**Section A** • Skin: Structure, pigmentation and barbels, scales and tails, fins and locomotion, gills, air	

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		in fish. • Describe general organization, diversity and different systems of fish. • Develop an understanding of fish endocrinology and behavior.		breathing organs, swim bladder, weberian ossicles, sound producing organs, electric and luminescence organs. **Section B** • Digestive system, blood vascular system, respiration: aquatic respiration, gills and mechanisms of respiration, excretion and osmoregulation: glomerular and aglomerular kidneys, excretion of nitrogenous wastes, water and ion balance and urea cycle. • Nervous system: brain and cranial nerves, sense organs: eye: structure and function; acoustico-lateralis system: labyrinth, lateral line organs, chemoreceptors: gustatory and olfactory and electroreceptors. **Section C** • Function of pituitary, thyroid, ultimobranchials, pancreas, adrenal, corpuscles of stannius, urophysis, pineal, reproduction and development, sex dimorphism, courtship, mating and parental care and migration **Suggested Books:** ➢ Khanna, S.S., & Singh, H.R. (2014). *A text book of fish biology and fisheries*. New Delhi, India: Narendra Publishing House ➢ Pandey, K. C. (2012). *Concepts of indian fisheries*. New Delhi, India: Shree Publishers & Distributors ➢ Khanna, S.S. (2019). *An introduction to fishes*. New Delhi, India: Surjeet Publications. ➢ Gupta S.K., & Gupta P.C. (2006). *General & applied ichthyology*. New Delhi, India: S chand ➢ Krishnaveni, G., Rao, V. N., & Veeranjaneyulu, K. (2016). *Recent*	

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				technologies in fish and fisheries. Punjab, India: Rigi Publications ➢ Brown, M.E. (1957). *Physiology of fishes*, Vols. I and II. London, UK: Academic press **Suggested e-Resources:** ➢ **Electric and Luminescence organs** http://www.yourarticlelibrary.com/fish/anatomy-and-physiology/luminous-organs-or-photophore-of-the-fishes-with-diagram/88411 ➢ **Alimentary canal** http://www.yourarticlelibrary.com/fish/anatomy-and-physiology/digestive-system-in-fishes-with-diagram/88195 ➢ **Respiratory system** https://www.britannica.com/animal/fish/The-respiratory-system ➢ **Excretory system** https://www2.estrellamountain.edu/faculty/farabee/biobk/BioBookEXCRET.html https://www.scribd.com/document/357935799/Excretory-Organs ➢ **Nervous system, Sensory organs** http://www.yourarticlelibrary.com/fish/anatomy-and-physiology/sensory-organs-of-fishes-with-diagram/88385	
4)	**Capture Fishery**	After successful completion of course students will be able to • Identify highly diverse capture fisheries resources • Understand sustainable harvesting and responsible aquaculture practices • Pursue a career in fisheries research, resource management, instruction,		**Section A** • Fishes of deep sea: characteristics of deep sea, adaptations, bioluminescence, inland fisheries, hill streams fishes: characteristics, adaptations, exotic and transplanted fishes, marine, coastal and estuarine. **Section B** • Fishing techniques: technologies for localizing catches- remote sensing, sonar and radar; crafts and gears, construction and maintenance of fish	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
		extension and production.		farm, polyculture, monoculture and integrated fish farming, fish culture: fresh water, paddy fields and manmade lakes, plankton and its role in fisheries. • Common diseases of fishes (Red pest, mouth fungus, tail rot/fin rot, icththyosporidium, ergasilus, lymphocystis and tumor/cancer) and economic value of fishes. **Section C** • Post harvest technology: Fish spoilage, rigor mortis, rancidity, enzymatic spoilage and microbial spoilage. • Fish preservation and processing: Handling of fish at harvest/on board, principles of fish preservations, methods of preservation, problems associated with fish preservations, quality control and fishery by-products. **Suggested Books:** ➢ Khanna, S.S., & Singh, H.R. (2014). *A Text Book of Fish Biology and fisheries*. New Delhi, India: Narendra Publishing House ➢ Pandey, K. C. (2012). *Concepts of indian fisheries*. New Delhi, India: Shree Publishers & Distributors ➢ Khanna, S.S. (2019). *An Introduction to Fishes*. New Delhi, India: Surjeet Publications. ➢ Gupta S.K., & Gupta P.C. (2006). *General & Applied Ichthyology*. New Delhi, India: S chand ➢ Krishnaveni, G., Rao,V. N. & Veeranjaneyulu, K. (2016). *Recent Technologies in Fish and Fisheries*. Punjab, India: Rigi Publications ➢ Brown, M.E. (1957). *Physiology of fishes*, Vols. I and II. London, UK: Academic press.	

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				Suggested e-Resources: ➢ **Fishes of deep sea** https://news.nationalgeographic.com/2018/04/fish-black-oceans-deep-sea-animals/ ➢ **Hill streams fishes** http://www.fishfarmingtechniques.com/fish-types/hill-stream-fishes ➢ **Fishing techniques** http://www.historyoffishing.com/fishing-facts/types-of-fishing-techniques/ ➢ **Fish Culture** https://krishijagran.com/featured/all-about-fish-farming-in-india/ ➢ **Economic value of fishes** http://www.notesonzoology.com/phylum-chordata/fishes/economic-importance-of-fish-vertebrates-chordata-zoology/8038	
5)	**Animal Biotechnology-I**	At successful completion of this course students will be able to: • Comprehend tools of molecular biology and biotechnology for the improved production and protection of animals. • Evaluate and discuss public and ethical concerns over the use of animal biotechnology. • Demonstrate an understanding of the key topics in tissue engineering		**Section-A** • History and importance of animal biotechnology, cryopreservation of gametes and embryos in mammals, artificial insemination (AI) techniques and their development: estrus synchronization; semen collection, evaluation, storage. • *In vitro* fertilization and embryo transfer; superovulation, microinjection and macroinjection: Introduction, procedure, applications, advantages and limitations. • Ethical, social and moral issues related to cloning, in situ and ex situ preservation of germplasm. **Section-B** • Introduction to stem cell-definition, classification, characteristics, differentiation and dedifferentiation, stem cell niche, stem	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				cells vs somatic cells, mechanism of pleuripotency in stem cells, different kinds of stem cells: adult stem cells, embryonic stem cells, fetal tissue stem cell, umbilical cord blood stem cells. • Human embryonic stem cells and society: The religious, legal, ethical and scientific debate, stem cell banking and ethical approaches on stem cells. • Stem cell therapies: Clinical applications of stem cell therapy, parkinsons and alzheimers disease, diabetes, kidney failure, lymphoma and leukemic malignancies requiring stem cell therapy. **Section-C** • Principles of tissue engineering- History and scope, basics of tissue engineering, cell-ecm interaction, wound healing mechanism, tissue engineering bioreactors, models of tissue engineering, biomaterials in tissue engineering. • Bioartificial organs: source of cells, choosing the right scaffold material, mode of transplantation. • Tissue Engineering and future perspectives: commercial products. **Suggested Books:** ➢ Portner, R. (2007). *Animal cell biotechnology*. New York, USA: Humana Press. ➢ Butler, M. (Ed.). *Mammalian cell biotechnology; A practical approach*, London, UK: Oxford university press ➢ Lanza, R., Gearhart, J., & Hogan, B. *Essentials of stem cell biology* (2nd ed.). London, UK: Academic Press. ➢ Lanza, R., Langer, R., & Vacanti, J. *Principles*	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				of tissue engineering (4^{th} ed.). London, UK: Academic Press. ➢ Kumaresan, V. (2008). *Applied animal biotechnology*. Tamil Nadu, India: Saras Publication. ➢ Singh, B., Gautam, S.K., & Chauhan, M.S. (2015). *Textbook of animal biotechnology*. New Delhi, India:Teri Publication. **Suggested e-Resources** ➢ **Cryopreservation of gametes and embryos in mammals** https://www.glowm.com/section_view/heading/Gamete and Embryo Cryopreservation ➢ **Human embryonic stem cell** https://www.eurostemcell.org/origins-ethics-and-embryos-sources-human-embryonic-stem-cells ➢ **Stem cell therapies** https://www.closerlookatstemcells.org/stem-cells-medicine ➢ **History and scope of Tissue Engineering** https://www.stoodnt.com/blog/tissue-engineering- applications-scopes/	
6)	**Animal Biotechnology-II**	At successful completion of this course students will be able to: • Explain the basic concepts and methods of animal breeding • Understand importance of new generation vaccines in animal biotechnology • Pursue research using animal models for human and animal diseases		**Section-A** • Sex determination; principles of animal breeding; structure of the livestock breeding industry: dairy cattle, sheep and poultry. • Selection for qualitatively inherited characters - gene frequency and selecting against recessive genes; detecting heterozygotes for recessives. • Parental determination and verification; the use of markers and/or molecular probes, selection criteria: multiple records, pedigree selection, family selection. **Section-B**	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				• Principles and methods of hybridoma technology, production and characterization of monoclonal antibodies and their application in animal health and production. • Biotechnological approaches to vaccine production: Development of animal vaccines for rabbies and anthrax. subunit-vaccines; peptide vaccines; dna vaccines; recombinant vaccines; edible vaccines; fusion protein vaccines; synthetic peptide vaccines; anti-ideotype antibody vaccines. **Section-C** • Animal right activities; Blue cross in India: Society for prevention of cruelty against animals. • Cloning of domestic animals (Dolly, Molly and Polly); Somatic Cell Nuclear Transfer (Conventional & HMC); ICSI and preservation of endangered species. Transgenic animal as models for human diseases and genetic disorders; • In utero testing of foetus for genetic defects, anti-fertility animal vaccines. **Suggested Books:** ➢ Singh, B., Gautam, S.K., & Chauhan, M.S. (2015). *Textbook of animal biotechnology*. New Delhi, India: Teri Publication. ➢ Sasidhara, R. (2006). *Animal biotechnology*. Tamil Nadu, India: MJP publishers ➢ Sateesh, M.K. (2010). *Biotechnology: V: (Including Animal Cell Biotechnology, Immunology and Plant Biotechnology)* (2nd ed.). New Delhi, India: New Age International Pvt. Ltd. Publishers. ➢ Babink, L.A., & Phillips, J.P. (Ed.). (1989).	

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				Animal biotechnology: *Comprehensive biotechnology first supplement*. Oxford, UK: Pregamon press. ➢ Gordon, I. (2005). *Reproductive techniques in farm animals*. Oxford, UK: Oxford University Press. ➢ Levine, M.M., Kaper, J.B., Rappuoli, R., Liu, M.A., & Good, M.F. (2004). *New generation vaccines* (3rd ed.). London, UK: Informa Healthcare. **Suggested e- Resources:** ➢ **Principles of animal breeding; structure of the livestock breeding, Selection for qualitatively inherited characters** https://www.britannica.com/science/animal-breeding ➢ **Animal vaccines** https://virology-online.com/general/typesofvaccines.htm ➢ **Blue cross in India** bluecrossofindia.org ➢ **Cloning of domestic animals** https://www.msdvetmanual.com/management-and-nutrition/cloning-of-domestic-animals https://www.fda.gov/AnimalVeterinary/Safety Health/AnimalCloning/	
7)	**BT 516:** Immunotechnology	After successful completion of the course, students should be able to: • Describe various theories describing antibody formation • Explain the mechanism of immune response to various stimuli		**Section- A** • Structure, genomic organization, expression and functions of major histocompatibility complex (MHC). • Organization and expression of immunoglobulin genes. • T-cell receptors- genomic organization, structure and isolation of TCR. • Antibody diversity- mini gene theory, mutation	

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		• Elucidate on vaccines and their development.		theory, germ line theory, somatic recombination, V(D) J recombination. Combinatorial diversity, junctional diversity. **Section-B** • ABO Blood groups, blood transfusion, Bombay phenotype, Rh blood group, DAT test, MN blood group. • Immunity to infectious diseases: Viral, bacterial, fungal and parasitic infections. • Immunodeficiency disease: Primary and secondary immunodeficiency disease (AIDS). **Section –C** • History of vaccination, immunization types and vaccination properties. • Types of vaccines: Live, killed, subunit, recombinant viral, synthetic peptide, anti-idiotype, DNA, toxoid, conjugate, recombinant vector & plant based vaccines. • Stages of vaccine development and some common vaccines used in human MMR, poliovaccine & BCG vaccines. **Suggested Books:** ➢ Austyn, J.M. &Wood, K.J. (1993). *Principles Of Cellular and Molecular Immunology*. London, U.K: Oxford University Press. ➢ Benjaminin, E., Coico, R. & Sunshine, G. (2000).*im*: A short course (4^{th} ed.). New York, USA: Wiley-Liss. ➢ Cunnigham, A.J. (1978).*Understanding Immunology*. London, U.K.: Academic Press Inc. ➢ Hildemann, W.H. (1984). *Essentials of Immunology*. USA: Elsevier Science Ltd. ➢ Johnstone, A. & Thorpe, R. (1996)	

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				Immunochemistry In Practice (3rd ed.). US: Wiley-Blackwell. ➢ Joshi, K.R. & Osama, N.O. (2004). *Immunology and Serology*. India: Agrobios. ➢ Khan, F.H. (2009). *The Elements Of Immunology*. India: Pearson Education. ➢ Punt, J., Stranford, S., Jones, P. & Owen, J. (2018). *Kuby Immunology (*8th ed.). New York, USA: W. H. Freeman and Company. ➢ Reeves, G. & Todd, I. (2001). *Lecture Notes on Immunology* (4th ed.). US: Wiley-Blackwell. ➢ Rich, R.R., Fleisher, T. A, Shearer, W.T., Schroeder, H., Frew, A.J. & Weyand, C.M. (2018). *Clinical Immunology: Principles and Practice* (5th ed.). USA: Elsevier Science Ltd. ➢ Tizard, I. R. (1995). *Immunology: Introduction,* (4th ed.). Philadelphia, USA: Saunders College Publishing. **Suggested e- Resources:** ➢ **Antibodies and antigens** https://nptel.ac.in/courses/102103038/download/module2.pdf ➢ **Vaccines** https://nptel.ac.in/courses/104108055/37 ➢ **DNA vaccines** https://nptel.ac.in/courses/102103041/18 ➢ **Transplantation immunology** https://nptel.ac.in/courses/102103038/31	
8)	**Immunotechnology-I**	After successful completion of the course, students should be able to: • Perform various		**Section A** • Cytokines: Introduction, general properties & structure, classification of cytokines, cytokines receptors and cytokines antagonists,	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
		experiment using different techniques covered in the course. • Understand how clinical immunology is performed. • Compare and describe various diagnostic techniques.		therapeutic uses of cytokines. • Chemokines: General structure, classification, function, chemokine receptor, chemokine-chemokine receptor interaction, diseases associated with receptor expression. • Interferons: Introduction, types, effect of interferons on immune system and therapeutic uses. **Section B** • Autoimmunity: introduction, autoimmune diseases (hashinoto diseases, SLE, autoimmune hemolytic anemia, multiple sclerosis, rheumatoid arthritis, psoriasis, insulin dependent diabetes mellitus, myasthenia gravis). • Tumor immunology: Introduction, types, origin, stages of tumor formation, metastasis, oncogenes, tumor ags, effector mechanism, tumor immunity, escape of tumor cells from immune surveillance & immunotherapy in cancer. • Transplantation: immunologic basis of graft rejection, clinical manifestation, tissue typing, general immunosuppressive therapy, Mab therapy. **Section C** • Antigen antibody reaction, cross reactivity, immunoprecipitation, Western Blot (Immunoplot), FACS, cytotoxicity, immunodiffusion, immunoelectrophoresis, rocket immunoelectrophoresis, counter immunoelectropheresis. • Agglutination: Direct & indirect; Widal test; VDRL test; Radioimmunoassay; ELISA-principle, methodology & applications.	

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				• Immunoflorescence- Direct, indirect & sandwich; ELISPOT. **Suggested Books:** ➢ Austyn, J.M. &Wood, K.J. (1993). *Principles Of Cellular and Molecular Immunology*. London, U.K: Oxford University Press. ➢ Benjaminin, E., Coico, R. & Sunshine, G. (2000).*im*: A short course (4th ed.). New York, USA: Wiley-Liss. ➢ Cunnigham, A.J. (1978).*Understanding Immunology*. London, U.K.: Academic Press Inc. ➢ Hildemann, W.H. (1984). *Essentials of Immunology*. USA: Elsevier Science Ltd. ➢ Johnstone, A. & Thorpe, R. (1996) *Immunochemistry In Practice* (3rded.). US: Wiley-Blackwell. ➢ Joshi, K.R. & Osama, N.O. (2004). *Immunology and Serology*. India: Agrobios. ➢ Khan, F.H. (2009). *The Elements of Immunology*. India: Pearson Education. ➢ Punt, J., Stranford, S., Jones, P. & Owen, J. (2018). *Kuby Immunology (*8th ed.). New York, USA: W. H. Freeman and Company. ➢ Reeves, G. & Todd, I. (2001). *Lecture Notes on Immunology* (4th ed.). US: Wiley-Blackwell. ➢ Rich, R.R., Fleisher, T. A, Shearer, W.T., Schroeder, H., Frew, A.J. & Weyand, C.M. (2018). *Clinical Immunology: Principles and Practice* (5th ed.). USA: Elsevier Science Ltd. ➢ Tizard, I.R. (1995). *Immunology: Introduction*, (4th ed.). Philadelphia, USA: Saunders College Publishing.	

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				Suggested e-Resources: ➢ **Laboratory techniques** https://nptel.ac.in/courses/102103038/39 ➢ **Cellular and molecular immunotechnology** https://nptel.ac.in/courses/102103038/40 ➢ **Transplantation immunology** https://nptel.ac.in/courses/102103038/31	
9)	Bio Physics-I	After completion of this course, the students will be able to- • Understand the concepts of physical principles in the biomolecular systems. • Know properties and conformations of biomolecules • Understand the interaction between physics and biology		**Section A** • Introduction: Brief introduction to all aspects of Biology, cellular automata, Conway's Game of life. • Cell structure and function: Cell theory, cell membrane and transport, membranous organelles, Non-membranous organelles, Nuclear components and major cell types, viruses. • Molecules in the cell: carbohydrates, lipids, proteins and nucleic acids, their structure and function. • Code of life: Central dogma, DNA replication, transcription and translation. • Energy in life forms: Cellular Respiration, Glycolysis, Krebs cycle, Electron transportchain, ATP calculation, Photosynthesis, C4 pathway. **Section B** • Intermolecular interactions: Covalent interactions, disulphide bonds, van der Waals interactions, bond angles and torsions. Role of hydrogen bonding and hydrophobicinteraction in biomolecular structures. Examples of α-helices and β-sheets in proteins, Watson-Crick pairs in DNA, stacking interactions in DNA and RNA. • Protein Conformation: Conformational	(New Introduced Elective Course, cw M.Sc. Physics)

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				properties of polypeptides, Ramachandran plot, Helical parameters and conformation, organization as secondary and super secondary structures in proteins, domains and motifs. Protein folding in vivo and in vitro of globular proteins, basic idea. **Section C** • Molecular Mechanics: Force field equation, Lennard Jones Potential, Potential energysurface, Z-matrix, Molecular modeling, Energy minimization techniques, Exhaustive search method, steepest descent and conjugate gradient methods, Molecular dynamics simulation, Verlet algorithm and simulated annealing protocol. • Experimental techniques used to determine biomolecular structure: Principles and application of UV-visible, circular dichroism and fluorescence spectroscopy. • Case studies on Helix to coil transitions, melting curves in proteins and DNA structures. X-ray crystallography of biomolecules: Obtaining single crystals of biomolecules, Single crystal data collection, Determination of point group, space group from symmetry of diffraction patterns, deducing cell parameters, interpretation of intensity data, Calculation of electron density, Solving the phase problem, Structure validation. **Suggested Books:** ➢ Tuszynski, J. A. &Kurzynski, M. (2003). *Introduction to molecular biophysics*. CRC press. ➢ Schlick, T. (2010). *Molecular modeling and*	

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				Simulation: An Interdisciplinary Guide: An Interdisciplinary Guide (Vol. 21). Springer Science & Business Media. ➢ Voet, D., Voet, J. G. & Pratt, C. W. (2013). *Fundamentals of Biochemistry: Life At The Molecular Level* (No. 577.1 VOE). Hoboken: Wiley. ➢ Cantor, C. R., & Schimmel, P. R. (1980). *Biophysical CHEMISTRY: PART III: THE BEHAVIOR OF BIOLOGICAL MACROMOLECULES*. Macmillan. ➢ Van Holde, K. E. J. W. *Principles Of Physical Biochemistry*/Kensal E. Van Holde, W. Curtis Johnson, P. Shing Ho. ➢ Jensen, J. H. (2010). *Molecular Modeling Basics*. CRC Press. ➢ Nelson, P. (2004). *Biological Physics*. New York: WH Freeman. **Suggested e-Resources:** ➢ **Non-Conventional Energy Systems** https://nptel.ac.in/syllabus/1021 • **Quantum-mechanics of molecular structure** https://bit.ly/2SoEqof https://bit.ly/2SoEqof	
10)	Bio Physics-II	After completion of this course, the students will be to- • Understand the concepts of physical principles in the biomolecular systems. • Know Properties and conformations of biomolecules • Understand the interaction between physics and biology		**Section A** • Physics of macromolecules: Biological polymers, modeling polymers as elasticity models, Random walk model, radius of gyration, freely jointed chain, calculation of the distribution of end-to-end distances, statistical segment, persistence length, relation to characteristic ratio, worm like chain, behavior of chain dimension, DNA Elasticity, Application of Porod-Kraty model to DNA. • Protein folding: Anfinsen's thermodynamic	New proposed Elective Course, introduced from M.Sc. Physics

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				hypothesis, Case study: Ribonuclease A, renaturation and denaturation, mechanism of disulphide exchange, determinants of protein folding, Levinthal's paradox, classical view of protein folding, the hydrophobic collapse, Energy landscape theory, Protein Folding problem as a NP-hard problem. **Section B** • Self assembly and membrane equilibria: Self assembly in miscelles as monolayers and bilayers, Thermodynamics of miscelle formation, co-operativity, packing parameter, Tanford's free energy model, Packing model, influence of tail packing, Fluid mosaic model, Langmuir adsorption model. • Electrical conduction in the nervous system: Structure of the neuron, Hodgkin-Huxley model and generation of action potential, Nernst relation in membrane potentials, Donnan equilibrium, ion pumping, voltage gating. Transport in cells: Diffusion, Fick's law, cells with sources, low Reynolds-number, friction in fluids, Transport across cells - osmosis. **Section C** • Blood flow: Blood as non-Newtonian fluid, Blood flow models, Navier Stokes equation, Dissipative particle dynamics, Erythrocyte model, elastic model. • Energy in muscle: Cytoskeleton, Muscle Contraction, biopolymers of the cytoskeleton, Tubulin, microtubules, associated protein, micro filaments, actin and Myosin. Molecular motors, Kinesin and Dyenin. Sliding filament model of contraction, ATP and muscle	

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				contraction, stochastic model of contraction. • Radiation Physics: Dosimetery, Photon interaction coefficients, Relations between exposure, Kerma and absorbed dose, Measurement of exposure, Bragg-Gray Cavity theory, determination of absorbed dose in a medium, radiotherapy, geometrical factors, specification of dose ratios, nuclear medicine. **Suggested Books** ➢ Tuszynski, J. A., & Kurzynski, M. (2003). *Introduction to molecular biophysics*. CRC press. ➢ Schlick, T. (2010). *Molecular modeling and simulation: an interdisciplinary guide: an interdisciplinary guide* (Vol. 21). Springer Science & Business Media. ➢ Nelson, P. (2004). *Biological physics*. New York: WH Freeman. ➢ Cantor, C. R., & Schimmel, P. R. (1980). *Biophysical chemistry: Part III: the behavior of biological macromolecules*. Macmillan. ➢ Smith, F. A. (2000). *A primer in applied radiation physics*. World Scientific Publishing Company. ➢ Van Holde, K. E., Johnson, W. C., & Ho, P. S. (2006). Principles of physical biochemistry. ➢ Jensen, J. H. (2010). *Molecular modeling basics*. CRC Press. ➢ Voet, D., Voet, J. G., & Pratt, C. W. (2013). *Fundamentals of biochemistry: life at the molecular level* (No. 577.1 VOE). Hoboken: Wiley. **Suggested e-Resources:**	

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				➢ https://www.coursera.org/learn/dynamicalmodeling?specialization=systems-biology	
11)	**ENVS 402**: Ecology and Environment	After the completion of this course, students will be able to: • Describe the interaction of organisms with their environment. • Identify the various threats to biodiversity. • Explain the concept of biomes. • Describe the various biogeochemical cycles.		**Section A** **Introduction to Environment** • Concept of Environment, Factors of the environment: Physiographic, Climatic, Edaphic, Biotic and Anthropogenic. • Bio Geochemical Cycles: The Carbon cycle, the Oxygen cycle, the Nitrogen cycle, The Hydrological cycle. **Section B** **Concept of Ecology, Ecosystem and Biomes** • Concept of Ecosystem: With special reference to desert, forest and aquatic ecosystem. Food chain, Food web & succession. Ecological Pyramids and their types. • Energy flow in ecosystem, Concepts of Biomes. Major biomes of the world: Tropical forest, Temperate forest, Grassland and Tundra. **Section C** **Environmental Pollution and its Effect** • Environmental pollution-Pollutants and sources: • Water pollution, Soil pollution, Air pollution and, Noise pollution. • Greenhouse Effect, Global warming • Biodiversity: Threats and Conservation. **Suggested Books:** ➢ Atkinson, Raw, M. (2007). *Biogeography*. Philip Allan Updates. ➢ Gautam, A. (2007). *Environmental Geography*. Allahabad, India: Sharda Pustak Bhawan. ➢ Huggett, R. J. (1998). *Fundamental of Biogeography*. London, UK: Routledge.	Introduced from M.Sc. Environmental Science

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				➢ Kayastha, S.L. & Kumra, V.K. (1986). *Environmental Studies*. Varanasi, India: Tara Book Agency. ➢ Mathur, H.S. (1998). *Essentials of Biogeography*. Jaipur, India: Pointer. ➢ Mehtani, S. &Sinha, A. (2010). *Biogeography*. Commonwealth. ➢ Odum, E. P. (1975). *Ecology*. Lanham, MD:Rowman and Littlefield. ➢ Odum, E.P. (1968).*Fundamentals of Ecology*. London, UK:W.B. Sanders Company ➢ Saxena, H. M. (1999). *Environmental Geography*. Jaipur, India:Rawat. ➢ Saxena, H. M. (2000). *Environmental Management*. Jaipur, India:Rawat. **Suggested e-Resources:** ➢ **Environment and Ecology, IIT Delhi** https://nptel.ac.in/courses/122102006/16 ➢ **Ecology and Environment, IIT Madras,** https://swayam.gov.in/courses/4905-july-2018-ecology-and-environment	
12)	ENVS 502 Biodiversity and Conservation	After the completion of this course, students will be able to: • Explain importance of biological diversity. • Describe major threats to biodiversity. • Recognize and implement the various methods of biodiversity conservation with co-existence of various environmental pressures. • Identify different geographical biodiversity hotspots and mega-diversity		Section A • Introduction to biodiversity concepts, significance, magnitude and distribution. • Biodiversity trends, diversity gradients and related hypotheses methods for monitoring biodiversity trends. • Threats to biodiversity, major causes, extinction’s, vulnerability of species to extinction, IUCN threat categories, Red data book. Section B • Principles of biodiversity conservation Ex situ and In situ methods of conservation, Genetical and evolutionary principles in conservation.	

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		centers.		Conservation of biological diversity and its significance- source of food, medicine, raw material, aesthetic, cultural and ecosystem services. • Concepts, distribution and importance of Hot spots. • Strategies for sustainable exploitation of biodiversity. Section C • Conservation – efforts in India, Endangered flora & fauna of India. • Ethno botany in India & selected medicinal plants. • Wildlife conservation in India- Project Tiger, Project crocodile, silent valley controversy. • Conservation of Himalayan, Gangetic ecosystems. **Suggested Books**: ➢ Kumar, U. &Asija, M.J. (2007). *Biodiversity – Principles and Conservation* (2nd ed.). Jodhpur, India: Agrobios. ➢ Mishra, R. (1968). *Ecology Workbook* (2nd ed.). Calcutta, India: Oxford and IBH. ➢ Odum, E.P. (1983). *Basic Ecology* (2nd ed.). Philadelphia,PA: Holt-Saunders International. ➢ Odum, E.P. (2004). *Fundamentals of Ecology*. Dehradun, India: Natraj. ➢ Singh, M.P., Singh, J.K., Mohanka, R., &Sah, R.B. (2007). *Forest Environment and Biodiversity* (2nd ed.). New Delhi, India: Daya. ➢ Sinha, B.N. (1990). *Ecosystem Degradation in India*. New Delhi, India: Ashish. ➢ Tewari, D.N. (1994) *Biodiversity and Forest Genetic Resources*. Dehradun, India:	

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				International Book. **Suggested e-resources**: ➢ **Aquatic Biodiversity and Environmental Pollution, IISc, Bangalore** https://nptel.ac.in/courses/120108002/16 ➢ **Wildlife Conservation, Indira Gandhi National Forest Academy, Dehradun** https://nptel.ac.in/noc/individual_course.php?id=noc18-bt26	
Proposed Reading Elective-I & II to be offered in the IV Semester					common with Applied Microbiology and Biotechnology for Sem III and IV, Bioscience Sem IV
1)	**BT: Drug Discovery**	On completion of this course, students should be able to: • Understand basics of R&D in drug discovery and should be able to apply knowledge gained in respective fields of pharmaceutical industry. • Understand the role of synthetic chemistry in the development of pharmaceutical agents; and the modification of chemical structures to develop new drug molecules. • Have an advanced understanding of the chemical structure of a pharmaceutical agent and		Modern drug discovery involves the identification of a target or drug lead using different techniques including molecular modeling, combinatorial libraries and high-throughput screening (HTS). Rational drug design is based on the understanding of the three-dimensional structures and physicochemical properties of drugs and receptors. Knowledge of molecular mechanisms, molecular dynamics simulations and homology modeling is necessary for studying drug/receptor interactions. The different conformational sampling techniques, fitness functions used in molecular docking and computational receptor-based and ligand-based drug design approaches are mostly used to design compounds with improved biological activity in rational drug design. Quantitative drug design using QSAR models are used to correlate structural molecular properties (descriptors) with functions (i.e. physicochemical properties, biological activities, toxicity, etc.) of the compounds. Understanding	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
		determine the chemical group/s responsible for a given biological effect. • Demonstrate a basic understanding of pharmacogenomics and bioinformatics as it relates to drug design and discovery. • Develop an understanding of drug targets as a recognition site for pharmaceutical agents; how the chemical structure of a substance influences interaction with a drug target; and the identification of new drug targets for future drug discovery.		the structure activity relationship between the 3D structure of a molecule and its biological activity may act as the basis for the prediction of compounds with improved biological activities. Different bio-analytical assays (LC/MS/MS, GC/MS and ELISA) could be developed further in support of *in vitro* and *in vivo* studies. Understanding the principles as well as an early characterization of drug toxicity, adsorption, distribution, metabolism and excretion (ADME) along with drug-drug interactions, plasma protein binding assays and metabolite profile studies helps in eliminating compounds with unacceptable pharmacokinetic characteristics, which is critical to successful drug discovery programs. **Suggested Books:** ➢ Krogsgaard-Larsen *et. al.* (2016). *Textbook of Drug Design and Discovery*. 5th Edition. CRC Press. ➢ Satyanarayanajois, S. D. (2011). *Drug Design and Discovery: Methods and Protocols*. Humana Press. ➢ Rahman, A. U., Caldwell, G. W. & Choudhary, M. I. (2007). *Frontiers in Drug Design and Discovery*. Bentham Science publishers Limited. ➢ Dastmalchi, S. *et. al.* (2016). *Methods and Algorithms for Molecular Docking-Based Drug Design and Discovery*. IGI Global. **Suggested e- Resources:** ➢ **Drug Discovery** https://bit.ly/2tCqdtE ➢ **Peptide therapeutics**	

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				https://www.sciencedirect.com/science/article/pii/S1359644614003997 ➢ **Bio-analytical techniques** https://www.pharmatutor.org/articles/bioanalytical-techniques-overview	
2)	**BT: Human Genetics and Diseases**	After successful completion of the course students will be able to: • Understand hereditary and molecular genetics with a strong human disease perspective. • Describe genetic abnormalities underlying human disease and disorders • Develop interest in biomedical research, genetic counseling, medicine, and clinical genetics		Since the rediscovery of Mendel's work in 1900, investigations on the genetic nature of human traits have gained significant importance. Understanding the genetic basis behind human disease is one of the most important reasons to study human chromosome structure, human karyotype, banding techniques, chromosome identification and nomenclature (ISCN). Classical genetics has considerable importance in constructing genetic hypothesis from pedigree data analysis in monogenetic traits, autosomal dominant, autosomal recessive, sex linked dominant, sex linked recessive and sex influenced traits. The impact of consanguinity in causing sex linked anomalies (haemophilia, colour blindness and Duchenne Muscular Dystrophy) has been observed in human population. Current knowledge on genetic variations across populations is applied to study human health and diseases which include chromosomal disorders, structural and numerical chromosomal anomalies (Klinefelter syndrome, Down's syndrome, Turner syndrome, Achondroplasia), inborn errors of metabolism (Phenylketonuria (PKU), Alkaptonuria, Albinism, Galactosemia), haemoglobinopathies, Thalassemia syndromes, multifactorial disorders (diabetes, schizophrenia, huntington disease). Medical genetics involves ethical issues therefore serious discussion is required for prenatal/adult diagnosis	

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				of genetic disorders, medical ethics, risks and benefits, informed consent and right of choice. **Suggested Books:** ➢ Strachan T. & Read. A. (2011). *Human Molecular Genetics* (4th ed.). Garland Science ➢ Pasternak J. Fitzgerald. (1999). *An introduction to Human Molecular Genetics-Mechanism of Inherited Diseases*. Science Press. ➢ Thompson and Thompson.(2007).*Genetics in Medicine (7th Ed.)*.Saunders **Suggested e- Resources** ➢ **Chromosome identification and nomenclature (ISCN)** http://www.cydas.org/Resources/ISCN_Discussion.html ➢ **Pedigree data analysis** https://learn.genetics.utah.edu/content/disorders/ ➢ **Genetic disorders** https://www.genome.gov/10001204/specific-genetic-disorders/ ➢ **Prenatal/ adult diagnosis of genetic disorders, medical ethics** https://www.michiganallianceforfamilies.org/all/#sectionD	
3)	**Intellectual Property Rights**	After completing this course, students will be able to: • Understand the concept of IPR and its types • Describe the steps for		Intellectual property rights (IPR) have an old history and are very relevant for economic development. Various types of IPR (patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications) are recognized with specific uses.	

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<tr><td></td><td></td><td>patenting
• Discuss the role of WTO and WIPO on IPR</td><td></td><td>There is currently an emergence of specific IP pertaining to plants and animals (UPOV, Plant Breeder's rights and plant variety protection and farmers rights act, patent protection of plant and animal inventions (WTO) and Law on the protection of New plant varieties and animal breeds (WIPO)). It is important to know about types of patent applications and the process of patenting with special emphasis to India. The role of WTO (GATT and TRIPS) and WIPO in implementation of IPR is significant as is understanding the relevance of Patent Cooperation Treaty (PCT) in patenting. IPR also are associated with certain ethical dilemma and there are some interesting case studies which highlight its relevance.
Suggested Books:
➢ Sateesh, M.K. (2008). Bioethics and Biosafety. I.K. International Publishing House.
➢ Goel D. & Parashar S. (2013). IPR, Biosafety and Bioethics (1st ed.) Pearson Education India.
➢ Pandey, N. & Dharni, K. (2014). Intellectual Property Rights. PHI Learning
➢ Ramakrishna, B. &Kumar, A. (2017). Fundamentals of Intellectual Property Rights: For Students, Industrialist and Patent Lawyers (1st ed.). Notion Press
Suggested e-resources:
➢ World Trade Organisation. http://www.wto.org
➢ World Intellectual Property Organisation. http://www.wipo.int
➢ International Union for the Protection of New Varieties of Plants.</td><td></td></tr>
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<tr><td></td><td></td><td></td><td></td><td>http://www.upov.int
➢ National Portal of India.
http://www.archive.india.gov.in</td><td></td></tr>
<tr><td>4)</td><td>BT: Medical Microbiology</td><td>After successful completion of the course, students should be able to:
• Identify various bacterial, fungal, viral and protozoan diseases and their epidemiology
• Understand the relevance of emerging and reemerging diseases</td><td>Medical Microbiology and Immunology
Section-A
• Innate and Acquired Immunity
• Antigens : types of Antigens, Antigen specificity, haptens, Antibody structure and functions
• MHC, Complement System
• Cell mediated cytotoxicity : Origin, maturation and characterization of T-lymphocytes, Monocytes & Macrophages, Mechanism of T cell and NK cell mediated lysis, ADCC, Macrophage mediated cytotoxicity, lymphokines - the product of T cell activation.
• Humoral immune response : Origin, maturation and characterization of B-lymphocytes, Activation and proliferation of B-cells, Formation of plasmablast, Plasma cells and memory cells, Interaction of B and T cells.
Section-B
• Hypersensitivity, Monoclonal antibodies and its applications.
• Radioimmunoassay, Enzyme linked immunosorbant assay, immunoblotting, immunofluorescence and flowcytometry
• Characteristics of infectious diseases, Herd immunity.
• Disease cycle (Source of disease, reservoir, carriers)
• Transmission of pathogens (Air borne, contact</td><td>Medical Microbiology (Reading Elective)

Medical Microbiology describes the cause, transmission, epidemiology, pathogenesis, symptoms, diagnosis and treatment of various bacterial (tuberculosis, typhoid, leprosy), fungal (superficial, subcutaneous, systemic mycosis), protozoan (Malaria, amoebiasis) and viral (AIDS, Influenza, measles) diseases. Currently, it is necessary to understand the impact of emerging and remerging diseases (cholera, dengue, multidrug resistant tuberculosis, H5N1 avian influenza, drug resistant malaria, chikungunya) on human health. Global assessment for various diseases also shows an increasing trend of nosocomial infections and opportunistic infections which cause significant mortality and health concerns.

Suggested Books:
➢ Brooks, G.F., Carroll, K.C., Butel, J.S., Morse, S.A. & Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's Medical Microbiology (26thed.). US: Lange Medical Books, McGraw-Hill.
➢ Madigan, M., Martinko, J., Stahl, D. & Clark, D. (2010). <i>Brock Biology of Microorganisms</i> (13thed.). UK: Pearson Education.
➢ Pelczar Jr., M.J., Chan, E.C.S. & Krieg, N.R. (2011). Microbiology. New York, USA:Tata</td><td>This course was earlier run as a core course in AMBT IIIrd sem.</td></tr>
</table>

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
			transmission and vector transmission). **Section-C** • Bacterial Diseases : Epidemiology, Pathogenicity, Laboratory diagnosis, Prevention & control of the following diseases : Anthrax, Tuberculosis, Typhoid, Whooping cough, Tetanus, Diphtheria, Leprosy. • General Account of fungal diseases : Mycosis, Subcutaneous and deep. • General Account of viral & protozoan diseases : Pneumonia, Influenza, Mumps, Measles, Polio, Hepatitis B, Chickenpox, AIDS and Malaria, Leishmaniasis. • Brief account of sexually transmitted diseases. **Books Recommended :** ➢ Text Book of Microbiology : R. Ananthanarayanan and C.K. JayaramPanicker, Orient Longman, 1997. ➢ Medical Microbiology, Vol, 1 : Microbial infection : Mackie and MaCartney, Churchil Livingstone, 1996. ➢ Bailey and Scott's Diagnostic Microbiology : Baron EJ, Peterson LR and Finegold, SM Mosby, 1990. ➢ Essential immunology (1995) :Roitt, I.M. Black well Scientific Publications, Oxford. ➢ Fundamental immunology : W.E. Paul 1984, Raven Press, New York. ➢ Fundamentals of Immunology : R.M. Coleman, M.F. Lombord and R.E. Sicard (1992) - 2nd ed. C. Brown publishers. ➢ Immunology : D.M. Weir and J Steward 7th Ed. (1993).	McGraw-Hill. **Suggested e- resources:** ➢ **Emerging Diseases** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3701702/ ➢ **Epidemiology** https://bit.ly/2SUmzum ➢ **Nosocomial Infections** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3470069/	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
			➢ Broude A.I. (1981) : Medical "Microbiology" : and Infectious Diseases W.B. Saunders & Co. Philadelphia. ➢ Immunology : Janis Kuby. ➢ An Introduction to Immunology :lan R. Tizzard.		
5)	**BT: Molecular Plant Breeding**	After completing this course, students will be able to: • Understand strategies and applications of plant breeding technologies. • Comprehend the knowledge of different plat molecular markers • Plan a research career in the area of plant biotechnology		Plant breeding study involves breeding methods for self and cross pollinated crops. There are several limitations of conventional breeding. Thus, there is need to have a better breeding approaches to overcome this limitation. Development of molecular markers (RFLP, RAPD, SSRs, ISSRs, SNPs), construction of molecular maps and linkage analysis, mapping populations for QTLs using molecular markers play an important role in plant breeding. In order to develop potential plant having better qualities, Marker Assisted Selection (MAS) is also a viable approach which can be done by using selection of traits and markers, trait association, marker assisted backcrossing and recurrent selection, marker assisted hybrid breeding and marker assisted improved varieties/germplasm. **Suggested Books:** ➢ Chawla, H. S. (2000). *Introduction to Plant Biotechnology*. USA: Science Publishers. ➢ Slater, A., Scott, N. & Fowler, M. (2008). *Plant Biotechnology: The Genetic Manipulation of Plants* (2nd ed.). UK: Oxford University Press. ➢ Primrose, S.B., Twyman R.H. & Old R.W. (2001). *Principles of Gene Manipulation* (6th ed.). Wiley-Blackwell. ➢ Nicholl, D.S.T. (2008). *An introduction to*	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				Genetic Engineering (3rd ed). Cambridge: Cambridge University Press. ➢ Glick, B.R., Pasternak, J.J. & Patten C.L. (2010). *Molecular Biotechnology: Principles and Applications of Recombinant DNA* (4th ed.). American Society for Microbiology. ➢ Watson, J.D., Gilman, M., Witkowski J. & Zoller, M. (1992). *Recombinant DNA* (2nd ed.). W. H. Freeman publisher. **Suggested e- Resources:** ➢ **Plant breeding** https://nptel.ac.in/courses/102103013/pdf/mod6.pdf ➢ **Molecular marker** https://bit.ly/2XmNm0M ➢ **Gene mapping in plant** https://bit.ly/2TaegKm	
6)	**BT: Protein Engineering**	On completion of this course, students should be able to: • Analyse structure and construction of proteins by computer-based methods • Describe structure and classification of proteins • Analyse and compare the amino acid sequence and structure of proteins, and relate this information to the function of proteins • Explain how proteins can be used for different industrial and academic		An introduction to protein engineering for developing proteins with desired functions. Various methods (rational design and directed evolution) of protein engineering are employed to manipulate the different features or characteristics (affinity, specificity and stability etc) of proteins. Engineering various physicochemical and biological properties (stability to changes in parameters as pH, temperature, amino acid sequence and aggregation propensities etc) of the proteins could be important in their use as protein drugs and/or catalysts in bioreactors. The insight into the fundamental understanding of the mechanisms and forces (Van der waals, electrostatic, hydrogen bonding, weakly polar interactions, and hydrophobic effects), by which	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
		purposes such as structure determination, organic synthesis and drug design. • Plan and carry out activity measurements of isolated proteins and characterize their purity and stability.		protein stabilizes, will help in the formulation of protein based pharmaceuticals. Protein engineering with site-specifically incorporation of unnatural or non-canonical amino acids has been used to improve protein function for medical and industrial applications. Different computational approaches (sequence and 3D structure analysis, data mining, Ramachandran map etc) to protein engineering would help to address the requirements in order to find amino acid sequences that will optimize a desired property (physicochemical property and/or biological function) of a protein. Determination of the physicochemical properties of proteins using various spectroscopic methods (Far-UV and Near-UV CD, Fluorescence, UV absorbance and Optical rotatory dispersion) would further support the drug development process. Yeast surface display (YSD)has become a valuable protein engineering tool for modifying the affinity, specificity, and stability of antibodies, as well as other proteins. YSD could be successfully used for protein epitope mapping, identification of protein-protein interactions, and uses of displayed proteins in industry and medicine. Developing vaccines and peptidomimetics will further allow the investigators to identify novel therapeutic leads for numerous unmet clinical needs. **Suggested Books:** ➢ Walsh, G. (2014). *Proteins: biochemistry and biotechnology*, Second edition. Chichester, West Sussex: Wiley Blackwell. ➢ Creighton, T. E. (1997). *Protein Structure: a Practical Approach*, 2nd Edition. Oxford	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				University press. ➢ Cleland, J. L. & Craik, C. S. (2006). *Protein Engineering, Principles and Practice*, Vol 7. Springer Netherlands. ➢ Mueller, K., and Arndt, K. (2006). *Protein Engineering Protocols*, 1st Edition. Humana Press. ➢ Robertson, D., and Noel, J. P. (2004). *Protein Engineering Methods in Enzymology*, Vol 388. Elsevier Academic Press. ➢ Kyte, J. (2006). *Structure in Protein Chemistry*, 2nd Edition. Garland publishers. ➢ Williamson, M. P. (2012). *How proteins Work*. New York: Garland Science. **Suggested e- Resources:** ➢ **Protein Engineering**: https://nptel.ac.in/courses/102103017/pdf/lecture%2022.pdf ➢ **Conformational stability of proteins**: https://bit.ly/2y85mid ➢ **Protein Engineering with Non-Natural Amino Acids:** https://library.umac.mo/ebooks/b2805488x.pdf	

List of online courses in M.Sc. Bioscience Animal Science Programme

S. No.	Portal	Name of course	Duration	Core/Elective/ Reading elective (Additional/ Alternate)	Credit point(s)	URL	Paid/ Free	Fee (course/ examination)	Remarks
III Semester Online Elective Course									
1	**Harvard**	Fundamentals of Ecology for Sustainable Ecosystem		Elective course	4	https://www.extension.harvard.edu/academics/courses/fundamentals-ecology/12779	Paid	$1550	
IV Semester Online Reading electives									
1	**NPTEL**	Bio- organic Chemistry	56 h	Reading Elective	4	http://nptel.ac.in/courses/104103018/#	Paid	Certification exam fee	
2	**IIT, Delhi**	Enzyme Science and Engineering	28 videos	Reading Elective	2	http://freevideolectures.com/Course/85/Enzyme-Science-and-Engineering/1	Free	-	
3	**NPTEL**	Biocatalysis in organic synthesis	46 h	Reading Elective	3	http://nptel.ac.in/courses/104105032/	Paid	Rs. 1000 for certification exam fee	

S. No.	Portal	Name of course	Duration	Core/Elective/ Reading elective (Additional/ Alternate)	Credit point(s)	URL	Paid/ Free	Fee (course/ examination)	Remarks
4	**National Institute of Disaster Management** (Ministry of Home Affairs, New Delhi)	Comprehensive Disaster Risk Management Framework	6 weeks Run in batches throughout the year	Reading Elective	2	www.nidm.gov.in/online.asp	Paid	Rs. 1500 Exam fee	
5	**WIPO Academy** - [DL] Distance Learning Program	DL101E - DL-101 General Course on Intellectual Property	55 h	Reading Elective	4	https://welc.wipo.int/acc/index.jsf?page=courseCatalog.xhtml	Free	-	
6	**Algonquin college**	Environmental Management - An Introduction		Reading Elective	-	http://www.algonquincollege.com/ccol/courses/environmental-management-an-i		-	

BANASTHALI VIDYAPITH
Department of Bioscience and Biotechnology
M.Sc. BIOSCIENCE-PLANT SCIENCE
PROGRAMME EDUCATIONAL OBJECTIVES

The M.Sc. Bioscience-Plant Science programme aims at holistic development of the students through the innovative and unique Five fold Educational ideology of Banasthali Vidyapith.
As a component of the ecosystem, botanists are instrumental regarding their all inclusive and widespread understanding of plants and their importance. Botanists require an understanding of the identification of various plant groups, their taxonomy, physiology, biochemistry, genetics, ecology and economic importance along with the modern approach of plant biotechnology, secondary metabolite production and their medicinal value. The program has identified necessary competencies in the respective areas for which all essential theoretical, practical and field based skills will be provided. On completion of the Programme, the student will be able to:

- become competent botanists at different levels
- elevate understanding regarding professional ethical codes of conduct, societal values and respect for all
- demonstrate standards of digital literacy that would support professional needs in botanical studies
- create awareness in society about the efficient, safe and sustainable use of plants and plant parts
- create awareness about environmental and anthropological threats on plant species, especially pollution and habitat loss
- develop a lifelong respect and perfect coordination towards all other species on this planet
- nurture a temperament that would enable our students to set and work towards self-driven performance-goals, entrepreneurial ventures and overall leadership.

BANASTHALI VIDYAPITH

Department of Bioscience and Biotechnology

M.Sc. BIOSCIENCE-PLANT SCIENCE PROGRAMME OUTCOMES

PO1: Botanical Knowledge: Possess acquaintance and command of the core and basic knowledge associated with the botany, including systematics, morphology, anatomy, physiology, genetics, biochemistry, plant pathology, economic botany, ecology, embryology; and lower plants.

PO2: Planning abilitiy: Demonstrate effective planning abilities, including time and resource management, delegation skills and organizational skills. Develop and execute plans and organize work to meet deadlines.

PO3: Problem analysis: Utilize the principles of scientific enquiry, thinking analytically, clearly and critically, while solving problems and making decisions during routine work. Find, analyse, appraise and apply information logically and will make justifiable decisions.

PO4: Modern tool usage: Learn, select, and apply appropriate methods and procedures, resources, and modern botanical science-related computing tools with an understanding of their limitations.

PO5: Leadership skills: Recognize and believe the as a most gifted species on earth we have to change and motivate others for the betterment of all life on this green planet. For this students will raise related issues, and appear as leaders of the team building when planning changes required for fulfilment of practice, professional and societal responsibilities.

PO6: Professional Identity: Understand, analyse and communicate the value of their professional roles in society (e.g. botanists, ecologists, researchers, educators, managers, employers, employees).

PO7: Botanical Ethics: Honour personal values and apply ethical principles in professional and social contexts. Demonstrate behaviour that recognizes cultural and personal variability in values, communication and lifestyles. Use ethical frameworks; apply ethical principles while making decisions and take responsibility for the outcomes associated with the decisions.

PO8: Communication: Communicate efficiently with the botanical community and with society at large, such as, being able to realize and write effectively, make effective presentations and documentation, and give and receive clear instructions.

PO9: The Botanist and society: Apply reasoning informed by the contextual acquaintance to assess societal, environmental, health, safety and legal issues and the consequent responsibilities relevant to the professional botanical practice.

PO10: Environment and sustainability: Understand the impact of the professional botanical solutions to societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development in eco-friendly manner.

PO11: Life- long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. Self access and use feedback effectively from others to identify learning needs and to satisfy theses needs on an ongoing basis.

Appendix-VC

Department of Bioscience and Biotechnology, Banasthali Vidyapith
M.Sc. Bioscience (Plant Science) Programme

Existing Courses					
M.Sc. Bioscience (Plant Science) Sem. I		**L**	**T**	**P**	**C**
BIO 407	Cell & Molecular Biology	4	0	0	4
BIO 403	Biochemistry & Biophysics	4	0	0	4
BIO 416	Microbiology	4	0	0	4
BIN 401	Bioinformatics	4	0	0	4
BIO 401	Analytical Techniques-I	4	0	0	4
BIO 404L	Bioscience Lab-I	0	0	12	6
	Total	**20**	**0**	**12**	**26**

Proposed Courses					
M.Sc. Bioscience (Plant Science) Sem. I		**L**	**T**	**P**	**C**
BIO	Cell and Molecular Biology	4	0	0	4
BIO	Biochemistry	4	0	0	4
BIO	Microbiology	4	0	0	4
BIN	Bioinformatics	4	0	0	4
BIO	Analytical Techniques-I	4	0	0	4
BIO	Bioscience Lab-I	0	0	12	6
	Total	**20**	**0**	**12**	**26**

Existing Courses					
M.Sc. Bioscience (Plant Science) Sem. II		**L**	**T**	**P**	**C**
BIO 406	Biostatistics and Research Methodology	4	0	0	4
BIO 410	Genetics	4	0	0	4
BIO 411	Immunology	4	0	0	4
BT 406	Enzymology and Enzyme Technology	4	0	0	4
BT 408	Genetic Engineering	4	0	0	4
BIO 405L	Bioscience Lab-II	0	0	12	6
	Total	**20**	**0**	**12**	**26**

Proposed Courses					
M.Sc. Bioscience (Plant Science) Sem. II		**L**	**T**	**P**	**C**
BIO 406	Biostatistics and Research Methodology	4	0	0	4
BIO	Genetics	4	0	0	4
BIO 411	Immunology	4	0	0	4
BIO	Environmental Biology and Biotechnology	4	0	0	4
BT	Genetic Engineering	4	0	0	4
BIO	Bioscience Lab-II	0	0	12	6
	Total	**20**	**0**	**12**	**26**

	Course proposed to be discontinued
	Course content modified
	Course shifted to/ from different semester
	New course proposed
	Course shifted to/from different programme

Existing Courses					
M.Sc. Bioscience (Plant Science) Sem. III		**L**	**T**	**P**	**C**
BIO 408	Environmental Biology & Toxicology (Common with M.Sc. Animal Science BIO 408)	4	0	0	4
BOT 511	Plant Tissue Culture & Experimental Embryology	4	0	0	4
BOT 507	Plant Pathology	4	0	0	4
BOT 502	Angiosperm Taxonomy	4	0	0	4
BOT 505D	Literature Dissertation	0	0	8	4
BOT 509L	Plant Science Lab-I	0	0	12	6
	Total	**16**	**0**	**20**	**26**

Proposed Courses					
M.Sc. Bioscience (Plant Science) Sem. III		**L**	**T**	**P**	**C**
BIO	Phycology, Mycology and Lichenology	4	0	0	4
BOT	Bryophyta, Pteridophyta and Gymnosperms	4	0	0	4
BT 507	Cell and Tissue Culture Technology	4	0	0	4
BOT 505D	Literature Dissertation	0	0	8	4
BOT 509L	Plant Science Lab-I	0	0	12	6
	Discipline Elective	4	0	0	4
	Total	**16**	**0**	**20**	**26**

Existing Courses					
M.Sc. Bioscience (Plant Science) Sem. IV		**L**	**T**	**P**	**C**
BOT 501	Advance Horticulture and Ethnobotany	4	0	0	4
BOT 503	Currents Trends in Plant Biotechnology	4	0	0	4
BOT 504	Cytogenetics and Plant Breeding	4	0	0	4
BOT 506	Plant Ecology and Biodiversity Conservation	4	0	0	4
BOT 508	Plant Physiology	4	0	0	4
BOT 510L	Plant Science Lab-II	0	0	12	6
	Total	**20**	**0**	**12**	**26**

Proposed Courses					
M.Sc. Bioscience (Plant Science) Sem. IV		**L**	**T**	**P**	**C**
BOT 501	Angiosperms	4	0	0	4
BOT 504	Cytogenetics and Plant Breeding	4	0	0	4
BOT 508	Plant Physiology **Alternate online core course** Plant Physiology and Taxonomy https://www.acs.edu.au/courses/botany-i-plant-physiology-and-taxonomy-199.aspx	4	0	0	4
BOT 507	Plant Pathology	4	0	0	4
BOT 510L	Plant Science Lab-II	0	0	12	6
	Open Elective	4	0	0	4
BIO	Reading Elective-I&II	0	0	0	2
	Total	**20**	**0**	**12**	**28**

	Proposed List of Elective courses to be offered in III & IV Semester
BOT	Phycology-I
BOT	Bryology-I
BOT	Angiosperms Taxonomy and Systematics-I
BT	Plant Biotechnology
	Biophysics-I
ENVS 402	Ecology and Environment
	Fundamentals of Ecology for Sustainable Ecosystem https://www.extension.harvard.edu/academics/courses/fundamentals-ecology/12779
BOT	Phycology-II
BOT	Bryology-II
BOT	Angiosperms Taxonomy and Systematics-II
BT	Advanced Plant Biotechnology
	Biophysics-II
ENVS 502	Biodiversity and Conservation

	Proposed List of Reading Elective-I & II to be offered in IV Semester
BT	Drug Discovery
BT	Human Genetics and Diseases
	Intellectual Property Rights
BT	Medical Microbiology
BT	Molecular Plant Breeding
BT	Protein Engineering
BIO	Bio- organic Chemistry: http://nptel.ac.in/courses/104103018/#
BT	Enzyme Science and Engineering
	http://freevideolectures.com/Course/85/Enzyme-Science-and-Engineering/1
BT	Biocatalysis in organic synthesis: http://nptel.ac.in/courses/104105032/
BT	Comprehensive Disaster Risk Management Framework
	www.nidm.gov.in/online.asp
BT	General Course on Intellectual Property: https://welc.wipo.int/acc/index.jsf?page=courseCatalog.xhtml
BT	Environmental Management - An Introduction: www.algonquincollege.com/ ccol/courses/environmental-management-an-introduction/

Comparative Table: M.Sc. Bioscience (Plant Science): Existing and Modified syllabus, Suggested Books and Suggested E-Resources

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
M.Sc. Bioscience (Plant Science) I Semester					
1.	**BIN 401:** Bioinformatics	After successful completion of the course, students should be able to: • Describe and identify various databases and tools used for phylogenetic analysis. • Apply protein structure prediction • Demonstrate and apply different tools for data-mining .	**Section-A** • ~~Introduction of computers: Basic components and their functions, hardware and software, Input-Output devices.~~ • ~~Basic concepts about data and information, Representation of data in computers in binary, bits and bytes~~. ~~Computer words coding (ASCII and EBCDIC), Number System Conversion.~~ • ~~Conceptual understanding of assemblers, Compilers, Operating System.~~ • ~~Introduction to Programming languages, C++, Perl~~. **Section-B** • ~~Information Retrieval: LAN, WAN, Introduction to Internet, WWW, NICNET, ERNET, On-line publishing ventures eg. Biomed Central,~~ BTIS Network in India. • ~~Introduction to Microarray Technology and its applications.~~ • Biological Databases: Primary Sequence databases (Protein and DNA databases), Secondary databases, Composite databases. Online international database access. **Section-C** • Sequence Alignment and Databases searching: ~~Evolutionary basis of sequence alignment~~, Optimal alignment methods; Dot Plot, ~~Dynamic Programming~~. • ~~Databases similarity searching: Algorithms of FASTA~~ BLAST.	**Section A** • Introduction and scope of bioinformatics, Introduction to biological databases: primary, composite, secondary databases and structural database. Description of specific databases: UniGene,UniProt, and RCSB – PDB). Introduction to genomics, proteomics and phylogenetics resources available at ExPassy. • Introduction to sequence analysis: Dot Plot, scoring matrices (PAM matrix) and gap penalty. **Section B** • Description and application of global and local sequence alignment. Sequence based database searching working algorithms of BLAST, variations of BLAST. Multiple Sequence alignment. Evolutionary significance of sequence alignment. • Evolutionary models: Jukes – Cantor and Kimura two parameter. • Phylogenetic Analysis: distance based (UPGMA, N-J Methods) and character based (Maximum Parsimony). **Section C** • Protein 2D structure prediction: Chou – Fasman algorithm • Protein 3D structure prediction: homology modeling, its advantage and limits. • Concept of structure optimization and energy minimization. • Forces stabilizing biomolecular interaction.	The components were very basic and mostly covered in undergraduate programs in almost every stream of science as compulsory computer knowledge. Learning languages such as C++ and Perl are extremely tedious; syntax of these two languages is very different to each other and not of use without hands-on sessions. More computer science information instead of bioinformatics. Further, the proposed syllabus is comprehensive for introductory course of bioinformatics. ClustalW is obsolete, progressive methods will include all the concept and methodology of programs like ClustalW. Protein structure prediction is the new introduction in the content to satisfy the need and requirement of a complete bioinformatics course.

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• ~~Statistical significance of alignment, Substitution Scores and Gap penalties.~~ • Multiple Sequence alignment: ~~CLUSTAL W~~. [redacted]. ~~EMBOSS~~. **Books Recommended :** ➢ A textbook of Bioinformatics : Sharma, Munjal&Shanker, Rastogi Publication, Meerut ➢ Fundamental of computer : P.K. Sinha ➢ Introduction to Bioinformatics : Parrysmith and Attwood ➢ Introduction to Bioinformatics : Baxevenis and Oulette ➢ Internet for Molecular Biologist : Swindell ➢ Molecular databases for protein sequences and structure studies - An Introduction Silence : J., Sillince M., Springerberlagd, Berlin 1972 ➢ Leaping from Basic to C++ : Robert J. Traister, A.P. Professional Cambridge ➢ Perl 5 Unleashed : Kamran Husain & Robert F Breedlore SAMS Publishing. ➢ Bioinformatics: David, Mount.	• Principle of Molecular Docking. Types of molecular docking, its advantage and limits. **Suggested Books:** ➢ Rastogi, S.C. & Rastogi, P. (2013). *Bioinformatics Methods and Applications* (4th ed.). New Delhi: PHI Learning Private Limited. ➢ Lesk, A.M. (2008). *Introduction to Bioinformatics.* UK: Oxford University Press. ➢ Krane, D.E. & Reymer, M.L. (2003). *Fundamental Concepts of Bioinformatics*. UK: Pearson Education. ➢ Attwood, T.K., Parry-Smith, D.J. & Phukam, S.(2009). *Introduction to Bioinformatics* (4th ed.). UK: Pearson Education. ➢ Sharma, V., Munjal, A. & Shanker, A.(2017). *A Text Book of Bioinformatics* (2nd ed.). Meerut: Rastogi Publications. **Suggested e- Resources:** ➢ **Chou-Fasman Method for protein secondary structure prediction** https://pdfs.semanticscholar.org/fd8c/c95aec2d7af19ed28eea3688b3c231d0e745.pdf ➢ **Homology modeling** https://proteinstructures.com/Modeling/homology-modeling.html ➢ **ExPASy** https://www.expasy.org/	
2.	**BIO 401:** Analytical Techniques-I	After successful completion of the course, students should be able to: • Comprehend the principles of various instrumentation techniques:	**Section-A** • Chromatographic methods for macromolecule separation- TLC and Paper chromatography, gel permeation; ion exchange; hydrophobic, Reverse-phase and Affinity chromatography; HPLC, FPLC and GLC. • Electrophoretic techniques :	**Section-A** • Chromatographic methods for macromolecule separation: TLC and Paper chromatography, Gel permeation, Ion exchange, Hydrophobic, Reverse-phase & Affinity chromatography; HPLC, FPLC & GLC.	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		• Identify suitable and relevant tools for use in research problems • Utilize the scope of the content for designing and performing future experiments	• Theory and application of polyacrylamide and agarose gel electrophoresis, capillary electrophoresis; 2D electrophoresis; Disc gel electrophoresis; Gradient electrophoresis; Pulse field gel electrophoresis, Isoelectric focusing. **Section-B** • Microscopy- Microscope and its modifications- Light, Phase contrast and interference, Fluorescence, Confocal, Electron (TEM & SEM), Electron tunneling and Atomic Force Microscopy • Centrifugation -Basic principle & theory, Types of centrifuges- Micro centrifuge, High speed & Ultracentrifuges; Preparative centrifugation, differential & density gradient centrifugation. Analytical centrifugation & its applications. **Section-C** • Spectroscopy-Principle, instrumentation applications in biological sciences: UV-visible spectrophotometry Florometry& Atomic absorption Spectrophotometer (AAS). Principle and application of NMR, X-ray crystallography, ~~API electrospray~~, mass spectroscopy and MALDI-TOF, Circular Dichroism • Radioactivity : • Radioactive and stable isotopes; Pattern and rate of radioactive decay; Measurement of radioactivity; Geiger-Muller counter; solid and liquid scintillation counters (Basic principal, instrumentation and technique); brief idea of radiation dosimetry; Cerenkov radiation; autoradiography.	• Electrophoretic techniques: Theory and applications of polyacrylamide and agarose gel electrophoresis, capillary electrophoresis, 2D electrophoresis, Disc gel electrophoresis, Gradient electrophoresis, Pulse field gel electrophoresis & Isoelectric focusing. **Section-B** • Microscopy: Microscope and its modifications- Light, Phase contrast and interference, Fluorescence, Confocal, Electron (TEM & SEM), Electron tunneling & Atomic Force Microscopy • Centrifugation: Basic principle & theory, types of centrifuges- Micro centrifuge, High speed & Ultracentrifuges. Preparative centrifugation: differential & density gradient centrifugation. Analytical centrifugation & its applications. **Section-C** • Spectroscopy: Principle, instrumentation applications in biological sciences. UV-visible spectrophotometry, Florometry & Atomic absorption spectrophotometer (AAS). Principle & applications of NMR, X-ray crystallography, Mass spectroscopy and MALDI-TOF, Circular Dichroism. • Radioactivity: Radioactive and stable isotopes, Pattern and rate of radioactive decay, Measurement of radioactivity, Geiger-Muller counter, solid and liquid scintillation counters (Basic principle, instrumentation and technique), brief idea of radiation dosimetry, Cerenkov radiation & autoradiography.	Typographical errors have been rectified.

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Books Recommended : ➢ Practical Biochemistry: Keith Wilson and John Walker, Cambridge University Press. ➢ Physical Biochemistry : David Friefelder. ➢ Instrumental methods of chemical analysis :Chatwal and Anand, Himalaya Publishing House. ➢ Instrumental methods of chemical analysis : B.K. Sharma, Goel Publishing House. ➢ X-Ray Methods : C. Whiston. ➢ The Electron Microscope in Biology : A. V. Grimstone. ➢ Tertiary level biology - Methods in Experimental biology : R. Ralph Blackie. ➢ Animal Tissue Technique : G.L. Humason. ➢ NMR and Chemistry : J.W. Akitt, Chapman and Hall.	**Suggested Books:** ➢ Wilson, K. & Walker, J. (2010). *Principles and Techniques of Biochemistry and Molecular Biology*. Cambridge, UK: Cambridge University Press. ➢ Friefelder, D. (1982). *Physical Biochemistry: Applications to Biochemistry and Molecular Biology*. New York, USA: W.H. Freeman and Company. ➢ Chatwal, G.R. & Anand, S.K. (2018). *Instrumental Methods of Chemical Analysis*. New Delhi, India: Himalaya Publishing House. ➢ Sharma,B.K. (2004). *Instrumental methods of Chemical Analysis, In: Introduction to Analytical Chemistry*. New Delhi, India: Goel Publishing House. ➢ Talluri, S. (2012). *Bioanalytical techniques*. New Delhi, India: I.K. International Publishing House Pvt. Ltd. ➢ Chatanta, D.K. & Mehra, P.S. (2012). *Instrumental Methods of Analysis in Biotechnology*. New Delhi, India: I.K. International Publishing House Pvt. Ltd. **Suggested e- Resources:** ➢ **Chromatographic Techniques** https://nptel.ac.in/courses/103108100/module7/module7.pdf ➢ **Spectroscopic techniques** https://nptel.ac.in/courses/102103044/pdf/mod2.pdf ➢ **Microscopic techniques** www.nptel.ac.in/courses/102103015/pdf/mod3.pdf	
3.	**BIO 403:** Biochemistry	After successful completion of the course, students should	**Biochemistry & Biophysics** **Section-A**	**Biochemistry** **Section-A**	The title is changed as Biophysics component has

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
	&Biophysics	be able to: • Understand the structure and role of various biomolecules • Identify, assess and explain various biochemical pathways • Develop understanding of enzymes and their mechanism of action	• ~~Hydrogen bonding and structure of water molecule, Ionization of water, pH and colligative properties of water~~. • Bioenergetics: First & second law of thermodynamics, concept of free energy, change in standard free energy, ~~ATP and its hydrolysis.~~ • Carbohydrates: general classification, Polysaccharides: ~~&proteoglycans~~: Starch, glycogen, cellulose, chitin ~~&bacterial cell wall~~. ~~Glycosaminoglycans& proteoglycans in extracellular matrix.~~ **Section-B** • Electron transport system in mitochondria & chloroplasts. Oxidative phosphorylation, P/O ratio, Uncouplers. • Lipids - Glycerophospholipids, sphingolipids, gangliosides, Eicosanoids & prostaglandins. ~~Cholesterol & its biosynthesis~~. • Proteins & amino acids - Zwitterionic properties of amino acids & titration curves. Peptide bonds, disulphide cross links, various levels of structural organization of proteins. • Ramachandran plot, Alpha-helix, Beta sheet, ~~Helix-coil transitions.~~ **Section-C** • Structure function relationship in model proteins like ribonuclease A, haemoglobin, chymotrypsin. • Biosynthesis of purines and pyrimidines, *de novo* and salvage pathway, ~~various confirmations of nucleotides,~~ glycosidic bond rotation, base-stacking. • ~~Mechano-Chemical Process: Molecular structure of muscle-Actin, myosin, troponin, tropomyosin, Muscle Contraction.~~	• Bioenergetics: First and Second law of thermodynamics, concept of free energy, change in standard free energy. • Carbohydrates: general classification, Polysaccharides: Starch, glycogen, cellulose & chitin. • Glycolysis, Citric acid cycle. Electron transport system in mitochondria & chloroplasts. Oxidative phosphorylation, Photosynthetic phosphorylation, P/O ratio, Uncouplers. **Section-B** • Lipids - glycerophospholipids, sphingolipids, gangliosides, eicosanoids & prostaglandins. • Proteins & amino acids – Zwitterionic properties of amino acids & titration curves. Peptide bonds, disulphide crosslinks, various levels of structural organization of proteins. • Ramachandran plot, Alpha-helix, Beta sheet, • Structure function relationship in model proteins like ribonuclease A, haemoglobin and chymotrypsin. • Biosynthesis of purines and pyrimidines, *de novo* and salvage pathway, **Section-C** • Introduction to enzymes: Classification of enzymes Nomenclature of enzymes, E.C. Number • Enzyme kinetics (Michaelis – Menten kinetics), importance and determination of Vmax and Km values, L & B plots. • Enzyme inhibition: competitive, non-competitive and un-competitive. • Coenzymes and Isozymes.	been removed as it does not fit in two year M.Sc. Biotechnology programme. Section B: Relevant topics, which were earlier not part of the syllabus, have been added. These topics are essential part of the carbohydrate metabolism, a key component of the living organisms. Section C: Biophysics topics have been deleted. Reshuffling done in order to coherently organize various topics of the syllabus.

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• ~~Action Potential and propagation of neuronal computation through nerve fibre.~~ **Books Recommended :** ➢ Principles of Biochemistry : A.L. Lehninger, Nelson and Cox, McMillan Worth Publishers. ➢ Biochemistry :Voet and Voet, John Wiley and Sons, Inc. USA. ➢ Biophysical Chemistry Vol. I, II &III : Cantor and Schimmel, Freeman. ➢ Biochemistry :Zubey, WCB. ➢ Biochemistry : Garrett and Grisham, Harcourt. ➢ Biochemistry :Stryer, W. H. Freeman. ➢ Understanding Enzymes : T. Palmer, Horwood. ➢ Harper's review of Biochemistry : R.K. Murray et al., Prentice-Hall International Inc. ➢ Fundamentals of Biochemistry : Cohn and Stumf. ➢ Molecular Biophysics-Structure in Motion :Michel Daune, Oxford University Press.	**Suggested Books:** ➢ Nelson, D. L. & Cox, M.M. (2012). *Lehninger Principles of Biochemistry* (6^{th}ed.). New York, USA: W. H. Freeman and Company. ➢ Rodwell, V.W., Bender, D., Botham, K.M., Kenelly, P.J.& Weil., P.A. (2018). *Harper's Illustrated Biochemistry* (31^{st}ed.). New York, USA: McGraw-Hill Education. ➢ Voet, D. &Voet, J.G.(2010). *Biochemistry* (4^{th}ed.). New Jersey, USA: Wiley. ➢ Berg, J.M., Tymoczko, J.L., Gatto Jr., G.J. & Stryer, L. (2015). *Biochemistry* (8^{th}ed.). New York, USA: W. H. Freeman and Company. ➢ Garrett, R. H. & Grisham, C. M. (2012). *Biochemistry* (5^{th}ed.). Belmont, USA: Wadsworth Publishing Co Inc. ➢ Palmer, T.& Bonner, P. (2014). *Enzymes: Biochemistry, Biotechnology and Clinical Chemistry*. UK: Woodhead Publishing Limited. ➢ Cantor, C.R. & Schimmel, P.R. (1980). *Biophysical Chemistry Part I, II & III*. New York, USA: W. H. Freeman and Company. ➢ Ferdinand, W. (1976). *The Enzyme Molecule*. New Jersey, USA: John Wiley & Sons Ltd. **Suggested e- Resources:** ➢ **Metabolic pathways, Biomolecules** https://epgp.inflibnet.ac.in/ahl.php?csrno=2 ➢ **Mechanism of enzyme action** http://www.biologydiscussion.com/enzymes/enzymes-properties-and-mechanism-of-enzyme-action/6145 ➢ **E-book for Garrett and Grisham** https://bit.ly/2TbDWWR	
4.	**BIO 404L:**	After successful completion	1. Demonstration, principle and use of lab	**Analytical Techniques-I**	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
	Bioscience Lab-I	of the course, students should be able to: • Demonstrate use of various tools and techniques for detection and quantification of biomolecules. • Perform various biochemical assays for fats, carbohydrate, protein and enzymes • Demonstrate microbiological techniques • Access, retrieve, and analyze nucleotide and protein sequences using bioinformatics tools	equipments: Centrifuges (~~Table top~~ and high speed), ~~Balances (electrical and digital).~~ ~~2. Demonstration, principle and use of lab equipments: Spectrophotometer, pH meter.~~ 3. Estimation of proteins by Lowry's ~~and TCA methods.~~ 5. Estimation of carbohydrates (reducing and non-reducing sugar). 6. Estimation of fats (cholesterol). 7. ~~Preparation and purification of casein from buffalo milk.~~ 8. Separation of amino acids by TLC and paper chromatography. 9. ~~Determination of Logic properties (pH value of Lysine by titration).~~ 10. ~~To find λmax for proteins.~~ 11. ~~Use of selective and diagnostic media for cultivation, isolation, enumeration and purification of microorganisms.~~ ~~12.~~ Measurement of bacterial ~~and fungal~~ growth. 13. Isolation and enumeration of microbes from air/soil by serial dilution/agar plating method. 14. Antibiotic sensitivity test. 15. ~~Microbiological examination of food~~. 16. Citric acid production by A. niger. ~~17.~~ Study of cell division in plants and animals,~~Giant chromosomes.~~ 18. Separation of different organelles/molecules by sucrose density gradient/differential gradient. 19. Separation and identification of serum proteins/plant proteins by gel electrophoresis. 20. ~~Histochemical localization of biomolecules (protein, carbohydrate or any other).~~ ~~21. Bioinformatics exercise 1~~ 22. ~~Bioinformatics exercise 2.~~	1. Demonstration: Working principle & applications of - Centrifuges (high speed refrigerated centrifuge & ultracentrifuge), - Fluorescence microscope. - Atomic absorption spectrophotometer, HPLC, FPLC, GC-MS 2. Separation of amino acids by TLC and Paper Chromatography. **Cell and Molecular Biology** 3. Study of different stages of mitosis (onion root tip) and meiosis (onion buds/grasshopper testis) and determine the mitotic index. 4. Separation of chloroplast by sucrose density gradient centrifugation **Biochemistry** 5. To prepare sodium acetate buffer and validate the Henderson-Hasselbach equation. 6. Extraction of crude enzyme from germinating mung bean seeds. 7. Estimation of total protein content by Lowry's method 8. Separation of protein by SDS PAGE. 9. Estimation of acid phosphatase activity using standard curve of p-nitrophenol. 10. Purification of the crude enzyme extract (from Expt. 6) using ammonium sulphate precipitation and ion exchange/ affinity chromatography (demonstration). 11. Determination of kinetic properties (K_m and V_{max} values) of acid phosphatase. 12. Estimation of total carbohydrates using Anthrone method. 13. Estimation of reducing sugar by Nelson-Somogyi method.	The experiments have been reframed and modified keeping in consideration, the suggested syllabus..

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				14. Estimation of fats (cholesterol). **Microbiology** 15. Isolation and enumeration of microbes from soil and water. 16. Staining of selected bacterial and fungal strains. 17. Estimation of bacterial growth by turbidometric method. 18. Antibiotic sensitivity test. 19. Estimation of infectivity titre of a virus sample using Plaque assay **Bioinformatics** 20. Database Search: Use and analysis of BLAST tool for protein and DNA sequences. 21. Molecular Evolution: Multiple sequence alignment and phylogenetic analysis. (Clustal X/ Mega/ Tree-View) 22. Structure Prediction: Protein secondary and tertiary structure prediction using online tools. 23. Molecular Visualization: Structural analysis of PDB entries for active and inactive states of protein (Pymol). **Suggested Books:** ➢ Aneja, K. R. (2001). *Experiments in Microbiology*, *Plant Pathology*, *Tissue Culture and Mushroom Production Technology*. New Delhi, India: New Age International Ltd. ➢ Cappuccino, J. G. & Welsh, C. (2019). *Microbiology: A Laboratory Manual*. New York, USA: Pearson. ➢ Sadasivam, S., & Manickam, A. (1996). *Biochemical Methods* (2nd ed.). New Delhi: New Age International Publishers. ➢ Saxena, J., Baunthiyal., & Ravi, I. (2015). *Laboratory Manual of Microbiology,*	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Biochemistry and Molecular Biology. Jodhpur: Scientific Publishers. **Suggested e- Resources:** ➢ **Harisha, S. Biotechnology procedures and experiments handbook** http://site.iugaza.edu.ps/mwhindi/files/BIOTECHNOLOGY-PROCEDURES-AND-EXPERIMENTS-HANDBOOK.pdf ➢ **Introduction to biotechnology** http://www.austincc.edu/awheeler/Files/BIOL%201414%20Fall%202011/BIOL1414_Lab%20Manual_Fall%202011.pdf	
5.	**BIO 407:** Cell and Molecular Biology	After successful completion of the course, students should be able to: • Understand membrane transport and cell signalling mechanisms. • Develop comprehensive understanding of endo-membrane system • Understand molecular mechanisms of prokaryotes and eukaryotes	**Section-A** • Molecular structure and function: ~~Structural models,Composition and dynamics;~~ Transport of ions and macromolecules; Pumps, carriers and channels; Membrane carbohydrates and their significance in cellular recognition; cellular junctions and adhesions; ~~structure and functional significance of plasmodesmata~~. • Endocytosis and exocytosis, clathrin~~&coatomer~~ coated vesicles, SNARE proteins. • Cell to cell signaling :autocrine, paracrine and endocrine stimulation. • Signaling via G-protein linked cell-surface receptors, adenylatecyclase system, inositol phosphate pathway, role of Ca^{2+} -ions. • Signallingvia enzyme-linked surface receptors, tyrosine kinases. • Steroid receptors. **Section-B** • ~~Mitochondrial membrane organization~~,transport of proteins into mitochondria and chloroplasts. ~~Genome of mitochondria and cholorplasts.~~ • Concept of signal peptide, SRP, SRP Receptor,	**Section-A** • Molecular structure and function of plasma membrane; Transport of ions & macromolecules; Pumps, carriers and channels; Membrane carbohydrates & their significance in cellular recognition; Cellular junctions & adhesions. • Endocytosis & exocytosis, clathrin coated vesicles, SNARE proteins. • Cell to cell signalling: autocrine, paracrine and endocrine stimulation. • Signaling via G-protein linked cell surface receptors, adenylate cyclase system, inositol phosphate pathway, role of Ca^{2+} ions. • Signaling via enzyme-linked surface receptors, tyrosine kinases. • Steroid receptors. **Section-B** • Protein sorting and targeting:Signal hypothesis, SRP, SRP Receptor, ER Resident proteins, ER chaperone proteins & their functions, glycosylation of proteins in ER.	Plasmodesmata already covered in 'cell junctions' The deleted portion has been replaced with more relevant topic Cell Cycle and its

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			~~transport of soluble and membrane bound proteins in Endoplasmic Reticulum,~~ ER Resident proteins, ER chaperone proteins and their functions, glycosylation of proteins in ER. • Golgi apparatus, role in protein glycosylation and transport. • Lysosomes, intracellular digestion, sorting of lysosomal enzymes in Golgi, lysosomal storage diseases. **Section-C** • Replication of genetic material in prokaryotes and eukaryotes: initiation, elongation and termination; Replication of single stranded circular DNA. • Prokaryotic transcription: Transcription units; RNA polymerase structure and assembly; Promotors; Rho-dependent and Rho-independent termination; Anti-termination. • Eukaryotic transcription: RNA polymerase structure and assembly; RNA polymerase I, II, III; eukaryotic promoters and enhancers; general transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF). • Post transcriptional modifications: processing of hnRNA, tRNA and rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; Splicing; RNA editing; Nuclear export of mRNA; ~~mRNA stability;~~ Catalytic RNA. • Translation: Translation machinery; ~~Ribosomes: composition and assembly;~~ Genetic code~~: degeneracy of codons, initiation and termination codons, wobble hypothesis,genetic code in mitochondria;~~IsoacceptingtRNA; ~~Mechanism of~~ initiation, elongation and termination; Co- and post-translational modifications. **Books recommended :**	• Golgi apparatus, role in protein glycosylation and transport. • Lysosomes, intracellular digestion, sorting of lysosomal enzymes in Golgi, lysosomal storage diseases. • Transport of proteins into mitochondria & chloroplasts. • Cell Cycle & its regulation,apoptosis. **Section-C** • Replication of genetic material in prokaryotes &eukaryotes: initiation, elongation & termination; Replication of single stranded circular DNA. • Prokaryotic transcription: Transcription units; RNA polymerase structure & assembly; Promotors, Rho-dependent & Rho-independent termination; Anti-termination. • Eukaryotic transcription: RNA polymerase structure and assembly; RNA polymerase I, II, III; eukaryotic promoters & enhancers; general transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF). • Post transcriptional modifications: processing of hnRNA, tRNA and rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; splicing; RNA editing; nuclear export of mRNA; catalytic RNA. • Genetic code,IsoacceptingtRNA; Translation: Translation machinery: initiation, elongation and termination; Co- and post-translational modifications. **Suggested Books:** ➢ De Robertis, E.D.R. & De Robertis, E.M.F. (2017). *Cell and Molecular Biology*. New	regulation and division.

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Cell and Molecular Biology : De Robertis& De Robertis, B.I. Waverly Pvt. Ltd., New Delhi. ➢ The world of the cell : W.M. Becker, Pearson Education. ➢ Cell and Molecular Biology : G. Karp, John Wiley & Sons. ➢ The Cell - A Molecular Approach : Cooper, Sinauer. ➢ Cell and Molecular Biology : P.K. Gupta, Rastogi Publications. ➢ Molecular Cell Biology :Lodish, Baltimore, W. H. Freeman & Co. ➢ Molecular Biology of the Cell : Bruce Albert, Garland Publication, NY. ➢ Essentials of Cytology : C.B. Powar, Himalaya Publications. ➢ Principles of Genetics : Gardner, Simmons, Snustad, John Wiley & Sons. ➢ Gene VIII :Lewin, Pearson Education. ➢ Molecular Biology of Gene : J.D. Watson, Pearson Education. ➢ Molecular Biology : David Freifelder, Narosa Publishing House, New Delhi. ➢ Molecular Biology : R. Weaver, WCB McGraw Hill.	York, USA: Lippincott Williams & Wilkins. ➢ Hardin, J., Bertoni, G. & Lewis, K.J. (2011). *Becker's World of the Cell*. Essex, UK: Pearson Education Limited. ➢ Karp, G., Lwasa, J. & Larshall, W. (2015). *Cell and Molecular Biology: Concepts and Experiments*. New Jersey, USA: John Wiley & Sons Ltd. ➢ Cooper, G., M. & Hausman, R. E. (2004). *The Cell: A Molecular Approach*. Washington, D.C.: ASM Press. ➢ Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretsher, A., Ploegh, H., Amon, A. & Martin, K. C. (2007). *Molecular Cell Biology*. New York, USA: W. H. Freeman and Company. ➢ Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K.& Walter, P. (2007). *Molecular Biology of the Cell*. UK: Garland Science. ➢ Freifelder, D. M. (1986). Molecular Biology. USA: Jones & Bartlett Publishers. **Suggested e- Resources:** ➢ **Cell Biology resources** https://www.nature.com/scitable ➢ **Sorting and trafficking of proteins** http://www.vcell.science/project/proteintrafficking ➢ **RNA editing** study.com/academy/lesson/rna-editing-definition-processes.html	
6.	**BIO 416:** Microbiology	After successful completion of the course, students should be able to: • Describe different methodologies for	**Section-A** ~~Discovery of Micro-organisms.~~ • Criteria for classification; molecular approaches • Bacteria: General features, Structural organisation, Nutrition, ~~Growth~~, ~~Respiration and Reproduction~~.	**Section-A** • History andscope of microbiology. • Bacteria: Structural organization. • Archaea: Structural organization and brief overview of major physiological groups	The current syllabus is too bulky and inadequately distributed in the three sections. Contents of section C will be taken up by

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		classification of microbes. • Understand structural, functional and metabolic diversity of bacteria • Explain viral structure, properties, replication and cultivation	• ~~Methanogens~~ and ~~Methylotrophs~~, Chemolithotrophs, Phototrophs, Sulphur reducing bacteria. • Archaebacteria **Section-B** • Nature of viruses, Organisation of virion, Animal, Plant and Bacterial Viruses. • Virus replication, Cultivation of viruses & Virulence factor. • Isolation and screening of industrially important microbes. • Improvement of strains. **Section-C** Biofertilizer and Compost. - Biopesticide~~s, Biopolymers and Biosurfactants~~ - ~~Industrial production of various metabolites with special example of antibiotics, organic acids and alcohol~~ ~~Microbes in the disposal of sewage: sewage treatment processes, sewage water and transmission of diseases, indicator organisms~~.	(Halophiles, Methanogens, Thermophiles). • Growth of bacteria- bacterial growth curve, factors affecting growth, • Nutrition in bacteria- nutritional classes, modes of nutritional uptake, media (types) and culture methods. • Modes of bacterial reproduction. • Regulation in bacteria-operon concept-lac, trp and ara **Section-B** • Classification of bacteria and approaches used (conventional and modern) Metabolic diversity in bacteria- aerobic and anaerobic respiration (suphate, nitrate), fermentation (lactic, mixed, acetone-butanol, stickland fermentations and acetogenesis), chemolithotrophy(hydrogen, sulphur, nitrate and iron oxidizers), phototrophy (oxygenic and anoxygenic). • Unculturable microbes. • Bacterial quorum sensing. **Section-C** General properties, structure, taxonomy (ICTV & Baltimore classification)of virus General features of viral replication, sub-viral particles – satellite virus, viroids& prions. Bacteriophages: one step growth curve, structure & life cycle of T_4 and lambda phages, molecular control of lytic & lysogenic cycle. Animal virus: structure and life cycle of- herpes simplex virus, papovavirus, reovirus & retroviruses. Plant virus: structure & life cycle of - geminivirus, caulimovirus & tobacco mosaic virus; virus-vector relationship.	biotechnology students in bioprocess engineering and environmental biotechnology papers. Also, the last two points of section B are more suited to bioprocess. In the proposed syllabus, the syllabus is more evenly distributed and pertinent content has been added for a more cohesive syllabus.

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Books Recommended : ➢ Introductory Microbiology : F.C. Ross, Columbus Charles E. Mehrill. ➢ Microbiology - Fundamentals and Applications : S.S. Purohit, Agro Botanical Publishers, Bikaner. ➢ Modern Concepts of Microbiology : H.D. Kumar and S. Kumar, Vikas Publishing House, New Delhi. ➢ Microbiology : M.J. Pelczar,C.E.C. Sun and N.R. Krieg, Tata McGraw Hill, New Delhi. ➢ A Text book of Microbiology : R.C. Dubey and D.K. Maheshwari, S. Chand and Company. ➢ Microbiology : K.L. Burdon and R.P. Williams, Mcmillan Worth Publishers. ➢ Microbiology : B.D. Davis et al. : Harper and Row Publishers. ➢ Microbiology : E.W. Nester et al., Saunders international edition. ➢ Principle of Fermentation Technology : P.F. Stanbury and A. Whittaker, Pegamon Press. ➢ Fundamental principles of Bacteriology : A.J. Salle, Tata McGraw Hill. ➢ T.D. Boock's World of Microbiology : Madigan ➢ Microbiology :Presscott.	Virus assay: Plaque, pock, hemagglutination & transformation assays and concept of ID50. Cultivation of viruses. **Suggested Books:** ➢ Willey, J. M., Sherwood, L.M. & Woolverton, C.J. (2014). *Prescott's Microbiology* (9th ed.). New York, USA: McGraw-Hill Education. ➢ Madigan, M., Martinko, J., Stahl, D. & Clark, D. (2010). *Brock Biology of Microorganisms* (13thed.). UK: Pearson Education. ➢ Pelczar Jr., M.J., Chan, E.C.S.& Krieg, N.R. (2011). *Microbiology*. New York, USA: Tata McGraw-Hill. ➢ Kungo, R. (Ed.). (2017). Nanthnarayanand Paniker's *Textbook of Microbiology* (10th ed.). New Delhi, India: Universities Press. ➢ Moat, A. G., Foster, J.W. & Spector, M.P. (2003). *Microbial Physiology* (4th ed.). US: WileyLiss Inc. ➢ Atlas, R.M.& Bartha, R. (1998), *Microbial Ecology: Fundamentals and Applications* (4thed.). UK: Pearson Education. ➢ Dimmock, N.J., Easton, A.J. & Leppard, K.N. (2016). *Introduction to Modern Virology* (8th ed.). Hoboken, NJ: Wiley Blackwell. ➢ Cann, A.J. (2015). Principles of Molecular Virology (6th ed.). Massachusetts, USA: Academic Press. **Suggested e- Resources:** ➢ **Bacteria structure** http://www.biologydiscussion.com/bacteria/cell-structure-of-bacteria-with-diagram/47058 ➢ **Bacterial growth & nutrition** http://www.biologydiscussion.com/bacteria/nutrition-and-growth-in-bacteria/47001	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				➢ **Bacterial quorum sensing** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3543102/ ➢ **Chemolithotrophy** https://courses.lumenlearning.com/boundless-microbiology/chapter/chemolithotrophy/ ➢ **Bacterial metabolism** https://www.ncbi.nlm.nih.gov/books/NBK7919/ ➢ **Structure and classification of Viruses** https://www.ncbi.nlm.nih.gov/books/NBK8174/ https://www.pnas.org/content/101/44/15556 ➢ **Virus replication** https://bit.ly/2BQLTa5	
M.Sc. Bioscience (Plant Science) II Semester					
7.	**BIO 405L:** Bioscience Lab-II	After successful completion of the course, students should be able to: • Demonstrate techniques used in immunology and genetic engineering • Perform key experiments for water quality analysis and other contaminants • Solve problems based on gene mapping and population genetics	1. To obtain standard curve of p-nitrophenol solution. 2. To prepare a sample of enzyme extract. 3. To determine activity of acid phosphatase from peas/moong seedlings. 4. Purification of an enzymatic protein by salt precipitation. 1. Determination of kinetic properties (Km and Vmax values) of an enzyme. 2. To check time and protein linearity of an enzymatic reaction. ~~3.~~ Immobilization of an enzyme. ~~4. Blood film preparation and identification of leucocytes.~~ 5. Lymphoid organs and their microscopic organization. 6. ~~Immunization, collection of serum~~. 7. Double diffusion and immuno-electrophoresis.	**Environmental Biology and Biotechnology** 1. Determination of total hardness of water. 2. Determination of fluoride content in water. 3. Determination of BOD values. 4. Determination of LD_{50} for common pesticides/weedicides. 5. Bacteriological analysis of waste water. **Immunology** 6. To perform differential leucocytes count. 7. Lymphoid organs and their microscopic organization 8. To perform immune diffusion by ouchterlony double diffusion method. 9. To perform immunoelectrophoresis. 10. ELISA: Determination of antibody titre. 11. Immunodiagnostics (Demonstration using commercial kits). **Genetic Engineering** 12. Extraction of genomic DNA by CTAB method	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			8. ELISA : Determination of antibody titre. 9. Immunodiagnostics (Demonstration using commercial kits). 10. Extraction and estimation of RNA. 11. Extraction and estimation of DNA. ~~12. max for nucleic□To find acids.~~ ~~13. Preparation of metaphase chromosomes.~~ ~~14. Detection of ADH activity in tissue/cells by cytochemical staining using Drosophila.~~ ~~15. Statistical problem.~~ 16. Genetic problem - (chromosome mapping).	and determination of its purity. 13. Estimation of DNA content by diphenyl amine (DPA) method. 14. PCR amplification of 'n' number of genotypes of a species using random primers (Demonstration). 15. Extraction of RNA by Phenol-Chloroform method and estimation by orcinol method. **Genetics** 16. Study of sex chromatin from buccal epithelial/ hair bud cells. 17. Genetic exercise - Chromosome mapping, two and three point cross. - Quantitative genetics/ population genetics. **Biostatistics and Research Methodology** 18. Biostatistics problems based on following: - Measures of dispersion (variance). - Correlation analysis. - Probability and probability distribution. - Testing hypothesis by student t- test, Fisher's test, chi-square test and one way analysis of variance. **Suggested Books:** ➢ Aneja, K.R. (1996). *Experiments in Microbiology, Plant Pathology, Tissue Culture and Mushroom Cultivation* (2nd ed.). New Delhi: Wishwa Prakashan. ➢ Green, M. R., & Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual.* Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. ➢ Gupta S.P. (2000). *Statistical Methods.* S. Chand Publications. **Suggested e- Resources:**	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				➢ **Harisha, S. Biotechnology procedures and experiments handbook** https://bit.ly/2U0e39D ➢ **Introduction to biotechnology** https://bit.ly/2IICkzE	
8.	**BIO 406:** Biostatistics and Research Methodology	After successful completion of the course, students should be able to: • Apply statistical analysis to biological data • Identify ethics in scientific research and associated methodologies • Develop skills in scientific writing.	**Section-A** • Scope of Biostatistics, variables in biology, collection, classification, tabulation of data. • Frequency distribution, diagrammatic and graphical presentation of statistical data, sampling techniques. • Measures of central location and dispersion, simple measure of skewness and kurtosis. • Probability, conditional probability. **Section-B** • Binomial, Poisson and Normal Distribution. • Correlation and Regression: Least Square method of fitting, Standard error of estimate, Correlation and regression coefficient. • Basic idea of significance testing, level of significance, students ‘t’ test, 2 (chi-square) test and F-test, Analysis of variance. **Section-C** • Introduction of Research Methodology: meaning and importance, nature and areas of research in Biological Sciences. • Formulation of a research problem (Hypothesis). • Elements in Research Methodology; Research Designs (CRD, RBD, LSD). • Ethical, legal and social issues in Biological Research. • Writing of Research Report/Research Paper: various components and their organization. **Recommended Books:** ➢ Singh S. (1988). Statistical methods for Research.	No change in the syllabus **Suggested Books:**	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Central publishing, Ludhiana. ➢ Gupta S.P. (2000). Statistical Methods. S. Chand Publications. ➢ Khan and Khanum (2012). Fundamentals of Biostatistics.Ukaz Publications. ➢ Zerold J. (2009). BiostatisticalAnalysis. UK: Pearson Education. ➢ Marcello P. and Kimberlee G. (2000). Principles of Biostatistics. Duxbury. ➢ Prasad S. (2012). Elements of Biostatistics.Rastogi Publications. ➢ Rastogi V. B. (2015). Biostatistics. Medtec publications. ➢ Basotia, G.R. and Sharma K.K. (1999). Research Methodology.Mangal Deep Publications. ➢ Chaudhary C.M. (1991). Research Methodology. RBSA Publications. ➢ Dorendro A. (2016). Research Methodology in Zoology.Pearlbooks . ➢ Kadam R.M. and Allapure R. B. (2016). Research Methodology in Botany.Gaurav Books	➢ Singh S. (1988). *Statistical methods for Research*. Central publishing, Ludhiana. ➢ Gupta S.P. (2000). *Statistical Methods*. S. Chand Publications. ➢ Khan and Khanum (2012). *Fundamentals of Biostatistics*. Ukaz Publications. ➢ Zerold J. (2009). *BiostatisticalAnalysis*.UK: Pearson Education. ➢ Marcello P. and Kimberlee G. (2000). *Principles of Biostatistics*. Duxbury. ➢ Prasad S. (2012). *Elements of Biostatistics*.Rastogi Publications. ➢ Rastogi V. B. (2015). *Biostatistics*. Medtec publications. ➢ Basotia, G.R. & Sharma K.K. (1999). *Research Methodology*. Mangal Deep Publications. ➢ Chaudhary C.M. (1991). *Research Methodology*. RBSA Publications. ➢ Dorendro A. (2016). *Research Methodology in Zoology*. Pearlbooks. ➢ Kadam R.M. & Allapure R. B. (2016). *Research Methodology in Botany*. Gaurav Books **Suggested e- Resources:** ➢ **ANOVA** https://www.analyticsvidhya.com/blog/2018/01/anova-analysis-of-variance/ ➢ **Regression Analysis** https://bit.ly/2s9vHdM ➢ **Student's t Test- Interactive tutorial** https://www.ruf.rice.edu/~bioslabs/Stats_tutorial/index.html	
9.	**BIO 410:** Genetics	After successful completion of the course, students should be able to:	**Section-A** • Definition of gene: genetic & biochemical view; Gene: unit of structure & function,	**Section A** • Definition of gene: genetic & biochemical view; Gene: unit of structure & function,	Genetic recombination models is important to be discussed to understand

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		• Understand the theoretical and experimental foundations of classical and molecular genetics. • Describe the basics of genetic mapping in bacteria, virus and eukaryotes • Understand the scope of cytogenetics and its applications.	complementation test. • Mendelian Genetics: Mendel's experimental design; Mendelian Genetics in humans: Pedigree analysis. • Extensions of Mendelian Genetics Principles: Modification of dominance relationships, Gene interactions and modified Mendelian ratios, Multiple alleles, Essential and lethal genes. • Non Mendelian inheritance: Extrachromosomal inheritance; Genomic imprinting; isodisomy; Complex inheritance-genetic and environmental variation; Heritability; Twin studies; Behavioral traits; Analysis of quantitative traits. • Linkage & Crossing over: Tetrad analysis, mapping of gene order and centromere location in fungi **Section-B** • Genome organization: Organization of bacterial genome; Structure of eukaryotic chromosomes, organization of DNA into chromosomes; Heterochromatin and euchromatin. • ~~Regulation of gene expression in prokaryotes: transcriptional regulation-Positive and negative; Operon concept- lac, trp and ara operons; transcriptional control in phage.~~ • ~~Regulation of gene expression in eukaryotes~~. • Mutations: Nonsense, missense and point mutations; Intragenic and intergenicsuppression; Frameshift mutations; Mutagens; Molecular mechanism of mutations. • ~~Transposable genetic elements in prokaryotes and eukaryotes: Insertion sequences, composite and complex transposons, replicative and non-replicative transposons; Mechanism of transposition; Role of transposons in mutation; Genetic analysis using transposons.~~	complementation test. • Mendelian Genetics: Mendel's experimental design; Mendelian Genetics in humans: Pedigree analysis. • Extensions of Mendelian Genetics: Modification of dominance relationships, gene interactions and modified Mendelian ratios, multiple alleles, essential and lethal genes. • Non Mendelian inheritance: Extrachromosomal inheritance. • Genomic imprinting. • Complex inheritance-genetic and environmental variation; Heritability; Twin studies; Behavioral traits; Analysis of quantitative traits. **Section-B** • Linkage & crossing over, models of genetic recombination, gene conversion, Tetrad analysis, mapping of gene order & centromere location in fungi. • Genome organization: Organization of bacterial genome. • Structure of eukaryotic chromosomes, organization of DNA into chromosomes; Heterochromatin and euchromatin • Mutations: Nonsense, missense & point mutations; Frameshift mutations; Mutagens; Molecular mechanism of mutations;Suppressor mutation. • Transposonmutagenesis, transposons as genetic tools: signature tagging mutagenesis, insertional inactivation, P- elements as genetic tool.	result of crossing over, gene conversion is important consequence of recombination. Gene regulation can be deleted because this content is covered in Cell and Molecular Biology After modification students will have basic understanding of cytogenetics and its application

<table>
<tr><th>S. No</th><th>Course List</th><th>Learning Outcome</th><th>Existing Syllabus</th><th>Suggested Syllabus</th><th>Remarks</th></tr>
<tr><td></td><td></td><td></td><td>Section-C
• Cytogenetics: Cell division and errors in cell division; Non disjunction; Structural and numerical chromosomal abnormalities-deletion; duplication; translocation; Sex determination; Lyon hypothesis; Role of Y chromosome; Genetic recombination; Disorders of sex chromosomes and autosomes;
• Molecular cytogenetics-Fluorescence In Situ Hybridization (FISH); Comparative Genomic Hybridization (CGH).
• Genetics of bacteria and bacteriophages: Genetic analysis of Bacteria; Genetic mapping in bacteria by conjugation, transformation and transduction; Mapping of bacteriophage gene.
• Population genetics: the Hardy-Weinberg law; Genetic variation in natural populations; Forces that change gene frequency in populations; Genetic basis of speciation.

Books Recommended :
➢ Principles of Genetics 4th Ed :Snustad& Simmons, John Wiley & Sons.
➢ i-Genetics : P.J. Russel, Pearson Education.
➢ Principles of Genetics 8th Ed : Gardner, Simmons, Snustad, John Wiley & Sons.
➢ Genetics : P.K. Gupta, Rastogi Publications.
➢ Genetics - A molecular approach : T.A. Brown, Chapman and Hall.
➢ Concepts of Genetics 7th Ed. : William S. Klug, Pearson Education.
➢ Principles of Genetics : R.H. Tamarin, Tata McGraw Hill.</td><td>Section-C
• Cytogenetics: Cytogenetics introduction, karyotype analysis, chromosome banding techniques
• Cell division & errors in cell division; Non disjunction.
• Structural and numerical chromosomal abnormalities- deletion, duplication, translocation; Sex determination; Lyon hypothesis; Role of Y chromosome; Disorders of sex chromosomes & autosomes.
• Molecular cytogenetics-Fluorescence in Situ Hybridization (FISH); Comparative Genomic Hybridization (CGH).
• Genetics of bacteria and bacteriophages; Genetic mapping in bacteria by conjugation, transformation and transduction
• Mapping of bacteriophage gene.
• Population genetics: Hardy-Weinberg law; Genetic variation in natural populations; Forces that change gene frequency in populations; Genetic basis of speciation.
Suggested Books:
➢ Klug, W. S., Cummings, M.R., Spencer, C.A. & Palladine, M.A. (2015). Concepts of Genetics (11th ed.). UK: Pearson Education.
➢ Gardner, E.J., Simmons, M.J., & Snustad, D.P. (2005).Principles of Genetics (8th ed.). New Jersey, USA: John Wiley & Sons Ltd.
➢ Benjamin, A.P. (2003). Genetics: A conceptual approach. New York, USA: W. H. Freeman and Company.
➢ Russel, P.J. (2010). iGenetics (3rd ed.). UK: Pearson Education.
➢ Brown, T.A. (1992). Genetics- A Molecular</td><td></td></tr>
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S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Genetics-From Genes to Genomes : Hartwell, McGraw Hill. ➢ Genetics 5th Eds. : D.L. Hartl and E.W. Jones, Jones and Barlett Publishers, Canada. ➢ An Introduction to Genetic Ananlysis : Suzuki, Griffith, Miller &Lewonith. ➢ Molecular Biology : Weaver, WCB McGraw Hill.	*Approach*. London, UK: Chapman & Hall. ➢ Gupta, P.K. (2010).*Genetics*. Meerut, India: Rastogi Publications. **Suggested e- Resources:** ➢ **Cytogenetic methods and Disease** www.nature.com/scitable/topicpage/cytogenetic-methods-and-disease-flow-cytometry-cgh-772 ➢ **CGH Analysis** www.cs.cmu.edu/~epxing/Class/10810-05/Lecture11.pdf ➢ **Population Genetics** https://biomed.brown.edu/Courses/BIO48/6.PopGen1.HW.drift.HTML	
10.	**BIO 411:** Immunology	After successful completion of the course, students should be able to: • Evaluate and compare the role of various components and mechanisms of the immune system. • Describe various immune response mechanisms • Develop concept of antibody generation and various immunological techniques	**Section-A** • Basic concepts of immunology: specific and nonspecific defense mechanisms (innate and acquired immunity), organs and cells of immune system. • Antigen and Antigenicity: concept of immunogens, antigens, heptans, mitogens and superantigens. Properties of antigens, ~~cross reactivity~~, special group of antigens: bacterial antigens, viral antigens, cell surface antigens (MHC), autoantigens, isoantigens and frossman antigens (Heterophilic antigens). • Immunoglobulins: structure and properties of immunoglobulins, immunoglobulin isotypes and their significance.Immunoglobulins as antigens: isotypes, allotypes and idiotypes. • Complement System. **Section-B**	**Section-A** • Basic concepts of immunology: Historical background of immunology, specific and nonspecific defense mechanisms (innate and acquired immunity), cells and organs of immune system. • Antigen and Antigenicity: Concept of immunogens, antigens, haptens, mitogens and superantigens. Properties of antigens, special group of antigens: bacterial antigens, viral antigens, cell surface antigens (MHC), autoantigens, isoantigens and frossman antigens (Heterophilic antigens). • Immunoglobulins: Structure and properties of immunoglobulins, immunoglobulin isotypes and their significance. Immunoglobulins as antigens: isotypes, allotypes and idiotypes, brief idea about instructive, selective & clonal selection theory of antibody formation. • Complement system. **Section-B** • Cell - mediated immune responses: origin,	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• Cell - mediated immune responses : origin, maturation and characterization of T-Lymphocytes, monocytes and macrophages, characteristics of antigen presentation and its significance, concepts of memory cell, mode of action and functioning of TH, TC, CTLS and NK cells, lymphokines, the product of T cell activation. • Humoral immune responses: Origin, maturation and characterisation of B Lymphocytes, activation and proliferation of B and T cells, antibody generation in vivo. • Immunological tolerance ~~and Autoimmunity~~: characteristics and mechanism of immunologic tolerance, factors affecting immunologic tolerance and ~~mechanisms of autoimmunity~~. Hypersensitivity: Type I, II, III and IV. **Section-C** • Hybrid and Chimeric monoclonal antibodies, catalytic antibodies • Surface plasmon resonance, Biosensor assay for assessing ligand-receptor interaction. • ~~Measurement of low molecular weight non-immunogenic compounds (such as secondary metabolites); phytohormones immunoassays.~~ • Advanced immunological techniques: Immunofluorescent and Immunogoldlabelling **Books Recommended:** ➢ Abbas, A.K.,&Lichtman, A.H. (2001). *Basic immunology: Functions and Disorders of Immune System*. US: W.B. Saunders. ➢ Delves, P.J., Martin, S.J., Burton, D.R.,&Roitt, I.M (2011). *Roitt's Essential Immunology*	maturation and characterization of T-Lymphocytes, monocytes and macrophages, characteristics of antigen presentation and its significance, concepts of memory cell, mode of action and functioning of TH, TC, CTLS and NK cells, lymphokines, the product of T-cell activation. • Humoral immune responses: Origin, maturation and characterization of B-Lymphocytes, activation and proliferation of B and T cells, antibody generation *in vivo*. • Immunological tolerance and characteristics and mechanism of immunologic tolerance, factors affecting immunologic tolerance of autoimmunity. Immune regulation, positive, negative selection, apoptosis. **Section-C** Hypersensitivity: Type I, II, III and IV. • Hybrid and Chimeric monoclonal antibodies, catalytic antibodies. • Surface plasmon resonance, biosensor assay for assessing ligand-receptor interaction. • Advanced immunological techniques: Immunofluorescent and immunogold labelling. **Suggested Books:** ➢ Abbas, A.K. & Lichtman, A.H. (2001). *Basic Immunology: Functions and Disorders of Immune System*. US: W.B. Saunders. ➢ Delves, P.J., Martin, S.J., Burton, D.R., & Roitt, I.M (2011). *Roitt's Essential Immunology* (12thed.). New Jersey, USA: John Wiley & Sons Ltd. ➢ Goldsby, R. A., Kindt, T.J. & Osborne, B. A. (2006). *Kuby Immunology* (6th ed.). New York, USA: W.H. Freeman & Co. Ltd.	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			(12th ed.). New Jersey, USA: John Wiley & Sons Ltd. ➢ Goldsby, R. A., Kindt, T.J., & Osborne, B. A. (2006). *Kuby Immunology* (6th ed.). New York, USA: W.H. Freeman & Co. Ltd. ➢ Paul, W.E. (1999). *Fundamental Immunology* (14th ed.). USA: Lippincott-Raven. ➢ Peakman, M.,&Vergani, D. (2009). *Basic and Clinical Immunology* (2nd ed.). US: Elsevier Health Sciences. ➢ Tizard, I.R. (2017). *Veterinary Immunology* (10th ed.). US: Elsevier Health Sciences.	➢ Paul, W.E. (1999). *Fundamental Immunology* (14th ed.). USA: Lippincott-Raven. ➢ Peakman, M. &Vergani, D. (2009). *Basic and Clinical Immunology* (2nd ed.). US: Elsevier Health Sciences. ➢ Tizard, I.R. (2017).*Veterinary Immunology* (10th ed.). US: Elsevier Health Sciences. **Suggested e- Resources:** ➢ **Basic Immunology** https://bit. y/2E6Zz16l ➢ **Monoclonal Antibodies** https://www.genscript.com/how-to-make-monoclonal-antibodies.html ➢ **Complement system** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3956958/	
11.	**BT 406:** Enzymology and Enzyme Technology	At the end of this course, the students will have fundamental knowledge of enzymes and varioustechniques involved in their production and purification. They would also learn about theirapplication in different fields such as medical, textile, chemical processes, etc. They can applythis knowledge for better understanding of other basic and advanced courses in biologicalsciences as well as to solve research based problems.	**Section-A** • History and introduction to enzymes: Classification of enzymes. IUPAC system, nomenclature, E.C. numbers. • Enzyme kinetics (Michaelis - Menten laws), importance and determination of Vmax and Km values, Hofstee's plot, L & B plots. • Bisubstrate reactions-ordered & random sequential mechanism. Theorell chance mechanism, ping pong mechanism, products of inhibition in bisubstrate reactions. • Enzyme inhibition: competitive, non-competitive and other types. **Section-B** • Extraction of soluble and membrane bound enzymes from microbial, plant and animal tissues. • Purification of enzymes: salt precipitation, gel filtration, ion exchange and affinity chromatography.	Course proposed to be discontinued	Some part of the syllabus is integrated with I Semester course "Biochemistry".

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• Regulation of enzyme activity, various controls (metabolic compartmentation, covalent modifications and others), feedback regulation, allosteric enzymes. • Coenzymes, Isozymes and Multienzyme complexes. • Methods of storing enzymes. **Section-C** • Large scale production of enzymes including genetic engineering approaches for their over production. • Enzyme engineering; identification of active sites, approaches for modification of catalytic properties. • Techniques of enzyme immobilization and their applications in: a. Food industry- High fructose syrup, cheese making and beer industry. b. Antibiotics and other Pharamaceuticals c. Medical applications d. Analysis of substances, enzyme electrodes, enzyme thermistors. • Basic idea of proteomics **Suggested Books:** ➢ Understanding Enzymes : T. Palmer. ➢ Fundamentals of Enzymology : Price and Stevenson. ➢ The Enzyme : Dixon and Webb, Academic Press, London. ➢ Methods in Enzymology : Academic Press. ➢ The Enzyme Molecule: W. Ferdinan, John Wiley and sons. ➢ Protein Methods: D.M. Bollag and S.J. Edelstein, Wiley-Liss. ➢ The Nature of Enzymology : F.L. Foster, John Wiley and sons.		

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Enzyme technology, biotechnology Vol7 : John Wiley and sons. ➢ Enzyme, Biomass, Food and Feed Biotechnology Vol. 9 : John Wiley and Sons.		
12.	**Environmental Biology and Biotechnology**	After successful completion of the course, students should be able to: • Identify key factors responsible for ecosystem balance and explain different efforts which can be undertaken for restoration and environmental remediation. • Comprehend the toxicity of various environmental pollutants and their influence on ecosystem. • Understand different waste management processes and generation of energy from waste. • Describe various roles played by microbes in biodegradation, bioremediation and plant growth promotion.	**M.Sc. III Semester Bioscience core course** **BIO 408: Environmental Biology and Toxicology** **Section-A** - ~~Concept of energy, conventional & non-conventional energy sources. Fossil fuels, hydro, wind and nuclear power, geothermal, solar and bioenergy.~~ - Energy flow in organisms, energy pathways & models, energy efficiencies, ~~conservation of energy.~~ - ~~Classification & characteristics of resources~~: water, soil, forest, wild life, ~~land use.~~ - Conservation of natural resources: water, soil, forest and wild life. **Section-B** - ~~Origin of pollutants : industrial, agricultural, domestic and vehicular sources.~~ - ~~Pollutant & their toxicology :~~ Heavy metals ~~and trace elements~~. Agrochemicals ~~(Pesticides, herbicides, rodenticides & fungicides, detergents) & particulate matter.~~ - ~~Types of radiations including ionizing & non-ionizing radiations & their interaction with matter.~~ - Radiations as environmental pollutants. - Effects of radiations at cellular, molecular	**Environmental Biology and Biotechnology** **Section A** ➢ Structure and functions of ecosystem. ➢ Energy flow in organisms, energy pathways & models, energy efficiencies. ➢ Basic concept of Population Ecology – Inter & intra-specific interactions among populations. ➢ Community structure & dynamics: Ecological succession. ➢ Natural resources & conservation: water, soil, forest, wild life. ➢ Environmental challenges & sustainable development; Environmental Laws & Acts. **Section B** ➢ Heavy metal toxicity, agrochemical pollutants. ➢ Bioremediation of heavy metal pollution and oil spills, phytoremediation. ➢ Radiations—as environmental pollutants. Effects of radiations at cellular, molecular & genetic level. Disposal of radioactive waste. ➢ Waste water treatment- sources of waste water, strategies used in primary, secondary & tertiary treatments, water reclamation. **Section C** ➢ Biofertilizers, biopesticides, compost & vermicompost. ➢ Biofuels: Biogas, bioethanol, biodiesel,	"Environmental Biology and Biotechnology" is proposed to be included as a new core course in the second semester instead of the existing core course "Enzymology and Enzyme Technology". The syllabus of "Environmental Biology and Biotechnology" is designed by updating and merging the contents of existing courses BIO 408 "Environmental Biology and Toxicology" which is running as a core course in third semester of M.Sc. Bioscience programme and another course BT 509 "Environmental Biotechnology" which is running as a core course in the third semester of M.Sc. Biotechnology programme.

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			& genetic level. **Section-C** - ~~Mutagenecity, carcinogencity~~. - ~~Green house effect, acid rains~~. - ~~Ozone layer depletion, photochemical smog~~. - Types of solid wastes, transport, reuse & recycling. **M.Sc. III Semester Biotechnology core course** **BT 509: Environmental Biotechnology** **Section-A** - ~~Current status of biotechnology in environmental protection.~~ - ~~Sewage &~~ waste water treatment: ~~Physical, Chemical and biological treaments; Aerobic processes & anaerobic processes,~~ Primary, secondary and tertiary treatments; ~~Sludge dewatering & its disposal;~~ Water reclamation. - Solid waste management: Methods & disposal ~~of non hazardous and hazardous solid wastes, recycling,~~ methods of disposal of radioactive waste. - ~~Conservation of Biodiversity: *Ex-situ* & *in-situ* methods.~~ **Section-B** - ~~Environmental Biotechnology in Agriculture~~: Biofertilizers ~~and microbial inoculants~~, Biopesticides. - Biodegradation of xenobiotic compounds: Simple aromatics, chlorinated polyaromatic petroleum products,	biohydrogen. Biodegradable plastics. ➢ Biodegradation of xenobiotic compounds: Simple aromatics, chlorinated polyaromatic petroleum products & pesticides; role of degradative plasmids. ➢ Solid waste management: types, treatment & disposal strategies. ➢ Bioleaching of metals, microbially enhanced oil recovery. Bioindicators. **Suggested Books** ➢ Allen, K. (2016). *Environmental Biotechnology*. New Delhi, India: CBS Publishers. ➢ Miller, G.T. (2004). *Environmental Science: Working With The Earth* (10^{th} ed.). Singapore: Thomson Asia. ➢ Milton, W. (Ed.). (1999). *An Introduction to Environmental Biotechnology*. USA: Springer. ➢ Milton, W. (Ed.). (1999). *An Introduction to Environmental Biotechnology*. USA: Springer. ➢ Modi, P. N. (2015). *Sewage treatment & disposal and waste water engineering*. New Delhi, India: Rajsons Publications Pvt. Ltd. ➢ Odum E. P. (2006). *Fundamentals of Ecology* (5^{th}ed.). Boston, US: Cengage. ➢ Sharma, P.D. (2008). *Environmental Biology and Toxicology*. Meerut, India: Rastogi Publications. ➢ Sodhi, G.S. (2002*). Fundamental Concepts of Environmental Chemistry*. New Delhi, India: Narosa Publishing House. ➢ Tripathi, B. N., Shekhawat, G. S., &	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Pesticides ~~and surfactants.~~ - Bioremediation ~~& Biorestoration: Reforestation through micro-propagation, development of stress tolerant plants, and use of mycorrhiza in reforestation of soil contaminated with heavy metals.~~ **Section-C** - Biofuels: ~~Energy crops, Conventional sources of biofuel, Second and third generation of biofuel,~~ Biogas, Bioethanol, Biohydrogen. Biodegradable plastics. - Bioindicators ~~and Biosensers for detection of environmental pollution.~~ - Environmental genetics: Degradative plasmids, ~~release of GE microbes in environment.~~	Sharma, V. (Ed.). (2009). *Applications of Biotechnology*. Jaipur, India: Aavishkar Publishers. ➢ Vallero, D.A. (2016). *Environmental Biotechnology: Abiosystems approach*. US: Elsevier. ➢ Wright, R. T. (2015). *Environmental Science: Toward a Sustainable Future*. UK: Pearson Education. **Suggested e-resources** ➢ **Ecosystem structure** http://www.biologydiscussion.com/ecosystem/ecosystem-its-structure-and-functions-with-diagram/6666 ➢ **Radioactive waste treatment** https://ehs.unc.edu › Manuals › Radiation Safety Manual ➢ **Environmental Remediation** https://www.iaea.org/sites/default/files/18/05/environmental_remediation.pdf ➢ **Biological treatment of wastewater** http://www.neoakruthi.com/blog/biological-treatment-of-wastewater.html ➢ **Biogas** http://www.biologydiscussion.com/biomass/production-of-biogas-from-biomass/10436 ➢ **Biofuel** http://uru.ac.in/uruonlinelibrary/BioFuels/Biomass%20and%20biofuels.pdf ➢ **Biological treatment of wastewater** http://www.neoakruthi.com/blog/biological-treatment-of-wastewater.html ➢ **Xenobiotic compound biodegradation** https://bit.ly/2GHRoMj	
13.	**BT 408:**	After successful completion	**Section-A**	**Section-A**	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
	Genetic Engineering	of the course, students should be able to: • Develop comprehensive understanding of gene manipulation techniques • Describe various cloning and expression vectors • Develop skills for primer designing, gene amplification and expression	• Basic concepts of DNA structure and properties, restriction enzymes, DNA ligase, Klenow enzyme, T4 DNA polymerase, Polynucleotide kinase, Alkaline phosphatase, Cohesive and blunt end ligation, Linkers, Adapters, Homopolymeric tailing, Labeling of DNA, Nick translation, Random priming, Radioactive and non-radioactive probes, Hybridization techniques, Northern, Southern and Colony Hybridization, ~~Fluorescence in situ hybridization~~, Chromatin immunoprecipitation, DNA-Protein Interaction-Electromobility shift assay, DNaseIfootprinting, Methyl interference assay, Isolation of genomic DNA from prokaryotes and eukaryotes, Isolation of Plasmid DNA and Bacteriophage DNA. Isolation of total RNA and mRNA. **Section-B** • Plasmids, Bacteriophages, pBR322 and pUC series of vectors, M13 and P2 phage based vectors, High capacity vectors: Cosmids, phagemid, ~~phasemid, YAC~~, BAC, Animal and Plant virus based cloning vectors, Shuttle vectors, Expression vectors, pMal, GST, pET-based vectors, ~~Insertion of foreign DNA into Host Cells, Transformation~~, Constructions of libraries, cDNA and genomic libraries, cDNA and genomic cloning, Expression cloning, Jumping and hopping libraries, South-western and Far-western cloning, Protein-protein interactive cloning and	• Basic concepts of DNA structure and properties, restriction enzymes, DNA ligase, Klenow enzyme, T_4 DNA polymerase, polynucleotide kinase, alkaline phosphatase. • Cohesive & blunt end ligation, linkers, adapters, homopolymeric tailing, labeling of DNA, nick translation, random priming, radioactive & non-radioactive probes. • Hybridization techniques: Colony hybridization, Northern, Southern,South-Western & far-western blotting. • DNA-Protein Interaction: Chromatin immunoprecipitation, electromobility shift assay, DNaseIfootprinting, methyl interference assay. • Protein-protein interaction: Yeast two hybrid system, split ubiquitin system, co-immunoprecipitation, Forster Resonance Energy Transfer, phage display. • Isolation of genomic DNA from prokaryotes and eukaryotes, isolation of Plasmid DNA and Bacteriophage DNA.Isolation of total RNA and mRNA. **Section-B** • Plasmids, Bacteriophages, pBR322 & pUCseries of vectors, M13 based vectors. • High capacity vectors:cosmids, phagemids, BAC, animal & plant virus based cloning vectors, shuttle vectors; expression vectors: pMal, GST, pET-based vectors; *Baculovirus* and *Pichia* vectors. Introduction of DNA into mammalian cells. • cDNA& genomic libraries, expression, cloning, jumping & hopping libraries.	Already covered in the Genetics course Yeast vectors have been covered in **Recombinant DNA Technology** paper. Relevant vectors have been added. Repeating topics have been removed

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Yeast two hybrid system, Phage display. **Section-C** • Primer designing, Fidelity of thermostable enzymes, ~~DNA polymerase~~, Types of PCR- multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, in situ PCR, cloning of PCR products, T-vectors, ~~Proof reading enzymes~~, Principles in maximizing gene expression, Gene expression analyses, differential gene expression methods, Introduction of DNA into mammalian cells, ~~transfection techniques.~~ **Books Recommended :** ➢ Molecular Cloning Vol. 1, 2 and 3 :Sambrook, Russell and Maniatis, Cold Spring Harber laboratory, 2001. ➢ Molecular Biology of Gene : J.D. Watson, Pearson Education. ➢ An Introduction to Gene Technology-From genes to clones :Winnacker, VCH. ➢ Principles of Gene Manipulation : Old and Primrose. ➢ MoleculerBiotechnology : B.R. Glick and J.J. Pasternak, ASM Press Washington, USA. ➢ Genetic Engineering : Science and ethics on new frontier : Michael Boylan, Pearson Education. ➢ An Introduction to Genetic Engineering : S.T. Nicholl, Cambridge University Press. ➢ Recombinant DNA Methodology : Grossman and Noldave, Academic Press.	**Section-C** • Primer designing, fidelity of thermostable enzymes. • Types of PCR- multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, *in situ* PCR, T-vectors. • Principles in maximizing gene expression, gene expression analyses, differential gene expression methods. **Suggested Books:** ➢ Old, R. W., Primrose, S. B. & Twyman, R. M. (2001). *Principles of Gene Manipulation: an Introduction to Genetic Engineering*. Oxford: Blackwell Scientific Publications. ➢ Brown, T. A. (2006). *Genomes* (3rd ed.). New York: Garland Science. ➢ Glick, B.R. & Pasternak, J.J. (1998). *Molecular Biotech: Principles and Application of Recombinant DNA*. US: ASM Press. ➢ Richard J. R. (2004). *Analysis of Genes and Genome*. New Jersey, USA: John Wiley & Sons Ltd. ➢ Green, M. R. & Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. **Suggested e- Resources:** ➢ **Genetic engineering – Basics, New Applications and Responsibilities** http://library.umac.mo/ebooks/b28055287.pdf ➢ **Construction of genomic libraries** https://nptel.ac.in/courses/102103013/20 ➢ **Enzymes in genetic engineering**	Repeating topics have been removed

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				https://nptel.ac.in/courses/102103013/7	
M.Sc. Bioscience (Plant Science) III Semester					
14.	**BIO 408: Environmental Biology and Toxicology**		**Environmental Biology and Toxicology** **Section-A** - ~~Concept of energy, conventional & non-conventional energy sources. Fossil fuels, hydro, wind and nuclear power, geothermal, solar and bioenergy.~~ - Energy flow in organisms, energy pathways & models, energy efficiencies, ~~conservation of energy.~~ - ~~Classification & characteristics of resources~~: water, soil, forest, wild life, ~~land use.~~ - Conservation of natural resources: water, soil, forest and wild life. **Section-B** - ~~Origin of pollutants : industrial, agricultural, domestic and vehicular sources.~~ - ~~Pollutant & their toxicology :~~ Heavy metals ~~and trace elements~~. Agrochemicals ~~(Pesticides, herbicides, rodenticides & fungicides, detergents) & particulate matter.~~ - ~~Types of radiations including ionizing & non-ionizing radiations & their interaction with matter.~~ - Radiations as environmental pollutants. - Effects of radiations at cellular, molecular & genetic level. **Section-C** - ~~Mutagenecity, carcinogenicity~~. - ~~Green house effect, acid rains~~. - ~~Ozone layer depletion, photochemical~~	This course is discontinued in the present form from Semester III. With some modification, revision and merging with another course it is proposed to be shifted in the II Semester as a new core course “Environmental Biology and Biotechnology”	The course contents are proposed to be modified and merged with M.Sc. Biotechnology III Semester core course “Environmental Biotechnology” to propose new core course named as “Environmental Biology and Biotechnology” in the II Semester.

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			~~smog~~. - Types of solid wastes, transport, reuse & recycling.		
15.	**BIO** Phycology, Mycology and Lichenology	After successful completion of the course, students will be able to: • Acquire the knowledge related to various life forms, ecological and economical importance of these groups. • After completion of this course student will be able to identify these forms in their surroundings and will convey the importance to the community which will help in the conservation of these forms to get better ecosystem.		**Section A** • Introduction, scope and general principles of classification of fungi • Myxomycotina: Plasmodiophorales • Mastigomycotina: Chytridiales, Blastocladiales, Saprolegniales and Peronosporales • Zygomycotina:Mucorales and Entomophthorales • Ascomycotina: Endomycetales, Protomycetales, Taphrinales, Erysiphales, Eurotiales, Sphaeriales, • Helotiales, Phacidiales and Pezizales • Basidiomycotina: Uredinales, Ustilaginales, Lycoperdales, Nidulariales, Sclerodermatales, Phallales, • Agaricales, Aphyllophorales, Tremellales and Auriculariales • Deuteromycotina: Sphaeropsidales, Melanconiales, Moniliales and Mycelia sterilia **Section B** • Algae-general characters, definitions and scope. Comparative survey of important systems of classification of algae, criteria for algal classification and modern trends. Diagnostic features of algal phyla: range of Thallus and reproductive diversity. Life history patterns: parallelism in evolution. • Comparative account of algal pigments; light microscopic structure, ultra structure, function and importance of cell wall, flagella chloroplasts pyrenoids eyespots, nucleus, contractile vacuole and their importance in taxonomy.	New course proposed

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				• Study of Cyanophyta (*Microcystis*, *Stigonema*), Prochlorophyta (*Prochloron*), Chlorophyta (*Chlorella Hydrodictyon*, *Nitella*) Xanthophyta (*Botrydium*), Bacillariophyta (*Navicula*), Phaeophyta (*Dictyota*) • Algae in biotechnology. • Economic importance of algae. **Section C** • A general account of Lichens and its symbionts, thallus structure, reproduction, physiology, classification and distribution, Chemistry of Lichens, Isolation of symbiont and synthesis of Thallus, Economic importance. • Study types: *Dermatocarpon*, *Parmelia*, *Heterodermia*. **Suggested Books:** ➢ Alexopoulus, C.J., Mims. C.W. & Blackwel, M. (1996). *Introductory Mycology*. John Wiley & Sons Ind. ➢ Mehrotra, R.S. and Aneja, R.S. (1998). *An Introduction to Mycology*.New Age Intermediate Press. ➢ Morris, I.(1986). *An Introduction to the Algae*. Cambridge University Press, U.K. ➢ Round, F.E. (1986). *The Biology of Algae*. Cambridge University Press, Cambridge. ➢ Kumar, H.D. and Singh, H.N. (1979). *A Textbook On Algae*. Macmillan Publishers Limited. ➢ Nash, T.H. 2011. *Lichen Biology*. Cambridge University Press. **Suggested e-Resources**: ➢ **Lichen: General account** https://www.anbg.gov.au/lichen/what-is-lichen.html	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				➢ **Introduction to Lichen** https://www.nybg.org/bsci/lichens/ ➢ **Algae: General account** https://www.livescience.com/54979-what-are-algae.html ➢ **Classification, Economic Uses of Algae** https://naturalhistory.si.edu/research/botany ➢ **Fungi: General account** https://microbiologyonline.org/about-microbiology/introducing-microbes/fungi ➢ **Fungal Biology** https://www.highveld.com/microbiology/what-are-fungi.html	
16.	**BOT 511** Bryophyta, Pteridophyta and Gymnosperm	After successful completion of the course, students will be able to: • Acquire the knowledge related to various cryptogamic and gymnospermic life forms, ecological and economical importance of these groups. • After completion of this course student will be able to identify these forms in their surroundings and will attract towards these branches of lower botany. • Students will be able to understand the morphological diversity of Bryophytes and		**Section A** • General characteristics of bryophytes, alternation of generation and classification. Life-cycle of bryophytes, asexual and sexual reproduction in various groups. Ecology - habitat diversity, growth forms, growth factors. • Role of bryophytes in pollution monitoring, geobotanical prospecting, horticultural uses, economic importance. • Moss protonema, protonemal differentiation and bud induction. • Comparative morphological and anatomical studies of gametophytes and sporophytes in various orders of: • Bryopsida: Sphagnales (*Sphagnum*), Andreaeales (*Andreaea*), Takakiales (*Takakia*), Buxbaumiales (*Buxbaumia*), Bryales (*Physcomitrium*), Polytrichales (*Polytrichum*) • Hepaticcopsida: • Calobryales (*Calobryum*), Metzgeriales (*Metzgeria*), Jungermanniales (*Jungermannia*), Sphaerocarpales (*Sphaerocarpous*),	New course proposed

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		Pteridophytes, and connections between gymnosperms and angiosperms. • They will know why these plants have to conserve for the sustainable ecosystem. • After passing this course they will be placed as researchers in research institutes and universities as these branches of botany searching for passionate young researchers.		Monocleales (*Monoclea*), Marchantiales (*Plagiochasma*, *Lunularia*, *Dumortiera*, *Cyathodium*) • Anthocerotopsida: • Anthocerotaceae – (*Anthoceros*, *Folioceros*), Notothyladaceae (*Notothylas*), Dendrocerotaceae (*Dendroceros*). **Section B** • General characteristics features and classification (Smith, 1955 and Bierhorst, 1971) of Pteridophytes. Morphology, anatomy and reproduction of Psilophyta (*Psilotum*), Lycophyta (*Lycopodium*, *Selaginella*), Sphenophyta (*Equisetum*), Pteropsida (*Marsilea*). Telome theory, Classification and evolution of steles. Heterospory and origin of seed habit. Apogamy, Apospory and Alternation of generations. • General account of fossil vascular cryptogams: *Rhynia*, *Horneophyton*, *Asteroxylon*, *Calamites* and *Lepidodendron*. Origin of cryptogams. Evolution of sorus in ferns. Economic importance of Pteridophytes **Section C** • General diagnostic features of gymnosperms with special reference to drop mechanism, vessel-less and fruitless seed plants. General account of anatomical variations in gymnospermic leaves (*Abies*, *Cedrus*, *Picea*, *Cycas* and *Taxus*) • Outline classification of gymnosperms as proposed by Sporne (1965) and Sandra Holms (1986), distribution of Gymnosperms with special reference to India. Economic importance of gymnosperms.	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				• A study of morphology, structure, outline life history of the following: . – Cycadopsida • Medullosaceae – *Medullosa* • Glossopteridaceae – *Glossopteris* • Cycadeoideaceae - *Cycadeoidea* (*Bennittites*) • Cycadaceae-*Cycas* – Coniferopsida • Ginkgoaceae – *Ginkgo* • Pinaceae – *Pinus* – Gnetopsida • Gnetales - *Gnetum* • Welwitschiales - *Welwitschia* **Suggested Books:** ➢ Bhatnagar, S.P. and Moitra, A. (1996). *Gymnosperm*. New Delhi: New Age International Pvt. Ltd. ➢ Parihar, N.S. (1996). *Biology and Morphology of Pteridophytes*. Allahabad: Central Book Depot. ➢ Singh, M. (1978). *Embryology of Gymnosperms, Encyclopaedia of Plant Anatomy*. Berlin: X. Gebruder Bortraeger. ➢ Sporne, K.K. (1991). *The morphology of pteridophytes*. Mumbai : B.I. Publishing Pvt. Ltd. ➢ Stewart, W.N and Rathwell, G.W. (1993). *Paleobotany and the evolution of plants*. Cambridge University press. ➢ Sunderrajan, S. (2007). *Introduction to pteridophyta*, New Delhi: New Age International Publishers. ➢ Alam, A. (2015). *Textbook of Bryophyta*. New Delhi: I K International Publishers.	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Suggested e-Resources: ➢ **Bryophytes: General account** http://bryophytes.plant.siu.edu/ ➢ **Bryophytes: Classification, structure** https://www.toppr.com/guides/biology/plant-kingdom/bryophytes/ ➢ **Bryophytes**: **Online lectures** https://www.swayamprabha.gov.in/index.php/program/ ➢ **Pteridophytes: General account, Classification, Life cycle** https://www.toppr.com/guides/biology/plant-kingdom/pteridophytes/ ➢ **Gymnosperms: General account, Classification, Life cycle** https://www.thoughtco.com/what-are-gymnosperms-4164250 ➢ **Gymnosperms: Economic importance** https://www.toppr.com/guides/biology/plant-kingdom/gymnosperms/	
17.	**BT 507** Cell and Tissue Culture Technology	After successful completion of the course, students will be able to: • Virtually develop an idea of cell culture laboratory. • Learn different techniques/methods of cell culture like primary cell culture, subculturing, cryopreservation, thawing etc. along with their applications. • Develop basics of	**Section-A** • Historical background and terminologies used in cell & tissue culture. • Basic techniques of cell and tissue culture, sterilization, aseptic tissue transfer, concept of totipotency. • Nutritional requirement of cell in vitro, various types of nutrient media. • Contamination and cytotoxicity • Cryopreservation and cell storage. • Isolation of plant cells, single cell cultures and cloning. **Section-B** • Organogenesis and somatic embryogenesis, applications in agriculture, horticulture & forestry.	**No change in syllabus, suggested books and E resources added** **Suggested Books:** ➢ Bhojwani, S.S. & Razdan, M.K. (1996). *Plant Tissue Culture*. USA: Elsevier Science. ➢ Chawla, H. S. (2000). *Introduction to Plant Biotechnology*. US: Science Publishers. ➢ Razdan, M. K. (2006). *Introduction to Plant Tissue Culture*. New Delhi, India: Oxford and IBH Pub. ➢ Smith, R. H (Ed.). (2013). *Plant tissue culture: Techniques and experiments*. Amsterdam: Academic Press. ➢ Buler, M. (2003). *Animal Cell Culture and*	Proposed to be introduced from M.Sc. Biotechnology, No modification

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		animal and plant cell culture which will help them to join any of the cellculture based research institution and industry of repute besides the academics employability. • Establish theirown cell culture laboratory as an entrepreneur.	• Haploid production: androgenesis, gynogenesis various techniques, applications. • Production of disease free plants by tissue culture methods. • Protoplast isolation and culture, fusion of protoplasts. • Somatic hybrids, selection methods, gene expression in somatic hybrids. **Section-C** • Disaggregation of animal tissue, isolation of cells, single cell culture, routine maintenance of animal cell lines. • Cloning & selection of specific animal cell types. • Transfection: gene transfer methods for adherent and non-adherent cell culture. • Cell fusion: fusogen, animal somatic cell fusion and selection of cybrids. • Animal organ culture. • Elementary idea about animal cell culture products. **Books Recommended :** ➢ Plant Tissue Culture: S.S. Bhojwani and M.K. Razdan, Elsevier Science, The Netherlands. ➢ An Introduction to Plant Tissue Culture: M.K. Razdan. ➢ Cell Culture Methods and Cell biology Vol. 4: D.W. Barens. ➢ Cell and Tissue Culture - laboratory procedure: A. Doyle. ➢ Plant Tissue Culture - A Practical Approach: R.A. Dixon, IRL Press. ➢ Biotechnology in Agriculture and Forestry: Y.P.S. Bajaj, Narosa. ➢ Plant cell and Tissue Culture: Rienert and Yeoman. ➢ Plant Cell Culture: Butenko. ➢ Plant Tissue Culture Methods and Applications in	*Technology* (2nd ed.). UK: Taylor & Francis. ➢ Mathur, S. (2006). *Animal Cell and Tissue Culture*. India: Agrobios. ➢ Clynes, M. (Ed.) (1998). *Animal Cell Culture Techniques*. Germany: Springer-Verlag Berlin Heidelberg. ➢ Pollard, J.W., & Walker, J.M. (Eds.). (1990). *Animal Cell Culture*. USA: Humana Press ➢ John, R. W. (2000). *Animal Cell Culture: A Practical Approach* (3rd ed.). UK: Oxford University Press. ➢ Freshney, R. I. (2011). *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications* (6th ed.). USA: Wiley-Blackwell. ➢ Davis, J. M. (2011). *Animal Cell Culture: Essential Methods*. New Jersey, USA: John Wiley & Sons Ltd. **Suggested e- Resources:** ➢ **Background of Tissue Culture Technology** http://www.biologydiscussion.com/botany/tissue-culture/tissue-culture-definition-history-and-importance/42944 ➢ **Embryogenesis and organogenesis** https://nptel.ac.in/courses/102103016/module1/lec8/3.html ➢ **Single cell cultures and cloning** http://www.biologydiscussion.com/botany/tissue-culture/methods-for-obtaining-single-cell-clones-from-callus-culture-plant-tissue-culture/43004 ➢ **Protoplasm isolation and regeneration** https://nptel.ac.in/courses/102103016/12 ➢ **Haploid plant production** http://www.biologydiscussion.com/plants/hapl	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Agriculture : T.A. Thorpe, Academic Press Inc.	oid-plants/production-of-haploid-plants-with-diagram/10700 ➢ **Preservation of cell lines** https://www.ukessays.com/essays/biology/techniques-for-cell-preservation-biology-essay.php ➢ **Somatic hybridization** http://www.biologydiscussion.com/somatic-hybridization/somatic-hybridization-aspects-applications-and-limitations/10686 ➢ **Animal cell culture products** http://www.biologydiscussion.com/biotechnology/animal-biotechnology/applications-of-animal-cell-cultures/10457 ➢ **Cell Culture Technology** https://onlinecourses.nptel.ac.in/noc17_bt21/preview	
18.	**BOT 505D** Literature Dissertation	After successful completion of the course, students will be able to: • Acquire the knowledge related to various life forms, ecological and economical importance of these groups. • After completion of this course student will be able to identify these forms in their surroundings and will convey the importance to the community which will help in the conservation of these forms to get better			

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		ecosystem.			
19.	**BOT 509L** Plant Science Lab I	After successful completion of the course, students will be able to: • Explain the puzzles of lower plants i.e., crytpogams. • Attain the knowledge about the life cycle, morphology, anatomy of important taxa of these plant groups. • Learn microscopy, anatomy, staining techniques which are basis of botany. • Understand the course of evolution by studying the interrelationships among cryptogams, gymnosperms and angiosperms. • Understand the importance of fossil plants. • Converse expertly through oral and written scientific media about these plants. • Recognize exact ways of training regarding lower plants and can address issues related to importance of these	~~1. Determination of dissolved O2 and total hardness in water.~~ ~~2. Fluoride estimation in different water samples.~~ ~~3. Biological assessment of water pollution.~~ 4. Preparation of media for tissue culture. 5. Embryo culture. ~~6. Calibration of microscope and Camera Lucida drawings.~~ ~~7. Screening of seed borne fungi by Blotter technique/Agar plate method.~~ ~~8. Study of important bacterial, fungal and viral diseases of plants mentioned in syllabus.~~ ~~9. Preparation of slides and identification of plant pathogens.~~ ~~10. Effect of temperature/pH/RH on the growth of fungi.~~ ~~11. Detailed study of locally available families~~ ~~12. Collection of plants and herbarium preparation.~~	Morphological and anatomical study of representative members of the following groups using whole mount preparations, dissections and sections: 1. **Algae:** Cyanophyta (*Microcystis*, *Stigonema*), Prochlorophyta (*Prochloron*), Chlorophyta (*Chlorella Hydrodictyon*, *Nitella*) Xanthophyta (*Botrydium*), Bacillariophyta (*Navicula*), Phaeophyta (*Dictyota*) 2. **Lichens:** Crustose, Foliose, Fruticose forms of lichen 3. **Fungi:** Myxomycota (*Plasmodiophora*), Mastigomycotina (*Peronospora*), Zygomycotina (*Mucor*), Ascomycotina (*Aspergillus*, *Erysiphe*), Basidiomycotina (*Puccinia*, *Ustilago*), Deutromycotina (*Fusarium*) 4. **Bryophyta:** Metzgeriales *(Metzgeria)*, Jungermanniales *(Porella*), Marchantiales *(Plagiochasma, Lunularia*, *Cyathodium)*, Sphagnales *)* *(Sphagnum)*, Polytrichales *(Polytrichum)*, Bryales *(Physcomitrium*) 5. **Pteridophytes**: Morphology and anatomy of vegetative and reproductive part of *Psilotum*, *Lycopodium*, *Selaginella*, *Equisetum*, *Gleichenia*, *Isoetes*, *Ophioglossum*, *Botrychium*, *Pteris* 6. **Gymnosperms:** Morphology and anatomy of vegetative and reproductive part of *Cycas*, *Ginkgo*, *Cedrus*, *Abies*, *Picea*, *Cupressus*, *Araucaria*,	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		plants in our ecosystem.		*Cryptomeria*, *Taxodium*, *Pedocarpus*, *Agathis*, *Taxus*, *Ephedra* and *Gnetum* and the members in their natural habitat found in your locality. Study of important fossil of Pteridophytes and Gymnosperms from specimens. 7. Preparation of media for tissue culture. 8. Embryo culture **Suggested Books:** ➢ Pandey, B.P. (2018). *Botany for Degree Students*. S. Chand Publishing, India ➢ Bendre, A. and Kumar, A. (2018). *A Text book of Practical Botany* Vol -I. Rastogi Publications, Meerut (India). ➢ Pandey, B.P. (2011). *Modern Practical Botany*, Vol-I. S. Chand Publishing, India ➢ Chaudhary, S.S., Chaudhary, P. and Prasad, T. (2010). *Practical Botany (Cryptogams and Gymnosperms).* CBS Publishers and Distributors. India. ➢ Kumar, S., Mishra, S. and Mishra, A.P. (2008). *Plant Tissue Culture: Theory and Techniques*. Scientific Publishers. India.	
M.Sc. Bioscience (Plant Science) IV Semester					
20.	**BOT 501** Angiosperms	After successful completion of the course, students will be able to: • Increase their capacity to think critically; ability to design and execute an experiment; confidence and ability in communicating ideas. • Serve as a lasting and practical basis for a career, for example, in		**Section-A** • Botanical explorations, historical perspectives. Botanical survey of India, its organization and role. Botanical nomenclature, History ICBN, Familiarity with Botanical literature, monographs, icones, floras, important periodicals with emphasis on Indian floristics, methods of literature Consultation. • Phytogeography with reference to discontinuous areas, endemism, floristic regions of the world. Principles of plant classification with emphasis on modern tools of taxonomy: cyto-, chemo-,	New course proposed

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		research whether industry or academia - as well as teaching, media, law, commerce, government or management.		palyno- and Numerical taxonomy: Taxonomy as a synthetic discipline; utility of taxonomy; biosystematics. Phylogenetic systems of classification with emphasis on comparative critical study of: Engler & Prantl, APG system of classification. • Phylogeny of Angiosperms: Origin, evolution, and interrelationships in dicots and monocots Interesting taxonomic features and phylogeny of the following families: – ***Dicotyledons***: Magnoleaceae, Nymphaeaceae, Ranunculaceae, Papaveraceae, Fumariaceae, Caryophylaceae, Bombacaceae, Malvaceae, Cucurbitaceae, Capparaceae, Brassicaceae, Rosaceae, Fabaceae, Myrtaceae, Rutaceae, Apiaceae, Apocynaceae, Asclepiadaceae, Solanaceae, Convolvulaceae, Cuscutaceae, Boraginaceae, Orobanchaceae, Acanthaceae, Rubiaceae, Asteraceae, Lamiaceae, Verbenaceae, Bignoniaceae, Moraceae, Cannabinaceae, Fagaceae. Betulaceae, Juglandaceae, Casuarinaceae, Nyctaginaceae, Chenopodiaceae, Amaranthaceae, Polygonaceae. – ***Monocotyledons:*** Alismatacea, Commelinaceae, Cyperaceae, Poaceae, Cannaceae, Arecaceae, Araceae, Lillaceae, Amaryliidaceae, Agavaceae, Smilacaceae and Orchidaceae. **Section B** • Origin, growth, differentiation and ultra structure of cells and tissues. Meristems-their structure and kinds; theories concerning root and shoot apices; organogenesis. Structure, ultra	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				structure ontogeny and evolution of primary secondary xylem and phloem indicating their phylogenetic role. • Normal and anomalous functioning of vascular cambium; cork cambium-periderm formation, abscission and wound healing. • Structural variability in leaves, leaf histogenesis, leaf meristem, origin, development and ultra structure of trichomes and stomata. • Comparative anatomy of typical dicot and monocot roots, stems and leaves. • Anomalies in the primary and secondary root and stem structures. • Organogamy of floral parts and floral biology. **Section C** • Historical perspective of the development of our knowledge in Embryology. • Microsporangium-structure and function of wall layers, nuclear behaviour in tapetum, microsporogenesis, microgametogenesis. • Megasporangium-structure, development and kinds of ovules, Morphological nature of ovules, megasporogenesis and megagametogenesis, embryo sac types and morphological nature of the embryo sac. • Pollination- natural and artificial, self and interspecific incompatibility, methods of overcoming incompatibilities. Fertilization-syngamy and triple fusion, post fertilization changes in ovules and embryo sac. • Endosperm-structure, kinds and morphological nature, endosperm haustoria, pseudo-embryo sac, xenia, metaxenia. mosaic endosperm, endosperm culture. • Embryo-structure and kinds of embryo	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				development, embryo culture. • Apomixis-vegetative propagation and agamospermy (adventive embryony, apospory and diplospory), parthenogenesis. • Polyembryony-origin, kinds and significance. **Suggested Books:** ➢ Zomlefer, W.B. (1995). *Flowering Plant Families*. USA: University of North Carolina Press. ➢ Gary, L. (2011). *Flowering Plants: A Pictorial Guide to the World Flora*. Firefly Books, Canada: Richmond Hill. ➢ Bhojwani, S.S., Bhatnagar , S.P. , Dantu, P.K. (1979). *The Embryology of Angiosperms* (6th ed.). India: Vikas Publishing House. ➢ Lawrence, G.H.M. (2017). *Taxonomy of Vascular Plants*. Jodhpur (Raj.): SENTIFIC Publishers, ➢ Alam, A., and Sharma, V. (2013). *Text Book of Economic Botany*. India: Pointer Publishers. ➢ Hill, A.F. (1952). *Economic Botany A Textbook of Useful Plants and Plant Products*. McGraw-Hill. ➢ Judd, W.S., & Campbell, C.S. (2007). *Plant Systematics A Phylogenetic Approach*. New York: Sinarue Publication. **Suggested e-Resources:** ➢ **Angiosperms: General account and Classification** https://www.toppr.com/guides/biology/plant-kingdom/angiosperms/ ➢ **Angiosperms: Taxonomy and evolution** https://www.britannica.com/plant/angiosperm ➢ **Angiosperms: Tree of Life Web project** http://tolweb.org/Angiosperms	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				➢ **Angiosperms: General account** http://landau.faculty.unlv.edu//angiosperms.htm ➢ **Angiosperm: Recent nomenclatural** www.theplantlist.org ➢ **Angiosperm: Palynology** https://www.floridamuseum.ufl.edu/index.php/paleobotany/palynology/about/ https://www.environmentalscience.org/palynology	
21.	**BOT 504** Cytogentics and Plant Breeding	After successful completion of the course, students will be able to: • Understand the chromosomal theory of inheritance and cytological & evolutionary consequences of polyploidy and aneuploidy on fertility in plants. • Learn about the fundamental concepts in cytogenetics. • Gain knowledge of the basic diagnostic tools of cytogenetics. • Familiarize with the common chromosomal aberrations and their evolutionary consequences in plants and animals. • Understand the	**Section-A** • Breeding methods of self pollinated & cross pollinated crops. • Improvement of Rice, Wheat & Maize through breeding in India • Inbreeding depression & heterosis. • Incompatibility, pollen fertility, male sterility. **Section-B** • Field technique including randomized block design (RBD) & complete randomized design (CRD). • Origin, cytology, effect & uses of structural chromosomal aberrations : ~~translocations, inversions, duplications, deficiencies and their role in evolution and genotypic & phenotypic variations.~~ • Karyotype analysis, uses and its evolution. • ~~Heterozygote systems in Oenathera.~~	**Section A** • Architecture of chromosome in prokaryotes and eukaryotes; Chromonemata, chromosome matrix, chromomeres, centromere, secondary constriction and telomere; artificial chromosome construction and its uses; Special types of chromosomes. • Introduction to techniques for karyotyping; Chromosome banding and painting - in situ hybridization and various applications • Origin, cytology, effect & uses of structural chromosomal aberrations. • Numerical variations of chromosomes and their implications. **Section B** • History of Plant Breeding (Pre and post-Mendelian era); Objectives of plant breeding, characteristics improved by plant breeding; Patterns of Evolution in Crop Plants-Centres of Origin-biodiversity and its significance. • Genetic basis of breeding self- and cross - pollinated crops including mating systems and response to selection - nature of variability, components of variation; Heritability and genetic advance, genotype environment	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		implications of chromosomal structural variation to plant breeding. • Attain the ability to operate basic consideration in order to analyze genetic data from cytogenetic diagnostic. An ability to incorporate cytogenetic considerations in breeding programs, in evolutionary studies, and in genetic analyses.	**Section-C** • ~~Euploidy, origin, cytology, genetics of haploids, haploids in agriculture.~~ • ~~Polyploid types, origin, cytology, genetics & genome analysis.~~ • ~~Aneuploids - Terminology & chromosome formula, origin, cytology, genetics, tranmission, effect & uses of Monosomics, trisomics & nullisomics.~~ • Extra nuclear inheritance. **Books Recommended :** ➢ Principles of Plant Breeding: Allard, R.W. 1990 John Willey & Sons. ➢ Cytogenetics & Plant Breeding : Chandrasekharan & F. Parthasarthy & Varadrachary & Co. Madras. ➢ Methods in Plant breeding : Hayas, H.K., F.R. Immer & I.D.C. Smith, Mc-graw Hill Book Company. ➢ Introduction to Plant breeding : Biggs, F.N. & Knowles P.F. Reinhold. ➢ Genetics, Plant breeding: B.D. Singh, Kalyani Publications. ➢ Cytogenetics, Plant breeding and Evolution: P.K.	interaction. • General and specific combining ability. • Self-incompatibility and male sterility in crop plants and their commercial exploitation. **Section C** • Plant introduction and role of plant genetic resources in plant breeding. • Pure line theory, pure line selection and mass selection methods; Line breeding, pedigree, bulk, backcross, single seed descent and multiline method; Population breeding in self-pollinated crops • Breeding methods in cross pollinated crops; Population breeding-mass selection and ear-to-row methods; S1 and S2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and interpopulation improvement and development of synthetics and composites; Hybrid breeding - heterosis and inbreeding. • Improvement of Rice, Wheat & Maize through breeding in India. **Suggested Books:** ➢ Gupta, P.K. (2007). *Cyotgenetics*. Meerut: Rastogi Publications. ➢ Gupta, P.K. (2005). *Cytology Genetics and Evolution*. Meerut: Rastogi Publications ➢ Mahabal, R. (2014). *Plant Breeding Methods*. Delhi: PHI Learning Private Ltd. ➢ Singh, B.D. (2009). *Plant Breeding, Principles & Methods*. Kalyani Publications. ➢ Allard, R. W. (1999). *Principles of Plant Breeding* (II ed.). Willey. ➢ Brown, J., Caligari, P.D.S. & Campos, H.A. (2014). Plant Breeding (II ed.). Wiley	

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			Gupta, Rastogi Publication. ➢ Elementary Principles of Plant breeding: H.K. Chaudhary, Oxford & IBH Publishing Co., New Delhi, Bombay.	Blackwell. ➢ Hayes, H., Immer, F.R. (2015). *Methods of Plant Breeding*. Create Space Independent Publishing Platform¸ Scotts Valley, California, United States. **Suggested e-Resources:** ➢ **Resource documents of the Genetic Engineering Appraisal Committee, Govt. of India**. http://www.geacindia.gov.in/resource-documents.aspx ➢ **Biology of Rice, Series of Crop specific Biology Documents, Ministry of Environment and Forests, DBT, Govt. of India** http://www.geacindia.gov.in/resource-documents/biosafety-regulations/resource-documents/Biology_of_Rice.pdf ➢ **Biology of Maize, Series of Crop specific Biology Documents, Ministry of Environment and Forests, DBT, Govt. of India** http://www.moef.gov.in/divisions/csurv/geac/Biology_of_Maize[1].pdf ➢ **Impact of Public and Private Sector Maize Breeding Research, CYMMYT.** https://repository.cimmyt.org/bitstream/handle/10883/1034/75341.pdf?sequence=1&isAllowed=y	
22.	**BOT 508** Plant Physiology	After successful completion of the course, students will be able to: • Demonstrate understanding of the organization of plants from the level of cells through tissues, tissue systems, and organs.	**Section-A** – Assimilation of Carbon in Plants: • Photosynthetic pigments, their distribution & functions. • Mechanism of Photosynthesis, Photosynthetic electron transport chain (Photophosphoryation). • Carbon dioxide reduction cycles in C3 & C4 Plants: Enzymes of C3 & C4 cycles & their location in the chloroplast.	No modification in the syllabus **Suggested Books:** ➢ Devlin, R.M., and Witham, F.H. (1969). *Plant Physiology*. New York: Van Norstand. ➢ Salisburry, F.B. and Ross, CW (1974). *Plant Physiology*. New Delhi: Prentice Hall of India. ➢ Noggle, G.R. and Fritz, J.F. (1976). *Introductory Plant Physiology*. New Delhi: Prentice Hall of Pvt.	No modification in the syllabus

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		• Demonstrate understanding of developmental patterns and processes of plants. • Demonstrate understanding of organellar function at the cellular level of architecture. Demonstrate understanding water potential and its effect on cellular function. • Demonstrate detailed understanding of the physiological mechanisms involved in the uptake and transport of water and the translocation of food by plants. • Demonstrate understanding of the cellular establishment of membrane potential and its role in solute transport. • Demonstrate understanding of the mechanisms for procurement of mineral ions by plants and mineral nutrition and the role these minerals play in organic molecule	• Photorespiration: pathway, enzymes & metabolic significance. • Crassulacean acid metabolism in plants. **Section-B** • Cell wall; Structure & functions, microfibril & matrix polysaccharides, proteins, lignins. • Plant growth regulators: Physiological importance & mechanism of action of: (a) Auxins (b) Gibberellins (c) Cytokinins (d) Abscissic acid (e) Ethylene. • Nitrogen Metabolism : ▪ Nitrate and nitrite reduction. ▪ Nitrogen fixation; mechanism and enzymes. • Role of temperature and light in plant development with reference to Photoperiodism & vernalization. • Phytochrome: Structure, function and mechanism of action. **Section-C** – Dormancy : • Nature and forms of dormancy, Mechanism of dormancy, Methods of breaking dormancy, Physiological basis of dormancy. • Macro & Micronutrients: Availability & Uptake, Role & specific functions of plant nutrients. • Biosynthesis of secondary metabolites, Major pathways : Shikimic acid, Acetate-malonate & acetate - mevalonate pathways. • Physiological importance of secondary metabolites. ➢ Plant Physiology : Devlin & Witham, Van Narst. ➢ Plant Physiology : Salisburry & Ross, Prentice Hall of India. ➢ Introductory Plant Physiology : Noggle & Fritz, Prentice Hall of Pvt. India. ➢ Plant Physiology: Taiz and Zeiger, Introduction to Plant Physiology: W.G. Hopkins, John Wiley and	➢ Taiz, L. and Zeiger, E. (2010). *Plant Physiology*. London: Sinauer Associate. ➢ Hopkins, W.G., and Huner, N.P.A. (2009). *Introduction to Plant Physiology*. John Wiley and Sons Inc. ➢ Pandey, S.N., and Sinha, B.K. (2005). *Plant Physiology*. New Delhi: Vikas Publishing House Pvt. Ltd. ➢ Buchanan, B.B., Greissum, G., and Jones, R.L. (2015*). Biochemistry and Molecular Biology of Plants*. Wiley Blackwell. **Suggested e-Resources** ➢ **Plant Physiology: Online course** https://has.nl/en/training/online-course-plant-physiology ➢ **Plant Physiology: Recent researches** http://www.plantphysiol.org/ ➢ **Plant Physiology: Online content** http://www.plantphysiol.org/content/by/year	

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		synthesis and use.	Sons Inc. ➢ Plant Physiology: Pandey & Sinha. ➢ Biochemistry and Molecular Biology of Plants: Buchanan, Greissum and Jons, I K International Publications.		
23.	**BOT 507** Plant Pathology	After successful completion of the course, students will be able to: • Develop learning goals and objectives in their courses and programs, in prioritizing and focusing the learning experiences, and in the selection of appropriate assessment tools. • Develop potential in outside agencies to assess the quality of our academic programs. • These learning outcomes areas include: Scholar, content and technical expertise, social accountability, communicator, and professional.	**Section A** – Host parasite relationship, Infection, development and establishment of the disease. – Epiphytotics : Compound and simple interest diseases, mathematical model, essential condition and analysis. – Effect of environment in epidemiology of the disease. – Genetic variability of plant pathogens. – Genetic basis of host pathogen interactions, its role in specificity of plant disease. **Section-B** – Plant disease control: Physical, Chemical and Biological (Biocontrol, Breeding, Genetic Engineering). – A general account of diseases caused by Bacteria, Viruses and Mycoplasma. – Bacterial diseases: Red stripe of sugarcane, Angular leaf spot of cotton, Soft rot of vegetables. – Viral diseases: Leaf roll of potato & tomato, Mosaic disease of tomato. – Mycoplasma diseases: Sandal spike, Sesamum phyllody, Little leaf of Brinjal. **Section-C** – Fungal diseases of cereals and millets: Rusts of wheat, Loose and covered smut of wheat and Barley, fungal diseases of Bajra, Charcoal rot of Maize. – Fungal diseases of vegetables and fruits : Early blight of Potato, Wart disease of Potato, Powdery	**Section-A** No modification in the syllabus, suggested books and E resources added. **Suggested Books:** ➢ Alexopoulus, C.M. (1996).*Introductory Mycology*. New York: John Wiley and Sons. ➢ Biswas, S. B., and Biswas, A. (2006) *An Introduction to Viruses*. India: Vikas Publishing House Pvt. Ltd. ➢ Bilgrami, K.S. and Dubey, H.C. (1998). *Text Book of Modern Pathology*. India: Vikas Publishing House Pvt. Ltd. ➢ Mehrotra, R.S. (1990). *Plant Pathology*. Tata McGraw Hill Publication Co. ➢ Butler, E.J. (1918). *Fungi and Diseases in Plants*. Kolkata: Thanker Spink and Co. ➢ Singh, R.S. (2017). *Plant Disease*. IBH, New Delhi: Oxford. ➢ Mundkur, B. (1967). *Fungi and Plant Diseases*. Macmillan and Co. Limited ➢ Agrios, G.N. (2005). *Plant Pathology*. USA: Elsevier Publication. **Suggested e-Resources:** ➢ **Fungi: *Aspergillus*** https://www.aspergillus.org.uk/content/mycology-online ➢ **Plant Pathology** https://www.apsnet.org/publications/apsnetfeatures/Pages/ICPP98PlantPath.aspx ➢ **Plant diseases: Identification and Control**	No modification in the syllabus

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			mildew of Cucurbits & Pea, Die back of Chillies, Tikka disease of Groundnut, Wilt & root rot of Gram, Red rot and smut of Sugarcane. – Nematode diseases: Root knot of vegetable (Cucumber), Molya disease of Wheat and Barley. – Insect diseases: General account of plant and animal galls with special reference to Mango & Ziziphus. **Books Recommended :** ➢ Introductory Mycology: C.M. Alexopoulus, John Wiley & Sons, New York. ➢ An Introduction to Viruses: S.B. Biswas, Vani Education. ➢ Text Book of Modern Pathology : K.S. Bilgrami & H.C. Dubey, Vikas Publishing House, New Delhi. ➢ Plant Pathology : R.S. Mehrotra, Tata McGraw Hill Publication Co. ➢ Fungi & Diseases in Plants: E.J. Butler, Thanker Spink & Co., Kolkata. ➢ Plant Disease: Singh, R.S., Oxford & IBH, New Delhi. ➢ Fungi & Plant Diseases, B. Mundkur: Macmillan & Co. ➢ Plant Pathology, Agrios, Simaner Publisher.	https://www.planetnatural.com/pest-problem-solver/plant-disease/ ➢ **Plant disease control** http://cemerced.ucanr.edu/files/40658.pdf	
24.	**BOT 510L** Plant Science Lab-II	After successful completion of the course, students will be able to: • Explain and justify the use of advanced techniques in taxonomy, microscopy, cytology, cyto-genetics, genotyping, plant physiology, and plant pathology especially	1. Morphotaxonomical and anatomical study of available plants mentioned in the syllabus ~~2. Study of economically important plants~~ 3. Preparation of MS media and demonstration of efficacy of growth hormones for the induction of shoot & root. 4. Estimation of Chlorophyll pigments. 5. Separation of plant pigments by TLC/Paper chromatography. 6. Isolation of chloroplast and demonstration of Hill's activity.	1. Morphotaxonomical and anatomical study of available plants mentioned in the syllabus 2. Emasculation technique 3. Preparation of various chemicals used for fixation, dehydration, staining and cleaning etc. for light microscopy. 4. Chromosome banding technique 5. Study of Mitosis and Meiosis 6. Study of endomitosis using endosperm of *Cocos nucifera* 7. Preparation of MS media and demonstration of	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		mycology, and to interpret the results of such analyses. • Utilize technical skills acquired through lab experience and apply these skills in formulating solutions to life science questions. • Communicate proficiently through oral and written scientific media. • Identify specific ways training in plant science that can address issues of earthly stewardship and sustainability, and demonstrate a strong desire to help Mankind in a socio-scientific way.	7. Calculation of RQ of Carbohydrates, fatty acids, and organic acids by Ganong's respirometer. 8. Extraction and analysis of phytochemicals from plant samples 9. Screening of seed borne fungi by Blotter technique/Agar plate method. 10. Study of important bacterial, fungal and viral diseases of plants mentioned in syllabus. 11. Preparation of slides and identification of plant pathogens. 12. Effect of temperature/pH/RH on the growth of fungi.	efficacy of growth hormones for the induction of shoot & root. 8. Estimation of Chlorophyll pigments. 9. Separation of plant pigments by TLC/Paper chromatography. 10. Isolation of chloroplast and demonstration of Hill's activity. 11. Calculation of RQ of Carbohydrates, fatty acids, and organic acids by Ganong's respirometer. 12. Extraction and analysis of phytochemicals from plant samples 13. Screening of seed borne fungi by Blotter technique/Agar plate method. 14. Study of important bacterial, fungal and viral diseases of plants mentioned in syllabus. 15. Preparation of slides and identification of plant pathogens. 16. Effect of temperature/pH/RH on the growth of fungi.	
Proposed Elective courses to be offered in III & IV Semester					
1)	**BOT Phycology-I**	After successful completion of the course, students will be able to: • Identify these algal forms in their surroundings and will be motivated to better understand this interesting branch of botany. • Know the basis of photosynthesis with		**Section A** • Diagnostic characters of major algal division Cyanophyta, Glaucophyta, Chlorophyta, Dinophyta, Phaeophyta and Rhodophyta • Principles, criteria (pigments, cell wall, flagellation, food reserve and eye spots) and systems of classification • Modern criteria of algal classification with special emphasis on chloroplast ultra structure, flagella and pigments. • Biodiversity and Conservation of Algae- Habit and Habitat diversity , Importance of	New course proposed

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		amazing diversification in these plants. • Gain placement as researchers in marine research, space research and biofuel research institutes.		Conservation : in situ and ex situ conservation • Wetlands and Algal assemblages: Role of Algae in Wetlands and structural Environment. • Work done on freshwater algae with special reference to India & Contributions of Prof. M. O. P. Iyengar. • Distribution pattern of Marine algae in Indian coasts. • Endosymbiosis theories and origin of Eukaryotic algae **Section** B • Cyanophyta: cell structure, heterocyst and akinete development and Physiological aspect ; chromatic adaptation, thallus organization and reproduction • Alternation of generation in Phaeophyta and post -fertilization development and site of meiosis in Rhodophyta **Section C** • A brief account of Xanthophyta, Chrysophyta, Bacillariophyta, Pyrrophyta, Euglenophyta, Eustigmatophyta, Prasinophyta and Prochlorophyta • Algae in Specialized habitats, Phytoplankton diversity , algal blooms and Phycoviruses • Algae as source of phycocolloids , types and Importance • Algal Culture brief idea and types • Algae in Human welfare – Nutraceutical, Pharmaceutical , Biofertilizer , Biofuel , CO_2 Sequestration and pollution control • Algal Biotechnology : Genome shuffling and evolutionary engineering ; application of Synthetic biology in algae **Suggested Books:**	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				➢ Kumar, H.D. and Singh, H.N. (1979). A textbook on Algae. Macmillan Publishers Limited. ➢ Round, F.E. (1986). *The Biology of Algae*. Cambridge University Press, Cambridge. ➢ Nash, T.H. (2011). *Lichen Biology*. Cambridge University Press. Cambridge. ➢ Bilgrami, K.S. and Saha, L. (2007). *A textbook of Algae*. CBS Publishers and Distributors. **Suggested e-Resources:** ➢ Algae https://www.livescience.com/54979-what-are-algae.html	
2)	**BOT** Phycology- II	After successful completion of the course, students will be able to: • Understand the various application and career opportunities in algology. • Know the industrialization aspects of these plants. • Work in various industries or build their career in algal research.		**Section A** • Biochemical taxonomy of algae. Fossil algae: Major events in the geological time scale during evolution of algae in relation to corresponding environment and other life forms; • Carbon dioxide concentrating mechanism (CCM) in algae. • Phytoplankton Ecology: factors (light, temperature, chemical & current) and distribution. • Terrestrial algal ecology: soil algae, cryo algae and subaerial algae • Macroalgal and periphyton ecology: biogeography of seaweeds; influence of biological factors • Algae of unusual habitats: thermal algae, halotolerant forms and their ecology **Section B** • Phylogeny of algal plastids. • Ultrastructure of flagella and its taxonomic importance. • Extracellular products of algae & toxic algae.	New course proposed

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				• Algae in Biotic associations. • Algal biotechnology with special reference to health, food, bio cosmetics, medicine, hydrocarbon production, biomonitoring and bioremediation. • Control of aquatic algae. • Biogeochemical role of algae • Isolation, purification & growth characteristics in relation to algal culture; indoor and outdoor cultivation culture; photobioreactors. **Section C** • Models (Monod and Droop) of nutrient-regulated phytoplankton growth; common methods for mass cultivation of microalgae • Causal factors and dynamics of freshwater and marine algal blooms; physical and chemical means and biomanipulation (top-down and bottom-up) for controlling nuisance blooms • Consequences of blooms including toxins of cyanobacteria and dinoflagellates; algal biofouling of ships and its control • Commercial potential of *Spirulina*, *Dunaliella*, *Botryococcus* and *Porphyra*; hydrogen production by algae • High-rate algal ponds for the treatment of wastewaters and for the production of useful biomass and energy; immobilized and inactivated algal biomass for metal and nutrient removal • A brief account of cyanobacterial genomics and proteomics • Paddy field cyanobacteria: Qualitative and quantitative assessment of their biodiversity using molecular tools; their use as biofertilizer, reclamation of user lands	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				• Influence of salt, heavy metals and acid rain on algae: Physiological and biochemical effects; biochemical and molecular mechanisms of tolerance **Suggested Books:** ➢ Kumar, H.D., and Singh, H.N. (1979). *A textbook on Algae*. Macmillan Publishers Limited. ➢ Round, F.E. (1986). *The Biology of Algae*. Cambridge: Cambridge University Press. ➢ Nash, T.H. (2011). *Lichen Biology*. Cambridge: Cambridge University Press. ➢ Bilgrami, K.S., and Saha, L. (2007). *A textbook of Algae*. CBS Publishers and Distributors. ➢ Lee, R. E. (2008). *Phycology*. Cambridge University Press, New York. **Suggested e-Resources:** **General account on Algae** https://www.livescience.com/54979-what-are-algae.html **Basic Algology**: http://allaboutalgae.com/what-are-algae/ **Algal Phylogeny and origin** http://www.plantphysiol.org/content/116/1/9 **Economic importance of Algae** http://news.algaeworld.org/2017/07/economic-importance-of-algae/	
3)	**BOT** Bryology-I	After successful completion of the course, students will be able to: • Identify these Lilliputians of plant kingdom in their surroundings and will be able to collect those		**Section A** • General characteristics of bryophytes, alternation of generations and classification. • Evolution in bryophytes • Life-cycle of bryophytes, asexual and sexual reproduction. **Section B** • Comparative morphological and anatomical	New course proposed

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		from their natural habitats hence motivated to better understand this fascinating group of plants. • Know the basis of thallus organization with amazing diversification. • Gain placement as researchers in various institutes and universities.		studies of gametophytes and sporophytes in various orders of the class Bryopsida: – Takakiales - Takakia – Sphagnales - *Sphagnum* – Andreaeales - *Andreaea* – Buxbaumiales - *Buxbaumia* – Bryales - *Physcomitrium*, *Fontinalis*, *Splachnum* – Polytrichales – *Polytrichum* **Section C** • Comparative morphological and anatomical studies of gametophytes and sporophytes in various orders of the class Hepaticopsida – Calobryales - *Calobryum*, *Haplomitrium* – Metzgeriales - *Pallavicinia*, *Riccardia*, *Metzgeria* – Jungermanniales - *Jungermannia*, *Porella*, *Ptychanthus*, *Radula* – Sphaerocarpales - *Riella*, *Sphaerocarpous* – Monocleales - *Monoclea* – Marchantiales - *Reboulia*, *Plagiochasma*, *Asterella*, *Lunularia*, *Dumortiera*, *Targionia*, *Cyathodium* **Suggested Books:** ➢ Alam, A. (2015). *Textbook of Bryophyta*. New Delhi : I K International Publishers. ➢ Schofield, W. B. (2001). *Introduction to Biology* (Reprint ed.). Caldwell, New Jersey: The Blackburn Press. ➢ Chopra, R.N. (2005). *Biology of Bryophytes*. India: New Age International Publishers. ➢ Pope, R. (2016). *Mosses, Liverworts, and Hornworts*: *A Field Guide to Common Bryophytes of the Northeast*. Ithaca, NY:	

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				Comstock Publishing Associates. ➢ Gangulee, H.C. (1978). *Mosses of Eastern India and adjacent regions*. India: Kalyani Publishers. **Suggested e-Resources:** ➢ **Bryophytes: Identification, Ecology** https://openlibrary.org/subjects/bryophytes ➢ **Bryophytes: General account, classification and structure** http://nsdl.niscair.res.in/jspui/bitstream/123456789/150/1/BRYOPHYTES%20.pdf ➢ **Bryophytes: Ecology** https://digitalcommons.mtu.edu/bryophyte-ecology/ ➢ **Bryophyte: Phylogenetic classification** http://bryophytes.plant.siu.edu/class.html	
4)	**BOT** Bryology-II	After successful completion of the course, students will be able to: • Know the various advances in the field of bryology. • Know the modern trends in bryology. • Carry on their research in India and abroad. • Gain good opportunities as researchers in various institutes and universities.		**Section A** Comparative morphological and anatomical studies of gametophytes and sporophytes in various orders of the class Anthocerotopsida: • Anthocerotaceae - *Anthoceros*, *Folioceros* • Notothyladaceae - *Notothylas*, *Phaeoceros* • Dendrocerotaceae - *Dendroceros*, *Megaceros* • Origin, evolution, fossil history, phylogeny of principal classes: Bryopsida, Hepaticopsida and Anthocerotopsida **Section B** • Ecology - habitat diversity, growth forms, growth factors. • Role of bryophytes in pollution monitoring, geobotanical prospecting, horticultural uses, economic importance. • Spore diversity, dispersal mechanism and their germination. • Moss protonema, protonemal differentiation and	New course proposed

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				bud induction. **Section C** • Ecological aspects of bryophytes: Bryophytes in relation to nutrient cycling, water restoration, bryophytes associations • Ethnobryology • Molecular Bryology • Phytochemicals from bryophytes • Horticultural uses of bryophytes **Suggested Books:** ➢ Rashid, A. (1998). *An Introduction to Bryophyta*. India: Vikas Publishing, ➢ Udar, R. (1978). *Bryology in India*. Chronica Botanica Company. ➢ Alam, A. (2015). *Text book of Bryophyta*. New Delhi: I K International Publishers. ➢ Schofield, W. B. (2001). *Introduction to Biology* (Reprint edition). The Blackburn Press. ➢ Chopra, R.N. (2005). *Biology of Bryophytes*. India: New Age International Publishers. ➢ Pope, R. (2016). *Mosses, Liverworts, and Hornworts: A Field Guide to Common Bryophytes of the Northeast*. Ithaca, NY: Comstock Publishing Associates. ➢ Gangulee, H.C. (1978). *Mosses of Eastern India and adjacent regions*. Kalyani Publishers, India. **Suggested e-Resources:** ➢ **Bryophyta: Classification** http://bryophytes.plant.siu.edu/class.html ➢ **Bryophyta: Phylogenetic classification** https://bryology.uconn.edu/classification/ ➢ **Bryophyta: Conventional classification** https://www.google.com/search?client=firefox-b&q=recent+classification%3A+liverworts ➢ **Bryophytes: Overall account**	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				https://openlibrary.org/subjects/bryophytes ➢ **Bryophyta: Cryptogamic account** http://nsdl.niscair.res.in/jspui/bitstream/123456789/150/1/BRYOPHYTES%20.pdf ➢ **Bryophyta: Ecology** https://digitalcommons.mtu.edu/bryophyte-ecology/	
5)	**BOT** Angiosperm Taxonomy and Systematics-I	After successful completion of the course, students will be able to: • Understand methods and principles of plant classification and nomenclature. • Learn representative plant families and genera of flowering plants will also help students to identify the plants. • Learn the embryology, biosystematics, bryodiversity and conservation methods of economically important plants.		**Section A** • Systematics: Outline of classification of Angiosperms; Hutchinson, Takhtajan, Cronquist, merits and demerits • Botanical nomenclature: International code of Botanic Nomenclature; principles: Rules and recommendations; priority; typification; Rules of effective and valid publications; retention and choice of names • Taxonomic features, systematic phylogeny and economic importance of families: Magnoliaceae, Capparidaceae, Combretaceae, Rosaceae, Amaranthaceae, Asteraceae, Apocynaceae, Asclepiadaceae, Convolvulaceae, Scrophulariaceae, Acanthaceae, Bignoniaceae, Lamiaceae, Verbenaceae, Polygonaceae, Euphorbiaceae, Orchidacae, Zingiberaceae, Araceae, Cyperaceae and Poaceae • Numerical taxonomy: Aims and objectives, characters and attributes, OTUs, coding, cluster analysis, merits and demerits • Chemotaxonomy: Role of phytochemicals (non-protein amino acids, alkaloids, betalins, cynogenic glucosides, silica, gypsum, raphides, glucosinolate, flavonoids, terpenoids) in taxonomy • Embryology in relation to taxonomy **Section B**	New course proposed

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				• Molecular approaches to plant taxonomy: Application of DNA markers in angiosperm taxonomy; molecular phylogeny • Self incompatibility: Structural and biochemical aspects; methods to overcome incompatibility – mixed pollination, bud pollination; intra - ovarian pollination, in vitro pollination • Experimental embryology: Haploid production; diploidization of haploids, importance of haploids; embyro culture; culture of differentiated and mature embryos; role of natural plant extracts and growth hormones; embryo-nurse endosperm transplantation; culturing of embryonal segments; practical aspects of embryo culture **Section C** • Biosystematics principles, practice, limitations and scope, phenotypic plasticity, epigenetics ; • Biodiversity: general concept, values, isolation and assessment of Genetic Diversity. • Distribution of endemic plant families in the southern hemisphere of the globe. • Conservation: Principles, categories of threatened plants (IUCN), strategies of conservation, Red Data Book. • Botanical Survey of India, its contribution and functions • Molecular markers in Taxonomy and phylogenetic analysis: Nuclear ribosomal DNA, Chloroplast DNA and Mitochondrial DNA **Suggested Books:** ➢ Naik V.N. (1988). *Taxonomy of Angiosperms*. New Delhi: Tata Mc-Graw Hill Publishing Co. ➢ Hoorn, C., Perrigo, A., & Antonelli, A. (2018). *Mountains, Climate and Biodiversity: A*	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				comprehensive and up-to-date synthesis for students and researchers. Wiley Science Publishers, USA. ➢ Rathod, M.M. (2016). *Floristic Ecology and Phytogeography*. Chandralok Prakashan**,** Kanpur, India ➢ Graf, A. B. (2010). *Flora of India*. Rajat Publications, India. ➢ Judd, W.S., & Campbell, C.S. (2007). *Plant Systematics Aphyllogenetic Approach*. Sinarue Publication, New York. **Suggested e-Resources:** ➢ **General account of angiosperms**: http://www.nhptv.org/natureworks/nwep14f.htm ➢ **Angiosperm-Life tree** http://tolweb.org/Angiosperms ➢ **Angiosperms: Classification and Reproduction** https://www.toppr.com/guides/biology/plant-kingdom/angiosperms/ ➢ **Angiosperms: Phylogeny** http://www.mobot.org/MOBOT/research/APweb/ ➢ **Angiosperms: APG system of classification** https://academic.oup.com/botlinnean/article/181/1/1/2416499	
6)	**BOT** Angiosperms Taxonomy and Systematics-II	After successful completion of the course, students will be able to: • Describe the evolution by natural selection and other causes. • Get knowledge about the nature of "species" and can compare		**Section A** • Plant taxonomy through ages in India: Major contributions of W. Roxburgh, N. Wallich, J.D. Hooker, C. B. Clarke, G. King and K.P. Biswas. Current status of Botanical Survey of India (B.S.I), Central National Herbarium (CAL): role in systematic study in India. Acharya Jagadish Chandra Bose Indian Botanic Garden (AJCBIBG) & National Botanical Research	New course proposed

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		contrasting concepts of species. • Describe binomial nomenclature and use scientific names of species correctly. • List levels of the Linnaean hierarchical classification system and use it properly. • Discuss advantages and disadvantages of the Linnaean system describe systematics. • Correctly interpret phylogenetic trees and explain their construction.		Institute (NBRI): activities in relation to taxonomic studies and conservation. • Taxonomic Literature: Categories, brief concept with examples. • Floristic regions of the world (Takhtajan, 1987); Floristic Composition of India: description and composition of Himalayan, Peninsular and Desert vegetation. Biodiversity Act, Role of National Biodiversity Authority (NBA) in biodiversity management; CBD and environmental protocols. **Section B** • Latest changes, addition and alteration in International Code of Botanical Nomenclature (ICBN); Valid Publication: provision of new taxa (Genus); Nomenclature of Hybrid Plants; Nomenclature of Cultivated Plants (ICNCP). • Evolutionary concepts: monophyly, paraphyly, polyphyly, plesiomorphy, apomorphy, anagenesis, stasigenesis, cladogenesis, homology, analogy, homoplasy, parallelism and convergence, synapomorphy and symplesiomorphy. • Modern trends in Taxonomy: Nodal Anatomy: structure, types, evolution and applications. • Palynotaxonomy: pollen structure, types and evolution of pollen grains, applications. Serology, Ultra structures. **Section C** • Biodiversity: components, levels, values, Hotspots and conservation. • Concept of Phytogeography: Endemism, Plant migration, Disjunction, Vicariance, Phytochorionomy (Brief introduction). • Major Phytochona of the World and India.	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				• Ministry of Environment and Forest, India **Suggested Books:** ➢ Hoorn, C., Perrigo, A., and Antonelli, A. (2018). *Mountains, Climate and Biodiversity: A comprehensive and up-to-date synthesis for students and researchers*. USA: Wiley Science Publishers. ➢ Rathod, M.M. (2016). *Floristic Ecology and Phytogeography*. Kanpur, India: Chandralok Prakashan. ➢ Graf, A. B. (2010). *Flora of India*. India: Rajat Publications. ➢ Judd, W.S., and Campbell, C.S. (2007). *Plant Systematics A phylogenetic Approach*. New York: Sinarue Publication. **Suggested e-Resources:** ➢ **IUCN Red List** https://www.iucnredlist.org/ ➢ **Angiosperms: Herbarium resources** http://apps.kew.org/herbcat/gotoWhatIsHerbarium.do ➢ **Angiosperms: Herbarium techniques** https://herbarium.duke.edu/about/what-is-a-herbarium ➢ **International Code of Botanical Nomenclature** https://www.iapt-taxon.org/icbn/main.htm ➢ **Biodiversity**: https://www.greenfacts.org/en/biodiversity/l-3/1-define-biodiversity.htm ➢ **Conservation of Biodiversity**: http://enviroeducation.com/resources/biodiversity-academic-requirements-professional-outlook ➢ **Angiosperms: Playnotaxonomy** https://openlibrary.org/subjects/palynotaxonom	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				y	
7)	**BT 521:** Plant Biotechnology	After successful completion of the course, students should be able to: • Demonstrate principles for development of various stress resistant plants • Understand various techniques used in plant biotechnology	**Section-A** • Introduction, examples of current use of plant biotechnology. • Development of pathogen resistant plants (virus & insect resistance). • Development of plants of improved seed quality. • Artificial seeds. • Development of plants resistant to environmental stress. • Development of herbicide resistant plants. • Future outlook. **Section-B** • Immobilization of cells. • Gene delivery methods in intact and cultured tissues and cells. ○ *Agrobacterium*, Ti plasmids, ~~co-integrate and binary vectors~~. Other vectors - viral vectors. ~~○~~ Direct DNA uptake~~, microprojectile delivery, electroporation, microinjection, Liposomes.~~ • Chloroplast engineering : Advantages of ~~chloroplast transgenics~~, applications in production of biopharmaceuticals, introduction of agronomic traits, viz. disease resistance, herbicide resistance, salt and drought resistance; phytoremediation etc. • Biotechnology of Biological Nitrogen fixation: *nif* genes **Section-C** • Production of metabolites; metabolic engineering and industrial products: plant secondary metabolites; control mechanisms and manipulation of phenyl propanoids and shikimate pathways; general strategy towards production of plant cell products. • Biotransformation using plant cells.	**Section A** • Introduction, examples of current use of plant biotechnology. • Development of pathogen resistant plants (virus & insect resistance). • Development of plants of improved seed quality; Artificial seeds. • Development of plants resistant to environmental stress and herbicides. • Future outlook. **Section-B** • Immobilization of cells. • Direct gene delivery methods. • Vector based gene delivery methods: *Agrobacterium* mediated, Ti plasmid based vectors, viral vectors. • Chloroplast engineering: Advantages of transplastomics, applications in production of biopharmaceuticals, introduction of agronomic traits, viz. disease resistance, herbicide resistance, salt and drought resistance; phytoremediation etc. • Biotechnology of biological nitrogen fixation: *nif* genes. **Section-C** • Production of metabolites; metabolic engineering and industrial products: Overview of plant secondary metabolites; control mechanisms and manipulation of phenyl propanoids and shikimate pathways; general strategy to regulate the production of plant cell	Modifications have been done in the light of current technologies.

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• Cryobiology of plant cell cultures~~and establishment of gene banks.~~ • Edible vaccines. • ~~Radiobiology of cultured plant cells.~~ **Books Recommended :** ➢ Biotechnology - A Laboratory Course: J. M. Becker, G.A. Coldwell and E.A. Zachgo, Academic Press, New York. ➢ Genetic Engineering Technology in Industrial Pharmacy: Ed. - J.M. Tabor. ➢ Tissue Culture, Methods and Applications: P.F. Kruse. ➢ Plant Tissue Culture: Sharma and Alam; IK International Publisher Pvt. Ltd.	products. • Biotransformation using plant cells. • Cryobiology of plant cell cultures. • Edible vaccines. • Molecular markers - hybridization and PCR based markers RFLP, RAPD, STS, SSR, AFLP, SNP markers. **Suggested Books:** ➢ Singh, B.D. (2011). *Plant Biotechnology* (2nd ed.). New Delhi, India: Kalyani Publisher. ➢ Chawla, H.S. (2009). *Plant Biotechnology* (3rd ed.). New Delhi, India: Oxford & IBH Publishing Co. Pvt. Ltd. ➢ Slater, A. (2008). *Plant Biotechnology: The Genetic Manipulation of Plants* (2nd ed.). Oxford, UK: Oxford Publisher. ➢ Peter, K.V., & Keshavachandran, R. (2008). Plant Biotechnology: Methods in Tissue Culture and Gene Transfer. India: Universities Press. ➢ Murphy, D. (2007). *Plant Breeding and Biotechnology: Societal Context and the Future of Agriculture* (1st ed.). UK: Cambridge University Press. ➢ Singh, B.S. (2007). *Fundamentals of Plant Biotechnology*. New Delhi, India: Satish Serial Publishing House. **Suggested e- Resources:** ➢ **Chloroplast Biotechnology** https://onlinelibrary.wiley.com/page/journal/14677652/homepage/chloroplast_biotechnology_special_issue.htm ➢ **Plant transformation technologies** http://repository.ias.ac.in/57240/1/23-pub.pdf ➢ **Abiotic stress and transgenics** http://repository.ias.ac.in/89833/1/1-pub.pdf	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
8)	**BT: Advanced Plant Biotechnology**	After successful completion of the course, students will be able to: • Gain advance knowledge in plant biotechnology and their applications in crop improvement, large scale production of plant metabolites • Get practical insight of techniques. • Carry out further research in plant biotechnology.		**Section A** • **Molecular Pharming -** concept of plants as Biofactories, production of industrial enzymes and Pharmaceutically important compounds. • Heavy metal toxicity in plants, metal hyperaccumulation & resistance mechanisms. • **Concept of Phytoremediation** and its applications • **Bioremediation of inorganic** (Metals and radionucloides) and organics (TCE/petroleum hydrocarbons/ solvents/ explosives etc.) in the environment **Section B** The improvement of crop yield and quality; – The genetic manipulation of fruit ripening – Genetic modifications of ethylene biosynthesis and ethylene based fruit sensor; – Golden Rice – Role of phytohormones in improving the yield of oil seed crops – CRISPER-CAS and marker free technology **Section C** – Production of Bio-fuels from Algal and Plant based biomass – Regulation of Abiotic and Biotic Stress Responses by Plant Hormones – Nanobiotechnology in Plant research: Effect of different nanomaterials and nanoparticles on Plant – The Regulation of GM crops and products and the current status of the GM crops – Intellectual Property in Agriculture Biotechnology	New course proposed

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				– The future of Plant Biotechnology **Suggested Books:** ➢ Stewart C. Neal (2018) Plant Biotechnology and Genetics Wiley Publications. ➢ Prasad, R (2018) Mycoremediation and Environmental sustainability, Springer Publication ➢ Evans, G. M. & Furlong, J. C. (2011), *Environmental Biotechnology: Theory and Applications*, Wiley Publishers. ➢ Oksman-Caldentey, Kirsi-Marja. (2014). *Plant biotechnology and transgenic plants*. Marcel Dekker. ➢ Slater, A. Scott, N.W. & MR Fowler. (2014). *Plant bio technology* (2nd ed.). Oxford University Press. ➢ Kumar, A. (2008) *Recent advances in plant biotechnology and its applications*. New Delhi: I.K. International Pub. ➢ Ahmed, P (2017). Oil seeds Crops. Wiley Publication **Suggested e- Resources:** ➢ **Book Oil Seed crops(https://onlinelibrary.wiley.com/doi/book/10.1002/9781119048800** ➢ **Plant environment interactions** http://fmipa.umri.ac.id/wp-content/uploads/2016/03/Frantisek_Baluska_Plant-Environment_InteractionsBookFi.org_.pdf ➢ **Biotechnology for crop improvement** https://nptel.ac.in/courses/102103013/pdf/mod6.pdf https://www.intechopen.com/books/plants-for-the-future/molecular-farming-in-plants	
9)	Bio Physics-I	After completion of this		**Section A**	(New Introduced Elective

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		course, the students will be able to- • Understand the concepts of physical principles in the biomolecular systems. • Know properties and conformations of biomolecules • Understand the interaction between physics and biology		• Introduction: Brief introduction to all aspects of Biology, cellular automata, Conway's Game of life. • Cell structure and function: Cell theory, cell membrane and transport, membranous organelles, Non-membranous organelles, Nuclear components and major cell types, viruses. • Molecules in the cell: carbohydrates, lipids, proteins and nucleic acids, their structure and function. • Code of life: Central dogma, DNA replication, transcription and translation. • Energy in life forms: Cellular Respiration, Glycolysis, Krebs cycle, Electron transport chain, ATP calculation, Photosynthesis, C4 pathway. **Section B** • Intermolecular interactions: Covalent interactions, disulphide bonds, van der Waals Interactions, bond angles and torsions. Role of hydrogen bonding and hydrophobic interaction in biomolecular structures. Examples of α-helices and β-sheets in proteins, Watson-Crick pairs in DNA, stacking interactions in DNA and RNA. • Protein Conformation: Conformational properties of polypeptides, Ramachandran plot, Helical parameters and conformation, organization as secondary and supersecondary structures in proteins, domains and motifs. Protein folding *in vivo* and *in vitro* of globular proteins, basic idea. **Section C** • Molecular Mechanics: Force field equation,	Course, cw M.Sc. Physics)

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Lennard Jones Potential, Potential energy surface, Z-matrix, Molecular modeling, Energy minimization techniques, Exhaustive search method, steepest descent and conjugate gradient methods, Molecular dynamics simulation, Verlet algorithm and simulated annealing protocol. • Experimental techniques used to determine biomolecular structure: Principles and application of UV-visible, circular dichroism and fluorescence spectroscopy. • Case studies on Helix to coil transitions, melting curves in proteins and DNA structures. X-ray crystallography of biomolecules: Obtaining single crystals of biomolecules, Single crystal data collection, Determination of point group, space group from symmetry of diffraction patterns, deducing cell parameters, interpretation of intensity data, Calculation of electron density, Solving the phase problem, Structure validation. **Suggested Books:** ➢ Tuszynski, J. A. & Kurzynski, M. (2003). *Introduction to Molecular Biophysics*. CRC press. ➢ Schlick, T. (2010). *Molecular Modeling and Simulation: An Interdisciplinary Guide: An Interdisciplinary Guide* (Vol. 21). Springer Science & Business Media. ➢ Voet, D., Voet, J. G. & Pratt, C. W. (2013). *Fundamentals of Biochemistry: Life at The Molecular Level* (No. 577.1 VOE). Hoboken: Wiley. ➢ Cantor, C. R., & Schimmel, P. R.	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				(1980). *Biophysical chemistry: Part III: The Behavior Of Biological Macromolecules*. Macmillan. ➢ Van Holde, K. E. J. W. Principles of physical biochemistry/Kensal E. Van Holde, W. Curtis Johnson, P. Shing Ho. ➢ Jensen, J. H. (2010). *Molecular Modeling Basics*. CRC Press. ➢ Nelson, P. (2004). *Biological Physics*. New York: WH Freeman. **Suggested e-Resources:** ➢ **Non-Conventional Energy Systems** https://nptel.ac.in/syllabus/1021 • **Quantum-mechanics of molecular structure** https://bit.ly/2SoEqof https://bit.ly/2SoEqof	
10)	Bio Physics-II	After completion of this course, the students will be to- • Understand the concepts of physical principles in the biomolecular systems. • Know Properties and conformations of biomolecules • Understand the interaction between physics and biology		**Section A** • Physics of macromolecules: Biological polymers, modeling polymers as elasticity models, Random walk model, radius of gyration, freely jointed chain, calculation of the distribution of end-to-end distances, statistical segment, persistence length, relation to characteristic ratio, worm like chain, behavior of chain dimension, DNA Elasticity, Application of Porod-Kraty model to DNA. • Protein folding: Anfinsen’s thermodynamic hypothesis, Case study: Ribonuclease A, renaturation and denaturation, mechanism of disulphide exchange, determinants of protein folding, Levinthal’s paradox, classical view of protein folding, the hydrophobic collapse, Energy landscape theory, Protein Folding problem as a NP-hard problem. **Section B**	New proposed Elective Course, introduced from M.Sc. Physics

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				• Self assembly and membrane equilibria: Self assembly in miscelles as monolayers and bilayers, Thermodynamics of miscelle formation, co-operativity, packing parameter, Tanford's free energy model, Packing model, influence of tail packing, Fluid mosaic model, Langmuir adsorption model. • Electrical conduction in the nervous system: Structure of the neuron, Hodgkin-Huxley model and generation of action potential, Nernst relation in membrane potentials, Donnan equilibrium, ion pumping, voltage gating. Transport in cells: Diffusion, Fick's law, cells with sources, low Reynolds-number, friction in fluids, Transport across cells - osmosis. **Section C** • Blood flow: Blood as non-Newtonian fluid, Blood flow models, Navier Stokes equation, Dissipative particle dynamics, Erythrocyte model, elastic model. • Energy in muscle: Cytoskeleton, Muscle Contraction, biopolymers of the cytoskeleton, Tubulin, microtubules, associated protein, micro filaments, actin and Myosin. Molecular motors, Kinesin and Dyenin. Sliding filament model of contraction, ATP and muscle contraction, stochastic model of contraction. • Radiation Physics: Dosimetery, Photon interaction coefficients, Relations between exposure, Kerma and absorbed dose, Measurement of exposure, Bragg-Gray Cavity theory, determination of absorbed dose in a medium, radiotherapy, geometrical factors, specification of dose ratios, nuclear medicine.	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Suggested Books ➢ Tuszynski, J. A., & Kurzynski, M. (2003). *Introduction to molecular biophysics*. CRC press. ➢ Schlick, T. (2010). *Molecular modeling and simulation: an interdisciplinary guide: an interdisciplinary guide* (Vol. 21). Springer Science & Business Media. ➢ Nelson, P. (2004). *Biological physics*. New York: WH Freeman. ➢ Cantor, C. R., & Schimmel, P. R. (1980). *Biophysical chemistry: Part III: the behavior of biological macromolecules*. Macmillan. ➢ Smith, F. A. (2000). *A primer in applied radiation physics*. World Scientific Publishing Company. ➢ Van Holde, K. E., Johnson, W. C., & Ho, P. S. (2006). Principles of physical biochemistry. ➢ Jensen, J. H. (2010). *Molecular modeling basics*. CRC Press. ➢ Voet, D., Voet, J. G., & Pratt, C. W. (2013). *Fundamentals of biochemistry: life at the molecular level* (No. 577.1 VOE). Hoboken: Wiley. **Suggested e-Resources:** ➢ https://www.coursera.org/learn/dynamicalmodeling?specialization=systems-biology	
11)	**ENVS 402**: Ecology and Environment	After the completion of this course, students will be able to: • Describe the interaction of organisms with their environment. • Identify the various		**Section A** **Introduction to Environment** • Concept of Environment, Factors of the environment: Physiographic, Climatic, Edaphic, Biotic and Anthropogenic. • Bio Geochemical Cycles: The Carbon cycle, the Oxygen cycle, the Nitrogen cycle, The	Introduced from M.Sc. Environmental Science

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		threats to biodiversity. • Explain the concept of biomes. • Describe the various biogeochemical cycles.		Hydrological cycle. **Section B** **Concept of Ecology, Ecosystem and Biomes** • Concept of Ecosystem: With special reference to desert, forest and aquatic ecosystem. Food chain, Food web & succession. Ecological Pyramids and their types. • Energy flow in ecosystem, Concepts of Biomes. Major biomes of the world: Tropical forest, Temperate forest, Grassland and Tundra. **Section C** **Environmental Pollution and its Effect** • Environmental pollution-Pollutants and sources: • Water pollution, Soil pollution, Air pollution and, Noise pollution. • Greenhouse Effect, Global warming • Biodiversity: Threats and Conservation. **Suggested Books:** ➢ Atkinson, Raw, M. (2007). *Biogeography*. Philip Allan Updates. ➢ Gautam, A. (2007). *Environmental Geography*. Allahabad, India: Sharda Pustak Bhawan. ➢ Huggett, R. J. (1998). *Fundamental of Biogeography*. London, UK: Routledge. ➢ Kayastha, S.L. & Kumra, V.K. (1986). *Environmental Studies*. Varanasi, India: Tara Book Agency. ➢ Mathur, H.S. (1998). *Essentials of Biogeography*. Jaipur, India: Pointer. ➢ Mehtani, S. &Sinha, A. (2010). *Biogeography*. Commonwealth. ➢ Odum, E. P. (1975). *Ecology*. Lanham, MD: Rowman and Littlefield. ➢ Odum, E.P. (1968).*Fundamentals of Ecology*.	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				London, UK:W.B. Sanders Company ➢ Saxena, H. M. (1999). *Environmental Geography*. Jaipur, India:Rawat. ➢ Saxena, H. M. (2000). *Environmental Management*. Jaipur, India:Rawat. **Suggested e-Resources:** ➢ **Environment and Ecology, IIT Delhi** https://nptel.ac.in/courses/122102006/16 ➢ **Ecology and Environment, IIT Madras,** https://swayam.gov.in/courses/4905-july-2018-ecology-and-environment	
12)	ENVS 502 Biodiversity and Conservation	After the completion of this course, students will be able to: • Explain importance of biological diversity. • Describe major threats to biodiversity. • Recognize and implement the various methods of biodiversity conservation with co-existence of various environmental pressures. • Identify different geographical biodiversity hotspots and mega-diversity centers.		Section A • Introduction to biodiversity concepts, significance, magnitude and distribution. • Biodiversity trends, diversity gradients and related hypotheses methods for monitoring biodiversity trends. • Threats to biodiversity, major causes, extinction's, vulnerability of species to extinction, IUCN threat categories, Red data book. Section B • Principles of biodiversity conservation *ex situ* and *in situ* methods of conservation, Genetical and evolutionary principles in conservation. Conservation of biological diversity and its significance- source of food, medicine, raw material, aesthetic, cultural and ecosystem services. • Concepts, distribution and importance of Hot spots. • Strategies for sustainable exploitation of biodiversity. Section C • Conservation – efforts in India, Endangered	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				flora & fauna of India. • Ethno botany in India & selected medicinal plants. • Wildlife conservation in India- Project Tiger, Project crocodile, silent valley controversy. • Conservation of Himalayan, Gangetic ecosystems. **Suggested Books**: ➢ Kumar, U. &Asija, M.J. (2007). *Biodiversity – Principles and Conservation* (2nd ed.). Jodhpur, India: Agrobios. ➢ Mishra, R. (1968). *Ecology Workbook* (2nd ed.). Calcutta, India: Oxford and IBH. ➢ Odum, E.P. (1983). *Basic Ecology* (2nd ed.). Philadelphia, PA: Holt-Saunders International. ➢ Odum, E.P. (2004). *Fundamentals of Ecology*. Dehradun, India: Natraj Publications. ➢ Singh, M.P., Singh, J.K., Mohanka, R., &Sah, R.B. (2007). *Forest Environment and Biodiversity (*2nd ed.*)*. New Delhi, India: Daya Publications. ➢ Sinha, B.N. (1990). *Ecosystem Degradation in India*. New Delhi, India: Ashish Publications. ➢ Tewari, D.N. (1994) *Biodiversity and Forest Genetic Resources*. Dehradun, India: International Book Publications. **Suggested e-learning resources**: ➢ **Aquatic Biodiversity and Environmental Pollution, IISc, Bangalore** https://nptel.ac.in/courses/120108002/16 ➢ **Wildlife Conservation, Indira Gandhi National Forest Academy, Dehradun** https://nptel.ac.in/noc/individual_course.php?id=noc18-bt26	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
	Proposed Reading Elective-I & II to be offered in IV Semester				common with Applied Microbiology and Biotechnology for Sem III and IV, Bioscience Sem IV
1)	**BT: Drug Discovery**	On completion of this course, students should be able to: • Understand basics of R&D in drug discovery and should be able to apply knowledge gained in respective fields of pharmaceutical industry. • Understand the role of synthetic chemistry in the development of pharmaceutical agents; and the modification of chemical structures to develop new drug molecules. • Have an advanced understanding of the chemical structure of a pharmaceutical agent and determine the chemical group/s responsible for a given biological effect. • Demonstrate a basic understanding of pharmacogenomics and bioinformatics as it relates to drug design and discovery. • Develop an understanding of drug targets as a		Modern drug discovery involves the identification of a target or drug lead using different techniques including molecular modeling, combinatorial libraries and high-throughput screening (HTS). Rational drug design is based on the understanding of the three-dimensional structures and physicochemical properties of drugs and receptors. Knowledge of molecular mechanisms, molecular dynamics simulations and homology modeling is necessary for studying drug/receptor interactions. The different conformational sampling techniques, fitness functions used in molecular docking and computational receptor-based and ligand-based drug design approaches are mostly used to design compounds with improved biological activity in rational drug design. Quantitative drug design using QSAR models are used to correlate structural molecular properties (descriptors) with functions (i.e. physicochemical properties, biological activities, toxicity, etc.) of the compounds. Understanding the structure activity relationship between the 3D structure of a molecule and its biological activity may act as the basis for the prediction of compounds with improved biological activities. Different bio-analytical assays (LC/MS/MS, GC/MS and ELISA) could be developed further in support of *in vitro* and *in vivo* studies. Understanding the principles as well as an early characterization of drug toxicity, adsorption, distribution, metabolism and excretion (ADME)	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		recognition site for pharmaceutical agents; how the chemical structure of a substance influences interaction with a drug target; and the identification of new drug targets for future drug discovery.		along with drug-drug interactions, plasma protein binding assays and metabolite profile studies helps in eliminating compounds with unacceptable pharmacokinetic characteristics, which is critical to successful drug discovery programs. **Suggested Books:** ➢ Krogsgaard-Larsen *et. al.* (2016). *Textbook of Drug Design and Discovery*. 5th Edition. CRC Press. ➢ Satyanarayanajois, S. D. (2011). *Drug Design and Discovery: Methods and Protocols*. Humana Press. ➢ Rahman, A. U., Caldwell, G. W. and Choudhary, M. I. (2007). *Frontiers in Drug Design and Discovery*. Bentham Science publishers Limited. ➢ Dastmalchi, S. *et. al.* (2016). *Methods and Algorithms for Molecular Docking-Based Drug Design and Discovery*. IGI Global. **Suggested e- Resources:** ➢ **Drug Discovery** https://bit.ly/2tCqdtE ➢ **Peptide therapeutics** https://www.sciencedirect.com/science/article/pii/S1359644614003997 ➢ **Bio-analytical techniques** https://www.pharmatutor.org/articles/bioanalytical-techniques-overview	
2)	**BT: Human Genetics and Diseases**	After successful completion of the course students will be able to: • Understand hereditary and molecular genetics with a strong human disease perspective.		Since the rediscovery of Mendel’s work in 1900, investigations on the genetic nature of human traits have gained significant importance. Understanding the genetic basis behind human disease is one of the most important reasons to study human chromosome structure, human karyotype, banding techniques, chromosome identification and	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		• Describe genetic abnormalities underlying human disease and disorders • Develop interest in biomedical research, genetic counseling, medicine, and clinical genetics		nomenclature (ISCN)**.** Classical genetics has considerable importance in constructing genetic hypothesis from pedigree data analysis in monogenetic traits, autosomal dominant, autosomal recessive, sex linked dominant, sex linked recessive and sex influenced traits. The impact of consanguinity in causing sex linked anomalies (haemophilia, colour blindness and Duchenne Muscular Dystrophy) has been observed in human population. Current knowledge on genetic variations across populations is applied to study human health and diseases which include chromosomal disorders, structural and numerical chromosomal anomalies (Klinefelter syndrome, Down's syndrome, Turner syndrome, Achondroplasia), inborn errors of metabolism (Phenylketonuria (PKU), Alkaptonuria, Albinism, Galactosemia), haemoglobinopathies, Thalassemia syndromes, multifactorial disorders (diabetes, schizophrenia, huntington disease). Medical genetics involves ethical issues therefore serious discussion is required for prenatal/adult diagnosis of genetic disorders, medical ethics, risks and benefits, informed consent and right of choice. **Suggested Books:** ➢ Strachan T. and Read. A. (2011). *Human Molecular Genetics* (4th ed.). Garland Science ➢ Pasternak J. Fitzgerald. (1999). *An introduction to Human Molecular Genetics-Mechanism of Inherited Diseases*. Science Press. ➢ Thompson and Thompson. (2007).*Genetics in Medicine (7th Ed.*).Saunders **Suggested e- Resources** ➢ **Chromosome identification and**	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				nomenclature (ISCN) http://www.cydas.org/Resources/ISCN_Discussion.html ➢ **Pedigree data analysis** https://learn.genetics.utah.edu/content/disorders/ ➢ **Genetic disorders** https://www.genome.gov/10001204/specific-genetic-disorders/ ➢ **Prenatal/ adult diagnosis of genetic disorders, medical ethics** https://www.michiganallianceforfamilies.org/all/#sectionD	
3)	**Intellectual Property Rights**	After completing this course, students will be able to: • Understand the concept of IPR and its types • Describe the steps for patenting • Discuss the role of WTO and WIPO on IPR		Intellectual property rights (IPR) have an old history and are very relevant for economic development. Various types of IPR (patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications) are recognized with specific uses. There is currently an emergence of specific IP pertaining to plants and animals (UPOV, Plant Breeder's rights and plant variety protection and farmers rights act, patent protection of plant and animal inventions (WTO) and Law on the protection of New plant varieties and animal breeds (WIPO)). It is important to know about types of patent applications and the process of patenting with special emphasis to India. The role of WTO (GATT and TRIPS) and WIPO in implementation of IPR is significant as understands the relevance of Patent Cooperation Treaty (PCT) in patenting. IPR also are associated with certain ethical dilemma and there are some interesting case studies which highlight its relevance. **Suggested Books:**	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				➢ Sateesh, M.K. (2008). *Bioethics and Biosafety*. I.K. International Publishing House. ➢ Goel D. & Parashar S. (2013). *IPR, Biosafety and Bioethics* (1st ed.) Pearson Education India. ➢ Pandey, N. and Dharni, K. (2014). *Intellectual Property Rights*. PHI Learning ➢ Ramakrishna, B. and Kumar, A. (2017). *Fundamentals of Intellectual Property Rights: For Students, Industrialist and Patent Lawyers* (1st ed.). Notion Press **Suggested e-resources:** ➢ **World Trade Organisation**. http://www.wto.org ➢ **World Intellectual Property Organisation**. http://www.wipo.int ➢ **International Union for the Protection of New Varieties of Plants.** http://www.upov.int ➢ **National Portal of India**. http://www.archive.india.gov.in	
4)	**BT: Medical Microbiology**	After successful completion of the course, students should be able to: • Identify various bacterial, fungal, viral and protozoan diseases and their epidemiology • Understand the relevance of emerging and reemerging diseases	**Medical Microbiology and Immunology** **Section-A** • Innate and Acquired Immunity • Antigens : types of Antigens, Antigen specificity, haptens, Antibody structure and functions • MHC, Complement System • Cell mediated cytotoxicity : Origin, maturation and characterization of T-lymphocytes, Monocytes & Macrophages, Mechanism of T cell and NK cell mediated lysis, ADCC, Macrophage mediated cytotoxicity, lymphokines - the product of T cell activation. • Humoral immune response: Origin, maturation and characterization of B-lymphocytes, Activation and proliferation of B-cells, Formation of plasmablast,	**Medical Microbiology (Reading Elective)** Medical Microbiology describes the cause, transmission, epidemiology, pathogenesis, symptoms, diagnosis and treatment of various bacterial (tuberculosis, typhoid, leprosy), fungal (superficial, subcutaneous, systemic mycosis), protozoan (Malaria, amoebiasis) and viral (AIDS, Influenza, measles) diseases. Currently, it is necessary to understand the impact of emerging and remerging diseases (cholera, dengue, multidrug resistant tuberculosis, H5N1 avian influenza, drug resistant malaria, chikungunya) on human health. Global assessment for various diseases also shows an increasing trend of nosocomial infections and	This course was earlier run as a core course in AMBT IIIrd sem.

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Plasma cells and memory cells, Interaction of B and T cells. **Section-B** • Hypersensitivity, Monoclonal antibodies and its applications. • Radioimmunoassay, Enzyme linked immunosorbant assay, immunoblotting, immunofluorescence and flow cytometry • Characteristics of infectious diseases, Herd immunity. • Disease cycle (Source of disease, reservoir, carriers) • Transmission of pathogens (Air borne, contact transmission and vector transmission). **Section-C** • Bacterial Diseases: Epidemiology, Pathogenicity, Laboratory diagnosis, Prevention & control of the following diseases: Anthrax, Tuberculosis, Typhoid, Whooping cough, Tetanus, Diphtheria, Leprosy. • General Account of fungal diseases: Mycosis, Subcutaneous and deep. • General Account of viral & protozoan diseases: Pneumonia, Influenza, Mumps, Measles, Polio, Hepatitis B, Chickenpox, AIDS and Malaria, Leishmaniasis. • Brief account of sexually transmitted diseases. **Books Recommended :** ➢ Text Book of Microbiology: R. Ananthanarayanan and C.K. JayaramPanicker, Orient Longman, 1997. ➢ Medical Microbiology, Vol, 1: Microbial infection: Mackie and MaCartney, Churchil Livingstone, 1996. ➢ Bailey and Scott's Diagnostic Microbiology: Baron EJ, Peterson LR and Finegold, SM Mosby, 1990.	opportunistic infections which cause significant mortality and health concerns. **Suggested Books:** ➢ Brooks, G.F., Carroll, K.C., Butel, J.S., Morse, S.A. and Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's Medical Microbiology (26thed.). US: Lange Medical Books, McGraw-Hill. ➢ Madigan, M., Martinko, J., Stahl, D. and Clark, D. (2010). *Brock Biology of Microorganisms* (13thed.). UK: Pearson Education. ➢ Pelczar Jr., M.J., Chan, E.C.S. and Krieg, N.R. (2011). *Microbiology*. New York, USA: Tata McGraw-Hill. **Suggested e- resources:** ➢ **Emerging Diseases** https://www.ncbi.nlm.nih.gov/pmc/articles/PM /PMC3701702/ ➢ **Epidemiology** https://bit.ly/2SUmzum ➢ **Nosocomial Infections** https://www.ncbi.nlm.nih.gov/pmc/articles/PM C3470069/	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Essential immunology (1995):Roitt, I.M. Black well Scientific Publications, Oxford. ➢ Fundamental immunology: W.E. Paul 1984, Raven Press, New York. ➢ Fundamentals of Immunology: R.M. Coleman, M.F. Lombord and R.E. Sicard (1992) - 2nd ed. C. Brown publishers. ➢ Immunology : D.M. Weir and J Steward 7th Ed. (1993). ➢ Broude A.I. (1981): Medical "Microbiology" : and Infectious Diseases W.B. Saunders & Co. Philadelphia. ➢ Immunology: Janis Kuby. ➢ An Introduction to Immunology: lan R. Tizzard.		
5)	**BT: Molecular Plant Breeding**	After completing this course, students will be able to: • Understand strategies and applications of plant breeding technologies. • Comprehend the knowledge of different plat molecular markers • Plan a research career in the area of plant biotechnology		Plant breeding study involves breeding methods for self and cross pollinated crops. There are several limitations of conventional breeding. Thus, there is need to have a better breeding approaches to overcome this limitation. Development of molecular markers (RFLP, RAPD, SSRs, ISSRs, SNPs), construction of molecular maps and linkage analysis, mapping populations for QTLs using molecular markers play an important role in plant breeding. In order to develop potential plant having better qualities, Marker Assisted Selection (MAS) is also a viable approach which can be done by using selection of traits and markers, trait association, marker assisted backcrossing and recurrent selection, marker assisted hybrid breeding and marker assisted improved varieties/germplasm. **Suggested Books:** ➢ Chawla, H. S. (2000). *Introduction to Plant Biotechnology*. USA: Science Publishers. ➢ Slater, A., Scott, N. and Fowler, M. (2008).	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Plant Biotechnology: The Genetic Manipulation of Plants (2nded.). UK: Oxford University Press. ➢ Primrose, S.B., Twyman R.H. and Old R.W. (2001). *Principles of Gene Manipulation* (6thed.). Wiley-Blackwell. ➢ Nicholl, D.S.T. (2008). *An introduction to Genetic Engineering* (3rded). Cambridge: Cambridge University Press. ➢ Glick, B.R., Pasternak, J.J. and Patten C.L. (2010). *Molecular Biotechnology: Principles and Applications of Recombinant DNA* (4thed.). American Society for Microbiology. ➢ Watson, J.D., Gilman, M., Witkowski J. and Zoller, M. (1992). *Recombinant DNA* (2nded.). W. H. Freeman publisher. **Suggested e- Resources:** ➢ **Plant breeding** https://nptel.ac.in/courses/102103013/pdf/mod 6.pdf ➢ **Molecular marker** https://bit.ly/2XmNm0M ➢ **Gene mapping in plant** https://bit.ly/2TaegKm	
6)	**BT: Protein Engineering**	On completion of this course, students should be able to: • Analyse structure and construction of proteins by computer-based methods • Describe structure and classification of proteins • Analyse and compare the amino acid sequence and structure of proteins, and		An introduction to protein engineering for developing proteins with desired functions. Various methods (rational design and directed evolution) of protein engineering are employed to manipulate the different features or characteristics (affinity, specificity and stability etc) of proteins. Engineering various physicochemical and biological properties (stability to changes in parameters as pH, temperature, amino acid sequence and aggregation propensities etc) of the proteins could be important in their use as protein	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		relate this information to the function of proteins • Explain how proteins can be used for different industrial and academic purposes such as structure determination, organic synthesis and drug design. • Plan and carry out activity measurements of isolated proteins and characterize their purity and stability.		drugs and/or catalysts in bioreactors. The insight into the fundamental understanding of the mechanisms and forces (Van der waals, electrostatic, hydrogen bonding, weakly polar interactions, and hydrophobic effects), by which protein stabilizes, will help in the formulation of protein based pharmaceuticals. Protein engineering with site-specifically incorporation of unnatural or non-canonical amino acids has been used to improve protein function for medical and industrial applications. Different computational approaches (sequence and 3D structure analysis, data mining, Ramachandran map etc) to protein engineering would help to address the requirements in order to find amino acid sequences that will optimize a desired property (physicochemical property and/or biological function) of a protein. Determination of the physicochemical properties of proteins using various spectroscopic methods (Far-UV and Near-UV CD, Fluorescence, UV absorbance and Optical rotatory dispersion) would further support the drug development process. Yeast surface display (YSD)has become a valuable protein engineering tool for modifying the affinity, specificity, and stability of antibodies, as well as other proteins. YSD could be successfully used for protein epitope mapping, identification of protein-protein interactions, and uses of displayed proteins in industry and medicine. Developing vaccines and peptidomimetics will further allow the investigators to identify novel therapeutic leads for numerous unmet clinical needs. **Suggested Books:** ➢ Walsh, G. (2014). *Proteins: biochemistry and*	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				biotechnology, Second edition. Chichester, West Sussex: Wiley Blackwell. ➢ Creighton, T. E. (1997). *Protein Structure: a Practical Approach*, 2nd Edition. Oxford University press. ➢ Cleland, J. L. &Craik, C. S. (2006). *Protein Engineering, Principles and Practice*, Vol 7. Springer Netherlands. ➢ Mueller, K., and Arndt, K. (2006). *Protein Engineering Protocols*, 1st Edition. Humana Press. ➢ Robertson, D., and Noel, J. P. (2004). *Protein Engineering Methods in Enzymology*, Vol 388. Elsevier Academic Press. ➢ Kyte, J. (2006). *Structure in Protein Chemistry*, 2nd Edition. Garland publishers. ➢ Williamson, M. P. (2012). *How proteins Work*. New York: Garland Science. **Suggested e- Resources:** ➢ **Protein Engineering**: https://nptel.ac.in/courses/102103017/pdf/lecture%2022.pdf ➢ **Conformational stability of proteins**: https://bit.ly/2y85mid ➢ **Protein Engineering with Non-Natural Amino Acids:** https://library.umac.mo/ebooks/b2805488x.pdf	

[*] Matter in contrast (black background & white letters) is shifted to some other units, and material brought as a result of shift is also in contrast.
[#] Matter in square brackets, bold, italic and crossed is deleted.
[@] Proposed added materials are shaded in grey.

Annexure- VD

List of online courses of M.Sc. Bioscience-Plant Science Programme

S No	Portal	Name of course	Duration	Semester (Core/Elective/ Additional)	Credit point(s)	URL	Paid/ Free	Fee	Remark
III Semester Online elective course									
1	**Harvard**	Fundamentals of Ecology for Sustainable Ecosystem	-	Elective course	4	https://www.extension.harvard.edu/academics/courses/fundamentals-ecology/12779	Paid	$1550	
IV Semester: Online core course BOT 508: Plant Physiology									
1	**ACS distance education**	Plant Physiology and Taxonomy	100 h	Alternative Core course	6	https://www.acs.edu.au/courses/botany-i-plant-physiology-and-taxonomy-199.aspx	Paid	Australian dollars 646	Suggested as Core course of BOT 508 Plant Physiology
IV Semester: Reading Elective I/II									
1	**NPTEL**	Bio- organic Chemistry	56 h	Reading elective	4	http://nptel.ac.in/courses/104103018/#	Paid	Certification exam fee	
2	**IIT, Delhi**	Enzyme Science and Engineering	28 videos	Reading Elective	2	http://freevideolectures.com/Course/85/Enzyme-Science-and-Engineering/1	Free	-	

Annexure- VD

S No	Portal	Name of course	Duration	Semester (Core/Elective/ Additional)	Credit point(s)	URL	Paid/ Free	Fee	Remark
3	**NPTEL**	Biocatalysis in organic synthesis	46 h	Reading Elective	3	http://nptel.ac.in/courses/104105032/	Paid	Rs. 1000 for certification exam fee	
4	**National Institute of Disaster Management** (Ministry of Home Affairs, New Delhi)	Comprehensive Disaster Risk Management Framework	6 weeks Run in batches throughout the year	Reading Elective	2	www.nidm.gov.in/online.asp	Paid	Rs. 1500 Exam fee	
5	**WIPO Academy** - [DL] Distance Learning Program	DL101E - DL-101 General Course on Intellectual Property	55 h	Reading Elective	4	https://welc.wipo.int/acc/index.jsf?page=courseCatalog.xhtml	Free	-	
6	**Algonquin college**	Environmental Management - An Introduction		Reading Elective	-	http://www.algonquincollege.com/ccol/courses/environmental-management-an-i		-	

BANASTHALI VIDYAPITH

Department of Bioscience and Biotechnology

M.Sc. APPLIED MICROBIOLOGY AND BIOTECHNOLOGY

PROGRAMME EDUCATIONAL OBJECTIVES

The M.Sc Applied Microbiology and Biotechnology programme aims for the holistic development of students through the unique and innovative five fold educational ideology of Banasthali Vidyapith and targets an extremely broad and yet specialized sector of microbial biotechnology having application in environmental, medical, agricultural, food and beverage industries. Due to the immense potential of research and entrepreneurial ventures present within these sectors, the curriculum has been devised specifically for students who wish to enter any of these sectors to develop their career as academicians, researchers, entrepreneurs or professionals. Through a well balanced and well distributed curriculum, the student will gain knowledge about diverse courses of biotechnology, microbiology, biochemistry, bioinformatics etc. This knowledge should find an amalgamative outcome in the practicals and eventually in the project work to be performed by the students. On completion of the Programme, students will be able to:

- use the fundamentals and concepts taught and translate it practically
- explore, interpret and analyse research literature and utilize it for scientific writing and designing experimental methodologies
- design and execute research problems relating to microbes and their various roles (pathogenesis, epidemiology studies, diagnostics, industrial applications, environmental remediation and molecular biology).
- identify potential domains and develop scope for entrepreneurial ventures.
- inculcate self-appraisal skills for fostering value added learning
- foster skills for public interaction to develop more awareness about microbes and their role in facilitating biotechnological advances.
- engage in lifelong learning in the broadest context of technological change.

BANASTHALI VIDYAPITH

Department of Bioscience and Biotechnology

M.Sc. APPLIED MICROBIOLOGY AND BIOTECHNOLOGY

PROGRAMME OUTCOMES

PO1: Knowledge: Generate knowledge and skills to interpret, experiment, formulate and evaluate various theories and hypotheses associated with microbiology, biochemistry, molecular biology, immunology, environmental sciences, statistics, bioinformatics, industrial biotechnology, microbial physiology and genetics.

PO2: Planning abilities: Practice setting up of time and resource efficient working while managing delegation and organizational skill to improve output.

PO3: Problem analysis: Developing scientific methodology for formulating hypothesis, testing and experimentation to select and propose logical outcomes.

PO4: Modern tool usage: Identify, employ and inventorize the procedures and resources available to use the best combination for achieving the goal.

PO5: Leadership skills: By acknowledging the limitations of individualistic efforts, learn to work in team and simultaneously develop organizational skills, recognize and accept contributions to decisively and effectively compete while fulfilling professional responsibilities.

PO6: Professional Identity: Recognize and appraise various roles (researchers, entrepreneurs, diagnostician, quality control, academia, industry professional, publication houses, patent agents etc) to identify one’s role as a productive and informed citizen.

PO7: Bioethics and Biosafety: Implementation of safe practices for containment following good lab practices and associated protocols are necessary to ensure protection and manage any risk for people and environment. Debate, argue and then conclude upon the most ethical route to pursue in research and subsequent commercialization is a must to overcome negative criticism and improve public perception.

PO8: Communication: Develop oral, written and presentation skill to achieve effective documentation procedures, standard operating protocols, along with research publications. Clarity in communication also helps in building transparency and generating good public support.

PO9: Role in society: Appraise the role played in society for solving various problems (technical, moral, ethical) to ensure social sustainability leading to generation of value added services and social recognition.

PO10: Environment and sustainability: Utilize the knowhow generated to create environmentally sustainable technology and work towards development of methodologies and practices for remediation and environment conservation.

PO11: Life- long learning: Formulate strategies for self appraisal, analysis and evolution to constantly innovate oneself and be a positive contributor to technology advancement.

Department of Bioscience and Biotechnology, Banasthali Vidyapith
M.Sc. Applied Microbiology and Biotechnology Programme

Existing Courses					
M.Sc. Applied Microbiology and Biotechnology Sem. I		**L**	**T**	**P**	**C**
BIO 407	Cell and Molecular Biology	4	0	0	4
BIO 403	Biochemistry and Biophysics	4	0	0	4
BIO 409	General Microbiology	4	0	0	4
BIN 401	Bioinformatics	4	0	0	4
BIO 401	Analytical Techniques-I	4	0	0	4
BIO 404L	Bioscience Lab-I	0	0	12	6
	Total	**20**	**0**	**12**	**26**

Proposed Courses					
M.Sc. Applied Microbiology and Biotechnology Sem. I		**L**	**T**	**P**	**C**
BIO	Cell and Molecular Biology	4	0	0	4
BIO	Biochemistry	4	0	0	4
BIO	General Microbiology	4	0	0	4
BIN	Bioinformatics	4	0	0	4
BIO	Analytical Techniques-I	4	0	0	4
BIO	Bioscience Lab-I	0	0	12	6
	Total	**20**	**0**	**12**	**26**

Existing Courses					
M.Sc. Applied Microbiology and Biotechnology Sem. II		**L**	**T**	**P**	**C**
BIO 406	Biostatistics and Research Methodology	4	0	0	4
BIO 414	Microbial Physiology and Genetics	4	0	0	4
BIO 413	Medical Microbiology and Immunology	4	0	0	4
BT 406	Enzymology and Enzyme Technology	4	0	0	4
BT 408	Genetic Engineering	4	0	0	4
BIO 415L	Microbial Technology Lab-I	0	0	12	6
	Total	**20**	**0**	**12**	**26**

Proposed Courses					
M.Sc. Applied Microbiology and Biotechnology Sem. II		**L**	**T**	**P**	**C**
BIO 406	Biostatistics and Research Methodology	4	0	0	4
BIO	Microbial Physiology and Genetics	4	0	0	4
BIO 411	Immunology	4	0	0	4
BIO	Environmental Biology and Biotechnology	4	0	0	4
BT	Genetic Engineering	4	0	0	4
BIO	Microbial Technology Lab-I	0	0	12	6
	Total	**20**	**0**	**12**	**26**

(red)	Course proposed to be discontinued
(yellow)	Course content modified
(orange)	Course shifted to/from different semester
(green)	New course proposed
(purple)	Course shifted to/from different programme
(light green)	Course shifted from core to elective course

Existing Courses					
M.Sc. Applied Microbiology and Biotechnology Sem. III		**L**	**T**	**P**	**C**
BT 522	Recombinant DNA Technology	4	0	0	4
BT 504	Bioprocess Engineering and Technology	4	0	0	4
BT 507	Cell and Tissue Culture Technology	4	0	0	4
BIO 504	Microbial Ecology and Diversity	4	0	0	4
BIO 506L	Microbial Technology Lab-II	0	0	12	6
	Elective	4	0	0	4
	Total	**20**	**0**	**12**	**26**
	List of Electives				
BIO 503	Fundamentals of Bioentrepreneurship				
BIO 505	Microbial Technology				
BT 513	Food Process & Biotechnology				
BT 515	Genomics and Proteomics				
BT 516	Immunotechnology				
BT 521	Plant Biotechnology				

Proposed Courses					
M.Sc. Applied Microbiology and Biotechnology Sem. III		**L**	**T**	**P**	**C**
BT	Bioprocess Engineering and Technology	4	0	0	4
BIO	Critical Analysis of Classical Papers/ Landmark Discoveries (Seminar)	0	2	0	2
BIO	Microbial Ecology and Diversity	4	0	0	4
BIO	Microbial Technology Lab-II	0	0	12	6
	Discipline Elective	4	0	0	4
	Open Elective	4	0	0	4
BT	Reading Elective-I/ II	0	0	0	2
	Total	**16**	**2**	**12**	**26**

Existing Courses					
M.Sc. Applied Microbiology and Biotechnology Sem. IV					
BT 508D	Dissertation	0	0	52	26
	Total	**0**	**0**	**52**	**26**

Proposed Courses					
M.Sc. Applied Microbiology and Biotechnology Sem. IV					
	Reading Elective-I/ II	0	0	0	2
BT 508D	Dissertation	0	0	48	24
	Total	0	0	48	26

Proposed List of Elective courses to be offered in III Semester	
BIO	Fundamentals of Bioentrepreneurship
BIO 505	Microbial Technology
BT	Food Process and Biotechnology
BT	Genomics and Proteomics
BT	Immunotechnology

BT	Plant Biotechnology
BT	Recombinant DNA Technology
BT	Animal Biotechnology-I
PHY	Biophysics-I
BT	Enzyme Technology
BT	Forensic Biology and Serology https://swayam.gov.in/course/264-forensic-biology-and-serology
BT	Water and Waste Treatment Engineering: Biochemical Technology https://www.edx.org/course/water-wastewater-treatment-engineering-tsinghuax-40050455-2x-0
BT	Industrial Biotechnology https://onlinecourses.nptel.ac.in/noc17_bt23/preview https://swayam.gov.in/search?keyword=Industrial%20Biotechnology
BT	Fundamentals of Ecology for Sustainable Ecosystem https://www.extension.harvard.edu/academics/courses/fundamentals-ecology/12779
Proposed List of Reading Elective-I/II to be offered in III & IV Semester	
BT	Drug Discovery
BT	Human Genetics and Diseases
	Intellectual Property Rights
BT	Medical Microbiology
BT	Molecular Plant Breeding
BT	Protein Engineering
BIO	Bio- organic Chemistry http://nptel.ac.in/courses/104103018/#
BT	Enzyme Science and Engineering http://freevideolectures.com/Course/85/Enzyme-Science-and-Engineering/1
BT	Biocatalysis in Organic Synthesis http://nptel.ac.in/courses/104105032/
BT	Comprehensive Disaster Risk Management Framework www.nidm.gov.in/online.asp
BT	General Course on Intellectual Property https://welc.wipo.int/acc/index.jsf?page=courseCatalog.xhtml
BT	Environmental Management - An Introduction http://www.algonquincollege.com/ccol/courses/environmental-management-an-introduction/

Comparative Table: M.Sc. Applied Microbiology and Biotechnology: Existing and Modified syllabus, Suggested Books and Suggested e-Resources

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
M.Sc. Applied Microbiology and Biotechnology I Semester					
1.	**BIN 401:** Bioinformatics	After successful completion of the course, students should be able to: • Describe and identify various databases and tools used for phylogenetic analysis. • Apply protein structure prediction • Demonstrate and apply different tools for data-mining .	**Section-A** • ~~Introduction of computers: Basic components and their functions, hardware and software, Input-Output devices.~~ • ~~Basic concepts about data and information, Representation of data in computers in binary, bits and bytes~~. ~~Computer words coding (ASCII and EBCDIC), Number System Conversion.~~ • ~~Conceptual understanding of assemblers, Compilers, Operating System.~~ • ~~Introduction to Programming languages, C++, Perl~~. **Section-B** • ~~Information Retrieval: LAN, WAN, Introduction to Internet, WWW, NICNET, ERNET, On-line publishing ventures eg. Biomed Central,~~ BTIS Network in India. • ~~Introduction to Microarray Technology and its applications.~~ • Biological Databases: Primary Sequence databases (Protein and DNA databases), Secondary databases, Composite databases. Online international database access. **Section-C** • Sequence Alignment and Databases searching: ~~Evolutionary basis of sequence alignment~~, Optimal alignment methods; Dot Plot, ~~Dynamic Programming~~. • ~~Databases similarity searching: Algorithms of FASTA~~ BLAST. • ~~Statistical significance of alignment, Substitution Scores and Gap penalties.~~ • Multiple Sequence alignment: ~~CLUSTAL W~~. [redacted]. ~~EMBOSS~~. **Books Recommended :** ➢ A textbook of Bioinformatics : Sharma, Munjal&Shanker,	**Section A** • Introduction and scope of bioinformatics, Introduction to biological databases: primary, composite, secondary databases and structural database. Description of specific databases: UniGene, UniProt, and RCSB – PDB). Introduction to genomics, proteomics and phylogenetics resources available at ExPassy. • Introduction to sequence analysis: Dot Plot, scoring matrices (PAM matrix) and gap penalty. **Section B** • Description and application of global and local sequence alignment. Sequence based database searching working algorithms of BLAST, variations of BLAST. Multiple Sequence alignment. Evolutionary significance of sequence alignment. • Evolutionary models: Jukes – Cantor and Kimura two parameter. • Phylogenetic Analysis: distance based (UPGMA, N-J Methods) and character based (Maximum Parsimony). **Section C** • Protein 2D structure prediction: Chou – Fasman algorithm • Protein 3D structure prediction: homology modeling, its advantage and limits. • Concept of structure optimization and energy minimization. • Forces stabilizing biomolecular interaction. • Principle of Molecular Docking. Types of molecular docking, its advantage and limits. **Suggested Books:** ➢ Rastogi, S.C. & Rastogi, P. (2013). *Bioinformatics*	The components were very basic and mostly covered in undergraduate programs in almost every stream of science as compulsory computerknowledge. Learning languages such as C++ and Perl are extremely tedious; syntax of these two languages is very different to each other and not of use without hands-on sessions. More computer science information instead of bioinformatics. Further, the proposed syllabus is comprehensive for introductory course of bioinformatics. clustalWis obsolete, progressive methods will include all the concept and methodology of

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			Rastogi Publication, Meerut ➢ Fundamental of computer : P.K. Sinha ➢ Introduction to Bioinformatics : Parrysmith and Attwood ➢ Introduction to Bioinformatics : Baxevenis and Oulette ➢ Internet for Molecular Biologist : Swindell ➢ Molecular databases for protein sequences and structure studies - An Introduction Silence : J., Sillince M., Springerberlagd, Berlin 1972 ➢ Leaping from Basic to C++ : Robert J. Traister, A.P. Professional Cambridge ➢ Perl 5 Unleashed : Kamran Husain & Robert F Breedlore SAMS Publishing. ➢ Bioinformatics : David, Mount.	*Methods and Applications* (4th ed.). New Delhi: PHI Learning Private Limited. ➢ Lesk, A.M. (2008). *Introduction to Bioinformatics*.UK: Oxford University Press. ➢ Krane, D.E. & Reymer, M.L. (2003). *Fundamental Concepts of Bioinformatics*. UK: Pearson Education. ➢ Attwood, T.K., Parry-Smith, D.J. & Phukam, S. (2009). *Introduction to Bioinformatics* (4th ed.). UK: Pearson Education. ➢ Sharma, V., Munjal, A. & Shanker, A. (2017). *A Text Book of Bioinformatics* (2nd ed.). Meerut: Rastogi Publications. **Suggested e- Resources:** ➢ **Chou-Fasman Method for protein secondary structure prediction** https://pdfs.semanticscholar.org/fd8c/c95aec2d7af19ed28eea3688b3c231d0e745.pdf ➢ **Homology modeling** https://proteinstructures.com/Modeling/homology-modeling.html ➢ **ExPASy** https://www.expasy.org/	programs like clustalW. Protein structure prediction is the new introduction in the content to satisfy the need and requirement of a complete bioinformatics course.
2.	**BIO 401:** Analytical Techniques-I	After successful completion of the course, students should be able to: Comprehend the principles of various instrumentation techniques: • Identify suitable and relevant tools	**Section-A** • Chromatographic methods for macromolecule separation- TLC and Paper chromatography, gel permeation; ion exchange; hydrophobic, Reverse-phase and Affinity chromatography; HPLC, FPLC and GLC. • Electrophoretic techniques : • Theory and application of polyacrylamide and agarose gel electrophoresis, capillary electrophoresis; 2D electrophoresis; Disc gel electrophoresis; Gradient electrophoresis; Pulse field gel electrophoresis, Isoelectric focusing.	**Section-A** • Chromatographic methods for macromolecule separation: TLC and Paper chromatography, Gel permeation, Ion exchange, Hydrophobic, Reverse-phase & Affinity chromatography; HPLC, FPLC & GLC. • Electrophoretic techniques: Theory and applications of polyacrylamide and agarose gel electrophoresis, capillary electrophoresis, 2D electrophoresis, Disc gel electrophoresis, Gradient electrophoresis, Pulse field gel electrophoresis & Isoelectric focusing.	Typographical errors have been rectified.

<table>
<tr><th>S No.</th><th>Course List</th><th>Learning Outcome</th><th>Existing Syllabus</th><th>Suggested Syllabus</th><th>Remarks</th></tr>
<tr><td></td><td></td><td>for use in research problems
• Utilize the scope of the content for designing and performing future experiments</td><td>Section-B
• Microscopy- Microscope and its modifications- Light, Phase contrast and interference, Fluorescence, Confocal, Electron (TEM & SEM), Electron tunneling and Atomic Force Microscopy
• Centrifugation -Basic principle & theory, Types of centrifuges- Micro centrifuge, High speed & Ultracentrifuges; Preparative centrifugation, differential & density gradient centrifugation. Analytical centrifugation & its applications.

Section-C
• Spectroscopy-Principle, instrumentation applications in biological sciences: UV-visible spectrophotometry Florometry& Atomic absorption Spectrophotometer (AAS). Principle and application of NMR, X-ray crystallography, ~~API electrospray~~, mass spectroscopy and MALDI-TOF, Circular Dichroism
• Radioactivity :
• Radioactive and stable isotopes; Pattern and rate of radioactive decay; Measurement of radioactivity; Geiger-Muller counter; solid and liquid scintillation counters (Basic principal, instrumentation and technique); brief idea of radiation dosimetry; Cerenkov radiation; autoradiography.

Books Recommended :
➢ Practical Biochemistry: Keith Wilson and John Walker, Cambridge University Press.
➢ Physical Biochemistry : David Friefelder.
➢ Instrumental methods of chemical analysis :Chatwal and Anand, Himalaya Publishing House.
➢ Instrumental methods of chemical analysis : B.K. Sharma, Goel Publishing House.</td><td>Section-B
• Microscopy:
Microscope and its modifications- Light, Phase contrast and interference, Fluorescence, Confocal, Electron (TEM & SEM), Electron tunneling & Atomic Force Microscopy
• Centrifugation:
Basic principle & theory, types of centrifuges- Micro centrifuge, High speed & Ultracentrifuges. Preparative centrifugation: differential & density gradient centrifugation. Analytical centrifugation & its applications.
Section-C
• Spectroscopy:
Principle, instrumentation applications in biological sciences. UV-visible spectrophotometry, Florometry & Atomic absorption spectrophotometer (AAS). Principle & applications of NMR, X-ray crystallography, Mass spectroscopy and MALDI-TOF, Circular Dichroism.
• Radioactivity:
Radioactive and stable isotopes, Pattern and rate of radioactive decay, Measurement of radioactivity, Geiger-Muller counter, solid and liquid scintillation counters (Basic principle, instrumentation and technique), brief idea of radiation dosimetry, Cerenkov radiation & autoradiography.
Suggested Books:
➢ Wilson, K. & Walker, J. (2010). Principles and Techniques of Biochemistry and Molecular Biology. Cambridge, UK: Cambridge University Press.
➢ Friefelder, D. (1982). Physical Biochemistry: Applications to Biochemistry and Molecular Biology. New York, USA: W.H. Freeman and Company.
➢ Chatwal, G.R. & Anand, S.K. (2018). Instrumental</td><td></td></tr>
</table>

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			➢ X-Ray Methods : C. Whiston. ➢ The Electron Microscope in Biology : A. V. Grimstone. ➢ Tertiary level biology - Methods in Experimental biology : R. Ralph Blackie. ➢ Animal Tissue Technique : G.L. Humason. ➢ NMR and Chemistry : J.W. Akitt, Chapman and Hall.	*Methods of Chemical Analysis*. New Delhi, India: Himalaya Publishing House. ➢ Sharma,B.K. (2004). *Instrumental methods of Chemical Analysis, In: Introduction to Analytical Chemistry*. New Delhi, India: Goel Publishing House. ➢ Talluri, S. (2012). *Bioanalytical techniques*. New Delhi, India: I.K. International Publishing House Pvt. Ltd. ➢ Chatanta, D.K. & Mehra, P.S. (2012). *Instrumental Methods of Analysis in Biotechnology*. New Delhi, India: I.K. International Publishing House Pvt. Ltd. **Suggested e- Resources:** ➢ **Chromatographic Techniques** https://nptel.ac.in/courses/103108100/module7/module7.pdf ➢ **Spectroscopic techniques** https://nptel.ac.in/courses/102103044/pdf/mod2.pdf ➢ **Microscopic techniques** www.nptel.ac.in/courses/102103015/pdf/mod3.pdf	
3.	**BIO 403:** Biochemistry & Biophysics	After successful completion of the course, students should be able to: • Understand the structure and role of various biomolecules • Identify, assess and explain various biochemical pathways • Develop understanding of enzymes and	**Biochemistry & Biophysics** **Section-A** • ~~Hydrogen bonding and structure of water molecule, Ionization of water, pH and colligative properties of water~~. • Bioenergetics: First & second law of thermodynamics, concept of free energy, change in standard free energy, ~~ATP and its hydrolysis.~~ • Carbohydrates: general classification, Polysaccharides: ~~&proteoglycans~~: Starch, glycogen, cellulose, chitin ~~&bacterial cell wall~~. ~~Glycosaminoglycans& proteoglycans in extracellular matrix.~~ **Section-B** • Electron transport system in mitochondria & chloroplasts. Oxidative phosphorylation, P/O ratio, Uncouplers. • Lipids - Glycerophospholipids, sphingolipids, gangliosides, Eicosanoids & prostaglandins~~. Cholesterol & its~~	**Biochemistry** **Section-A** • Bioenergetics: First and Second law of thermodynamics, concept of free energy, change in standard free energy. • Carbohydrates: general classification, Polysaccharides: Starch, glycogen, cellulose & chitin. • Glycolysis, Citric acid cycle. Electron transport system in mitochondria & chloroplasts. Oxidative phosphorylation, Photosynthetic phosphorylation, P/O ratio, Uncouplers. **Section-B** • Lipids-glycerophospholipids, sphingolipids, gangliosides, eicosanoids & prostaglandins. • Proteins & amino acids – Zwitterionic properties of amino acids & titration curves, Peptide bonds, disulphide crosslinks, various levels of structural organization of	The title is changed as Biophysics component has been removed as it does not fit in two year M.Sc. Biotechnology programme. Section B: Relevant topics, which were earlier not part of the syllabus, have been added. These topics are essential part of

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		their mechanism of action	~~biosynthesis~~. • Proteins & amino acids - Zwitterionic properties of amino acids & titration curves. Peptide bonds, disulphide cross links, various levels of structural organization of proteins. • Ramachandran plot, Alpha-helix, Beta sheet, ~~Helix-coil transitions.~~ **Section-C** • Structure function relationship in model proteins like ribonuclease A, haemoglobin, chymotrypsin. • Biosynthesis of purines and pyrimidines, *de novo* and salvage pathway, ~~various confirmations of nucleotides,~~ glycosidic bond rotation, base-stacking. • ~~Mechano-Chemical Process: Molecular structure of muscle-Actin, myosin, troponin, tropomyosin, Muscle Contraction.~~ • ~~Action Potential and propagation of neuronal computation through nerve fibre.~~ **Books Recommended :** ➢ Principles of Biochemistry : A.L. Lehninger, Nelson and Cox, McMillan Worth Publishers. ➢ Biochemistry :Voet and Voet, John Wiley and Sons, Inc. USA. ➢ Biophysical Chemistry Vol. I, II &III : Cantor and Schimmel, Freeman. ➢ Biochemistry :Zubey, WCB. ➢ Biochemistry : Garrett and Grisham, Harcourt. ➢ Biochemistry :Stryer, W. H. Freeman. ➢ Understanding Enzymes : T. Palmer, Horwood. ➢ Harper's review of Biochemistry : R.K. Murray et al., Prentice-Hall International Inc. ➢ Fundamentals of Biochemistry : Cohn and Stumf. ➢ Molecular Biophysics-Structure in Motion :Michel Daune, Oxford University Press.	proteins. • Ramachandran plot, Alpha-helix, Beta sheet, • Structure function relationship in model proteins like ribonuclease A, haemoglobin and chymotrypsin. • Biosynthesis of purines and pyrimidines, *de novo* and salvage pathway, **Section-C** • Introduction to enzymes: Classification of enzymes Nomenclature of enzymes, E.C. Number. • Enzyme kinetics (Michaelis – Menten kinetics), importance and determination of Vmax and Km values, L & B plots. • Enzyme inhibition: competitive, non-competitive and un-competitive. • Coenzymes and Isozymes. **Suggested Books:** ➢ Nelson, D. L. & Cox, M.M. (2012). *Lehninger Principles of Biochemistry* (6thed.). New York, USA: W. H. Freeman and Company. ➢ Rodwell, V.W., Bender, D., Botham, K.M., Kenelly, P.J. & Weil., P.A. (2018). *Harper's Illustrated Biochemistry* (31sted.). New York, USA: McGraw-Hill Education. ➢ Voet, D. &Voet, J.G. (2010). *Biochemistry* (4thed.). New Jersey, USA: Wiley. ➢ Berg, J.M., Tymoczko, J.L., Gatto Jr., G.J. & Stryer, L. (2015). *Biochemistry* (8thed.). New York, USA: W. H. Freeman and Company. ➢ Garrett, R. H. & Grisham, C. M. (2012). *Biochemistry* (5thed.). Belmont, USA: Wadsworth Publishing Co Inc. ➢ Palmer, T.& Bonner, P. (2014). *Enzymes: Biochemistry, Biotechnology and Clinical Chemistry*. UK: Woodhead Publishing Limited. ➢ Cantor, C.R. & Schimmel, P.R. (1980). *Biophysical*	the carbohydrate metabolism, a key component of the living organisms. Section C: Biophysics topics have been deleted. Reshuffling done in order to coherently organize various topics of the syllabus

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Chemistry Part I, II & III. New York, USA: W. H. Freeman and Company. ➢ Ferdinand, W. (1976). *The Enzyme Molecule*. New Jersey, USA: John Wiley & Sons Ltd. **Suggested e- Resources:** ➢ **Metabolic pathways, Biomolecules** https://epgp.inflibnet.ac.in/ahl.php?csrno=2 ➢ **Mechanism of enzyme action** http://www.biologydiscussion.com/enzymes/enzymes-properties-and-mechanism-of-enzyme-action/6145 ➢ **E-book for Garrett and Grisham** https://bit.ly/2TbDWWR	
4.	**BIO 404L:** Bioscience Lab-I	After successful completion of the course, students should be able to: • Demonstrate use of various tools and techniques for detection and quantification of biomolecules. • Perform various biochemical assays for fats, carbohydrate, protein and enzymes • Demonstrate microbiologica l techniques	1. Demonstration, principle and use of lab equipments: Centrifuges (~~Table top~~ and high speed), ~~Balances (electrical and digital).~~ ~~2. Demonstration, principle and use of lab equipments: Spectrophotometer, pH meter.~~ 3. Estimation of proteins by Lowry's ~~and TCA methods.~~ 5. Estimation of carbohydrates (reducing and non-reducing sugar). 6. Estimation of fats (cholesterol). 7. ~~Preparation and purification of casein from buffalo milk.~~ 8. Separation of amino acids by TLC and paper chromatography. 9. ~~Determination of Logic properties (pH value of Lysine by titration).~~ 10. ~~To find λmax for proteins.~~ 11. ~~Use of selective and diagnostic media for cultivation, isolation, enumeration and purification of microorganisms.~~ ~~12.~~ Measurement of bacterial ~~and fungal~~ growth. 13. Isolation and enumeration of microbes from air/soil by serial dilution/agar plating method. 14. Antibiotic sensitivity test. 15. ~~Microbiological examination of food~~.	**Analytical Techniques-I** 1. Demonstration: Working principle & applications of - Centrifuges (high speed refrigerated centrifuge & ultracentrifuge), - Fluorescence microscope. - Atomic absorption spectrophotometer, HPLC, FPLC, GC-MS **2.** Separation of amino acids by TLC and Paper Chromatography. **Cell and Molecular Biology** 3. Study of different stages of mitosis (onion root tip) and meiosis (onion buds/grasshopper testis) and determine the mitotic index. **4.** Separation of chloroplast by sucrose density gradient centrifugation **Biochemistry** 5. To prepare sodium acetate buffer and validate the Henderson-Hasselbach equation. 6. Extraction of crude enzyme from germinating mung bean seeds. 7. Estimation of total protein content by Lowry's method. 8. Separation of protein by SDS PAGE.	The experiments have been reframed and modified keeping in consideration, the suggested syllabus.

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		• Access, retrieve, and analyze nucleotide and protein sequences using bioinformatics tools	16. Citric acid production by A. niger. ~~17.~~ Study of cell division in plants and animals,~~Giant chromosomes.~~ 18. Separation of different organelles/molecules by sucrose density gradient/differential gradient. 19. Separation and identification of serum proteins/plant proteins by gel electrophoresis. 20. ~~Histochemical localization of biomolecules (protein, carbohydrate or any other).~~ ~~21. Bioinformatics exercise 1~~ 22. ~~Bioinformatics exercise 2.~~	9. Estimation of acid phosphatase activity using standard curve of p-nitrophenol. 10. Purification of the crude enzyme extract (from Expt. 6) using ammonium sulphate precipitation and ion exchange/ affinity chromatography (demonstration). 11. Determination of kinetic properties (K_m and V_{max} values) of acid phosphatase. 12. Estimation of total carbohydrates using Anthrone method. 13. Estimation of reducing sugar by Nelson-Somogyi method. 14. Estimation of fats (cholesterol). **Microbiology** 15. Isolation and enumeration of microbes from soil and water. 16. Staining of selected bacterial and fungal strains. 17. Estimation of bacterial growth by turbidometric method. 18. Antibiotic sensitivity test. 19. Estimation of infectivity titre of a virus sample using Plaque assay. **Bioinformatics** 20. Database Search: Use and analysis of BLAST tool for protein and DNA sequences. 21. Molecular Evolution: Multiple sequence alignment and phylogenetic analysis. (Clustal X/ Mega/ Tree-View). 22. Structure Prediction: Protein secondary and tertiary structure prediction using online tools. 23. Molecular Visualization: Structural analysis of PDB entries for active and inactive states of protein (Pymol). **Suggested Books:** ➢ Aneja, K. R. (2001). *Experiments in Microbiology, Plant Pathology, Tissue Culture and Mushroom Production Technology*. New Delhi, India: New Age International Ltd.	

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				➢ Cappuccino, J. G. & Welsh, C. (2019). *Microbiology: A Laboratory Manual*. New York, USA: Pearson. ➢ Sadasivam, S., & Manickam, A. (1996). *Biochemical Methods* (2^{nd} ed.). New Delhi: New Age International Publishers. ➢ Saxena, J., Baunthiyal., & Ravi, I. (2015). *Laboratory Manual of Microbiology, Biochemistry and Molecular Biology*. Jodhpur: Scientific Publishers. **Suggested e- Resources:** ➢ **Harisha, S. Biotechnology procedures and experiments handbook** ➢ http://site.iugaza.edu.ps/mwhindi/files/BIOTECHNOLOGY-PROCEDURES-AND-EXPERIMENTS-HANDBOOK.pdf ➢ **Introduction to biotechnology** http://www.austincc.edu/awheeler/Files/BIOL%201414%20Fall%202011/BIOL1414_Lab%20Manual_Fall%202011.pdf	
5.	**BIO 407:** Cell and Molecular Biology	After successful completion of the course, students should be able to: • Understand membrane transport and cell signalling mechanisms. • Develop comprehensive understanding of endo-membrane system • Understand	**Section-A** • Molecular structure and function: ~~Structural models,Composition and dynamics;~~ Transport of ions and macromolecules; Pumps, carriers and channels; Membrane carbohydrates and their significance in cellular recognition; cellular junctions and adhesions; ~~structure and functional significance of plasmodesmata~~. • Endocytosis and exocytosis, clathrin~~&coatomer~~ coated vesicles, SNARE proteins. • Cell to cell signaling :autocrine, paracrine and endocrine stimulation. • Signaling via G-protein linked cell-surface receptors, adenylatecyclase system, inositol phosphate pathway, role of Ca^{2+} -ions. • Signallingvia enzyme-linked surface receptors, tyrosine kinases.	**Section-A** • Molecular structure and function of plasma membrane; Transport of ions & macromolecules; Pumps, carriers and channels; Membrane carbohydrates & their significance in cellular recognition; Cellular junctions & adhesions. • Endocytosis & exocytosis, clathrin coated vesicles, SNARE proteins. • Cell to cell signalling: autocrine, paracrine and endocrine stimulation. • Signaling via G-protein linked cell surface receptors, adenylate cyclase system, inositol phosphate pathway, role of Ca^{2+} ions. • Signaling via enzyme-linked surface receptors, tyrosine kinases. • Steroid receptors.	Plasmodesmata already covered in 'cell junctions'

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		molecular mechanisms of prokaryotes and eukaryotes	• Steroid receptors. **Section-B** • ~~Mitochondrial membrane organization~~,transport of proteins into mitochondria and chloroplasts. ~~Genome of mitochondria and cholorplasts.~~ • Concept of signal peptide, SRP, SRP Receptor, ~~transport of soluble and membrane bound proteins in Endoplasmic Reticulum,~~ ER Resident proteins, ER chaperone proteins and their functions, glycosylation of proteins in ER. • Golgi apparatus, role in protein glycosylation and transport. • Lysosomes, intracellular digestion, sorting of lysosomal enzymes in Golgi, lysosomal storage diseases. **Section-C** • Replication of genetic material in prokaryotes and eukaryotes: initiation, elongation and termination; Replication of single stranded circular DNA. • Prokaryotic transcription: Transcription units; RNA polymerase structure and assembly; Promotors; Rho-dependent and Rho-independent termination; Anti-termination. • Eukaryotic transcription: RNA polymerase structure and assembly; RNA polymerase I, II, III; eukaryotic promoters and enhancers; general transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF). • Post transcriptional modifications: processing of hnRNA, tRNA and rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; Splicing; RNA editing; Nuclear export of mRNA; ~~mRNA stability;~~ Catalytic RNA. • Translation: Translation machinery; ~~Ribosomes: composition and assembly;~~ Genetic code~~: degeneracy of codons, initiation and termination codons, wobble hypothesis,genetic code in mitochondria;~~IsoacceptingtRNA; ~~Mechanism of~~ initiation, elongation and termination; Co- and post-translational	**Section-B** • Protein sorting and targeting: Signal hypothesis, SRP, SRP Receptor, ER Resident proteins, ER chaperone proteins & their functions, glycosylation of proteins in ER. • Golgi apparatus, role in protein glycosylation and transport. • Lysosomes, intracellular digestion, sorting of lysosomal enzymes in Golgi, lysosomal storage diseases. • Transport of proteins into mitochondria & chloroplasts. • Cell Cycle & its regulation, apoptosis. **Section-C** • Replication of genetic material in prokaryotes &eukaryotes: initiation, elongation & termination; Replication of single stranded circular DNA. • Prokaryotic transcription: Transcription units; RNA polymerase structure & assembly; Promotors, Rho-dependent & Rho-independent termination; Anti-termination. • Eukaryotic transcription: RNA polymerase structure and assembly; RNA polymerase I, II, III; eukaryotic promoters & enhancers; general transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF). • Post transcriptional modifications: processing of hnRNA, tRNA and rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; splicing; RNA editing; nuclear export of mRNA; catalytic RNA. • Genetic code, Isoaccepting t-RNA; Translation: Translation machinery: initiation, elongation and termination; Co- and post-translational modifications.	The deleted portion has been replaced with more relevant topic Cell Cycle and its regulation and division.

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			modifications. **Books recommended :** ➢ Cell and Molecular Biology : De Robertis& De Robertis, B.I. Waverly Pvt. Ltd., New Delhi. ➢ The world of the cell : W.M. Becker, Pearson Education. ➢ Cell and Molecular Biology : G. Karp, John Wiley & Sons. ➢ The Cell - A Molecular Approach : Cooper, Sinauer. ➢ Cell and Molecular Biology : P.K. Gupta, Rastogi Publications. ➢ Molecular Cell Biology :Lodish, Baltimore, W. H. Freeman & Co. ➢ Molecular Biology of the Cell : Bruce Albert, Garland Publication, NY. ➢ Essentials of Cytology : C.B. Powar, Himalaya Publications. ➢ Principles of Genetics : Gardner, Simmons, Snustad, John Wiley & Sons. ➢ Gene VIII :Lewin, Pearson Education. ➢ Molecular Biology of Gene : J.D. Watson, Pearson Education. ➢ Molecular Biology : David Freifelder, Narosa Publishing House, New Delhi. ➢ Molecular Biology : R. Weaver, WCB McGraw Hill.	**Suggested Books:** ➢ De Robertis, E.D.R. & De Robertis, E.M.F. (2017). *Cell and Molecular Biology*. New York, USA: Lippincott Williams & Wilkins. ➢ Hardin, J., Bertoni, G. & Lewis, K.J. (2011). *Becker's World of the Cell*. Essex, UK: Pearson Education Limited. ➢ Karp, G., Lwasa, J. & Larshall, W. (2015). *Cell and Molecular Biology: Concepts and Experiments*. New Jersey, USA: John Wiley & Sons Ltd. ➢ Cooper, G., M. & Hausman, R. E. (2004). *The Cell: A Molecular Approach*. Washington, D.C.: ASM Press. ➢ Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretsher, A., Ploegh, H., Amon, A. & Martin, K. C. (2007). *Molecular Cell Biology*. New York, USA: W. H. Freeman and Company. ➢ Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K.& Walter, P. (2007). *Molecular Biology of the Cell*. UK: Garland Science. ➢ Freifelder, D. M. (1986). Molecular Biology. USA: Jones & Bartlett Publishers. **Suggested e- Resources:** ➢ **Cell Biology resources** https://www.nature.com/scitable ➢ **Sorting and trafficking of proteins** http://www.vcell.science/project/proteintrafficking ➢ **RNA editing** study.com/academy/lesson/rna-editing-definition-processes.html	
6.	**BIO 409:** General Microbiology	After successful completion of the course, students should be able to:	**General Microbiology** **Section-A** • Significance of Micro-organisms and Historical background. • Classification of ~~Bacteria~~ (up to sections based on bergey's	**General Microbiology** **Section-A** • History of Microbiology. • Classification of Eubacteria (upto sections based on	Course specific to M.Sc. AMBT.

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		• Describe bacterial structure, nutrition, growth and tools used for microbial classification. • Explain classification of protists and fungi. • Develop comprehensive concepts of virology including viral structure, replication, classification, cultivation and assay.	Manual), ~~Ultrastructure and morphology of Bacteria~~. • ~~Composition of Cell wall of archaebacteria & eubacteria, L-forms, cell membrane, capsules, reserve food materials, nutrition and reproductio~~n. • Brief Idea about Prochlorons & cyanelles. **Section-B** • Classification of fungi ~~and algae.~~ • Ultrastructure ~~and characteristics~~ of Fungi, nutrition and metabolism, reproduction, heterothallism, physiological specialization. • Brief idea about Cyanobacteria, Mycorrhiza and Lichens. **Section-C** • Classification of Viruses ~~(Plant, animal and bacteriophage)~~ • ~~Distinct properties of viruses.~~ • ~~Morphology and ultrastructure of viruses Animal, plant and bacteriophages,~~ one step growth curve, ~~replication of viruses~~, cultivation of viruses. • ~~Serological and immunological assay of viruses~~. • Brief idea about prions **Recommended Books:** ➢ Bergey's Manual of Systematic Bacteriology - P.H.A. Sneath, N.S. Mair, M. Elizabeth. ➢ General Microbiology : RY Stainer, JL Ingharam, ML Wheelis, PR Painter (1999) Macmillan Educational Ltd. London.	Bergey's manual) & Archaebacteria. • Classical & molecular tools used for classification. • Structure of eubacteria & archaebacteria. • Nutrition in bacteria- nutritional classes, modes of nutritional uptake, media (types) & culture methods. • Bacterial growth, factors affecting growth, measurement of bacterial growth & modes of bacterial reproduction. **Section –B** • Classification of fungi- a brief overview. • Ultrastructure of fungi, nutrition, growth, metabolism heterothallism, physiological specialization. • Classification of protists -brief overview. • Brief idea about Cyanobacteria, Mycorrhiza, Lichens, Cyanelles & Prochlorons. **Section-C** • Classification of Viruses- ICTV classification, Baltimore classification. • Structure & properties of viruses. • General scheme of viral replication. • Bacteriophages: one step growth curve, structure and life cycle of T_4 and lambda phages, molecular control of lytic & lysogenic cycle. • Animal virus: structure and life cycle of herpes simplex virus, papovavirus, reovirus and retroviruses. • Plant virus: structure and life cycle of geminivirus, caulimovirus & tobacco mosaic virus; virus-vector relationship. • Assay methods for viruses; virus cultivation. • Brief idea about prions, satellites & viroids. **Suggested Books:** ➢ Willey, J. M., Sherwood, L.M. & Woolverton, C.J. (2014). *Prescott's Microbiology* (9th ed). New York, USA: McGraw-Hill Education.	

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Microbiology : MJ Pelczar, ECS Chan, NR Kreig, Mc Graw Hill. ➢ Microbiology : B.D. Davis, R. Dulbecco, H.N. Eisen and H.S. Guisberg. Harper and Row Publishers, Hagerstorn, 3rd Ed. ➢ Microbiology, A Laboratory Manual : Cappuccino, J.G. and Sherman, N., Addison Wesley.	➢ Madigan, M., Martinko, J., Stahl, D. & Clark, D. (2010). *Brock Biology of Microorganisms* (13^{th} ed.). UK: Pearson Education. ➢ Pelczar Jr., M.J., Chan, E.C.S. & Krieg, N.R. (2011). *Microbiology*. New York, USA: Tata McGraw-Hill. ➢ Kungo, R. (Ed.) (2017). *Ananthnarayan and Paniker's Textbook of Microbiology* (10^{th} ed.). New Delhi, India: Universities Press. ➢ Moat, A. G., Foster, J.W. & Spector, M.P. (2003). *Microbial Physiology* (4thed). US: Wiley- Liss Inc. ➢ Atlas, R.M. & Bartha, R. (1998), *Microbial Ecology: Fundamentals and Applications* (4^{th} ed.). UK: Pearson Education. ➢ Dimmock, N.J., Easton, A.J. & Leppard, K.N. (2016). *Introduction to Modern Virology* (8^{th} ed.). Hoboken, NJ: Wiley Blackwell. ➢ Cann, A.J. (2015). *Principles of Molecular Virology* (6^{th} ed). Massachusetts, USA: Academic Press. **Suggested e- Resources:** ➢ **Bacteria structure** http://www.biologydiscussion.com/bacteria/cell-structure-of-bacteria-with-diagram/47058 ➢ **Bacterial growth & nutrition** http://www.biologydiscussion.com/bacteria/nutrition-and-growth-in-bacteria/47001 ➢ **Bacterial metabolism** https://www.ncbi.nlm.nih.gov/books/NBK7919/ ➢ **Structure and classification of Viruses** https://www.ncbi.nlm.nih.gov/books/NBK8174/ https://www.pnas.org/content/101/44/15556 ➢ **Virus replication** https://virology-online.com/general/Replication.htm http://paperpdfland.com/principles-of-microbiology-ronald-m-atlas-land-is-your-guide-to-reading.pdf	

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3577227/pdf/jmbe-11-1-64b.pdf	
M.Sc. Applied Microbiology and Biotechnology II Semester					
7.	**BT 415L:** Microbial Technology Lab - I	After successful completion of the course, students should be able to: • Demonstrate techniques used in immunology and genetic engineering. • Perform key experiments for water quality analysis and microbial physiology. • Solve problems based on bacterial gene mapping.	**Microbial Technology Lab - I** 1. To obtain standard curve of p-nitrophenol solution 2. To prepare a sample of enzyme extract. 3. To determine activity of acid phosphatase from peas/moong seedlings. 4. Purification of an enzymatic protein by salt precipitation. 5. Determination of kinetic properties (Km and Vmax values) of an enzyme. 6. To check time and protein linearity of an enzymatic reaction. 7. Immobilization of an enzyme. ~~8. Blood film preparation and identification of leucocytes.~~ 9. Lymphoid organs and their microscopic organization. ~~10. Immunization, collection of serum.~~ 11. Double diffusion and immuno-electrophoresis. 12. ELISA : Determination of antibody titre. ~~13. Immunodiagnostics (Demonstration using commercial kits).~~ ~~14. Clinical tests : eg. malarial parasite and widal test.~~ 15. Extraction and estimation of RNA. 16. Extraction and estimation of DNA. ~~17. To find λ max for nucleic acids.~~ ~~18. Preparation of metaphase chromosomes.~~ ~~19. Detection of ADH activity in tissue/cells by cytochemical staining using Drosophila.~~ ~~20. Statistical problem.~~ 21. Genetic problem ~~- (chromosome mapping).~~	**Microbial Technology Lab-I** **Environmental Biology and Biotechnology** 1. Determination of total hardness of water. 2. Determination of fluoride content in water. 3. Determination of BOD values. 4. Determination of LD50 for common pesticides/weedicides. 5. Bacteriological analysis of waste water. **Immunology** 6. To perform differential leucocytes count. 7. Lymphoid organs and their microscopic organization 8. To perform immune diffusion by ochterlony double diffusion method. 9. To perform immunoelectrophoresis. 10. ELISA: Determination of antibody titre. **Genetic Engineering** 11. Extraction of genomic DNA by CTAB method and determination of purity. 12. Estimation of DNA content by diphenyl amine (DPA) method. 13. PCR amplification of 'n' number of genotypes of a species using random primers (Demonstration). 14. Extraction of RNA by Phenol chloroform method and estimation by orcinol method. **Microbial Physiology and Genetics** 15. Measurement of superoxide dismutase activity in bacteria under different physiological conditions (Temperature, pH). 16. Analysis of photopigments of Rhodospirillaceae / Cyanobacteria. 17. Genetic exercise: bacterial mapping.	The experiments have been reframed and modified keeping in consideration, the suggested syllabus.

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Biostatistics and Research Methodology 18. Biostatistics problems based on following: - Measures of dispersion (variance). - Correlation analysis. - Probability and probability distribution. - Testing hypothesis by student t- test, Fisher's test, chi-square test and one way analysis of variance. **Suggested Books:** ➢ Aneja, K.R. (1996). *Experiments in Microbiology, Plant Pathology, Tissue Culture and Mushroom Cultivation* (2nd ed.). New Delhi: Wishwa Prakashan. ➢ Green, M. R. & Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. ➢ Gupta S.P. (2000). *Statistical Methods.* S. Chand Publications. **Suggested e- Resources:** ➢ **Harisha, S. Biotechnology procedures and experiments handbook** http://site.iugaza.edu.ps/mwhindi/files/BIOTECHNOLOGY-PROCEDURES-AND-EXPERIMENTS-HANDBOOK.pdf ➢ **Introduction to biotechnology** : http://www.austincc.edu/awheeler/Files/BIOL%201414%20Fall%202011/BIOL1414_Lab%20Manual_Fall%202011.pdf	
8.	**BIO 406:** Biostatistics and Research Methodology	After successful completion of the course, students should be able to: • Apply statistical analysis to biological data	**Section-A** • Scope of Biostatistics, variables in biology, collection, classification, tabulation of data. • Frequency distribution, diagrammatic and graphical presentation of statistical data, sampling techniques. • Measures of central location and dispersion, simple measure of skewness and kurtosis. • Probability, conditional probability.	No change in the syllabus	

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		• Identify ethics in scientific research and associated methodologies • Develop skills in scientific writing.	**Section-B** • Binomial, Poisson and Normal Distribution. • Correlation and Regression: Least Square method of fitting, Standard error of estimate, Correlation and regression coefficient. • Basic idea of significance testing, level of significance, students 't' test, □ 2 (chi-square) test and F-test, Analysis of variance. **Section-C** • Introduction of Research Methodology: meaning and importance, nature and areas of research in Biological Sciences. • Formulation of a research problem (Hypothesis). • Elements in Research Methodology; Research Designs (CRD, RBD, LSD). • Ethical, legal and social issues in Biological Research. • Writing of Research Report/Research Paper: various components and their organization. **Recommended Books:** ➢ Singh S. (1988). Statistical methods for Research. Central publishing, Ludhiana. ➢ Gupta S.P. (2000). Statistical Methods. S. Chand Publications. ➢ Khan and Khanum (2012). Fundamentals of Biostatistics.Ukaz Publications. ➢ Zerold J. (2009). BiostatisticalAnalysis. UK: Pearson Education. ➢ Marcello P. and Kimberlee G. (2000). Principles of Biostatistics. Duxbury. ➢ Prasad S. (2012). Elements of Biostatistics.Rastogi Publications. ➢ Rastogi V. B. (2015). Biostatistics. Medtec publications. ➢ Basotia, G.R. and Sharma K.K. (1999). Research Methodology.Mangal Deep Publications.	**Suggested Books:** ➢ Singh S. (1988). *Statistical methods for Research.* Central publishing, Ludhiana. ➢ Gupta S.P. (2000). *Statistical Methods.* S. Chand Publications. ➢ Khan and Khanum (2012). *Fundamentals of Biostatistics.* Ukaz Publications. ➢ Zerold J. (2009). *Biostatistical Analysis.*UK: Pearson Education. ➢ Marcello P. and Kimberlee G. (2000). *Principles of Biostatistics.* Duxbury. ➢ Prasad S. (2012). *Elements of Biostatistics.* Rastogi Publications. ➢ Rastogi V. B. (2015). *Biostatistics*. Medtec Publications.	

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			➢ Chaudhary C.M. (1991). Research Methodology. RBSA Publications. ➢ Dorendro A. (2016). Research Methodology in Zoology.Pearlbooks . ➢ Kadam R.M. and Allapure R. B. (2016). Research Methodology in Botany.Gaurav Books	➢ Basotia, G.R. & Sharma K.K. (1999). *Research Methodology*. Mangal Deep Publications. ➢ Chaudhary C.M. (1991). *Research Methodology*. RBSA Publications. ➢ Dorendro A. (2016). *Research Methodology in Zoology*. Pearlbooks. ➢ Kadam R.M. & Allapure R. B. (2016). *Research Methodology in Botany*. Gaurav Books **Suggested e- Resources:** ➢ **ANOVA** https://www.analyticsvidhya.com/blog/2018/01/anova-analysis-of-variance/ ➢ **Regression Analysis** https://bit.ly/2s9vHdM ➢ **Student's t Test- Interactive tutorial** https://www.ruf.rice.edu/~bioslabs/Stats_tutorial/index.html	
9.	**BIO 414**: Microbial Physiology and Genetics	After successful completion of the course, students should be able to: • Demonstrate differences between bacteria on basis of metabolism and physiology. • Compare and interpret various regulatory mechanisms in a bacterial cell. • Conceptualize	**Microbial Physiology and Genetics** **Section-A** • ~~Metabolic diversity among micro-organisms~~ • ~~Photosynthesis in micro-organisms~~, Role of chlorophylls, carotenoids and phycobilins; Calvin cycle; chemolithotrophy; Hydrogen-iron-nitrite-oxidising bacteria; Nitrate and sulfate reduction; ~~Methanogenesis and Acetogenesis~~. • Nitrogen metabolism • Nitrogen fixation • ~~Hydrocarbon transformation~~ **Section-B** • Microbial development, sporulation ~~and morphogenesis~~, hyphae vs. yeast forms and their significance. • Respiratory metabolism - Embedden - Mayerhoff-Parnas pathway, Entner-Duodroff pathway, Glyoxylate pathways,	**Section A** • Overview of metabolic diversity among micro-organisms. • Phototrophy- Oxygenic & Anoxygenic Photosynthetic reactions; Role of chlorophylls, carotenoids and phycobilins. Calvin cycle. • Chemolithotrophy: hydrogen, sulfur, iron oxidizing bacteria; nitrate & sulfate reduction. • Nitrogen metabolism : Nitrifying and denitrifying bacteria. Nitrogen fixation: Mechanism of N_2 fixation, nif genes organization & regulation. **Section-B** • Microbial development, hyphae vs. yeast forms & their significance. • Regulation of cellular processes: Quorum sensing by *Vibrio sp* , Sporulation in *Bacillus subtilis*. • Metabolic pathways & regulation - Embedden - Mayerhoff-Parnas pathway, Entner-Duodroff pathway,	Topics need to be elaborative. Hydrocarbon transformation Repeated in AMBT III sem

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		microbial genetics and utilize it for mapping.	Krebs Cycle, Oxidative and substrate level phosphorylation, ATP generation. • ~~Prokaryotic genome : Organization of DNA into chromosomes.~~ • ~~Gene unit of structure and function : complementation test.~~ **Section-C** • Genetics of bacteriophages. • Mapping of bacterial chromosomes. • Gene transfer mechanisms - conjugation, transduction and transformation. • Transposable genetic elements. • Regulation of gene expression in prokaryotes (lac & trp), ~~genetic code, extrachromosomal inheritance.~~ **Suggested Books:** ➢ Microbial Genetics : Maloy et. al., Jones & Bartlett Publishers. ➢ Molecular Genetics of Bacteria : J.W. Dale, John Wiley & Sones. ➢ Microbial Physiology and Metabolism : D.R. Caldwell, Brown Publishers. ➢ Microbial Physiology : A.G. Moat & J.W. Foster, Wiley. ➢ Microbial Genetics : D. Friefelder. ➢ Genetics of Bacteria and their Bacteriophasge : W. Hayes.	Pentose phosphate pathway. • Glyoxylate pathways, Krebs Cycle, Oxidative & Substrate level phosphorylation, ATP generation. **Section-C** • Genetics of bacteriophages: Classification of bacteriophages, genome map & replication cycle of T4, T7 phages, ʎ -phages, ØX174, & M13 bacteriophages. • Mapping of bacterial chromosomes. • Gene transfer mechanisms - conjugation, transduction & transformation. • Transposable genetic elements: Different types of mobile DNA elements, IS- elements, composite transposons, Retrotransposons. • Regulation of gene expression in prokaryotes (*lac & trp*), **Suggested Books:** ➢ Willey, J. M., Sherwood, L.M. & Woolverton, C.J. (2014). *Prescott's Microbiology* (9thed.). New York, USA: McGraw-Hill Education. ➢ Madigan, M., Martinko, J., Stahl, D. & Clark, D. (2010). *Brock Biology of Microorganisms* (13thed.). UK: Pearson Education. ➢ Maloy, S.R., Cronan, J.E. & Freifelder, D. (1994). *Microbial Genetics* (2nd ed.). US:Jones & Bartlett Publishers. ➢ Dale, J.W. & Park, S.F. (2010). *Molecular Genetics of Bacteria* (5th ed.). Hoboken, NJ: Wiley Blackwell. ➢ Caldwell, D.R. (1995). *Microbial Physiology and Metabolism*. Dubuque, Iowa, US: W C Brown. ➢ Moat, A. G., Foster, J. W. & Spector, M. P. (2002). *Microbial Physiology* (4th ed.). US: Wiley. ➢ Atlas, R.M. & and Bartha, R. (1998). *Microbial Ecology: Fundamentals and Applications* (4th ed.). UK: Pearson Education. ➢ Barton, L.L. & Northup, D.E. (2011). *Microbial*	We need to specify all types of bacteriophages to be covered in the syllabus.

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				Ecology. Hoboken, NJ: Wiley Blackwell. **Suggested e- Resources:** ➢ **Microbial metabolism** https://nptel.ac.in/courses/102103015/pdf/mod6.pdf ➢ **Bacteriophages and Their Structural Organization** http://eprints.bbk.ac.uk/9131/1/doc.pdf ➢ **Nitrogen fixation** https://bit.ly/2SXz3RZ ➢ **Transposable elements** https://opencourses.auth.gr/modules/document/file.php/OCRS474/Presentations/9.%20Transposable%20elements.pdf ➢ **Bacterial quorum sensing** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3543102/ ➢ **Chemolithotrophy** https://courses.lumenlearning.com/boundless-microbiology/chapter/chemolithotrophy/	
10.	**BIO 411:** Immunology	After successful completion of the course, students should be able to: • Evaluate and compare the role of various components and mechanisms of the immune system. • Describe various immune response mechanisms • Develop	**Section-A** • Basic concepts of immunology: specific and nonspecific defense mechanisms (innate and acquired immunity), organs and cells of immune system. • Antigen and Antigenicity: concept of immunogens, antigens, heptans, mitogens and superantigens. Properties of antigens, ~~cross reactivity~~, special group of antigens: bacterial antigens, viral antigens, cell surface antigens (MHC), autoantigens, isoantigens and frossman antigens (Heterophilic antigens). • Immunoglobulins: structure and properties of immunoglobulins, immunoglobulin isotypes and their significance.Immunoglobulins as antigens: isotypes, allotypes and idiotypes. • Complement System.	**Section-A** • Basic concepts of immunology: Historical background of immunology, specific and nonspecific defense mechanisms (innate and acquired immunity), cells and organs of immune system. • Antigen and Antigenicity: Concept of immunogens, antigens, haptens, mitogens and superantigens. Properties of antigens, special group of antigens: bacterial antigens, viral antigens, cell surface antigens (MHC), autoantigens, isoantigens and frossman antigens (Heterophilic antigens). • Immunoglobulins: Structure and properties of immunoglobulins, immunoglobulin isotypes and their significance. Immunoglobulins as antigens: isotypes, allotypes and idiotypes, brief idea about instructive, selective & clonal selection theory of antibody formation. • Complement system.	

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		concept of antibody generation and various immunological techniques	**Section-B** • Cell - mediated immune responses : origin, maturation and characterization of T-Lymphocytes, monocytes and macrophages, characteristics of antigen presentation and its significance, concepts of memory cell, mode of action and functioning of TH, TC, CTLS and NK cells, lymphokines, the product of T cell activation. • Humoral immune responses: Origin, maturation and characterisation of B Lymphocytes, activation and proliferation of B and T cells, antibody generation in vivo. • Immunological tolerance ~~and Autoimmunity~~: characteristics and mechanism of immunologic tolerance, factors affecting immunologic tolerance and ~~mechanisms of autoimmunity~~. Hypersensitivity: Type I, II, III and IV. **Section-C** • Hybrid and Chimeric monoclonal antibodies, catalytic antibodies • Surface plasmon resonance, Biosensor assay for assessing ligand-receptor interaction. • ~~Measurement of low molecular weight non-immunogenic compounds (such as secondary metabolites); phytohormones immunoassays.~~ • Advanced immunological techniques: Immunofluorescent and Immunogoldlabelling **Books Recommended:** ➢ Abbas, A.K.,&Lichtman, A.H. (2001). *Basic immunology: Functions and Disorders of Immune System*. US: W.B. Saunders. ➢ Delves, P.J., Martin, S.J., Burton, D.R.,&Roitt, I.M (2011). *Roitt's Essential Immunology* (12th ed.). New Jersey, USA: John Wiley & Sons Ltd.	**Section-B** • Cell - mediated immune responses: origin, maturation and characterization of T-Lymphocytes, monocytes and macrophages, characteristics of antigen presentation and its significance, concepts of memory cell, mode of action and functioning of TH, TC, CTLS and NK cells, lymphokines, the product of T-cell activation. • Humoral immune responses: Origin, maturation and characterization of B-Lymphocytes, activation and proliferation of B and T cells, antibody generation *in vivo*. • Immunological tolerance and characteristics and mechanism of immunologic tolerance, factors affecting immunologic tolerance of autoimmunity. Immune regulation, positive, negative selection, apoptosis. **Section-C** Hypersensitivity: Type I, II, III and IV. • Hybrid and Chimeric monoclonal antibodies, catalytic antibodies. • Surface plasmon resonance, biosensor assay for assessing ligand-receptor interaction. • Advanced immunological techniques: Immunofluorescent and immunogold labelling. **Suggested Books:** ➢ Abbas, A.K. & Lichtman, A.H. (2001). *Basic Immunology: Functions and Disorders of Immune System.* US: W.B. Saunders. ➢ Delves, P.J., Martin, S.J., Burton, D.R., & Roitt, I.M (2011). *Roitt's Essential Immunology* (12th ed.). New Jersey, USA: John Wiley & Sons Ltd. ➢ Goldsby, R. A., Kindt, T.J. & Osborne, B. A. (2006). *Kuby Immunology* (6th ed.). New York, USA: W.H.	

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			➢ Goldsby, R. A., Kindt, T.J., & Osborne, B. A. (2006). *Kuby Immunology* (6^{th}ed.). New York, USA: W.H. Freeman & Co. Ltd. ➢ Paul, W.E. (1999). *Fundamental Immunology* (14^{th}ed.). USA: Lippincott-Raven. ➢ Peakman, M.,&Vergani, D. (2009). *Basic and Clinical Immunology* (2^{nd}ed.). US: Elsevier Health Sciences. ➢ Tizard, I.R. (2017). *Veterinary Immunology* (10^{th}ed.). US: Elsevier Health Sciences.	Freeman & Co. Ltd. ➢ Paul, W.E. (1999). *Fundamental Immunology* (14^{th}ed.). USA: Lippincott-Raven. ➢ Peakman, M. &Vergani, D. (2009). *Basic and Clinical Immunology* (2^{nd}ed.). US: Elsevier Health Sciences. ➢ Tizard, I.R. (2017).*Veterinary Immunology* (10^{th}ed.). US: Elsevier Health Sciences. **Suggested e- Resources:** ➢ **Basic Immunology** https://bit. y/2E6Zz16l ➢ **Monoclonal Antibodies** https://www.genscript.com/how-to-make-monoclonal-antibodies.html ➢ **Complement system** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3956958/	
12.	**BT 406:** Enzymology and Enzyme Technology	At the end of this course, the students will have fundamental knowledge of enzymes and varioustechniques involved in their production and purification. They would also learn about theirapplication in different fields such as medical, textile, chemical processes, etc. They can applythis knowledge for	**Section-A** • History and introduction to enzymes: ~~Classification of enzymes. IUPAC system, nomenclature, E.C. numbers.~~ ~~• Enzyme kinetics (Michaelis - Menten laws), importance and determination of Vmax and Km values, Hofstee's plot, L & B plots.~~ • Bisubstrate reactions-ordered & random sequential mechanism. Theorell chance mechanism, ping pong mechanism, products of inhibition in bisubstrate reactions. ~~• Enzyme inhibition: competitive, non-competitive and other types.~~ **Section-B** • Extraction of soluble and membrane bound enzymes from microbial, plant and animal tissues. • Purification of enzymes: salt precipitation, gel filtration, ion exchange and affinity chromatography. Regulation of enzyme activity, various controls (metabolic compartmentation, covalent modifications and others), feedback regulation, allosteric enzymes	This course is proposed to be discontinued in the present form from the II Semester.	Some part of the syllabus is integrated with core course “Biochemistry”. Remaining part of the syllabus is revised as per the present need and proposed as an elective course named as “Enzyme Technology” in the III Semester.

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		better understanding of other basic and advanced courses in biologicalsciences as well as to solve research based problems.	~~Coenzymes, Isozymes and~~ Multienzyme complexes • Methods of storing enzymes. **Section-C** • Large scale production of enzymes including genetic engineering approaches for their over production. • Enzyme engineering; identification of active sites, approaches for modification of catalytic properties. • Techniques of enzyme immobilization ~~and their applications in:~~ ~~i.~~ Food industry- ~~High fructose syrup, cheese making and beer industry.~~ ii. Antibiotics and other Pharamaceuticals iii. Medical applications ~~iv.~~ Analysis of substances, ~~enzyme electrodes, enzyme thermistors.~~ ~~• Basic idea of proteomics~~ **Suggested Books:** ➢ Understanding Enzymes: T. Palmer. ➢ Fundamentals of Enzymology: Price and Stevenson. ➢ The Enzyme: Dixon and Webb, Academic Press, London. ➢ Methods in Enzymology: Academic Press. ➢ The Enzyme Molecule: W. Ferdinan, John Wiley and sons. ➢ Protein Methods: D.M. Bollag and S.J. Edelstein, Wiley-Liss. ➢ The Nature of Enzymology : F.L. Foster, John Wiley and sons. ➢ Enzyme technology, biotechnology Vol7 : John Wiley and sons. ➢ Enzyme, Biomass, Food and Feed Biotechnology Vol. 9 : John Wiley and Sons.		
13.	**Environmental Biology and**	After successful completion of the course, students	**M.Sc. III Semester Bioscience core course** **BIO 408: Environmental Biology and Toxicology** **Section-A**	**Environmental Biology and Biotechnology** **Section A** ➢ Structure and functions of ecosystem.	"Environmental Biology and Biotechnology" is

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
	Biotechnology	should be able to: • Identify key factors responsible for ecosystem balance and explain different efforts which can be undertaken for restoration and environmental remediation. • Comprehend the toxicity of various environmental pollutants and their influence on ecosystem. • Understand different waste management processes and generation of energy from waste. • Describe various roles played by microbes in biodegradation, bioremediation and plant	- ~~Concept of energy, conventional & non-conventional energy sources. Fossil fuels, hydro, wind and nuclear power, geothermal, solar and bioenergy.~~ - Energy flow in organisms, energy pathways & models, energy efficiencies, ~~conservation of energy.~~ - ~~Classification & characteristics of resources~~: water, soil, forest, wild life, ~~land use.~~ - Conservation of natural resources: water, soil, forest and wild life. **Section-B** - ~~Origin of pollutants : industrial, agricultural, domestic and vehicular sources.~~ - ~~Pollutant & their toxicology :~~ Heavy metals ~~and trace elements~~. Agrochemicals ~~(Pesticides, herbicides, rodenticides & fungicides, detergents) & particulate matter.~~ - ~~Types of radiations including ionizing & non-ionizing radiations & their interaction with matter.~~ - Radiations as environmental pollutants. - Effects of radiations at cellular, molecular & genetic level. **Section-C** - ~~Mutagenecity, carcinogenecity~~. - ~~Green house effect, acid rains~~. - ~~Ozone layer depletion, photochemical smog~~. - Types of solid wastes, transport, reuse & recycling. **M.Sc. III Semester Biotechnology core course** **BT 509: Environmental Biotechnology** **Section-A** - ~~Current status of biotechnology in environmental protection.~~ - ~~Sewage &~~ waste water treatment: ~~Physical, Chemical and biological treaments; Aerobic~~	➢ Energy flow in organisms, energy pathways & models, energy efficiencies. ➢ Basic concept of Population Ecology – Inter & intra-specific interactions among populations. ➢ Community structure & dynamics: Ecological succession. ➢ Natural resources & conservation: water, soil, forest, wild life. ➢ Environmental challenges & sustainable development; Environmental Laws & Acts. **Section B** ➢ Heavy metal toxicity, agrochemical pollutants. ➢ Bioremediation of heavy metal pollution and oil spills, phytoremediation. ➢ Radiations as environmental pollutants. Effects of radiations at cellular, molecular & genetic level. Disposal of radioactive waste. ➢ Waste water treatment- sources of waste water, strategies used in primary, secondary & tertiary treatments, water reclamation. **Section C** ➢ Biofertilizers, biopesticides, compost & vermicompost. ➢ Biofuels: Biogas, bioethanol, biodiesel, biohydrogen. Biodegradable plastics. ➢ Biodegradation of xenobiotic compounds: Simple aromatics, chlorinated polyaromatic petroleum products & pesticides; role of degradative plasmids. ➢ Solid waste management: types, treatment & disposal strategies. ➢ Bioleaching of metals, microbially enhanced oil recovery. Bioindicators. **Suggested Books** ➢ Allen, K. (2016). *Environmental Biotechnology*.	proposed to be included as a new core course in the second semester instead of the existing core course "Enzymology and Enzyme Technology". The syllabus of "Environmental Biology and Biotechnology" is designed by updating and merging the contents of existing courses BIO 408 "Environmental Biology and Toxicology" which is running as a core course in third semester of M.Sc. Bioscience programme and another course BT 509 "Environmental Biotechnology" which is running as a core course in the third semester of M.Sc. Biotechnology programme.

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		growth promotion.	~~processes & anaerobic processes,~~ Primary, secondary and tertiary treatments; ~~Sludge dewatering & its disposal;~~ Water reclamation. - Solid waste management: Methods & disposal ~~of non hazardous and hazardous solid wastes, recycling,~~ methods of disposal of radioactive waste. - ~~Conservation of Biodiversity: *Ex-situ* & *in-situ* methods.~~ **Section-B** - ~~Environmental Biotechnology in Agriculture~~: Biofertilizers ~~and microbial inoculants~~, Biopesticides. - Biodegradation of xenobiotic compounds: Simple aromatics, chlorinated polyaromatic petroleum products, Pesticides ~~and surfactants.~~ - Bioremediation ~~& Biorestoration: Reforestation through micro-propagation, development of stress tolerant plants, and use of mycorrhiza in reforestation of soil contaminated with heavy metals.~~ **Section-C** - Biofuels: ~~Energy crops, Conventional sources of biofuel, Second and third generation of biofuel,~~ Biogas, Bioethanol, Biohydrogen. Biodegradable plastics. - Bioindicators ~~and Biosensers for detection of environmental pollution.~~ - Environmental genetics: Degradative plasmids, ~~release of GE microbes in environment.~~	New Delhi, India: CBS Publishers. ➢ Miller, G.T. (2004). *Environmental Science: Working With The Earth* (10th ed.). Singapore: Thomson Asia. ➢ Milton, W. (Ed.). (1999). *An Introduction to Environmental Biotechnology*. USA: Springer. ➢ Milton, W. (Ed.). (1999). *An Introduction to Environmental Biotechnology*. USA: Springer. ➢ Modi, P. N. (2015). *Sewage treatment & disposal and waste water engineering*. New Delhi, India: Rajsons Publications Pvt. Ltd. ➢ Odum E. P. (2006). *Fundamentals of Ecology* (5th ed.). Boston, US: Cengage. ➢ Sharma, P.D. (2008). *Environmental Biology and Toxicology*. Meerut, India: Rastogi Publications. ➢ Sodhi, G.S. (2002). *Fundamental Concepts of Environmental Chemistry*. New Delhi, India: Narosa Publishing House. ➢ Tripathi, B. N., Shekhawat, G. S., & Sharma, V. (Ed.). (2009). *Applications of Biotechnology*. Jaipur, India: Aavishkar Publishers. ➢ Vallero, D.A. (2016). *Environmental Biotechnology: Abiosystems approach*. US: Elsevier. ➢ Wright, R. T. (2015). *Environmental Science: Toward a Sustainable Future.* UK: Pearson Education. **Suggested e-resources** ➢ **Ecosystem structure** http://www.biologydiscussion.com/ecosystem/ecosystem-its-structure-and-functions-with-diagram/6666 ➢ **Radioactive waste treatment** https://ehs.unc.edu › Manuals › Radiation Safety Manual ➢ **Environmental Remediation** https://www.iaea.org/sites/default/files/18/05/environme	

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				ntal_remediation.pdf ➢ **Biological treatment of wastewater** http://www.neoakruthi.com/blog/biological-treatment-of-wastewater.html ➢ **Biogas** http://www.biologydiscussion.com/biomass/production-of-biogas-from-biomass/10436 ➢ **Biofuel** http://uru.ac.in/uruonlinelibrary/BioFuels/Biomass%20and%20biofuels.pdf ➢ **Biological treatment of wastewater** http://www.neoakruthi.com/blog/biological-treatment-of-wastewater.html ➢ **Xenobiotic compound biodegradation** https://bit.ly/2GHRoMj	
14.	**BT 408:** Genetic Engineering	After successful completion of the course, students should be able to: • Develop comprehensive understanding of gene manipulation techniques • Describe various cloning and expression vectors • Develop skills for primer designing, gene amplification and expression	**Section-A** • Basic concepts of DNA structure and properties, restriction enzymes, DNA ligase, Klenow enzyme, T4 DNA polymerase, Polynucleotide kinase, Alkaline phosphatase, Cohesive and blunt end ligation, Linkers, Adapters, Homopolymeric tailing, Labeling of DNA, Nick translation, Random priming, Radioactive and non-radioactive probes, Hybridization techniques, Northern, Southern and Colony Hybridization, ~~Fluorescence in situ hybridization~~, Chromatin immunoprecipitation, DNA-Protein Interaction-Electromobility shift assay, DNaseIfootprinting, Methyl interference assay, Isolation of genomic DNA from prokaryotes and eukaryotes, Isolation of Plasmid DNA and Bacteriophage DNA. Isolation of total RNA and mRNA. **Section-B**	**Section-A** • Basic concepts of DNA structure and properties, restriction enzymes, DNA ligase, Klenow enzyme, T_4 DNA polymerase, polynucleotide kinase, alkaline phosphatase. • Cohesive & blunt end ligation, linkers, adapters, homopolymeric tailing, labeling of DNA, nick translation, random priming, radioactive & non-radioactive probes. • Hybridization techniques: Colony hybridization, Northern, Southern, South-Western & far-western blotting. • DNA-Protein Interaction: Chromatin immunoprecipitation, electromobility shift assay, DNaseI footprinting, methyl interference assay. • Protein-protein interaction: Yeast two hybrid system, split ubiquitin system, co-immunoprecipitation, Forster Resonance Energy Transfer, phage display. • Isolation of genomic DNA from prokaryotes and eukaryotes, isolation of Plasmid DNA and Bacteriophage	Already there in the genetics paper

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• Plasmids, Bacteriophages, pBR322 and pUC series of vectors, M13 and P2 phage based vectors, High capacity vectors: Cosmids, phagemid, ~~phasemid, YAC~~, BAC, Animal and Plant virus based cloning vectors, Shuttle vectors, Expression vectors, pMal, GST, pET-based vectors, ~~Insertion of foreign DNA into Host Cells, Transformation~~, Constructions of libraries, cDNA and genomic libraries, cDNA and genomic cloning, Expression cloning, Jumping and hopping libraries, South-western and Far-western cloning, Protein-protein interactive cloning and Yeast two hybrid system, Phage display. **Section-C** • Primer designing, Fidelity of thermostable enzymes, ~~DNA polymerase~~, Types of PCR- multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, in situ PCR, cloning of PCR products, T-vectors, ~~Proof reading enzymes~~, Principles in maximizing gene expression, Gene expression analyses, differential gene expression methods, Introduction of DNA into mammalian cells, ~~transfection techniques.~~ **Books Recommended :** ➢ Molecular Cloning Vol. 1, 2 and 3 :Sambrook, Russell and Maniatis, Cold Spring Harber laboratory, 2001. ➢ Molecular Biology of Gene : J.D. Watson, Pearson Education. ➢ An Introduction to Gene Technology-From genes to clones :Winnacker, VCH. ➢ Principles of Gene Manipulation : Old and Primrose. ➢ MoleculerBiotechnology : B.R. Glick and J.J. Pasternak, ASM Press Washington, USA. ➢ Genetic Engineering : Science and ethics on new frontier : Michael Boylan, Pearson Education. ➢ An Introduction to Genetic Engineering : S.T. Nicholl, Cambridge University Press.	DNA. Isolation of total RNA and mRNA. **Section-B** • Plasmids, Bacteriophages, pBR322 & pUCseries of vectors, M13 based vectors. • High capacity vectors:cosmids, phagemids, BAC, animal & plant virus based cloning vectors, shuttle vectors; expression vectors: pMal, GST, pET-based vectors; *Baculovirus* and *Pichia* vectors. Introduction of DNA into mammalian cells. • cDNA & genomic libraries, expression, cloning, jumping & hopping libraries. **Section-C** • Primer designing, fidelity of thermostable enzymes. • Types of PCR- multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, *in situ* PCR, T-vectors. • Principles in maximizing gene expression, gene expression analyses, differential gene expression methods. **Suggested Books:** ➢ Brown, T. A. (2006). *Genomes* (3rd ed.). New York: Garland Science. ➢ Glick, B.R. & Pasternak, J.J. (1998). *Molecular Biotech: Principles and Application of Recombinant DNA*. US: ASM Press. ➢ Green, M. R. & Sambrook, J. (2012). *Molecular Cloning: A Laboratory Manual*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. ➢ Old, R. W., Primrose, S. B. & Twyman, R. M. (2001). *Principles of Gene Manipulation: an Introduction to Genetic Engineering*. Oxford: Blackwell Scientific Publications.	Yeast vectors have been covered in Recombinant DNA Technology course. Relevant vectors have been added. Repeated topics have been removed

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Recombinant DNA Methodology : Grossman and Noldave, Academic Press.	➢ Richard J. R. (2004). *Analysis of Genes and Genome*. New Jersey, USA: John Wiley & Sons Ltd. **Suggested e- Resources:** ➢ **Genetic engineering – Basics, New Applications and Responsibilities** http://library.umac.mo/ebooks/b28055287.pdf ➢ **Construction of genomic libraries** https://nptel.ac.in/courses/102103013/20 ➢ **Enzymes in genetic engineering** https://nptel.ac.in/courses/102103013/7	
M.Sc. Applied Microbiology and Biotechnology III Semester					
15.	**BT 522:** Recombinant DNA Technology				The course BT 522: Recombinant DNA Technology which is offered as a core course in the existing syllabus but now contents of this course have been modified and proposed to be offered as an elective course.
16.	**BT504:** Bioprocess Engineering and Technology	After successful completion of the course, students should be able to: • Identify bioreactor design and differentiate between types • Explain	**Section-A** • Microbial growth and ~~death kinetics.~~ • Mass balance, ~~maintenance coefficient~~ and yield concepts in bioprocesses engineering. • Substrate utilization and product formation kinetics. • Basic concept of volumetric mass transfer coefficient (kLa) and Medium Rheology. • Sterilization. **Section-B**	**Section – A** General concept of Fermentation, Types of bioreactors (CSTR, Bubble driven bioreactor, Packed bed bioreactor, Fluidized Bed bioreactor). • Basic concept of mass balance & yield coefficient. • Unstructured & structured growth model. Batch, continuous & fed batch processes with substrate utilization & product formation kinetics. • Sterilization kinetics.	The syllabus has been remodeled to include more relevant topics which are of current significance. Certain topics have been accommodated in different sections of the paper and other courses as per to their

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		kinetics of scale up and sterilization along with processes of downstreaming. • Demonstrate large scale production of biomolecules	• Batch, continuous and fed batch processes. • ~~Brief overview of~~ different bioreactor configurations (Stirred tank, ~~Air lift~~ and Bubble columns). • Downstream processing: Bioseparation- ~~filtration,centrifugation,sedimentation, flocculation~~; Cell disruption; Liquid-liquid extraction; ~~Purification by~~chromatographic techniques; Reverse osmosis and ultra filtration; Drying; Crystallization. **Section-C** • Analysis of a few industrially important bioprocesses/products such as (taking into consideration, the raw material, media, organism metabolic pathway, bioreactor, product separation and uses). ~~a.~~ Organic acids (acetic acid, citric acid, ~~lactic acid and propionic acid).~~ b. Solvents (Butanol, Acetone, Ethanol). c. Industrial enzymes (a-amylase, proteases~~, rennin~~, lipase) and d. Antibiotics (Penicillin, Streptomycin, ~~Cephalosporin~~, Tetracycline, ~~Bacitracin~~). **Books Recommended :** ➢ Biochemical Engineering : J.M. Lee. Prentice Hall. ➢ Bioprocess Engineering : M. Shuler and F. Kargi, Prentice Hall. ➢ Comprehensive Biotechnology : M. Moo Young, Editor. ➢ Biotechnology : H.J. Rehm and G. Reed, VCH.	**Section-B** Volumetric mass transfer coefficient (kLa). • Medium Rheology in bioprocesses engineering. • Downstream processing: Bioseparation-ultrafiltration, precipitation, Cell disruption, Liquid-liquid extraction, chromatography, drying, crystallization. • Upscaling of bioprocess. • Enzyme immobilization & immobilized cell systems. **Section-C** • Screening, maintenance & strain improvement of industrially important microbes. • Analysis of a few industrially important bioprocesses/products (taking into consideration- the raw material, media, organism metabolic pathway, bioreactor, product separation and uses): a. Organic acids (acetic acid, citric acid). b. Solvents (butanol, acetone, ethanol). c. Enzymes (α amylases, proteases, lipases) d. Antibiotics (penicillin, streptomycin). e. Recombinant product (humulin, erythropoietin) **Suggested Books:** ➢ Stanbury, P.F., Whitaker, A. & Hall, S.J. (1995).*Principles of Fermentation Technology* (2nd& 3rded.). US: Elsevier Science Ltd. ➢ Crueger, W. & Crueger, A. (1990). *Biotechnology, A Text Book of Industrial Microbiology* (2nd ed.). U.S.: Sinauer Associates Inc. ➢ Bailey, J.E. & Ollis, D.F. (1986). *Biochemical Engineering Fundamentals* (2nded.). New York, USA: McGraw-Hill Education. ➢ Clark, D.S. & Blanch, H.W. (1997). *Biochemical Engineering*. USA: CRC Press. ➢ Shuler, M.L., & Kargi, F. (2002). *Bioprocess Engineering Basic Concepts* (2nded.). New Jersey, USA:	suitability. In Section C, the numbers of examples have been limited in order to generate a balance between sections.

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Prentice Hall PTR Upper Saddle River. **Suggested e- Resources:** ➢ **Microbial Enzymes** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5387804/pdf/BMRI2017-2195808.pdf ➢ **Acetone-Butanol Fermentation** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4894279/pdf/fnw134.pdf ➢ **Microbial culture fermentation** https://pdfs.semanticscholar.org/b4d3/7ed66ef2e37ce22ff7a3be09e3df7568fe49.pdf ➢ **Reverse Osmosis** https://www.oas.org/dsd/publications/unit/oea59e/ch20.htm	
17.	**BIO 506L:** Microbial Technology Lab-II	After successful completion of the course, students should be able to: • Perform production and scale up of some industrially relevant bioactive molecules from microbes • Demonstrate gene transfer and tissue culture techniques • Identify microbes in	1. **Microbial Technology Lab - II** ~~1. Degradation of pesticide in soil and estimation of its residue.~~ ~~2. Determination of LD50 for common pesticides/weedicides.~~ ~~3. Bacteriological analysis of waste water.~~ ~~4. Detection of mutagens by Ames test.~~ 5. Isolation and determination of plasmid DNA from E.coli. ~~6. Electrophoretic separation of plasmid DNA.~~ 7. Restriction digestion of plasmid DNA. ~~8. To obtain transposon Tn5 insertion into the genome of AK 631 strain of Rhizobium meliloti using suicide plasmid vector PGS 9.~~ 9. To transfer plasmid PJB3JI from J53 strain of E. coli to HB101 strain of E.coli. 10. Estimation of growth and product yield. ~~11. Estimation of Biomass.~~ 12. Comparison between aerobic and anaerobic process. 13. Enzyme biosynthesis and measurement of its activity. ~~14. Culture of stem explants.~~	**Microbial Technology Lab – II** **Bioprocess Engineering and Technology** 1. Production of citric acid from *Aspergillus* sp.and its estimation by titration. 2. Estimation of K_{La} by sodium sulphite method. 3. Production of alpha amylase from *Bacillus* sp. and its estimation. 4. Scale up of alpha amylase production from100 ml to 1 L. 5. Immobilization of enzyme by sodium alginate method. 6. Estimation of growth and product yield in a Bioconversion process. 7. Comparison between aerobic and anaerobic process **Genetic Engineering** 8. Preparation of competent cells (*E. coli* DH5α strain). 9. Transformation of *E. coli* with plasmid and calculation of transformation efficiency. 10. Isolation of plasmid DNA from *E. coli*by alkaline lysis method. 11. Restriction digestion of plasmid DNA and its	The experiments have been reframed and modified keeping in consideration, the suggested syllabus.

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		specific habitats and their role in environmental processes.	15. Embryo culture. ~~16. Identification of Microbes through permanent slides.~~ ~~17. Preparation of permanent mounts of various microbes.~~ 18. Antagonistic activity of Trichoderma viridae against few plant pathogens.	electrophoretic separation. 12. To transfer plasmid PJB3JI from J53 strain of *E. coli* to HB101 strain of *E.coli*. **Microbial Ecology and Diversity** 13. Biochemical tests for identification of bacteria- (IMVic tests, carbohydrate fermentation) 14. Degradation of pesticide in soil & estimation of its residue. 15. Study of diversity in rhizosphere soil 16. Antagonistic activity of *Trichoderma* against selected fungal strains. **Suggested Books:** ➢ Kulandaivel, S. & Janarthanan, S. (2012). *Practical Manual of Fermentation Technology*. New Delhi, India: I.K.International Publishing House Pvt. Ltd. ➢ Cappuccino, J. G. & Welsh, C. (2016). *Microbiology: A Laboratory Manual*. USA: Benjamin-Cummings Publishing Company. ➢ Collins, C. H., Lyne, P. M., Grange, J. M. & Falkinham, J.O. (2004). *Collins and Lyne's Microbiological Methods* (8th ed.). London, UK: Arnold. ➢ Green, M. R. & Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. **Suggested e- Resources:** ➢ **Harisha, S. Biotechnology procedures and experiments handbook** http://site.iugaza.edu.ps/mwhindi/files/BIOTECHNOLOGY-PROCEDURES-AND-EXPERIMENTS-HANDBOOK.pdf ➢ **Introduction to biotechnology** http://www.austincc.edu/awheeler/Files/BIOL%201414%20Fall%202011/BIOL1414_Lab%20Manual_Fall%202011.pdf	

<table>
<tr><th>S No.</th><th>Course List</th><th>Learning Outcome</th><th>Existing Syllabus</th><th>Suggested Syllabus</th><th>Remarks</th></tr>
<tr><td>18.</td><td>BT 507: Cell and Tissue Culture Technology</td><td>After successful completion of the course, students should be able to:
Develop comprehensive concepts of cell and tissue culture techniques and methodology
Demonstrate use of various plant and animal tissue culture techniques
Explain applications of cell and tissue culture in agriculture, horticulture, medicine and pharmaceutical industry</td><td>Section-A
Historical background and terminologies used in cell & tissue culture.
Basic techniques of cell and tissue culture, sterilization, aseptic tissue transfer, concept of totipotency.
Nutritional requirement of cell in vitro, various types of nutrient media.
Contamination and cytotoxicity
Cryopreservation and cell storage.
Isolation of plant cells, single cell cultures and cloning.
Section-B
Organogenesis and somatic embryogenesis, applications in agriculture, horticulture & forestry.
Haploid production: androgenesis, gynogenesis various techniques, applications.
Production of disease free plants by tissue culture methods.
Protoplast isolation and culture, fusion of protoplasts.
Somatic hybrids, selection methods, gene expression in somatic hybrids.
Section-C
Disaggregation of animal tissue, isolation of cells, single cell culture, routine maintenance of animal cell lines.
Cloning & selection of specific animal cell types.
Transfection: gene transfer methods for adherent and non-adherent cell culture.
Cell fusion: fusogen, animal somatic cell fusion and selection of cybrids.
Animal organ culture.
Elementary idea about animal cell culture products.
Recommended Books:
➢ Bhojwani, S.S. &Razdan, M.K. (1996). Plant Tissue Culture.USA: Elsevier Science.
➢ Chawla, H. S. (2000). Introduction to Plant Biotechnology.</td><td>Proposed to be discontinued in AMBT, will continue in MSc Biotechnology and MSc Bioscience

Suggested Books:
➢ Bhojwani, S.S. & Razdan, M.K. (1996). Plant Tissue Culture. USA: Elsevier Science. Chawla, H. S. (2000). Introduction to Plant Biotechnology. US: Science</td><td>Proposed to be discontinued in AMBT, will continue in MSc Biotechnology and MSc Bioscience</td></tr>
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S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			US: Science Publishers. ➢ Razdan, M. K. (2006). *Introduction to Plant Tissue Culture*. New Delhi, India: Oxford and IBH Pub. ➢ Smith, R. H (Ed.). (2013). *Plant tissue culture: Techniques and experiments*. Amsterdam: Academic Press. ➢ Butler, M. (2003).*Animal Cell Culture and Technology* (2nd ed.). UK: Taylor & Francis. ➢ Mathur, S. (2006). *Animal Cell and Tissue Culture*. India: Agrobios. ➢ Clynes, M. (Ed.) (1998). *Animal Cell Culture Techniques*. Germany: Springer-Verlag Berlin Heidelberg. ➢ Pollard, J.W.,&Walker, J.M. (Eds.). (1990). *Animal Cell Culture*. USA: Humana Press ➢ John, R. W. (2000). *Animal Cell Culture: A Practical Approach* (3rd ed.). UK: Oxford University Press. ➢ Freshney, R. I. (2011). *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications* (6th ed.). USA: Wiley-Blackwell. ➢ Davis, J. M. (2011). *Animal Cell Culture: Essential Methods*. New Jersey, USA: John Wiley & Sons Ltd.	Publisher Razdan, M. K. (2006). *Introduction to Plant Tissue Culture*. New Delhi, India: Oxford and IBH Pub. ➢ Smith, R. H (Ed.). (2013). *Plant Tissue Culture: Techniques and Experiments*. Amsterdam: Academic Press. ➢ Buler, M. (2003). *Animal Cell Culture and Technology* (2nd ed.). UK: Taylor & Francis. ➢ Mathur, S. (2006). *Animal Cell and Tissue Culture*. India: Agrobios. ➢ Clynes, M. (Ed.) (1998). *Animal Cell Culture Techniques*. Germany: Springer-Verlag Berlin Heidelberg. ➢ Pollard, J.W. &Walker, J.M. (Eds.). (1990). *Animal Cell Culture*. USA: Humana Press ➢ John, R. W. (2000). *Animal Cell Culture: A Practical Approach* (3rd ed.). UK: Oxford University Press. ➢ Freshney, R. I. (2011). *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications* (6th ed.). USA: Wiley-Blackwell. ➢ Davis, J. M. (2011). *Animal Cell Culture: Essential Methods*. New Jersey, USA: John Wiley & Sons Ltd. **Suggested e- Resources:** ➢ **Background of Tissue Culture Technology** https://bit.ly/2EsffNI ➢ **Embryogenesis and organogenesis** https://nptel.ac.in/courses/102103016/module1/lec8/3.html ➢ **Single cell cultures and cloning** https://bit.ly/2E5i1ae ➢ **Protoplasm isolation and regeneration** https://nptel.ac.in/courses/102103016/12 ➢ **Haploid plant production** http://www.biologydiscussion.com/plants/haploid-plants/production-of-haploid-plants-with-	

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				diagram/10700 ➢ **Preservation of cell lines** https://www.ukessays.com/essays/biology/techniques-for-cell-preservation-biology-essay.php ➢ **Somatic hybridization** ➢ https://bit.ly/2Ix8Tk1 ➢ **Animal cell culture products** http://www.biologydiscussion.com/biotechnology/animal-biotechnology/applications-of-animal-cell-cultures/10457 ➢ **Cell Culture Technology** https://onlinecourses.nptel.ac.in/noc17_bt21/preview	
19.	**BIO 504:** Microbial Ecology and Diversity	After successful completion of the course, students should be able to: • Describe microbial diversity with special reference to microbial ecosystem. • Identify various habitats of extremophiles and their mechanism of survival. • Explain microbial interactions of relevance in environmental	**Microbial Ecology and Diversity** **Section-A** • Microbial diversity : Distribution; Abundance and Ecological niche; Different types of microbial interactions. • ~~Study of different ecological groups : Oxygenic and anoxygenic photosynthetic microbes.~~ • ~~Oxidative transformation of Sulphur, Iron, Ammonia and Hydrogen.~~ • ~~Culturable~~ and Unculturable bacteria, Conventional and modern methods to study microbial diversity. **Section-B** • Extremophiles : Mechanisms and adoption of Psychrophiles, Acidophiles, Alkaliphiles, Hyperthermophiles, ~~Basophiles~~ and Osmophiles. • Halophiles, membrane variation, electron transport. • Methanogens and Biogas production, Rumen microbiology - action of rumen microorganisms, microbial fermentation in the rumen. • Applications of thermophiles and extremophiles.	**Microbial Ecology and Diversity** Section –A • Brief historical overview of microbial ecology and its scope, Microbial community dynamics (r and K selection, succession within microbial communities), species diversity indices, Microbial ecosystem models. • Different types of microbial interactions (Microbe-microbe, Plant-microbe, Animal-microbe). • Biogeochemical cycling of sulphur, Iron, ammonia & hydrogen. • Unculturable bacteria & approaches to culture, Conventional & modern methods to study microbial diversity. **Section –B** • Extremophiles: Adaptations of Psychrophiles, Acidophiles, Alkaliphiles, Hyperthermophiles, Barophiles & Osmophiles. • Halophiles, membrane variation, electron transport. • Methanogens & Biogas production, Rumen microbiology - action of rumen microorganisms, microbial fermentation in the rumen. • Applications of thermophiles & extremophiles.	Students should have some idea about history and scope of the subject which is lacking in present the syllabus. Distribution, Abundance and Ecological niche(All will be covered in microbial community dynamics) Microbial ecosystem models will provide a better understanding of how microbial communities assemble and operate This part of syllabus is not defined. It will be better if we define

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		remediation.	**Section-C** • Stress microbiology : ~~Environmental stress (density dependent & density independent) strain,~~ Methanotrophs and Methylotrophs. • Bioleaching - Microbes and mechanism of Bioremediation of iron and copper ores, ~~Heavy metal detoxicants (~~Metal microbe interaction, biosorption, bioaccumulation~~ and metal scavenging by microbes).~~ • Catabolic pathway of recalcitrant molecule degradation and mineralization. **Recommended Books** ➢ Extremophiles: Johri, B.N. 2000. Spinger Verlag, New York. ➢ Microbial Diversity: Colwd, D. 1999. Academic Press. ➢ Introduction to Environmental Microbiology Michel, R., 1999. ➢ Microbial Ecology: Alexander, M. (1971) John Wiley and Sons, Inc. New York.	**Section-C** • Stress response systems in microbes: Heat shock response, envelope stress response, cold shock response, starvation strategies. • Methanotrophs and Methylotrophs. • Bioleaching - Microbes and mechanism of Bioremediation of iron and copper ores, metal microbe interaction: biosorption, bioaccumulation, redox transformation and biomineralization • Catabolic pathway of recalcitrant molecule degradation and mineralization (halocarbons, nitroaromatic, • petroleum hydrocarbons, pesticides) **Suggested Books:** ➢ Atlas, R.M. & Bartha, R. (1998). *Microbial Ecology: Fundamentals and Applications* (4th ed.). UK: Pearson Education. ➢ Satyanarayan, T. & Johri, B.N. (2005). *Microbial Diversity: Current Perspectives and Potential* (1st ed.). New Delhi, India: I.K International Publishing House. ➢ Barton, L.L. & Northup, D.E. (2011). *Microbial Ecology*. Hoboken, NJ: Wiley Blackwell. ➢ Mitchell, R. & Gu, J.D. (Ed.). (2010). *Environmental Microbiology* (2^{nd} ed.). Hoboken, NJ: Wiley Blackwell. **Suggested e- Resources:** ➢ **Microbial Ecology: History & Importance** https://study.com/academy/lesson/microbial-ecology-history-importance.html ➢ **Modern methods to study microbial diversity** https://www.highveld.com/microbiology/microbial-ecology.html ➢ **Biogeochemical cycle, Catabolic pathway of recalcitrant molecule degradation**	the relevant topics to be covered. (Type of interactions) It will be appropriate if we include complete biogeochemical cycles as it is important to discuss complete redox cycle Students should have an idea of different recent approaches to grow unculturable bacteria It's a printing mistake in syllabus There is no proper concept of Environmental stress in microbiology related to density. Different types of stress are already discussed under extremophiles in section B. There is no concept of strain microbiology the term 'strain' in microbiology is used to denote species type. Instead we can include different

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				https://bit.ly/2E7X66l ➢ **Microbial Ecology** https://onlinelibrary.wiley.com/doi/book/10.1002/9781118015841 ➢ **Environmental Microbiology** https://onlinelibrary.wiley.com/doi/book/10.1002/9780470495117	Stress response systems in microbes and study important systems such as (Heat shock response, Envelope stress response, Cold shock response, and General stress response) These four modes of metal-microbe interaction are most common so we can elaborate on these. 'metal scavenging by microbes' may be deleted from present syllabus. As this part is also covered when discussing bioleaching and metal-microbe interaction There is no proper concept of environmental stress in microbiology related to density. Different types of stress are already discussed under extremophiles in Section-B
20.	Critical	After successful		**Suggested reading:**	Seminar mode

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
	Analysis of classical papers/ Landmark Discoveries	completion of the course, students should be able to: • Analyze and give a critical description of the papers studied. • Discuss the significance of the research work.		• Studies on the chemical nature of the substance inducing transformation of Pneumococcal types: Induction of transformation by a desoxyribonucleic acid fraction isolated from *Pneumococcus* type III. Avery OT, Macleod CM, McCarty M.; J Exp Med. 1944 Feb 1;79(2):137-58. • Independent functions of viral protein and nucleic acid in growth of bacteriophage. Hershey AD and Chase M.; J Gen Physiol. 1952 May;36(1):39-56. • Molecular structure of nucleic acids; a structure for deoxyribose nucleic acid. Watson JD and Crick FH; Nature. 1953 Apr 25;171(4356):737-8. Transposable mating type genes in *Saccharomyces cerevisiae* James Hicks, Jeffrey N. Strathern& Amar J.S. Klar; Nature 282, 478-483,1979. • Messelson& Stahl experiment demonstrating semi-conservative replication of DNA. Meselson M and Stahl FW.; Proc Natl Acad Sci U S A. 1958 Jul 15;44(7):671-82 • In vivo alteration of telomere sequences and senescence caused by mutated *Tetrahymena* telomerase RNAs Guo-Liang Yu, John D. Bradley, Laura D. Attardi & Elizabeth H. Blackburn; Nature 344, 126-132, 1990 • A protein-conducting channel in the endoplasmic reticulum Simon SM and Blobel G.; Cell. 1991 May 3;65(3):371-80 • Identification of 23 complementation groups required for post-translational events in the yeast secretory pathway Novick P, Field C, Schekman R.; Cell. 1980 Aug;21(1):205-15 • A yeast mutant defective at an early stage in import of secretory protein precursors into the endoplasmic reticulum Deshaies RJ and Schekman R.; J Cell Biol. 1987 Aug;105(2):633-45	Proposed to be introduced

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				• Reconstitution of the Transport of Protein between Successive Compartments of the Golgi Balch WE, Dunphy WG, Braell WA, Rothman JE.; Cell. 1984 Dec;39(2 Pt 1):405-16 • A complete immunoglobulin gene is created by somatic recombination Brack C, Hirama M, Lenhard-Schuller R, Tonegawa S.; Cell. 1978 Sep;15(1):1- • A novel multigene family may encode odorant receptors: a molecular basis for odor recognition Buck L and Axel R; Cell. 1991 Apr 5;65(1):175-87 • Kinesin walks hand-over-hand Yildiz A, Tomishige M, Vale RD, Selvin PR.; Science. 2004 Jan 30;303(5658):676-8 • Mutations affecting segment number and polarity in *Drosophila* Christiane Nusslein-Volhard and Eric Weischaus; Nature 287, 795-801, • Information for the dorsal--ventral pattern of the *Drosophila* embryo is stored as maternal mRNA Anderson KV and Nüsslein-Volhard C; Nature. 1984 Sep 20-26;311(5983):223-7 • Hedgehog signalling in the mouse requires intraflagellar transport proteins Huangfu D, Liu A, Rakeman AS, Murcia NS, Niswander L, Anderson KV.; Nature. 2003 Nov 6;426(6962):83-7	
Elective courses to be offered in III Semester					(Common with M.Sc. Biotechnology III Sem.)
1)	**BT:** Enzyme Technology	After successful completion of the course, students should be able to: • Develop understanding of enzymes and	**BT 406: Enzymology and Enzyme Technology** **Section-A** • History and introduction to enzymes: ~~Classification of enzymes. IUPAC system, nomenclature, E.C. numbers.~~ • ~~Enzyme kinetics (Michaelis - Menten laws), importance and determination of Vmax and Km values, Hofstee's plot, L & B plots.~~	**Enzyme Technology** **Section-A** • Enzymes: Scope, historical developments, distinguishing features. • Mechanisms of enzyme action: Concept of active site, specificity of enzyme action. • Methods of characterization of enzymes – Development of	The course "Enzyme Technology" is proposed as a new elective course by updating and shifting the existing core course BT 406

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		their mechanism of action and regulation. • Explain the production of enzymes. • Learn wide applications of enzymes and their future potential.	• Bisubstrate reactions-ordered & random sequential mechanism. Theorell chance mechanism, ping pong mechanism, products of inhibition in bisubstrate reactions. • ~~Enzyme inhibition: competitive, non-competitive and other types.~~ **Section-B** • Extraction of soluble and membrane bound enzymes from microbial, plant and animal tissues. • Purification of enzymes: salt precipitation, gel filtration, ion exchange and affinity chromatography. Regulation of enzyme activity, various controls (metabolic compartmentation, covalent modifications and others), feedback regulation, allosteric enzymes ~~Coenzymes, Isozymes and~~ Multienzyme complexes • Methods of storing enzymes. **Section-C** • Large scale production of enzymes including genetic engineering approaches for their over production. • Enzyme engineering; identification of active sites, approaches for modification of catalytic properties. • Techniques of enzyme immobilization ~~and their applications in:~~ ~~v.~~ Food industry- ~~High fructose syrup, cheese making and beer industry.~~ vi. Antibiotics and other Pharamaceuticals vii. Medical applications ~~viii.~~ Analysis of substances, ~~enzyme electrodes, enzyme thermistors.~~ • ~~Basic idea of proteomics~~	enzymatic assays • Bisubstrate reactions-ordered & random sequential mechanism. Theorell chance mechanism, ping pong mechanism, products of inhibition in bisubstrate reactions. Regulation of enzyme activity, various controls (metabolic compartmentation, covalent modifications and others), feedback regulation, allosteric enzymes. **Section-B** • Extraction of soluble and membrane bound enzymes from microbial, plant and animal tissues. • Purification of enzymes: salt precipitation, gel filtration, ion exchange, affinity chromatography, enzyme crystallization, drying and freeze drying. • Large scale production of enzymes including genetic engineering approaches for their over production • Methods of storing enzymes. • Multienzyme complexes. • Designer enzymes, Thermophilic enzymes, Metal degrading enzymes. **Section-C** • Enzyme engineering; identification of active sites, approaches for modification of catalytic properties. Synzymes. • Techniques of enzyme immobilization: Adsorbtion, Covalent bonding, Gel Entrapment and Microencapsulation. • Applications of enzymes in: i. Food industry- Baking industry, Dairy industry, Beverage industry ii. Antibiotics and other pharamaceuticals iii. Medical applications iv. Analysis of substances	"Enzymology and Enzyme Technology" from the II Semester to III Semester.

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				v. Leather industry vi. Textile industry • Enzyme biosensors. **Suggested Books:** ➢ Palmer, T. & Bonner, P. (2014). *Enzymes: Biochemistry, Biotechnology and Clinical Chemistry*. UK: Woodhead Publishing Limited. ➢ Buchholz, K., Kasche, V. and Bornscheuer, U. (2005). *Biocatalysts and Enzyme Technology*, WILEY–VCH. ➢ Pandey A., Webb C., Soccol, C. R. and Larroche, C. (2006). *Enzyme Technology*. Springer. ➢ Price N. & Stevenson L. (1999). *Fundamentals of Enzymology: Cell and Molecular Biology of catalytic Proteins*, Oxford University Press. ➢ Daniel L. Purich (2009). *Contemporary Enzyme Kinetics and Mechanism.* Atlantic Publishers and Distributers. ➢ Blanch, H.W., & Clark, D.S. (1997). *Biochemical Engineering*, Marcel Dekker. ➢ Drauz K., Gröger, H. and May, O. (2012). *Enzyme Catalysis in Organic Synthesis: A Comprehensive Handbook*, Volume 1, Wiley-VCH Verlag & Co. **Suggested e-resources:** ➢ **Enzymes: properties and mechanisms** http://www.biologydiscussion.com/enzymes/enzymes-properties-and-mechanism-of-enzyme-action/6145 ➢ **Enzyme technology: metagenomics, evolution and biocatalysis** https://searchworks.stanford.edu/view/8775255	
2)	**BIO 503:** Fundamentals of Bioentrepreneurship	After successful completion of the course, students should be able to: • Understand	**Section-A** • ~~Accounting and Finance: Taking decision on starting a venture; Assessment of feasibility of a given venture/new venture; Approach a bank for a loan; Sources of financial assistance~~; Making a business proposal/~~Plan for seeking~~	**Section-A** • Concept of entrepreneurship; Classification and types of entrepreneurship, Myths about entrepreneurship; Role of entrepreneurship in wealth building and creating an impact; Society, Technology and Entrepreneurship.	

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		role of entrepreneurship in promoting innovation and wealth generation. • Develop skills for writing business models for new ideas and market segments. • Explain various financial, marketing, sales and legal issues associated with entrepreneurship.	~~loans from financial institution and banks; Funds from bank for capital expenditure and for working; Statutory and legal requirements for starting a company/venture; Budget planning and cash flow management.~~ • ~~Basics in accounting practices: concepts of balance sheet, P~~ & L ~~account and double entry book keeping; Estimation of income, expenditure, income tax etc.~~ **Section-B** • Marketing: Assessment of market demand for potential product (s) of interest; Market conditions, segments; prediction of market changes; Identifying needs of customers including gaps in the market, packaging the product; Market linkages, branding issues; Developing distribution channels; Pricing/Policies/Competition; Promotion/Advertising; Services Marketing. • ~~Negotiations/Strategy: with financiers, bankers etc; with government/law enforcement authorities: with companies/Institutions for technology transfer; Dispute resolution skills; External environment/changes; Crisis/Avoiding/Managing; Broader version-Global thinking.~~ **Section-C** • ~~Information Technology: How to use IT for business administration; Use of IT in improving business performance; Available software for better financial management; E-business setup, management.~~ • ~~Human Resource Development (HRD): Leadership skills; Managerial skills; Organization structure, pros & cons of different structures; Team building, teamwork; Appraisal; Rewards in small scale set up.~~ • Fundamentals of Entrepreneurship, Support mechanism for ~~entrepreneurship in India, Role of knowledge centre and R & D, knowledge centres like universities and research~~	• Creativity and Innovation; Types and forms of Innovation; Sources of innovative opportunity; Entrepreneurship as a career option. **Section-B** • Introduction to the Design Thinking Process; Problem identification; Idea Generation; Value Proposition; Lean Canvas. • Identifying Customer Segments; Idea Validation; Developing Business Model; Sizing the opportunity; Building MVP; Concept of Start-up, Importance of Incubation. **Section-C** • Financial and Non financial support**:** Revenue streams; Pricing and Costs; Sources of funds; Importance of project management. • Marketing and Sales: Positioning; Channels and Strategy; Sales Planning. • Team: Importance of teambuilding; Complementary skill sets. • Legal issues: Brief overview of- intellectual property rights, patents, trademarks, copy rights, trade secrets, licensing and GI. • Business Plan writing. • Policies and Initiatives to promote Entrepreneurship in India. **Suggested Books:** ➢ Jain, P.C. (2001). *Hand Book for New Entrepreneurs*. UK: Oxford University Press.	

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			~~institutions; Role of technology and upgradation; Managing Technology Transfer; Regulations for transfer of foreign technologies; Technology transfer agencies.~~ **Recommended Books:** ➢ Patzelt, H., &Bernner, T. (Eds.). (2008). *Handbook of Bioentrepreneurship*. Berlin, Germany: Springer. ➢ Robert, D. H., & Peters, M. P. (2002). *Entrepreneurship*. New York, USA: McGraw-Hill Education ➢ Shane, S. (2004). *Academic Entrepreneurship: University Spinoffs and Wealth Creation*. Northampton, M.A.: Edward Elgar	➢ Hisrich R. D., Manimala M. J., Peters Michael P. & Shepherd D. A. *Entrepreneurship* (9th ed.). McGraw Hill Publication. ➢ Roy, R. (2011). Entrepreneurship (2nd ed.). UK: Oxford University Press. ➢ Drucker, P. (2015). *Innovation and Entrepreneurship* (1st ed.). Routledge Classics. ➢ Kotler, P & Keller, K.L. (2017).*Marketing Management* (15th ed.). Pearson Publications ➢ Desai, V. (2011) *Dynamics of Entrepreneurial Development & Management* (6t ed.). Mumbai: Himalaya Publishing House. ➢ Khanka, S.S. (2007) *Entrepreneurial Development*. New Delhi: S. Chand & Company Ltd. ➢ Mohanty, S K. (2005). *Fundamentals of Entrepreneurship*. EEE Prentice Hall India Learning Private Limited. ➢ Gupta C.B. & Srinivasan N.P. (2013). *Entrepreneurship Development in India.* Sultan Chand & Sons. ➢ Gupta A.K. (2016).*Grassroots Innovations (Minds On the Margin Are Not Marginal Minds).* Random House. ➢ Patzelt, H., &Bernner, T. (Eds.). (2008). *Handbook of Bioentrepreneurship*. Berlin, Germany: Springer. ➢ Robert, D. H., & Peters, M. P. (2002). *Entrepreneurship*. New York, USA: McGraw-Hill Education ➢ Shane, S. (2004). *Academic Entrepreneurship: University Spinoffs and Wealth Creation*. Northampton, M.A.: Edward Elgar **Suggested e-Resources:** ➢ **Entrepreneurship** https://www.startupcommons.org/what-is-startup-ecosystem.html https://getproductmarketfit.com/how-to-select-test-to-get-market-validation-for-new-product-or-business-idea/	

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				https://www.coursera.org/learn/wharton-launching-startup https://www.coursera.org/learn/wharton-entrepreneurship-opportunity http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.463.4354&rep=rep1&type=pdf ➢ **Accounts and Bioentrepreneur** https://www.nature.com/bioent/2003/031101/full/bioent779.html ➢ **Bioentrepreneurship** www.birac.nic.in/webcontent/jk.pdf ➢ **Biotechnology and entrepreneurship** http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.463.4354&rep=rep1&type=pdf	
3)	**BIO 505:** Microbial Technology	After successful completion of the course, students should be able to: • Utilize various strategies for strain improvement, overexpression, maintenance and containment of microbes • Describe strategies used for large scale production of various industrially relevant bioactive	**Section-A** • Biotechnological innovation in pharmaceutical, health, agricultural and industrial sectors. • Strategies for selection and improvement of industrial strains. • Measurement and control of bioprocess parameters. • Genetic and environmental control of metabolic pathways. **Section-B** • Industrial production of Biofuel, Biotransformation of Steroids, Single Cell Protein. • Biofertilizers (Rhizobium and BGA); Biopesticides (Bt toxin) • Biosensors (NH4, Sulphide); Biofilms. • Biopolymers (-PHB, Xanthum gum) **Section-C** • Microbial overproduction of recombinant molecules: Selection of suitable promoter sequences, ribosome binding sites, fusion protein tags, purification tags, protease cleavage sites and enzymes, inducible expression systems, limitations of metabolic engineering. • Large scale production using recombinant microorganisms:	**Section-A** • Biotechnological innovation in pharmaceutical, health, agricultural & industrial sectors. • Strategies for selection & improvement of industrial strains. • Measurement & control of bioprocess parameters. • Genetic & environmental control of metabolic pathways. **Section-B** • Industrial production of Biofuel, Biotransformation of Steroids, Single Cell Protein. • Biofertilizers (*Rhizobium* and BGA); Biopesticides (Bt toxin). • Biosensors (NH_4, Sulphide); Biofilms. • Biopolymers (PHB, Xanthum gum). **Section-C** • Microbial overproduction of recombinant molecules: Selection of suitable promoter sequences, ribosome binding sites, fusion protein tags, purification tags, protease cleavage sites and enzymes, inducible expression systems, limitations of metabolic engineering.	Typological corrections have been made.

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		molecules from microorganism s .	peptic hormones (secretin), metabolic engineering of antibiotics, basic ides of biohydrometallury. • Maintenance and containment of recombinant microorganisms. • **Books Recommended :** ➢ Biotechnological Innovations in Chemical Synthesis, BIOTOL, Butterworth - Heinemann. ➢ Industrial Microbiology, G. Reed (editor), CBS Publishers (A VI Publishing Company) ➢ Genetics and Biotechnology of Industrial Microorganisms. C.L. I-le' -shnergev, S.W. Queener and Q Hegen. American Society of Microbiology. ➢ Protein Expression A Practical Approach: Edited by S.J. Higgins and B.D. Hames (OUP).	• Large scale production using recombinant microorganisms: peptic hormones (secretin), metabolic engineering of antibiotics, basic idea of biohydrometallurgy. • Maintenance and containment of recombinant microorganisms. **Suggested Books:** ➢ BIOTOL, Currell, B.C. & Dam-Miera, R.C.E. (1997). *Biotechnological Innovations in Chemical Synthesis (BiotolSer)*. Oxford, UK: Butterworth-Heinemann, Elsevier. ➢ Reed, G. (2004). Prescott and Dunn’s Industrial Microbiology. New Delhi, India: CBS Publishers. ➢ Glazer, A.N. &Nikaido, H. (2008). *Microbial Biotechnology*. UK: Cambridge University Press. ➢ Kun, L.Y. (Ed.) (2003). *Microbial Biotechnology: Principles and Applications*. Singapore: World Scientific Publication Co.Ptv. Ltd. ➢ Braun,V. & Gotz, F. (Eds.). (2002). *Microbial Fundamentals of Biotechnology*. Germany: Wiley-Vch. ➢ Gupta, V.K. (Ed.), Sharma, G.D. (Ed.),Tuohy, M.G. (Ed.), Gaur, R. (Ed.). (2016). *The Handbook of Microbial Bioresources* (1st ed.). New Delhi, India: CABI Publishing. ➢ Crueger, W. &Crueger, A. (1990). *Biotechnology*, *A Text Book of Industrial Microbiology* (2nd ed.). U.S: Sinauer Associates Inc. **Suggested e- Resources:** ➢ **Microbial Biotechnology** http://www.biologydiscussion.com/microbial-biotechnology-2/microbial-biotechnology-biotechnology-2/71609 ➢ **Biosensor** https://www.edgefx.in/biosensors-types-its-working-and-	

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				applications/ ➢ **Biofertilizer** www.krishisewa.com/articles/organic-agriculture/115-biofertilizers.html ➢ ***Biopesticide*** www.agriinfo.in/default.aspx?page=topic&superid=3&topicid=1950	
4)	**BT 513:** Food Process and Biotechnology	After successful completion of the course, students should be able to: • Explain strategies of food preservation, spoilage and quality assessment • Understand various policies related to GM food and its safety assessment • Demonstrate the principles for production of various processed food	**Section-A** • Introduction and development of food biotechnology; Current status of Transgenic crops for crop improvement and enhanced agronmic performance. • International and National guidelines for safety assessment of genetically modified (GM) foods. • Contemporary food related policy issue and their implications. • General principals of Food spoilage, factors affecting spoilage; Methods of food preservation. Food products with enhanced shelf-life. **Section-B** • Mechanism of enzyme function and reactions in Food processing; Enzymic bioconversions e.g. starch and sugar conversion process; HFCS; Interesterified fat, hydrolysed protein etc. and their downstream processing. • Baking by amylases; Deoxygenation and desugaring by glucose oxidases; Beer mashing and chill proofing. • ~~Cheese making by proteases and~~ various other enzyme catalytic actions in food processing.-Fermented dairy products: cheese, yogurt, ~~butter~~; Bacteriocin from lactic acid bacteria and Alcoholic beverages. • Fermented vegetables, oriental foods, meat products, Fish& poultry products. **Section-C** • Process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products.	**Section-A** • Introduction and development of food biotechnology; Current status of transgenic crops for crop improvement & enhanced agronomic performance. • International and National guidelines for safety assessment of genetically modified (GM) foods. • Contemporary food related policy issue & their implications. • General principles of food spoilage, factors affecting spoilage; Methods of food preservation. Food products with enhanced shelf-life. **Section-B** • Mechanism of enzyme function and reactions in food processing; Enzymic bioconversions e.g. starch and sugar conversion process; HFCS; Interesterified fat, hydrolysed protein etc. and their downstream processing. • Baking by amylases; Deoxygenation and desugaring by glucose oxidases; Beer mashing and chill proofing. • Various enzyme catalysed actions in food processing- fermented dairy products (cheese, yogurt, kefir), alcoholic beverages, fermented vegetables, oriental foods, meat products, fish & poultry products. Bacteriocin from lactic acid bacteria. **Section-C** • Bioconversion of process wastes to useful products - whey, molasses, starch substrates and other food wastes. • Biotechnology applications in the production of	Some typological errors have been corrected. Butter has been replaced by kefir as it is a more important fermentation product of milk. Also food yeasts have been deleted as it is more relevant in fermentation.

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• Biotechnology applications in the production of additives/ingredients: Enzymes. • Carotenoids, amino acids, organic acids, vitamins, colouringflavours and nutraceuticals. • Production of new protein foods-Single cell proteins (SCP), mushroom, ~~food yeasts~~, algal proteins. • Quality control of food-Detection system, Enzyme Immunoassay and Radio-immunoassay. **Books Recommended :** ➢ Food Microbiology: W.C. Fragier, D.C. 1995. Westhoft 3rd Ed. Tata McGraw Hill. ➢ Food Microbiology : M.R. Adams, M.O. Moss, 1998 New Age International (P) Ltd. ➢ Principles of Fermentation Technology: P.F. Stanbury, A. Whittaker, S.J. Hall 1995. 2nd Edn. Pergamon Press. ➢ Basic Food Microbiology: G.J. Banwart (1898) CBS Publishers and Distributors, Delhi. ➢ Dairy Microbiology: R.K. Robinson (1990) Elsevier Applied Sciences, London.	additives/ingredients: enzymes, carotenoids, amino acids, organic acids, vitamins, colouring flavours and nutraceuticals. • Production of new protein foods- Single cell proteins (SCP), mushroom, algal proteins. • Quality control of food- detection system, Enzyme Immunoassay and Radio-immunoassay. **Suggested Books:** ➢ Frazier, W.C. & Westhoff, D.C. (2003). *Food Microbiology*. New York, USA: Tata McGraw Hill. ➢ Adams, M. R. & Moss, M. O. (2007). *Food Microbiology*. UK: Royal Society of Chemistry. ➢ Stanbury, P.F., Hall, S. J. & Whitaker, A. (1999). *Principles of Fermentation Technology*. Oxford, UK: Butterworth-Heinemann, Elsevier. ➢ Banwart, G.J. (1989). *Basic Food Microbiology*. New Delhi, India: CBS Publishers. ➢ Robinson, R.K. (1990). *Dairy Microbiology*. London, UK: Elsevier Applied Sciences. Pandey, A., Larroche, C., Soccol, C. R. & Dussap, C. (2008). *Advances in Fermentation Technology*. New Delhi, India: Asiatech Publishers, Inc. ➢ Joshi, V. K. & Pandey, A. (1999). *Biotechnology: Food Fermentation*. New Delhi, India: Asiatech Publishers Inc. **Suggested e- Resources:** ➢ **Quality control of food detection system** https://www.engineersgarage.com/Contribution/Arduino-based-Smart-IoT-Food-Quality-Monitoring-System ➢ **Food Preservation** https://sciencesamhita.com/methods-of-food-preservation/ ➢ **History of microorganisms in food**	

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				https://faculty.weber.edu/coberg/class/3853/3853%20HistoryofFood.htm ➢ **Genetically modified food** http://anrcatalog.ucdavis.edu/pdf/8180.pdf	
5)	**BT 515:** Genomics and Proteomics	After successful completion of the course, students should be able to: • Describe principles of functional genomics • Develop an understanding of proteomics and associated techniques • Understand comprehensive concept of nucleotide and protein sequencing.	**Section-A** • ~~Whole genome analysis: preparation of ordered cosmid libraries, bacterial artificial chromosome libraries. Shotgun libraries and sequencing, YAC.~~ • ~~Sequence analysis: computational methods, homology algorithms (BLAST) for proteins and nucleic acids, open reading frames, annotation of genes, EST.~~ • ~~Conserved protein motifs related structure/function (PROSITE, PI' AM, Profilescan).~~ • ~~Physical and Genetic mapping.~~ **Section-B** • ~~DNA microarray: printing of oligonucleotides and PCR products on glass slides, nitrocellulose paper.~~ • ~~Analysis of SNP using DNA chips.~~ • ~~Whole genome analysis for global patterns of gene expression using fluorescent labeled cDNA or end labeled RNA probes.~~	**Section – A** • Genomics – Introduction to genome & genomics; genetics *vs.* genomics. DNA microarray; preparation, understanding of microarray data, normalizing microarray data, detecting differential gene expression, correlation of gene expression data to biological process & analysis tools. Gene Expression Omnibus (GEO). • Large scale genome sequencing strategies. Genome assembly & annotation. Genome databases of plants, animals & pathogens. • Metagenomics: Gene networks: basic concepts, computational model such as Lambda receptor & lac operon. • Prediction of genes, promoters, splices sites, regulatory regions: basic principles, application of methods to prokaryotic & eukaryotic genomes. **Section – B** • Introduction to proteome and proteomics; protein chemistry *vs.* proteomics. Analytical techniques of proteomics; working principles of 2D – gel electrophoresis, mass spectrometry with their merits and demerits. • Mass spectrometers for protein and peptide sequencing; MALDI – TOF, electospray ionization coupled tandem Mass spectrometry. Tandem mass analyzer, triple quadrupole mass analyzer, ion – trap mass analyzer and FT – ion cyclotron resonance MS. Peptide Mass Fingerprinting. • Sequencing the protein fragments: Scoring Algorithm for Spectral analysis. Application of SALSA in amino acid –	The syllabus has been remodeled keeping in mind the current advances in technology.

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Section-C • ~~Proteomics Technology - Separation & isolation of protein, acquisition of protein structure database utilization.~~ • ~~Applications of Mass spectroscopy in proteomics : Isolation and sequence analysis of individual protein spots.~~ • ~~Types of Proteomics.~~ • ~~Proteomics Applications.~~ • ~~Protein and Peptide microarray.~~ • ~~Advantages & disadvantages of DNA & Protein microarrays~~. **Books Recommended :** ➢ Introduction to Bioinformatics - Parrysmith and Attwood. ➢ Introduction to Bioinformatics - Baxevenis and Oulette	Motif searching. **Section – C** • Next generation sequencing & assembly: elements of big data analysis, NGS Platforms based on pyrosequencing, sequencing by synthesis, emulsion PCR approach with small magnetic beads & single molecule real time (SMRT) sequencing. • Genome assembly algorithms, De-novo assembly algorithms. • Sequence Alignment formats: Sequence Alignment/Map (SAM) format, Binary Alignment/Map (BAM) format. Protein function prediction using Machine learning tools: supervised/unsupervised learning, neural network, SVM. • Protein-protein interactions: databases such as STRINGS, DIP, PPI server & tools for analysis of protein-protein interactions. **Suggested Books:** ➢ Brown, S.M. (2015). *Next-generation DNA sequencing Informatics* (2nd ed.). Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. ➢ Liebler, D. C. (2001). *Introduction to proteomics tools for the new biology*. US: Humana Press. ➢ Lesk, A.M. (2015). *Introduction to Genomics* (2nd ed.). Oxford, UK: Oxford University Press. ➢ Pevsner, J. (2017). *Bioinformatics and Functional Genomics* (3rd ed.). New Jersey, USA: John Wiley & Sons Ltd. ➢ Twyman, R.M. (2004). *Principles of Proteomics*. New Delhi, India: CBS Publishers. ➢ Thangadurai, D. & Sangeetha, J. (2015). *Genomics and Proteomics: Principles, Technologies, and Applications*. USA: CRC Press. ➢ Pennington, S. R. & Dunn, M. J. (Eds.). (2000). *Proteomics: From protein sequence to function*.	

<table>
<tr><th>S No.</th><th>Course List</th><th>Learning Outcome</th><th>Existing Syllabus</th><th>Suggested Syllabus</th><th>Remarks</th></tr>
<tr><td></td><td></td><td></td><td></td><td>Oxford, UK: Bios Scientific Pub Ltd.
Suggested e- Resources:
➢ Proteomics
https://nptel.ac.in/courses/102101055/4
➢ Genomics
https://bit.ly/2Nq86jQ</td><td></td></tr>
<tr><td>6)</td><td>BT 516: Immunotechnology</td><td>After successful completion of the course, students should be able to:
• Describe various theories describing antibody formation
• Explain the mechanism of immune response to various stimuli
• Elucidate on vaccines and their development.</td><td>Section-A
• Structure, genomic organisation, expression and functions of major histocompatibility complex.
• Organisation and expression of immunoglobulin genes ~~and antibody diversity~~.
• T cell receptors - genomic organisation, structure and isolation of TCR.
• ~~Immune regulation, positive and negative selection in thymus, apoptosis.~~

Section-B
• ~~Immunity to infectious diseases.~~
• Immunodeficiency and AIDS.
• ~~Transplantation Immunology.~~
• ~~Tumor Biology.~~

Section-C
• ~~Various approaches to vaccines.~~
• ~~T cell cloning,engineered antibodies production~~.
• ~~Radioimmunoassay, Enzyme linked immunosorbant assay, ELISPOT, Immunoblotting (western blotting).~~
• ~~Immunofluroescence, Immunoelectron microscopy, cell cytotoxicity assays and flow cytom~~etry.
Books Recommended:
➢ Abbas, A. K., Lichtman, A. H., &Pillai, S. (2017). Cellular and Molecular Immunology (9th ed.). Amsterdam,</td><td>Section- A
• Structure, genomic organization, expression and functions of major histocompatibility complex (MHC).
• Organization and expression of immunoglobulin genes.
• T-cell receptors- genomic organization, structure and isolation of TCR.
• Antibody diversity- mini gene theory, mutation theory, germ line theory, somatic recombination, V(D) J recombination. Combinatorial diversity, junctional diversity.

Section-B
• ABO Blood groups, blood transfusion, Bombay phenotype, Rh blood group, DAT test, MN blood group.
• Immunity to infectious diseases: Viral, bacterial, fungal and parasitic infections.
• Immunodeficiency disease: Primary and secondary immunodeficiency disease (AIDS).
Section –C
• History of vaccination, immunization types and vaccination properties.
• Types of vaccines: Live, killed, subunit, recombinant viral, synthetic peptide, anti-idiotype, DNA, toxoid, conjugate, recombinant vector and plant based vaccines.
• Stages of vaccine development and some common vaccines used in human MMR, poliovaccine & BCG vaccines.
Suggested Books:</td><td></td></tr>
</table>

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Netherlands: Elsevier. ➢ Delves, P. J., Martin, S. J., Burton, D. R., &Roitt, I. M. (2006*). Roitt's Essential Immunology* (11th ed.). New Jersey, USA: Wiley-Blackwell. ➢ Punt, J., Stranford, S., Jones, P., & Owen, J. (2018). *Kuby Immunology (*8th ed.). New York, USA: W. H. Freeman and Company. ➢ Tizard, I. R. (1995). *Immunology: Introduction*, (4th ed.). Philadelphia, USA: Saunders College Publishing.	➢ Austyn, J.M. &Wood, K.J. (1993). *Principles Of Cellular and Molecular Immunology*. London, U.K: Oxford University Press. ➢ Benjaminin, E., Coico, R. & Sunshine, G. (2000).*im*: A short course (4th ed.). New York, USA: Wiley-Liss. ➢ Cunnigham, A.J. (1978).*Understanding Immunology*. London, U.K.: Academic Press Inc. ➢ Hildemann, W.H. (1984). *Essentials of Immunology*. USA: Elsevier Science Ltd. ➢ Johnstone, A. & Thorpe, R. (1996) *Immunochemistry In Practice* (3rd ed.). US: Wiley-Blackwell. ➢ Joshi, K.R. & Osama, N.O. (2004). *Immunology and Serology*. India: Agrobios. ➢ Khan, F.H. (2009). *The Elements Of Immunology*. India: Pearson Education. ➢ Punt, J., Stranford, S., Jones, P. & Owen, J. (2018). *Kuby Immunology (*8th ed.). New York, USA: W. H. Freeman and Company. ➢ Reeves, G. & Todd, I. (2001). *Lecture Notes on Immunology* (4th ed.). US: Wiley-Blackwell. ➢ Rich, R.R., Fleisher, T. A, Shearer, W.T., Schroeder, H., Frew, A.J. & Weyand, C.M. (2018). *Clinical Immunology: Principles and Practice* (5th ed.). USA: Elsevier Science Ltd. ➢ Tizard, I. R. (1995). *Immunology: Introduction*, (4th ed.). Philadelphia, USA: Saunders College Publishing. **Suggested e- Resources:** ➢ **Antibodies and antigens** https://nptel.ac.in/courses/102103038/download/module2.pdf ➢ **Vaccines** https://nptel.ac.in/courses/104108055/37	

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				➢ **DNA vaccines** https://nptel.ac.in/courses/102103041/18 ➢ **Transplantation immunology** https://nptel.ac.in/courses/102103038/31	
7)	**BT 521:** Plant Biotechnology	After successful completion of the course, students should be able to: • Demonstrate principles for development of various stress resistant plants • Understand various techniques used in plant biotechnology	**Section-A** • Introduction, examples of current use of plant biotechnology. • Development of pathogen resistant plants (virus & insect resistance). • Development of plants of improved seed quality. • Artificial seeds. • Development of plants resistant to environmental stress. • Development of herbicide resistant plants. • Future outlook. **Section-B** • Immobilization of cells. • Gene delivery methods in intact and cultured tissues and cells. ○ *Agrobacterium*, Ti plasmids, ~~co-integrate and binary vectors~~. Other vectors - viral vectors. ~~○~~ Direct DNA uptake~~, microprojectile delivery, electroporation, microinjection, Liposomes.~~ • Chloroplast engineering : Advantages of ~~chloroplast transgenics~~, applications in production of biopharmaceuticals, introduction of agronomic traits, viz. disease resistance, herbicide resistance, salt and drought resistance; phytoremediation etc. • Biotechnology of Biological Nitrogen fixation : *nif* genes **Section-C** • Production of metabolites; metabolic engineering and industrial products : plant secondary metabolites; control mechanisms and manipulation of phenyl propanoids and shikimate pathways; general strategy towards production of plant cell products.	**Section A** • Introduction, examples of current use of plant biotechnology. • Development of pathogen resistant plants (virus & insect resistance). • Development of plants of improved seed quality; Artificial seeds. • Development of plants resistant to environmental stress and herbicides. • Future outlook. **Section-B** • Immobilization of cells. • Direct gene delivery methods. • Vector based gene delivery methods: *Agrobacterium*, Ti plasmid based vectors, viral vectors. • Chloroplast engineering: Advantages of transplastomics, applications in production of biopharmaceuticals, introduction of agronomic traits, viz. disease resistance, herbicide resistance, salt and drought resistance; phytoremediation etc. • Biotechnology of biological nitrogen fixation : *nif* genes. **Section-C** • Production of metabolites; metabolic engineering and industrial products: Overview of plant secondary metabolites; control mechanisms and manipulation of phenyl propanoids and shikimate pathways; general strategy to regulate the production of plant cell products. • Biotransformation using plant cells.	Modifications have been done in the light of current technologies.

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• Biotransformation using plant cells. • Cryobiology of plant cell cultures~~and establishment of gene banks.~~ • Edible vaccines. • ~~Radiobiology of cultured plant cells.~~ **Books Recommended :** ➢ Biotechnology - A Laboratory Course : J. M. Becker, G.A. Coldwell and E.A. Zachgo, Academic Press, New York. ➢ Genetic Engineering Technology in Industrial Pharmacy : Ed. - J.M. Tabor. ➢ Tissue Culture, Methods and Applications : P.F. Kruse. ➢ Plant Tissue Culture : Sharma and Alam; IK International Publiser Pvt. Ltd.	• Cryobiology of plant cell cultures. • Edible vaccines. • Molecular markers - hybridization and PCR based markers RFLP, RAPD, STS, SSR, AFLP, SNP markers. **Suggested Books:** ➢ Singh, B.D. (2011). *Plant Biotechnology* (2nd ed.). New Delhi, India: Kalyani Publisher. ➢ Chawla, H.S. (2009). *Plant Biotechnology* (3rd ed.). New Delhi, India: Oxford & IBH Publishing Co. Pvt. Ltd. ➢ Slater, A. (2008). *Plant Biotechnology: The Genetic Manipulation of Plants* (2nd ed.). Oxford, UK: Oxford Publisher. ➢ Peter, K.V., & Keshavachandran, R. (2008). Plant Biotechnology: Methods in Tissue Culture and Gene Transfer. India: Universities Press. ➢ Murphy, D. (2007). *Plant Breeding and Biotechnology: Societal Context and the Future of Agriculture* (1st ed.). UK: Cambridge University Press. ➢ Singh, B.S. (2007). *Fundamentals of Plant Biotechnology*. New Delhi, India: Satish Serial Publishing House. **Suggested e- Resources:** ➢ **Chloroplast Biotechnology** https://onlinelibrary.wiley.com/page/journal/14677652/homepage/chloroplast_biotechnology_special_issue.htm ➢ **Plant transformation technologies** http://repository.ias.ac.in/57240/1/23-pub.pdf ➢ **Abiotic stress and transgenics** http://repository.ias.ac.in/89833/1/1-pub.pdf	
8)	**BT 522:** Recombinant DNA Technology	After successful completion of the course, students should be able to: • Explain	**Section-A** • Chemical synthesis of DNA: Phosphodiester, triester approaches, ~~amidite method~~, solid phase automated synthesis of DNA. • Sequencing of DNA : ~~Chemical and dideoxy methods~~,	**Section-A** • Chemical synthesis of DNA: phosphodiester, phosphotriester, phosphite triester approaches, phosphoramidite solid phase automated synthesis of DNA, post-synthetic processing.	

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		techniques used for DNA synthesis, amplification and sequencing • Describe strategies of cloning in both prokaryotes and eukaryotes. • Identify novel diagnostic tools of rDNA and gene therapy	~~random and directed approaches~~, automated DNA sequencing, improved gel based sequencers, mass spectrometry based sequencing, pyrosequencing, 454 sequencing technologies. • PCR in gene recombination, Deletion, Addition, Overlap extension. PCR in molecular diagnostics. Viral and bacterial detection, PCR based mutagenesis~~,~~ Mutation detection: SSCP, DGGE, RFLP, Oligo ligation assay (OLA), Mismatch chemical cleavage (MCC), High resolution melt analyses, Allele-specific amplification (ASA). • Applications of Transposons in genetic engineering : construction of R plasmids, gene tagging and isolation, mutagenesis genome characterization etc. **Section-B** • ~~Vectors expressing cloned DNA in *E. coli*.~~ • Molecular cloning in ~~*E. coli* &~~ *Bacillus subtilis*. • Cloning in yeast. • DNA cloning in mammalian cells with SV-40 vector. • Cloning in plants: Direct and vector based approaches. **Section-C** • Site directed mutagenesis. • New Diagnostics in rDNA technology: Detection of genetic disorders, ~~test for pathogens,~~ DNA finger printing. • Gene Silencing techniques, ~~Introduction of siRNA and~~ siRNA technology, Micro RNA, Construction of siRNA vectors, ~~Principle and~~ application of gene silencing, ~~Gene~~ knockouts, ~~Gene replacement, Gene targeting, Transgenics~~, gene therapy. ~~Basic idea of~~ drug designing. • Cloning and expression of human interferon gene **Books recommended :**	• Sequencing of DNA: Maxam-Gilbert method, Sanger sequencing technique, automated DNA sequencing, improved gel based sequencers, primer walking method, whole genome shotgun sequencing, mass spectrometry based sequencing, pyrosequencing, 454 sequencing technologies. • Overlap-extension PCR in gene recombination, deletion and addition. • Mutation detection: SSCP, DGGE, RFLP, Oligo ligation assay (OLA), Mismatch chemical cleavage (MCC), High resolution melt analyses, Allele-specific amplification (ASA). • Applications of Transposons in genetic engineering: construction of R plasmids, gene tagging and isolation, mutagenesis, genome characterization etc. **Section-B** • Molecular cloning in *Bacillus subtilis*. • Cloning in yeast. • DNA cloning in mammalian cells with SV-40 vector. • Cloning in plants: Direct and vector based approaches. • Site directed mutagenesis: Oligonucleotide directed mutagenesis, PCR based mutagenesis. • Introduction to genome editing by CRISPR-CAS and its applications. **Section-C** • New diagnostics in rDNA technology: detection of genetic disorders, PCR in molecular diagnostics: Viral and bacterial detection, DNA finger printing. • Gene silencing techniques: RNAi, siRNA technology, construction of siRNA vectors, micro RNA, ribozymes, applications of gene silencing. • Knockout mice. • Gene therapy: types, viral and non viral vectors. An overview of structure & ligand based drug designing.	"Gene cloning and expression in *E. coli*," is a repetition of the paper Genetic Engineering taught in M.Sc. II Semester. The same has been replaced with recent genome editing technique "CRISPR-CAS"

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Molecular Cloning Vol. 1, 2 and 3 :Sambrook and Russell, Cold Spring Harberlaboratory, 2001. ➢ Molecular Biology of Gene : J.D. Watson, Pearson Education. ➢ An Introduction to Gene Technology-From genes to clones :Winnacker, VCH. ➢ Principles of Gene Manipulation : Old and Primrose. ➢ Molecular Biotechnology : B.R. Glick and J.J. Pasternak, ASM Press, Washington, USA. ➢ Genetic Engineering : Science and ethics on new frontier : Michael Boylan, Pearson Education. ➢ An Introduction to Genetic Engineering : S.T. Nicholl, Cambridge University Press. ➢ Recombinant DNA : J.D. Watson, W.H. Freeman. ➢ Nucleic acid and biotechnology : H.D. Kumar. ➢ Understanding DNA and Gene Cloning :Darlica, John Wiley and Sons.	• Cloning and expression of human interferon gene. **Suggested Books:** ➢ Sambrook, J.F. & Russell, D.W. (2001). *Molecular Cloning: A Laboratory Manual* (3rd ed.) Vol. 1, 2 and 3. Cold Spring Harbor laboratory. NY: Cold Spring Harbor Laboratory Press. ➢ Watson,J. D., Baker, T.A. & Bell, S.P. (2014). *Molecular Biology of the Gene* (7th ed.). US: Pearson. ➢ Winnacker, E.L. (1987). *From Genes to Clones: Introduction to Gene Technology*. Germany: Wiley VCH. ➢ Primrose, S. B. & Old, R.W. (2001). *Principles of Gene Manipulation* (6th ed.). New Jersey, USA: Wiley-Blackwell. ➢ Glick, B.R., Pasternak, J.J. & Patten, C.L. (2010). *Molecular Biotechnology: Principles and Applications of Recombinant DNA* (4thed.). US: American Society for Microbiology. ➢ Boylan, M. & Brown, K.E. (2001). *Genetic Engineering: Science and Ethics on New Frontier*. UK: Pearson Education. ➢ Nicholl, D.S.T. (2008). *An Introduction to Genetic Engineering* (3rded.). UK: Cambridge University Press. ➢ Watson, J.D., Meyers, R.M., Caudy, A.A. & Witkowski, J.A. (2007). *Recombinant DNA: Genes and Enomes-A short Course* (3rded.). Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. ➢ Kumar, H.D. (1990). *Nucleic Acid And Biotechnology*. New Delhi, India: Vikas Publication. ➢ Drlica, K. (2003). *Understanding DNA and Gene Cloning* (4thed.). New Jersey, USA: John Wiley & Sons Ltd. **Suggested e-Resources :** ➢ **Solid phase oligonucleotide**	

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				synthesis:https://www.atdbio.com/content/17/Solid-phase-oligonucleotide-synthesis ➢ **DNA sequencing** approaches:https://www.ncbi.nlm.nih.gov/books/NBK21117/CRISPR/ ➢ **Cas technology** https://bit.ly/2Edvm06 ➢ **Construction of siRNA expression vectors** https://bit.ly/2EqNLI8 ➢ **Gene knockout and transgenic mice** https://www.ncbi.nlm.nih.gov/books/NBK21632/	
9)	Bio Physics-I	After completion of this course, the students will be able to- • Understand the concepts of physical principles in the biomolecular systems. • Know properties and conformations of biomolecules • Understand the interaction between physics and biology		**Section A** ➢ Introduction: Brief introduction to all aspects of Biology, cellular automata, Conway's Game of life. ➢ Cell structure and function: Cell theory, cell membrane and transport, membranous organelles, Non-membranous organelles, Nuclear components and major cell types, viruses. ➢ Molecules in the cell: carbohydrates, lipids, proteins and nucleic acids, their structure and function. ➢ Code of life: Central dogma, DNA replication, transcription and translation. ➢ Energy in life forms: Cellular Respiration, Glycolysis, Krebs cycle, Electron transportchain, ATP calculation, Photosynthesis, C4 pathway. **Section B** ➢ Intermolecular interactions: Covalent interactions, disulphide bonds, Van der Waals interactions, bond angles and torsions. Role of hydrogen bonding and hydrophobic interaction in biomolecular structures. Examples of α-helices and β-sheets in proteins, Watson-Crick pairs in DNA, stacking interactions in DNA and RNA. ➢ Protein Conformation: Conformational properties of	New proposed Elective Course, c.w. M.Sc. Physics

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				polypeptides, Ramachandran plot, Helical parameters and conformation, organization as secondary and super secondary structures in proteins, domains and motifs. Protein folding in vivo and in vitro of globular proteins, basic idea. **Section C** ➢ Molecular Mechanics: Force field equation, Lennard Jones Potential, Potential energy surface, Z-matrix, Molecular modeling, Energy minimization techniques, Exhaustive search method, steepest descent and conjugate gradient methods, Molecular dynamics simulation, Verlet algorithm and simulated annealing protocol. ➢ Experimental techniques used to determine biomolecular structure: Principles and application of UV-visible, circular dichroism and fluorescence spectroscopy. ➢ Case studies on Helix to coil transitions, melting curves in proteins and DNA structures. X-ray crystallography of biomolecules: Obtaining single crystals of biomolecules, Single crystal data collection, Determination of point group, space group from symmetry of diffraction patterns, deducing cell parameters, interpretation of intensity data, Calculation of electron density, Solving the phase problem, Structure validation. **Suggested Books:** ➢ Tuszynski, J. A. &Kurzynski, M. (2003). *Introduction to molecular biophysics*. CRC press. ➢ Schlick, T. (2010). *Molecular modeling and Simulation: An Interdisciplinary Guide: An Interdisciplinary Guide* (Vol. 21). Springer Science & Business Media. ➢ Voet, D., Voet, J. G. & Pratt, C. W. (2013). *Fundamentals of Biochemistry: Life At The Molecular Level* (No. 577.1 VOE). Hoboken: Wiley. ➢ Cantor, C. R., & Schimmel, P. R. (1980). *Biophysical*	

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Chemistry: PART III: The Behavior of Biological Macromolecules. Macmillan. ➢ Van Holde, K. E. J. W. *Principles of Physical Biochemistry*/Kensal E. Van Holde, W. Curtis Johnson, P. Shing Ho. ➢ Jensen, J. H. (2010). *Molecular Modeling Basics*. CRC Press. ➢ Nelson, P. (2004). *Biological Physics*. New York: WH Freeman. **Suggested e-Resources:** ➢ **Non-Conventional Energy Systems** https://nptel.ac.in/syllabus/1021 ➢ **Quantum-mechanics of molecular structure** https://bit.ly/2SoEqof https://bit.ly/2SoEqof	
10)	Animal Biotechnology-I	At successful completion of this course students will be able to: • Comprehend tools of molecular biology and biotechnology for the improved production and protection of animals. • Evaluate and discuss public and ethical concerns over the use of		**Section-A** • History and importance of animal biotechnology, cryopreservation of gametes & embryos in mammals, artificial insemination (AI) techniques & their development: estrus synchronization; semen collection, evaluation & storage. • *In Vitro* fertilization and embryo transfer; superovulation, Microinjection & macroinjection: introduction, procedure, applications advantages and limitations. Ethical, social & moral issues related to cloning, in situ & ex situ preservation of germplasm. **Section-B** • Introduction to stem cell-definition, classification, characteristics, differentiation and dedifferentiation, stem cell niche, stem cells vs somatic cells, mechanism of pleuripotency in stem cells, different kinds of stem cells: adult stem cells, embryonic stem cells, fetal tissue stem cell, umbilical cord blood stem cells. • Human embryonic stem cells and society: The religious,	New proposed elective

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		animal biotechnology. • Demonstrate an understanding of the key topics in tissue engineering		legal, ethical and scientific debate, stem cell banking and ethical approaches on stem cells. • Stem cell therapies: Clinical applications of stem cell therapy, parkinsons and alzheimers disease, diabetes, kidney failure, lymphoma and leukemic malignancies requiring stem cell therapy. **Section-C** • Principles of Tissue Engineering- History & scope, basics of tissue engineering, cell- ecm interaction, wound healing mechanism, tissue engineering bioreactors, models of tissue engineering, biomaterials in tissue engineering, bioartificial organs: source of cells, choosing the right scaffold material, mode of transplantation. • Tissue Engineering & future perspectives: commercial products. **Suggested Books:** ➢ Portner, R. (2007). *Animal Cell Biotechnology*. New York, USA: Humana Press. ➢ Butler, M. (Ed.). (1991). *Mammalian Cell Biotechnology; A Practical Approach*, London, UK: Oxford university press ➢ Lanza, R., Gearhart, J., & Hogan, B. (2009). *Essentials of Stem Cell Biology* (2nd ed.).London, UK: Academic Press. ➢ Lanza, R., Langer, R. & Vacanti, J.(2013). *Principles of Tissue Engineering* (4th ed.). London, UK: Academic Press. ➢ Kumaresan, V. (2008). *Applied Animal Biotechnology*. Tamil Nadu, India: Saras Publication. ➢ Singh, B., Gautam, S.K., & Chauhan, M.S. (2015). *Textbook of Animal Biotechnology*. New Delhi, India:Teri Publication. **Suggested e-Resources**	

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				➢ **Cryopreservation of gametes and embryos in mammals** https://www.glowm.com/section_view/heading/Gamete and Embryo Cryopreservation ➢ **Human embryonic stem cell** https://bit.ly/2GX5SXW ➢ **Stem cell therapies** https://www.closerlookatstemcells.org/stem-cells-medicine ➢ **History and scope of Tissue Engineering** https://www.stoodnt.com/blog/tissue-engineering-applications-scopes/	
Proposed Reading Elective-I & II to be offered in III & IV Semester					common with Applied Microbiology and Biotechnology for Sem III and IV, Bioscience Sem IV
1)	**Drug Discovery**	On completion of this course, students should be able to: • Understand basics of R&D in drug discovery and should be able to apply knowledge gained in respective fields of pharmaceutical industry.		Modern drug discovery involves the identification of a target or drug lead using different techniques including molecular modeling, combinatorial libraries and high-throughput screening (HTS). Rational drug design is based on the understanding of the three-dimensional structures and physicochemical properties of drugs and receptors. Knowledge of molecular mechanisms, molecular dynamics simulations and homology modeling is necessary for studying drug/receptor interactions. The different conformational sampling techniques, fitness functions used in molecular docking and computational receptor-based and ligand-based drug design approaches are mostly used to design compounds with improved biological activity in rational drug design. Quantitative drug design using QSAR models are used to correlate structural molecular properties (descriptors) with functions (i.e. physicochemical properties,	

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		• Understand the role of synthetic chemistry in the development of pharmaceutical agents; and the modification of chemical structures to develop new drug molecules. • Have an advanced understanding of the chemical structure of a pharmaceutical agent and determine the chemical group/s responsible for a given biological effect. • Demonstrate a basic understanding of pharmacogenomics and bioinformatics as it relates to drug design and		biological activities, toxicity, etc.) of the compounds. Understanding the structure activity relationship between the 3D structure of a molecule and its biological activity may act as the basis for the prediction of compounds with improved biological activities. Different bio-analytical assays (LC/MS/MS, GC/MS and ELISA) could be developed further in support of *in vitro* and *in vivo* studies. Understanding the principles as well as an early characterization of drug toxicity, adsorption, distribution, metabolism and excretion (ADME) along with drug-drug interactions, plasma protein binding assays and metabolite profile studies helps in eliminating compounds with unacceptable pharmacokinetic characteristics, which is critical to successful drug discovery programs. **Suggested Books:** ➢ Krogsgaard-Larsen *et. al.* (2016). *Textbook of Drug Design and Discovery*. 5th Edition. CRC Press. ➢ Satyanarayanajois, S. D. (2011). *Drug Design and Discovery: Methods and Protocols*. Humana Press. ➢ Rahman, A. U., Caldwell, G. W. & Choudhary, M. I. (2007). *Frontiers in Drug Design and Discovery*. Bentham Science publishers Limited. ➢ Dastmalchi, S. *et. al.* (2016). *Methods and Algorithms for Molecular Docking-Based Drug Design and Discovery*. IGI Global. **Suggested e- Resources:** ➢ **Drug Discovery** https://bit.ly/2tCqdtE ➢ **Peptide therapeutics** https://www.sciencedirect.com/science/article/pii/S1359644614003997 ➢ **Bio-analytical techniques** https://www.pharmatutor.org/articles/bioanalytical-techniques-overview	

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		discovery.			
2)	**Human Genetics and Diseases**	After successful completion of the course students will be able to: • Understand hereditary and molecular genetics with a strong human disease perspective. • Describe genetic abnormalities underlying human disease and disorders • Develop interest in biomedical research, genetic counseling, medicine, and clinical genetics		Since the rediscovery of Mendel's work in 1900, investigations on the genetic nature of human traits have gained significant importance. Understanding the genetic basis behind human disease is one of the most important reasons to study human chromosome structure, human karyotype, banding techniques, chromosome identification and nomenclature (ISCN)**.** Classical genetics has considerable importance in constructing genetic hypothesis from pedigree data analysis in monogenetic traits, autosomal dominant, autosomal recessive, sex linked dominant, sex linked recessive and sex influenced traits. The impact of consanguinity in causing sex linked anomalies (haemophilia, colour blindness and Duchenne Muscular Dystrophy) has been observed in human population. Current knowledge on genetic variations across populations is applied to study human health and diseases which include chromosomal disorders, structural and numerical chromosomal anomalies (Klinefelter syndrome, Down's syndrome, Turner syndrome, Achondroplasia), inborn errors of metabolism (Phenylketonuria (PKU), Alkaptonuria, Albinism, Galactosemia), haemoglobinopathies, Thalassemia syndromes, multifactorial disorders (diabetes, schizophrenia, huntington disease). Medical genetics involves ethical issues therefore serious discussion is required for prenatal/adult diagnosis of genetic disorders, medical ethics, risks and benefits, informed consent and right of choice. **Suggested Books:** ➢ Strachan T. & Read. A. (2011). *Human Molecular Genetics*(4thed.). Garland Science ➢ Pasternak J. Fitzgerald. (1999). *An introduction to Human Molecular Genetics-Mechanism of Inherited Diseases*. Science Press.	

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				➢ Thompson and Thompson.(2007).*Genetics in Medicine (7th Ed.*).Saunders **Suggested E-Resources:** ➢ **Chromosome identification and nomenclature (ISCN)** http://www.cydas.org/Resources/ISCN_Discussion.html ➢ **Pedigree data analysis** https://learn.genetics.utah.edu/content/disorders/ ➢ **Genetic disorders** https://www.genome.gov/10001204/specific-genetic-disorders/ ➢ **Prenatal/ adult diagnosis of genetic disorders, medical ethics** https://www.michiganallianceforfamilies.org/all/#sectionD	
3)	**Intellectual Property Rights**	After completing this course, students will be able to: • Understand the concept of IPR and its types • Describe the steps for patenting • Discuss the role of WTO and WIPO on IPR		Intellectual property rights (IPR) have an old history and are very relevant for economic development. Various types of IPR (patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications) are recognized with specific uses. There is currently an emergence of specific IP pertaining to plants and animals (UPOV, Plant Breeder's rights and plant variety protection and farmers rights act, patent protection of plant and animal inventions (WTO) and Law on the protection of New plant varieties and animal breeds (WIPO)). It is important to know about types of patent applications and the process of patenting with special emphasis to India. The role of WTO (GATT and TRIPS) and WIPO in implementation of IPR is significant as is understanding the relevance of Patent Cooperation Treaty (PCT) in patenting. IPR also are associated with certain ethical dilemma and there are some interesting case studies which highlight its relevance. **Suggested Books**: ➢ Sateesh, M.K. (2008). *Bioethics and Biosafety*. I.K.	

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				International Publishing House. ➢ Goel D. & Parashar S. (2013). *IPR, Biosafety and Bioethics* (1st ed.) Pearson Education India. ➢ Pandey, N. & Dharni, K. (2014). *Intellectual Property Rights.* PHI Learning ➢ Ramakrishna, B. & Kumar, A. (2017). *Fundamentals of Intellectual Property Rights: For Students, Industrialist and Patent Lawyers* (1st ed.). Notion Press **Suggested e- Resources:** ➢ **World Trade Organisation**. http://www.wto.org ➢ **World Intellectual Property Organisation.** http://www.wipo.int ➢ **International Union for the Protection of New Varieties of Plants.** http://www.upov.int ➢ **National Portal of India**. http://www.archive.india.gov.in	
4)	**Medical Microbiology**	After successful completion of the course, students should be able to: • Identify various bacterial, fungal, viral and protozoan diseases and their epidemiology • Understand the relevance of emerging and reemerging diseases	**Medical Microbiology and Immunology** **Section-A** • Innate and Acquired Immunity • Antigens : types of Antigens, Antigen specificity, haptens, Antibody structure and functions • MHC, Complement System • Cell mediated cytotoxicity : Origin, maturation and characterization of T-lymphocytes, Monocytes & Macrophages, Mechanism of T cell and NK cell mediated lysis, ADCC, Macrophage mediated cytotoxicity, lymphokines - the product of T cell activation. • Humoral immune response : Origin, maturation and characterization of B-lymphocytes, Activation and proliferation of B-cells, Formation of plasmablast, Plasma cells and memory cells, Interaction of B and T cells. **Section-B**	**Medical Microbiology** Medical Microbiology describes the cause, transmission, epidemiology, pathogenesis, symptoms, diagnosis and treatment of various bacterial (tuberculosis, typhoid, leprosy), fungal (superficial, subcutaneous, systemic mycosis), protozoan (Malaria, amoebiasis) and viral (AIDS, Influenza, measles) diseases. Currently, it is necessary to understand the impact of emerging and remerging diseases (cholera, dengue, multidrug resistant tuberculosis, H5N1 avian influenza, drug resistant malaria, chikungunya) on human health. Global assessment for various diseases also shows an increasing trend of nosocomial infections and opportunistic infections which cause significant mortality and health concerns.	The immunology portion is very relevant and should be taught separately. This paper should focus only on human pathogen interaction. The importance is that students become well versed with clinical microbiology and epidemiology studies.

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• Hypersensitivity, Monoclonal antibodies and its applications. • Radioimmunoassay, Enzyme linked immunosorbant assay, immunoblotting, immunofluorescence and flowcytometry • Characteristics of infectious diseases, Herd immunity. • Disease cycle (Source of disease, reservoir, carriers) • Transmission of pathogens (Air borne, contact transmission and vector transmission). **Section-C** • Bacterial Diseases : Epidemiology, Pathogenicity, Laboratory diagnosis, Prevention & control of the following diseases : Anthrax, Tuberculosis, Typhoid, Whooping cough, Tetanus, Diphtheria, Leprosy. • General Account of fungal diseases : Mycosis, Subcutaneous and deep. • General Account of viral & protozoan diseases : Pneumonia, Influenza, Mumps, Measles, Polio, Hepatitis B, Chickenpox, AIDS and Malaria, Leishmaniasis. • Brief account of sexually transmitted diseases. **Books Recommended :** ➢ Text Book of Microbiology : R. Ananthanarayanan and C.K. Jayaram Panicker, Orient Longman, 1997. ➢ Medical Microbiology, Vol, 1 : Microbial infection : Mackie and MaCartney, Churchil Livingstone, 1996. ➢ Bailey and Scott's Diagnostic Microbiology : Baron EJ, Peterson LR and Finegold, SM Mosby, 1990. ➢ Essential immunology (1995) : Roitt, I.M. Black well Scientific Publications, Oxford. ➢ Fundamental immunology : W.E. Paul 1984, Raven Press, New York. ➢ Fundamentals of Immunology : R.M. Coleman, M.F. Lombord and R.E. Sicard (1992) - 2nd ed. C. Brown publishers. ➢ Immunology : D.M. Weir and J Steward 7th Ed. (1993).	**Suggested Books:** ➢ Brooks, G.F., Carroll, K.C., Butel, J.S., Morse, S.A. & Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's Medical Mcirobiology (26^{th} ed.). US: Lange Medical Books, Mc Graw-Hill. ➢ Madigan, M., Martinko, J., Stahl, D. & Clark, D. (2010). *Brock Biology of Microorganisms* (13^{th}ed.). UK: Pearson Education. ➢ Pelczar Jr., M.J., Chan, E.C.S. & Krieg, N.R. (2011). *Microbiology*. New York, USA:Tata McGraw-Hill. **Suggested e- Resources:** ➢ **Emerging Diseases** *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3701702 /* ➢ **Epidemiology**	

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Broude A.I. (1981) : Medical "Microbiology" : and Infectious Diseases W.B. Saunders & Co. Philadelphia. ➢ Immunology : Janis Kuby. ➢ An Introduction to Immunology : lan R. Tizzard.	https://bit.ly/2SUmzum ➢ **Nosocomial Infections** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3470069/	
5)	**Molecular Plant Breeding**	After completing this course, students will be able to: • Understand strategies and applications of plant breeding technologies. • Comprehend the knowledge of different plat molecular markers • Plan a research career in the area of plant biotechnology		Plant breeding study involves breeding methods for self and cross pollinated crops. There are several limitations of conventional breeding. Thus, there is need to have a better breeding approaches to overcome this limitation. Development of molecular markers (RFLP, RAPD, SSRs, ISSRs, SNPs), construction of molecular maps and linkage analysis, mapping populations for QTLs using molecular markers play an important role in plant breeding. In order to develop potential plant having better qualities, Marker Assisted Selection (MAS) is also a viable approach which can be done by using selection of traits and markers, trait association, marker assisted backcrossing and recurrent selection, marker assisted hybrid breeding and marker assisted improved varieties/germplasm. **Suggested Books:** ➢ Chawla, H. S. (2000). *Introduction to Plant Biotechnology*. USA: Science Publishers. ➢ Slater, A., Scott, N. & Fowler, M. (2008). *Plant Biotechnology: The Genetic Manipulation of Plants* (2nd ed.). UK: Oxford University Press. ➢ Primrose, S.B., Twyman R.H. & Old R.W. (2001). *Principles of Gene Manipulation* (6th ed.). Wiley-Blackwell. ➢ Nicholl, D.S.T. (2008). *An introduction to Genetic Engineering* (3rd ed). Cambridge: Cambridge University Press. ➢ Glick, B.R., Pasternak, J.J. & Patten C.L. (2010). *Molecular Biotechnology: Principles and applications of recombinant DNA* (4th ed.). American Society for Microbiology.	

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				➢ Watson, J.D., Gilman, M., Witkowski J. & Zoller, M. (1992). *Recombinant DNA* (2nd ed.). W. H. Freeman publisher. **Suggested e-Resources:** ➢ **Plant breeding** https://nptel.ac.in/courses/102103013/pdf/mod6.pdf ➢ **Molecular marker** https://bit.ly/2XmNm0M ➢ **Gene mapping in plant** https://bit.ly/2TaegKm	
6)	**Protein Engineering**	On completion of this course, students should be able to: • Analyse structure and construction of proteins by computer-based methods • Describe structure and classification of proteins • Analyse and compare the amino acid sequence and structure of proteins, and relate this information to the function of proteins		An introduction to protein engineering for developing proteins with desired functions. Various methods (rational design and directed evolution) of protein engineering are employed to manipulate the different features or characteristics (affinity, specificity and stability etc) of proteins. Engineering various physicochemical and biological properties (stability to changes in parameters as pH, temperature, amino acid sequence and aggregation propensities etc) of the proteins could be important in their use as protein drugs and/or catalysts in bioreactors. The insight into the fundamental understanding of the mechanisms and forces (Van der waals, electrostatic, hydrogen bonding, weakly polar interactions, and hydrophobic effects), by which protein stabilizes, will help in the formulation of protein based pharmaceuticals. Protein engineering with site-specifically incorporation of unnatural or non-canonical amino acids has been used to improve protein function for medical and industrial applications. Different computational approaches (sequence and 3D structure analysis, data mining, Ramachandran map etc) to protein engineering would help to address the requirements in order to find amino acid sequences that will optimize a desired property (physicochemical property and/or biological function) of a protein. Determination of the	

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		• Explain how proteins can be used for different industrial and academic purposes such as structure determination, organic synthesis and drug design. • Plan and carry out activity measurements of isolated proteins and characterize their purity and stability.		physicochemical properties of proteins using various spectroscopic methods (Far-UV and Near-UV CD, Fluorescence, UV absorbance and Optical rotatory dispersion) would further support the drug development process. Yeast surface display (YSD) has become a valuable protein engineering tool for modifying the affinity, specificity, and stability of antibodies, as well as other proteins. YSD could be successfully used for protein epitope mapping, identification of protein-protein interactions, and uses of displayed proteins in industry and medicine. Developing vaccines and peptidomimetics will further allow the investigators to identify novel therapeutic leads for numerous unmet clinical needs. **Suggested Books:** ➢ Walsh, G. (2014). *Proteins: Biochemistry and Biotechnology*, Second edition. Chichester, West Sussex: Wiley Blackwell. ➢ Creighton, T. E. (1997). *Protein Structure: a Practical Approach*, 2nd Edition. Oxford University press. ➢ Cleland, J. L. & Craik, C. S. (2006). *Protein Engineering*, *Principles and Practice*, Vol 7. Springer Netherlands. ➢ Mueller, K. & Arndt, K. (2006). *Protein Engineering Protocols*, 1st Edition. Humana Press. ➢ Robertson, D. & Noel, J. P. (2004). *Protein Engineering Methods in Enzymology*, Vol 388. Elsevier Academic Press. ➢ Kyte, J. (2006). *Structure in Protein Chemistry*, 2nd Edition. Garland publishers. ➢ Williamson, M. P. (2012). *How Proteins Work*. New York: Garland Science. **Suggested e- Resources:** ➢ **Protein Engineering**: https://nptel.ac.in/courses/102103017/pdf/lecture%2022.	

S No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				pdf ➢ **Conformational stability of proteins**: https://bit.ly/2y85mid ➢ **Protein Engineering with Non-Natural Amino Acids:** https://library.umac.mo/ebooks/b2805488x.pdf	

* Matter in contrast (black background & white letters) is shifted to some other units, and material brought as a result of shift is also in contrast.
\# Matter in square brackets, bold, italic and crossed is deleted.
@ Proposed added materials are shaded in grey.

Annexure VI D

List of online courses in M.Sc. Applied Microbiology and Biotechnology Programme

S. No.	Portal	Name of course	Duration	Core/Elective/ Reading elective (Additional/ Alternate)	Credit point(s)	URL	Paid/ Free	Fee (course/ examination)	Remarks
	III Semester Elective Courses								
1	**SWAYAM** Dr. Adarsh Kumar Additional Professor, Department of Forensic Medicine & Toxicology AIIMS, New Delhi.	Forensic Biology and Serology	15 weeks (2 weeks for revision and assessment)	Elective	4	https://swayam.gov.in/course/264-forensic-biology-and-serology	Free	-	
2	**edX** TsinghuaX	Water and waste treatment engineering: Biochemical Technology	10 weeks 5-6 h/week	Elective	4	https://www.edx.org/course/water-wastewater-treatment-engineering-tsinghuax-40050455-2x-0	Paid	Add a Verified Certificate for $49	
3	**NPTEL**	Industrial Biotechnology	12 weeks	Elective	4	https://onlinecourses.nptel.ac.in/noc17_bt23/preview https://swayam.gov.in/search?keyword=Industrial%20Biotechnology	Paid	Certificate exam fee	
4	**Harvard**	Fundamentals of Ecology for Sustainable Ecosystem	-	Elective	4	https://www.extension.harvard.edu/academics/courses/fundamentals-ecology/12779	Paid	$1550	

S. No.	Portal	Name of course	Duration	Core/Elective/ Reading elective (Additional/ Alternate)	Credit point(s)	URL	Paid/ Free	Fee (course/ examination)	Remarks
	III/IV Semester Reading elective								
1	**NPTEL**	Bio- organic Chemistry	56 h	Reading elective	4	http://nptel.ac.in/courses/104103018/#	Paid	Certification exam fee	
2	**IIT, Delhi**	Enzyme Science and Engineering	28 videos	Reading Elective	2	http://freevideolectures.com/Course/85/Enzyme-Science-and-Engineering/1	Free	-	
3	**NPTEL**	Biocatalysis in organic synthesis	46 h	Reading Elective	3	http://nptel.ac.in/courses/104105032/	Paid	Rs. 1000 for certification exam fee	
4	**National Institute of Disaster Management** (Ministry of Home Affairs, New Delhi)	Comprehensive Disaster Risk Management Framework	6 weeks Run in batches throughout the year	Reading Elective	2	www.nidm.gov.in/online.asp	Paid	Rs. 1500 Exam fee	
5	**WIPO Academy** - [DL] Distance Learning Program	DL101E - DL-101 General Course on Intellectual Property	55 h	Reading Elective	4	https://welc.wipo.int/acc/index.jsf?page=courseCatalog.xhtml	Free	-	

S. No.	Portal	Name of course	Duration	Core/Elective/ Reading elective (Additional/ Alternate)	Credit point(s)	URL	Paid/ Free	Fee (course/ examination)	Remarks
6	**Algonquin college**	Environmental Management - An Introduction		Reading Elective	-	http://www.algonquincollege.com/ccol/courses/environmental-management-an-i			

BANASTHALI VIDYAPITH
Department of Bioscience and Biotechnology
M.Sc. BIOTECHNOLOGY
PROGRAMME EDUCATIONAL OBJECTIVES

The M.Sc Biotechnology programme aims for the holistic development of students through the unique and innovative five fold educational ideology of Banasthali Vidyapith. Biotechnology is identified as a potential technology which can impact all facets of life particularly agriculture and health sectors. The Programme has been designed to develop technically skilled personnel who as academicians, researchers, entrepreneurs and professionals can play a pivotal role in biotechnology and its allied sectors. Through a comprehensively designed course structure it is envisaged that students will realise their potential in academics as well as industry. The programme would inculcate moral values accompanied with an understanding of ethical and societal issues and safety concerns that a biotechnologist is increasingly facing. On completion of the Programme, students will be able to:

- identify, analyze and formulate solutions for complex biotechnological problems through team work and multidisciplinary approach
- design and apply appropriate tools for biotechnological manipulations.
- apply knowledge to solve societal problems keeping in mind the legal and ethical issues concerning genetic manipulation technologies
- develop scientific communication skills and be well versed with the latest technologies
- improve public perception of biotechnology and its role
- identify and generate ideas for entrepreneurial ventures
- engage in lifelong learning in the broadest context of technological change.

BANASTHALI VIDYAPITH
Department of Bioscience and Biotechnology
M.Sc. BIOTECHNOLOGY PROGRAMME OUTCOMES

PO1: **Knowledge**: Develop skills and theories associated with reconstruction, explanation and interpretation of knowledge associated with diverse fields of biochemistry, molecular biology, immunology, microbiology, tissue culture, environmental sciences, statistics, bioinformatics, genetics and industrial biotechnology.

PO2: Planning abilities: Demonstrate, design and execute research problems to highlight skills in planning, resource management, organsization and execution in a timely manner.

PO3: Problem analysis: Interpret, compare and analyze following rules of scientific methodology to arrive at a defensible conclusion of a problem.

PO4: Modern tool usage: Learn, identify, select and apply biotechnological tools and techniques for problem solving; choose correct statistical methods for data validation and bioinformatics computational tools and techniques for further analyses and interpretation.

PO5: Leadership skills: Understand the value of organization and team support to form and build units addressed towards problem solving. Ability to motivate, encourage, support and empathize.

PO6: Professional Identity: Cognition of the professional niche to be fulfilled in society as a part of social and economic capital.

PO7: Bioethics and Biosafety: Understand principle of bioethics to govern profession behavior to enable development of biotechnology with more positivity. Develop thorough understanding and knowledge of levels and types of biosafety to facilitate formation and development of infrastructure and methodology which imposes minimal to no damage to the stakeholders including society and environment.

PO8: Communication: Ability to perceive and to facilitate the understanding of science and its associated technology. Develop good written and oral skills, prepare effective presentations, development of standard operating procedures and publish research documents.

PO9: The biotechnologist and society: Identify problems in society related to biotechnology and its scope, formulate a solution, apply and execute it while taking responsibilities for ethical, moral and legal consequences.

PO10: Environment and sustainability: Comprehend and describe the environmental impact of biotechnology research and advancements. Identify possible solutions and methodologies to eliminate or mitigate or restore any negative influences while developing technologies as part of sustainable development highlighted by Convention of Biological Diversity.

PO11: Life- long learning: Self analysis, appraisal and constructive criticism to be used for further improvement which facilitates continued involvement and developments in mediating technological advances.

Department of Bioscience and Biotechnology, Banasthali Vidyapith
M.Sc. Biotechnology Programme

Existing Courses					
M.Sc. Biotechnology Sem. I		**L**	**T**	**P**	**C**
BIO 407	Cell and Molecular Biology	4	0	0	4
BIO 403	Biochemistry & Biophysics	4	0	0	4
BIO 416	Microbiology	4	0	0	4
BIN 401	Bioinformatics	4	0	0	4
BIO 401	Analytical Techniques-I	4	0	0	4
BIO 404L	Bioscience Lab-I	0	0	12	6
	Total	**20**	**0**	**12**	**26**

Proposed Courses					
M.Sc. Biotechnology Sem. I		**L**	**T**	**P**	**C**
BIO	Cell and Molecular Biology	4	0	0	4
BIO	Biochemistry	4	0	0	4
BIO	Microbiology	4	0	0	4
BIN	Bioinformatics	4	0	0	4
BIO	Analytical Techniques-I	4	0	0	4
BIO	Bioscience Lab-I	0	0	12	6
	Total	**20**	**0**	**12**	**26**

Existing Courses					
M.Sc. Biotechnology Sem. II		**L**	**T**	**P**	**C**
BIO 406	Biostatistics and Research Methodology	4	0	0	4
BIO 410	Genetics	4	0	0	4
BIO 411	Immunology	4	0	0	4
BT 406	Enzymology and Enzyme Technology	4	0	0	4
BT 408	Genetic Engineering	4	0	0	4
BIO 405L	Bioscience Lab-II	0	0	12	6
		20	**0**	**12**	**26**

Proposed Courses					
M.Sc. Biotechnology Sem. II		**L**	**T**	**P**	**C**
BIO 406	Biostatistics and Research Methodology	4	0	0	4
BIO	Genetics	4	0	0	4
BIO 411	Immunology	4	0	0	4
BIO 408	Environmental Biology and Biotechnology	4	0	0	4
BT	Genetic Engineering	4	0	0	4
BIO	Bioscience Lab-II	0	0	12	6
		20	**0**	**12**	**26**

(red)	Course proposed to be discontinued
(yellow)	Course content modified
(peach)	Course shifted to different semester
(green)	New course proposed
(purple)	Course shifted from different programme
(light green)	Course shifted from core to elective course

Existing Courses					
M.Sc. Biotechnology Sem. III		**L**	**T**	**P**	**C**
BT 522	Recombinant DNA Technology	4	0	0	4
BT 504	Bioprocess Engineering and Technology	4	0	0	4
BT 507	Cell and Tissue Culture Technology	4	0	0	4
BT 509	Environmental Biotechnology	4	0	0	4
BT 505L	Biotechnology Lab-I	0	0	12	6
	Elective	4	0	0	4
	Total	**20**	**0**	**12**	**26**
	List of Electives				
BIO 503	Fundamentals of Bioentrepreneurship				
BIO 505	Microbial Technology				
BT 513	Food Process and Biotechnology				
BT 515	Genomics and Proteomics				
BT 516	Immunotechnology				
BT 521	Plant Biotechnology				

Proposed Courses					
M.Sc. Biotechnology Sem. III		**L**	**T**	**P**	**C**
BT	Bioprocess Engineering and Technology	4	0	0	4
BT 507	Cell and Tissue Culture Technology	4	0	0	4
BIO	Critical Analysis of Classical Papers/ Landmark Discoveries (Seminar)	0	2	0	2
BT	Biotechnology Lab-I	0	0	12	6
	Discipline Elective	4	0	0	4
	Open Elective	4	0	0	4
BT	Reading Elective-I/ II	0	0	0	2
	Total	**16**	**2**	**12**	**26**

Existing Courses					
M.Sc. Biotechnology Sem. IV					
BT 508D	Dissertation	0	0	52	26
	Total	**0**	**0**	**52**	**26**

Proposed Courses					
M.Sc. Biotechnology Sem. IV					
	Reading Elective-I/ II	0	0	0	2
BT 508D	Dissertation	0	0	48	24
	Total	**0**	**0**	**48**	**26**

Proposed List of Elective courses to be offered in III Semester	
BIO	Fundamentals of Bioentrepreneurship
BIO 505	Microbial Technology
BT	Food Process and Biotechnology
BT	Genomics and Proteomics
BT	Immunotechnology
BT	Plant Biotechnology
BT	Recombinant DNA Technology
BT	Animal Biotechnology-I
PHY	Biophysics-I
BT	Enzyme Technology
BT	Forensic Biology and Serology https://swayam.gov.in/course/264-forensic-biology-and-serology
BT	Water and Waste Treatment Engineering: Biochemical Technology https://www.edx.org/course/water-wastewater-treatment-engineering-tsinghuax-40050455-2x-0
BT	Industrial Biotechnology https://onlinecourses.nptel.ac.in/noc17_bt23/preview https://swayam.gov.in/search?keyword=Industrial%20Biotechnology
BT	Fundamentals of Ecology for Sustainable Ecosystem https://www.extension.harvard.edu/academics/courses/fundamentals-ecology/12779

Proposed List of Reading Electives-I/II to be offered in III & IV Semester	
BT	Drug Discovery
BT	Human Genetics and Diseases
	Intellectual property rights
BT	Medical Microbiology
BT	Molecular Plant Breeding
BT	Protein Engineering
BIO	Bio- organic Chemistry http://nptel.ac.in/courses/104103018/#
BT	Enzyme Science and Engineering http://freevideolectures.com/Course/85/Enzyme-Science-and-Engineering/1
BT	Biocatalysis in organic synthesis http://nptel.ac.in/courses/104105032/
BT	Comprehensive Disaster Risk Management Framework www.nidm.gov.in/online.asp
BT	General Course on Intellectual Property https://welc.wipo.int/acc/index.jsf?page=courseCatalog.xhtml
BT	Environmental Management - An Introduction http://www.algonquincollege.com/ccol/courses/environmental-management-an-introduction/

Comparative Table: M.Sc. Biotechnology: Existing and Modified syllabus, Suggested Books and Suggested E-Resources

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
M. Sc. Biotechnology I Semester					
1.	**BIN 401:** Bioinformatics	After successful completion of the course, students should be able to: • Describe and identify various databases and tools used for phylogenetic analysis. • Apply protein structure prediction • Demonstrate and apply different tools for data-mining .	**Section-A** • ~~Introduction of computers: Basic components and their functions, hardware and software, Input-Output devices.~~ • ~~Basic concepts about data and information, Representation of data in computers in binary, bits and bytes~~. ~~Computer words coding (ASCII and EBCDIC), Number System Conversion.~~ • ~~Conceptual understanding of assemblers, Compilers, Operating System.~~ • ~~Introduction to Programming languages, C++, Perl~~. **Section-B** • ~~Information Retrieval: LAN, WAN, Introduction to Internet, WWW, NICNET, ERNET, On-line publishing ventures eg. Biomed Central,~~ BTIS Network in India. • ~~Introduction to Microarray Technology and its applications.~~ • Biological Databases: Primary Sequence databases (Protein and DNA databases), Secondary databases, Composite databases. Online international database access. **Section-C** • Sequence Alignment and Databases searching: ~~Evolutionary basis of sequence alignment~~, Optimal alignment methods; Dot Plot, ~~Dynamic Programming~~. • ~~Databases similarity searching: Algorithms of FASTA~~ BLAST.	**Section A** • Introduction and scope of bioinformatics, Introduction to biological databases: primary, composite, secondary databases and structural database. Description of specific databases: UniGene,UniProt, and RCSB – PDB). Introduction to genomics, proteomics and phylogenetics resources available at ExPassy. • Introduction to sequence analysis: Dot Plot, scoring matrices (PAM matrix) and gap penalty. **Section B** • Description and application of global and local sequence alignment. Sequence based database searching working algorithms of BLAST, variations of BLAST. Multiple Sequence alignment. Evolutionary significance of sequence alignment. • Evolutionary models: Jukes – Cantor and Kimura two parameter. • Phylogenetic Analysis: distance based (UPGMA, N-J Methods) and character based (Maximum Parsimony). **Section C** • Protein 2D structure prediction: Chou – Fasman algorithm • Protein 3D structure prediction: homology modeling, its advantage and limits. • Concept of structure optimization and energy minimization.	The components were very basic and mostly covered in undergraduate programs in almost every stream of science as compulsory computer knowledge. Learning languages such as C++ and Perl are extremely tedious; syntax of these two languages is very different to each other and not of use without hands-on sessions. More computer science information instead of bioinformatics. Further, the proposed syllabus is comprehensive for introductory course of bioinformatics. ClustalW is obsolete, progressive methods will include all the concept and methodology of programs like ClustalW. Protein structure prediction is the new introduction in the content to satisfy the need and requirement of a complete bioinformatics course.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• ~~Statistical significance of alignment, Substitution Scores and Gap penalties.~~ • Multiple Sequence alignment: ~~CLUSTAL W~~. [redacted]. ~~EMBOSS~~. **Books Recommended :** ➢ A textbook of Bioinformatics : Sharma, Munjal&Shanker, Rastogi Publication, Meerut ➢ Fundamental of computer : P.K. Sinha ➢ Introduction to Bioinformatics : Parrysmith and Attwood ➢ Introduction to Bioinformatics : Baxevenis and Oulette ➢ Internet for Molecular Biologist : Swindell ➢ Molecular databases for protein sequences and structure studies - An Introduction Silence : J., Sillince M., Springerberlagd, Berlin 1972 ➢ Leaping from Basic to C++ : Robert J. Traister, A.P. Professional Cambridge ➢ Perl 5 Unleashed : Kamran Husain & Robert F Breedlore SAMS Publishing. ➢ Bioinformatics : David, Mount.	• Forces stabilizing biomolecular interaction. • Principle of Molecular Docking. Types of molecular docking, its advantage and limits. **Suggested Books:** ➢ Rastogi, S.C. & Rastogi, P. (2013). *Bioinformatics Methods and Applications* (4thed.). New Delhi: PHI Learning Private Limited. ➢ Lesk, A.M. (2008). *Introduction to Bioinformatics.*UK: Oxford University Press. ➢ Krane, D.E. & Reymer, M.L. (2003).*Fundamental Concepts of Bioinformatics*. UK: Pearson Education. ➢ Attwood, T.K., Parry-Smith, D.J. & Phukam, S.(2009). *Introduction to Bioinformatics* (4thed.). UK: Pearson Education. ➢ Sharma, V., Munjal, A. & Shanker, A.(2017). *A Text Book of Bioinformatics* (2nded.). Meerut: Rastogi Publications. **Suggested e- Resources:** ➢ **Chou-Fasman Method for protein secondary structure prediction** https://pdfs.semanticscholar.org/fd8c/c95aec2d7af19ed28eea3688b3c231d0e745.pdf ➢ **Homology modeling** https://proteinstructures.com/Modeling/homology-modeling.html ➢ **ExPASy** https://www.expasy.org/	
2.	**BIO 401:** Analytical Techniques-I	After successful completion of the course, students should be able to: Comprehend the principles of	**Section-A** • Chromatographic methods for macromolecule separation- TLC and Paper chromatography, gel	**Section-A** • Chromatographic methods for macromolecule separation:	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		various instrumentation techniques: • Identify suitable and relevant tools for use in research problems • Utilize the scope of the content for designing and performing future experiments	permeation; ion exchange; hydrophobic, Reverse-phase and Affinity chromatography; HPLC, FPLC and GLC. • Electrophoretic techniques : • Theory and application of polyacrylamide and agarose gel electrophoresis, capillary electrophoresis; 2D electrophoresis; Disc gel electrophoresis; Gradient electrophoresis; Pulse field gel electrophoresis, Isoelectric focusing. **Section-B** • Microscopy- Microscope and its modifications- Light, Phase contrast and interference, Fluorescence, Confocal, Electron (TEM & SEM), Electron tunneling and Atomic Force Microscopy • Centrifugation -Basic principle & theory, Types of centrifuges- Micro centrifuge, High speed & Ultracentrifuges; Preparative centrifugation, differential & density gradient centrifugation. Analytical centrifugation & its applications. **Section-C** • Spectroscopy-Principle, instrumentation applications in biological sciences: UV-visible spectrophotometry Florometry& Atomic absorption Spectrophotometer (AAS). Principle and application of NMR, X-ray crystallography, ~~API electrospray~~, mass spectroscopy and MALDI-TOF, Circular Dichroism • Radioactivity : • Radioactive and stable isotopes; Pattern and rate of radioactive decay; Measurement of radioactivity; Geiger-Muller counter; solid and liquid scintillation counters (Basic principal,	TLC and Paper chromatography, Gel permeation, Ion exchange, Hydrophobic, Reverse-phase & Affinity chromatography; HPLC, FPLC & GLC. • Electrophoretic techniques: Theory and applications of polyacrylamide and agarose gel electrophoresis, capillary electrophoresis, 2D electrophoresis, Disc gel electrophoresis, Gradient electrophoresis, Pulse field gel electrophoresis & Isoelectric focusing. **Section-B** • Microscopy: Microscope and its modifications- Light, Phase contrast and interference, Fluorescence, Confocal, Electron (TEM & SEM), Electron tunneling & Atomic Force Microscopy. • Centrifugation: Basic principle & theory, types of centrifuges- Micro centrifuge, High speed & Ultracentrifuges. Preparative centrifugation: differential & density gradient centrifugation. Analytical centrifugation & its applications. **Section-C** • Spectroscopy: Principle, instrumentation applications in biological sciences. UV-visible spectrophotometry, Florometry & Atomic absorption spectrophotometer (AAS). Principle & applications of NMR, X-ray crystallography, Mass spectroscopy and MALDI-TOF, Circular Dichroism. • Radioactivity: Radioactive and stable isotopes, Pattern and rate of radioactive decay, Measurement of	Typographical errors have been rectified.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			instrumentation and technique); brief idea of radiation dosimetry; Cerenkov radiation; autoradiography. **Books Recommended :** ➢ Practical Biochemistry: Keith Wilson and John Walker, Cambridge University Press. ➢ Physical Biochemistry : David Friefelder. ➢ Instrumental methods of chemical analysis :Chatwal and Anand, Himalaya Publishing House. ➢ Instrumental methods of chemical analysis : B.K. Sharma, Goel Publishing House. ➢ X-Ray Methods : C. Whiston. ➢ The Electron Microscope in Biology : A. V. Grimstone. ➢ Tertiary level biology - Methods in Experimental biology : R. Ralph Blackie. ➢ Animal Tissue Technique : G.L. Humason. ➢ NMR and Chemistry : J.W. Akitt, Chapman and Hall.	radioactivity, Geiger-Muller counter, solid and liquid scintillation counters (Basic principle, instrumentation and technique), brief idea of radiation dosimetry, Cerenkov radiation & autoradiography. **Suggested Books:** ➢ Wilson, K. & Walker, J. (2010). *Principles and Techniques of Biochemistry and Molecular Biology*. Cambridge, UK: Cambridge University Press. ➢ Friefelder, D. (1982). *Physical Biochemistry: Applications to Biochemistry and Molecular Biology*. New York, USA: W.H. Freeman and Company. ➢ Chatwal, G.R. & Anand, S.K. (2018). *Instrumental Methods of Chemical Analysis*. New Delhi, India: Himalaya Publishing House. ➢ Sharma,B.K. (2004). *Instrumental methods of Chemical Analysis, In: Introduction to Analytical Chemistry*. New Delhi, India: Goel Publishing House. ➢ Talluri, S. (2012). *Bioanalytical techniques*. New Delhi, India: I.K. International Publishing House Pvt. Ltd. ➢ Chatanta, D.K. & Mehra, P.S. (2012). *Instrumental Methods of Analysis in Biotechnology*. New Delhi, India: I.K. International Publishing House Pvt. Ltd. **Suggested e- Resources:** ➢ **Chromatographic Techniques** https://nptel.ac.in/courses/103108100/module7/module7.pdf ➢ **Spectroscopic techniques** https://nptel.ac.in/courses/102103044/pdf/mod	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				2.pdf ➢ **Microscopic techniques** www.nptel.ac.in/courses/102103015/pdf/mod3 .pdf	
3.	**BIO 403:** Biochemistry &Biophysics	After successful completion of the course, students should be able to: • Understand the structure and role of various biomolecules • Identify, assess and explain various biochemical pathways • Develop understanding of enzymes and their mechanism of action	**Biochemistry & Biophysics** **Section-A** • ~~Hydrogen bonding and structure of water molecule, Ionization of water, pH and colligative properties of water~~. • Bioenergetics: First & second law of thermodynamics, concept of free energy, change in standard free energy, ~~ATP and its hydrolysis.~~ • Carbohydrates: general classification, Polysaccharides: ~~&proteoglycans~~: Starch, glycogen, cellulose, chitin ~~&bacterial cell wall~~. ~~Glycosaminoglycans& proteoglycans in extracellular matrix.~~ **Section-B** • Electron transport system in mitochondria & chloroplasts. Oxidative phosphorylation, P/O ratio, Uncouplers. • Lipids - Glycerophospholipids, sphingolipids, gangliosides, Eicosanoids & prostaglandins~~.~~ ~~Cholesterol & its biosynthesis~~. • Proteins & amino acids - Zwitterionic properties of amino acids & titration curves. Peptide bonds, disulphide cross links, various levels of structural organization of proteins. • Ramachandran plot, Alpha-helix, Beta sheet, ~~Helix-coil transitions.~~ **Section-C** • Structure function relationship in model proteins like ribonuclease A, haemoglobin, chymotrypsin.	**Biochemistry** **Section-A** • Bioenergetics: First and Second law of thermodynamics, concept of free energy, change in standard free energy. • Carbohydrates: general classification, Polysaccharides: Starch, glycogen, cellulose & chitin. • Glycolysis, Citric acid cycle. Electron transport system in mitochondria & chloroplasts. Oxidative phosphorylation, Photosynthetic phosphorylation, P/O ratio, Uncouplers. **Section-B** • Lipids - glycerophospholipids, sphingolipids, gangliosides, eicosanoids & prostaglandins. • Proteins & amino acids – Zwitterionic properties of amino acids & titration curves. Peptide bonds, disulphide crosslinks, various levels of structural organization of proteins. • Ramachandran plot, Alpha-helix, Beta sheet, • Structure function relationship in model proteins like ribonuclease A, haemoglobin and chymotrypsin. • Biosynthesis of purines and pyrimidines, *de novo* and salvage pathway, **Section-C** • Introduction to enzymes: Classification of	The title is changed as Biophysics component has been removed as it does not fit in two year M.Sc. Biotechnology programme. Section B: Relevant topics, which were earlier not part of the syllabus, have been added. These topics are essential part of the carbohydrate metabolism, a key component of the living organisms. Section C: Biophysics topics have been deleted. Reshuffling done in order to coherently organize various topics of the syllabus.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• Biosynthesis of purines and pyrimidines, *de novo* and salvage pathway, ~~various confirmations of nucleotides,~~ glycosidic bond rotation, base-stacking. • ~~Mechano-Chemical Process: Molecular structure of muscle-Actin, myosin, troponin, tropomyosin, Muscle Contraction.~~ • ~~Action Potential and propagation of neuronal computation through nerve fibre.~~ **Books Recommended :** ➢ Principles of Biochemistry : A.L. Lehninger, Nelson and Cox, McMillan Worth Publishers. ➢ Biochemistry :Voet and Voet, John Wiley and Sons, Inc. USA. ➢ Biophysical Chemistry Vol. I, II &III : Cantor and Schimmel, Freeman. ➢ Biochemistry :Zubey, WCB. ➢ Biochemistry : Garrett and Grisham, Harcourt. ➢ Biochemistry :Stryer, W. H. Freeman. ➢ Understanding Enzymes : T. Palmer, Horwood. ➢ Harper's review of Biochemistry : R.K. Murray et al., Prentice-Hall International Inc. ➢ Fundamentals of Biochemistry : Cohn and Stumf. ➢ Molecular Biophysics-Structure in Motion :Michel Daune, Oxford University Press.	enzymes Nomenclature of enzymes, E.C. Number • Enzyme kinetics (Michaelis – Menten kinetics), importance and determination of Vmax and Km values, L & B plots. • Enzyme inhibition: competitive, non-competitive and un-competitive. • Coenzymes and Isozymes. **Suggested Books:** ➢ Nelson, D. L. & Cox, M.M. (2012). *Lehninger Principles of Biochemistry* (6th ed.). New York, USA: W. H. Freeman and Company. ➢ Rodwell, V.W., Bender, D., Botham, K.M., Kenelly, P.J.& Weil., P.A. (2018). *Harper's Illustrated Biochemistry* (31st ed.). New York, USA: McGraw-Hill Education. ➢ Voet, D. &Voet, J.G.(2010). *Biochemistry* (4th ed.). New Jersey, USA: Wiley. ➢ Berg, J.M., Tymoczko, J.L., Gatto Jr., G.J. & Stryer, L. (2015). *Biochemistry* (8th ed.). New York, USA: W. H. Freeman and Company. ➢ Garrett, R. H. & Grisham, C. M. (2012). *Biochemistry* (5th ed.). Belmont, USA: Wadsworth Publishing Co Inc. ➢ Palmer, T. & Bonner, P. (2014). *Enzymes: Biochemistry*, *Biotechnology and Clinical Chemistry*. UK: Woodhead Publishing Limited. ➢ Cantor, C.R. & Schimmel, P.R. (1980). *Biophysical Chemistry Part I, II & III*. New York, USA: W. H. Freeman and Company. ➢ Ferdinand, W. (1976). *The Enzyme Molecule*. New Jersey, USA: John Wiley & Sons Ltd.	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Suggested e- Resources: ➢ **Metabolic pathways, Biomolecules** https://epgp.inflibnet.ac.in/ahl.php?csrno=2 ➢ **Mechanism of enzyme action** http://www.biologydiscussion.com/enzymes/enzymes-properties-and-mechanism-of-enzyme-action/6145 ➢ **E-book for Garrett and Grisham** https://bit.ly/2TbDWWR	
4.	**BIO 404L:** Bioscience Lab-I	After successful completion of the course, students should be able to: • Demonstrate use of various tools and techniques for detection and quantification of biomolecules. • Perform various biochemical assays for fats, carbohydrate, protein and enzymes • Demonstrate microbiological techniques • Access, retrieve, and analyze nucleotide and protein sequences using bioinformatics tools	1. Demonstration, principle and use of lab equipments: Centrifuges (~~Table top~~ and high speed), ~~Balances (electrical and digital).~~ ~~2. Demonstration, principle and use of lab equipments: Spectrophotometer, pH meter.~~ 3. Estimation of proteins by Lowry's ~~and TCA methods.~~ 5. Estimation of carbohydrates (reducing and non-reducing sugar). 6. Estimation of fats (cholesterol). 7. ~~Preparation and purification of casein from buffalo milk.~~ 8. Separation of amino acids by TLC and paper chromatography. 9. ~~Determination of Logic properties (pH value of Lysine by titration).~~ 10. ~~To find λmax for proteins.~~ 11. ~~Use of selective and diagnostic media for cultivation, isolation, enumeration and purification of microorganisms.~~ ~~12.~~ Measurement of bacterial ~~and fungal~~ growth. 13. Isolation and enumeration of microbes from air/soil by serial dilution/agar plating method. 14. Antibiotic sensitivity test. 15. ~~Microbiological examination of food~~.	**Analytical Techniques-I** 1. Demonstration: Working principle & applications of - Centrifuges (high speed refrigerated centrifuge & ultracentrifuge). - Fluorescence microscope. - Atomic absorption spectrophotometer, HPLC, FPLC, GC-MS. 2. Separation of amino acids by TLC and Paper Chromatography. **Cell and Molecular Biology** 3. Study of different stages of mitosis (onion root tip) and meiosis (onion buds/grasshopper testis) and determine the mitotic index. 4. Separation of chloroplast by sucrose density gradient centrifugation. **Biochemistry** 5. To prepare sodium acetate buffer and validate the Henderson-Hasselbach equation. 6. Extraction of crude enzyme from germinating mung bean seeds. 7. Estimation of total protein content by Lowry's method. 8. Separation of protein by SDS PAGE. 9. Estimation of acid phosphatase activity using	The experiments have been reframed and modified keeping in consideration, the suggested syllabus.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			16. Citric acid production by A. niger. ~~17.~~ Study of cell division in plants and animals,~~Giant chromosomes.~~ 18. Separation of different organelles/molecules by sucrose density gradient/differential gradient. 19. Separation and identification of serum proteins/plant proteins by gel electrophoresis. 20. ~~Histochemical localization of biomolecules (protein, carbohydrate or any other).~~ ~~21. Bioinformatics exercise 1~~ 22. ~~Bioinformatics exercise 2.~~	standard curve of p-nitrophenol. 10. Purification of the crude enzyme extract (from Expt. 6) using ammonium sulphate precipitation and ion exchange/ affinity chromatography (demonstration). 11. Determination of kinetic properties (K_m and V_{max} values) of acid phosphatase. 12. Estimation of total carbohydrates using Anthrone method. 13. Estimation of reducing sugar by Nelson-Somogyi method. 14. Estimation of fats (cholesterol). **Microbiology** 15. Isolation and enumeration of microbes from soil and water. 16. Staining of selected bacterial and fungal strains. 17. Estimation of bacterial growth by turbidometric method. 18. Antibiotic sensitivity test. 19. Estimation of infectivity titre of a virus sample using Plaque assay. **Bioinformatics** 20. Database Search: Use and analysis of BLAST tool for protein and DNA sequences. 21. Molecular Evolution: Multiple sequence alignment and phylogenetic analysis (Clustal X/ Mega/ Tree-View). 22. Structure Prediction: Protein secondary and tertiary structure prediction using online tools. 23. Molecular Visualization: Structural analysis of PDB entries for active and inactive states of protein(Pymol). **Suggested Books:**	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				➢ Aneja, K. R. (2001). *Experiments in Microbiology, Plant Pathology, Tissue Culture and Mushroom Production Technology*. New Delhi, India: New Age International Ltd. ➢ Cappuccino, J. G. & Welsh, C. (2019). *Microbiology: A Laboratory Manual*. New York, USA: Pearson. ➢ Sadasivam, S., & Manickam, A. (1996). *Biochemical Methods* (2nd ed.). New Delhi: New Age International Publishers. ➢ Saxena, J., Baunthiyal., & Ravi, I. (2015). *Laboratory Manual of Microbiology, Biochemistry and Molecular Biology*. Jodhpur: Scientific Publishers. ➢ Tille, P. M. & Forbes, B. A. (2017). *Bailey & Scott's Diagnostic Microbiology*. St. Louis, Missouri: Elsevier. **Suggested e- Resources:** ➢ **Harisha, S. Biotechnology procedures and experiments handbook** http://site.iugaza.edu.ps/mwhindi/files/BIOTECHNOLOGY-PROCEDURES-AND-EXPERIMENTS-HANDBOOK.pdf ➢ **Introduction to biotechnology** http://www.austincc.edu/awheeler/Files/BIOL%201414%20Fall%202011/BIOL1414_Lab%20Manual_Fall%202011.pdf	
5.	**BIO 407:** Cell and Molecular Biology	After successful completion of the course, students should be able to: • Understand membrane transport and cell signalling mechanisms. • Develop comprehensive understanding of endo-membrane system	**Section-A** • Molecular structure and function: ~~Structural models,Composition and dynamics;~~ Transport of ions and macromolecules; Pumps, carriers and channels; Membrane carbohydrates and their significance in cellular recognition; cellular junctions and adhesions; ~~structure and functional~~	**Section-A** • Molecular structure and function of plasma membrane: Transport of ions & macromolecules; Pumps, carriers and channels; Membrane carbohydrates & their significance in cellular recognition; Cellular junctions & adhesions.	Plasmodesmata already covered in 'cell junctions'

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		• Understand molecular mechanisms of prokaryotes and eukaryotes	~~significance of plasmodesmata~~. • Endocytosis and exocytosis, clathrin~~&coatomer~~ coated vesicles, SNARE proteins. • Cell to cell signaling :autocrine, paracrine and endocrine stimulation. • Signaling via G-protein linked cell-surface receptors, adenylatecyclase system, inositol phosphate pathway, role of Ca^{2+} -ions. • Signallingvia enzyme-linked surface receptors, tyrosine kinases. • Steroid receptors. **Section-B** • ~~Mitochondrial membrane organization~~,transport of proteins into mitochondria and chloroplasts. ~~Genome of mitochondria and cholorplasts.~~ • Concept of signal peptide, SRP, SRP Receptor, ~~transport of soluble and membrane bound proteins in Endoplasmic Reticulum,~~ ER Resident proteins, ER chaperone proteins and their functions, glycosylation of proteins in ER. • Golgi apparatus, role in protein glycosylation and transport. • Lysosomes, intracellular digestion, sorting of lysosomal enzymes in Golgi, lysosomal storage diseases. **Section-C** • Replication of genetic material in prokaryotes and eukaryotes: initiation, elongation and termination; Replication of single stranded circular DNA. • Prokaryotic transcription: Transcription units; RNA polymerase structure and assembly; Promotors; Rho-dependent and Rho-independent termination; Anti-termination.	• Endocytosis & exocytosis, clathrin coated vesicles, SNARE proteins. • Cell to cell signalling: autocrine, paracrine and endocrine stimulation. • Signaling via G-protein linked cell surface receptors, adenylate cyclase system, inositol phosphate pathway, role of Ca^{2+} ions. • Signaling via enzyme-linked surface receptors, tyrosine kinases. • Steroid receptors. **Section-B** • Protein sorting and targeting: Signal hypothesis, SRP, SRP Receptor, ER Resident proteins, ER chaperone proteins & their functions, glycosylation of proteins in ER. • Golgi apparatus, role in protein glycosylation and transport. • Lysosomes, intracellular digestion, sorting of lysosomal enzymes in Golgi, lysosomal storage diseases. • Transport of proteins into mitochondria & chloroplasts. • Cell Cycle & its regulation, apoptosis. **Section-C** • Replication of genetic material in prokaryotes & eukaryotes: initiation, elongation & termination; Replication of single stranded circular DNA. • Prokaryotic transcription: Transcription units; RNA polymerase structure & assembly; Promotors, Rho-dependent & Rho-independent	The deleted portion has been replaced with more relevant topic Cell Cycle and its regulation and division.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• Eukaryotic transcription: RNA polymerase structure and assembly; RNA polymerase I, II, III; eukaryotic promoters and enhancers; general transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF). • Post transcriptional modifications: processing of hnRNA, tRNA and rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; Splicing; RNA editing; Nuclear export of mRNA; ~~mRNA stability;~~ Catalytic RNA. • Translation: Translation machinery; ~~Ribosomes: composition and assembly;~~ Genetic code~~: degeneracy of codons, initiation and termination codons, wobble hypothesis,genetic code in mitochondria;~~IsoacceptingtRNA; ~~Mechanism of~~ initiation, elongation and termination; Co- and post-translational modifications. **Books recommended :** ➢ Cell and Molecular Biology : De Robertis& De Robertis, B.I. Waverly Pvt. Ltd., New Delhi. ➢ The world of the cell : W.M. Becker, Pearson Education. ➢ Cell and Molecular Biology : G. Karp, John Wiley & Sons. ➢ The Cell - A Molecular Approach : Cooper, Sinauer. ➢ Cell and Molecular Biology : P.K. Gupta, Rastogi Publications. ➢ Molecular Cell Biology :Lodish, Baltimore, W. H. Freeman & Co. ➢ Molecular Biology of the Cell : Bruce Albert, Garland Publication, NY. ➢ Essentials of Cytology : C.B. Powar, Himalaya Publications.	termination; Anti-termination. • Eukaryotic transcription: RNA polymerase structure and assembly; RNA polymerase I, II, III; eukaryotic promoters & enhancers; general transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF). • Post transcriptional modifications: processing of hnRNA, tRNA and rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; splicing; RNA editing; nuclear export of mRNA; catalytic RNA. • Genetic code, Isoaccepting tRNA; Translation: Translation machinery: initiation, elongation and termination; Co-and post-translational modifications. **Suggested Books:** ➢ De Robertis, E.D.R. & De Robertis, E.M.F. (2017). *Cell and Molecular Biology*. New York, USA: Lippincott Williams & Wilkins. ➢ Hardin, J., Bertoni, G. & Lewis, K.J. (2011). *Becker's World of the Cell*. Essex, UK: Pearson Education Limited. ➢ Karp, G., Lwasa, J. & Larshall, W. (2015). *Cell and Molecular Biology: Concepts and Experiments*. New Jersey, USA: John Wiley & Sons Ltd. ➢ Cooper, G., M. & Hausman, R. E. (2004). *The Cell: A Molecular Approach*. Washington, D.C.: ASM Press. ➢ Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretsher, A., Ploegh, H., Amon, A. & Martin, K. C. (2007). *Molecular Cell Biology*.	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Principles of Genetics : Gardner, Simmons, Snustad, John Wiley & Sons. ➢ Gene VIII :Lewin, Pearson Education. ➢ Molecular Biology of Gene : J.D. Watson, Pearson Education. ➢ Molecular Biology : David Freifelder, Narosa Publishing House, New Delhi. ➢ Molecular Biology : R. Weaver, WCB McGraw Hill.	New York, USA: W. H. Freeman and Company. ➢ Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. & Walter, P. (2007). *Molecular Biology of the Cell*. UK: Garland Science. ➢ Freifelder, D. M. (1986). Molecular Biology. USA: Jones & Bartlett Publishers. **Suggested e- Resources:** ➢ **Cell Biology resources** https://www.nature.com/scitable ➢ **Sorting and trafficking of proteins** http://www.vcell.science/project/proteintrafficking ➢ **RNA editing** study.com/academy/lesson/rna-editing-definition-processes.html	
6.	**BIO 416:** Microbiology	After successful completion of the course, students should be able to: • Describe different methodologies for classification of microbes. • Understand structural, functional and metabolic diversity of bacteria • Explain viral structure, properties, replication and cultivation	**Section-A** ~~– Discovery of Micro-organisms.~~ • Criteria for classification; molecular approaches • Bacteria: General features, Structural organisation, Nutrition, ~~Growth~~, ~~Respiration~~ ~~and Reproduction~~. • ~~Methanogens~~ and ~~Methylotrophs~~, Chemolithotrophs, Phototrophs, Sulphur reducing bacteria. • Archaebacteria **Section-B** • Nature of viruses, Organisation of virion, Animal, Plant and Bacterial Viruses. • Virus replication, Cultivation of viruses &	**Section-A** • History and scope of microbiology. • Bacteria: Structural organization. • Archaea: Structural organization and brief overview of major physiological groups (Halophiles, Methanogens, Thermophiles). • Growth of bacteria- bacterial growth curve, factors affecting growth. • Nutrition in bacteria- nutritional classes, modes of nutritional uptake, media (types) and culture methods. • Modes of bacterial reproduction. • Regulation in bacteria-operon concept-lac, trp and ara. **Section-B** • Classification of bacteria and approaches used (conventional and modern).	The current syllabus is too bulky and inadequately distributed in the three sections. Contents of section C will be taken up by biotechnology students in bioprocess engineering and environmental biotechnology papers. Also, the last two points of section B are more suited to bioprocess. In the proposed syllabus, the syllabus is more evenly distributed and pertinent content has been added for a more cohesive syllabus.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Virulence factor. • Isolation and screening of industrially important microbes. • Improvement of strains. **Section-C** Biofertilizer and Compost. - Biopesticide~~s, Biopolymers and Biosurfactants~~ ~~- Industrial production of various metabolites with special example of antibiotics, organic acids and alcohol~~ ~~Microbes in the disposal of sewage: sewage treatment processes, sewage water and transmission of diseases, indicator organisms.~~ **Books Recommended :** ➢ Introductory Microbiology : F.C. Ross, Columbus Charles E. Mehrill. ➢ Microbiology - Fundamentals and Applications : S.S. Purohit, Agro Botanical Publishers, Bikaner. ➢ Modern Concepts of Microbiology : H.D. Kumar and S. Kumar, Vikas Publishing House,	Metabolic diversity in bacteria- aerobic and anaerobic respiration (suphate, nitrate), fermentation (lactic, mixed, acetone-butanol, stickland fermentations and acetogenesis), chemolithotrophy(hydrogen, sulphur, nitrate and iron oxidizers), phototrophy (oxygenic and anoxygenic). • Unculturable microbes. • Bacterial quorum sensing. **Section-C** General properties, structure, taxonomy (ICTV & Baltimore classification)of virus. General features of viral replication, sub-viral particles – satellite virus, viroids& prions. Bacteriophages: one step growth curve, structure & life cycle of T_4 and lambda phages, molecular control of lytic & lysogenic cycle. Animal virus: structure and life cycle of- herpes simplex virus, papovavirus, reovirus & retroviruses. Plant virus: structure & life cycle of - geminivirus, caulimovirus & tobacco mosaic virus; virus-vector relationship. Virus assay: Plaque, pock, hemagglutination & transformation assays and concept of ID50. Cultivation of viruses. **Suggested Books:** ➢ Willey, J. M., Sherwood, L.M. & Woolverton, C.J. (2014). *Prescott's Microbiology* (9th ed.). New York, USA: McGraw-Hill Education. ➢ Madigan, M., Martinko, J., Stahl, D. & Clark, D. (2010). *Brock Biology of Microorganisms* (13thed.). UK: Pearson Education.	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			New Delhi. ➢ Microbiology : M.J. Pelczar,C.E.C. Sun and N.R. Krieg, Tata McGraw Hill, New Delhi. ➢ A Text book of Microbiology : R.C. Dubey and D.K. Maheshwari, S. Chand and Company. ➢ Microbiology : K.L. Burdon and R.P. Williams, Mcmillan Worth Publishers. ➢ Microbiology : B.D. Davis et al. : Harper and Row Publishers. ➢ Microbiology : E.W. Nester et al., Saunders international edition. ➢ Principle of Fermentation Technology : P.F. Stanbury and A. Whittaker, Pegamon Press. ➢ Fundamental principles of Bacteriology : A.J. Salle, Tata McGraw Hill. ➢ T.D. Boock's World of Microbiology : Madigan ➢ Microbiology :Presscott.	➢ Pelczar Jr., M.J., Chan, E.C.S. & Krieg, N.R. (2011). *Microbiology*. New York, USA: Tata McGraw-Hill. ➢ Kungo, R. (Ed.). (2017). Nanthnarayanand Paniker's *Textbook of Microbiology* (10th ed.). New Delhi, India: Universities Press. ➢ Moat, A. G., Foster, J.W. & Spector, M.P. (2003). *Microbial Physiology* (4^{th} ed.). US: WileyLiss Inc. ➢ Atlas, R.M.& Bartha, R. (1998), *Microbial Ecology: Fundamentals and Applications* (4thed.). UK: Pearson Education. ➢ Dimmock, N.J., Easton, A.J. & Leppard, K.N. (2016). *Introduction to Modern Virology* (8^{th} ed.). Hoboken, NJ: Wiley Blackwell. ➢ Cann, A.J. (2015). Principles of Molecular Virology (6^{th} ed.). Massachusetts, USA: Academic Press. **Suggested e- Resources:** ➢ **Bacteria structure** http://www.biologydiscussion.com/bacteria/cell-structure-of-bacteria-with-diagram/47058 ➢ **Bacterial growth & nutrition** http://www.biologydiscussion.com/bacteria/nutrition-and-growth-in-bacteria/47001 ➢ **Bacterial quorum sensing** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3543102/ ➢ **Chemolithotrophy** https://courses.lumenlearning.com/boundless-microbiology/chapter/chemolithotrophy/ ➢ **Bacterial metabolism** https://www.ncbi.nlm.nih.gov/books/NBK7919/	

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				➢ **Structure and classification of Viruses** https://www.ncbi.nlm.nih.gov/books/NBK8174/ https://www.pnas.org/content/101/44/15556 ➢ **Virus replication** https://bit.ly/2BQLTa5	
M. Sc. Biotechnology II Semester					
7.	**BIO 405L:** Bioscience Lab-II	After successful completion of the course, students should be able to: • Demonstrate techniques used in immunology and genetic engineering • Perform key experiments for water quality analysis and other contaminants • Solve problems based on gene mapping and population genetics	1. To obtain standard curve of p-nitrophenol solution. 2. To prepare a sample of enzyme extract. 3. To determine activity of acid phosphatase from peas/moong seedlings. 4. Purification of an enzymatic protein by salt precipitation. 1. Determination of kinetic properties (Km and Vmax values) of an enzyme. 2. To check time and protein linearity of an enzymatic reaction. ~~3.~~ Immobilization of an enzyme. ~~4. Blood film preparation and identification of leucocytes.~~ 5. Lymphoid organs and their microscopic organization. 6. ~~Immunization, collection of serum~~. 7. Double diffusion and immuno-electrophoresis. 8. ELISA : Determination of antibody titre. 9. Immunodiagnostics (Demonstration using commercial kits). 10. Extraction and estimation of RNA. 11. Extraction and estimation of DNA. ~~12. To find □ max for nucleic acids~~. ~~13. Preparation of metaphase chromosomes.~~ ~~14. Detection of ADH activity in tissue/cells by cytochemical staining using Drosophila.~~	**Environmental Biology and Biotechnology** 1. Determination of total hardness of water. 2. Determination of fluoride content in water. 3. Determination of BOD values. 4. Determination of LD_{50} for common pesticides/weedicides. 5. Bacteriological analysis of waste water. **Immunology** 6. To perform differential leucocytes count. 7. Lymphoid organs and their microscopic organization. 8. To perform immune diffusion by ouchterlony double diffusion method. 9. To perform immunoelectrophoresis. 10. ELISA: Determination of antibody titre. 11. Immunodiagnostics (Demonstration using commercial kits). **Genetic Engineering** 12. Extraction of genomic DNA by CTAB method and determination of its purity. 13. Estimation of DNA content by diphenyl amine (DPA) method. 14. PCR amplification of 'n' number of genotypes of a species using random primers (Demonstration). 15. Extraction of RNA by Phenol-Chloroform method and estimation by orcinol method.	

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			~~15. Statistical problem.~~ 16. Genetic problem - (chromosome mapping).	**Genetics** 16. Study of sex chromatin from buccal epithelial/ hair bud cells. 17. Genetic exercise - Chromosome mapping, two and three point cross. - Quantitative genetics/ population genetics. **Biostatistics and Research Methodology** 18. Biostatistics problems based on following: - Measures of dispersion (variance). - Correlation analysis. - Probability and probability distribution. - Testing hypothesis by student t- test, Fisher's test, chi-square test and one way analysis of variance. **Suggested Books:** ➢ Aneja, K.R. (1996). *Experiments in Microbiology, Plant Pathology, Tissue Culture and Mushroom Cultivation* (2nd ed.). New Delhi: Wishwa Prakashan. ➢ Green, M. R., & Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual.* Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. ➢ Gupta S.P. (2000). *Statistical Methods.* S. Chand Publications. **Suggested e- Resources:** ➢ **Harisha, S. Biotechnology procedures and experiments handbook** https://bit.ly/2U0e39D ➢ **Introduction to biotechnology** https://bit.ly/2IICkzE	

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8.	**BIO 406:** Biostatistics and Research Methodology	After successful completion of the course, students should be able to: • Apply statistical analysis to biological data • Identify ethics in scientific research and associated methodologies • Develop skills in scientific writing.	**Section-A** • Scope of Biostatistics, variables in biology, collection, classification, tabulation of data. • Frequency distribution, diagrammatic and graphical presentation of statistical data, sampling techniques. • Measures of central location and dispersion, simple measure of skewness and kurtosis. • Probability, conditional probability. **Section-B** • Binomial, Poisson and Normal Distribution. • Correlation and Regression: Least Square method of fitting, Standard error of estimate, Correlation and regression coefficient. • Basic idea of significance testing, level of significance, students 't' test, $\chi 2$ (chi-square) test and F-test, Analysis of variance. **Section-C** • Introduction of Research Methodology: meaning and importance, nature and areas of research in Biological Sciences. • Formulation of a research problem (Hypothesis). • Elements in Research Methodology; Research Designs (CRD, RBD, LSD). • Ethical, legal and social issues in Biological Research. • Writing of Research Report/Research Paper: various components and their organization. **Recommended Books:** ➢ Singh S. (1988). Statistical methods for Research. Central publishing, Ludhiana. ➢ Gupta S.P. (2000). Statistical Methods. S. Chand Publications. ➢ Khan and Khanum (2012). Fundamentals of	No change in the syllabus **Suggested Books:** ➢ Singh S. (1988). *Statistical methods for Research.* Central publishing, Ludhiana. ➢ Gupta S.P. (2000). *Statistical Methods.* S. Chand Publications. ➢ Khan and Khanum (2012). *Fundamentals of*	

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			Biostatistics.Ukaz Publications. ➢ Zerold J. (2009). BiostatisticalAnalysis. UK: Pearson Education. ➢ Marcello P. and Kimberlee G. (2000). Principles of Biostatistics. Duxbury. ➢ Prasad S. (2012). Elements of Biostatistics.Rastogi Publications. ➢ Rastogi V. B. (2015). Biostatistics. Medtec publications. ➢ Basotia, G.R. and Sharma K.K. (1999). Research Methodology.Mangal Deep Publications. ➢ Chaudhary C.M. (1991). Research Methodology. RBSA Publications. ➢ Dorendro A. (2016). Research Methodology in Zoology.Pearlbooks . ➢ Kadam R.M. and Allapure R. B. (2016). Research Methodology in Botany.Gaurav Books	*Biostatistics*. Ukaz Publications. ➢ Zerold J. (2009). *Biostatistical Analysis*.UK: Pearson Education. ➢ Marcello P. and Kimberlee G. (2000). *Principles of Biostatistics*. Duxbury. ➢ Prasad S. (2012). *Elements of Biostatistics*.Rastogi Publications. ➢ Rastogi V. B. (2015). *Biostatistics*. Medtec publications. ➢ Basotia, G.R. & Sharma K.K. (1999). *Research Methodology*. Mangal Deep Publications. ➢ Chaudhary C.M. (1991). *Research Methodology*. RBSA Publications. ➢ Dorendro A. (2016). *Research Methodology in Zoology*. Pearlbooks. ➢ Kadam R.M. & Allapure R. B. (2016). *Research Methodology in Botany*. Gaurav Books. **Suggested e- Resources:** ➢ **ANOVA** https://www.analyticsvidhya.com/blog/2018/01/anova-analysis-of-variance/ ➢ **Regression Analysis** https://bit.ly/2s9vHdM ➢ **Student's t Test- Interactive tutorial** https://www.ruf.rice.edu/~bioslabs/Stats_tutorial/index.html	
9.	**BIO 410:** Genetics	After successful completion of the course, students should be able to: • Understand the theoretical and experimental foundations of classical and molecular genetics. • Describe the basics of genetic	**Section-A** • Definition of gene: genetic & biochemical view; Gene: unit of structure & function, complementation test. • Mendelian Genetics: Mendel's experimental design; Mendelian Genetics in humans: Pedigree analysis.	**Section A** • Definition of gene: genetic & biochemical view; Gene: unit of structure & function, complementation test. • Mendelian Genetics: Mendel's experimental design; Mendelian Genetics in humans: Pedigree analysis.	Genetic recombination models is important to be discussed to understand result of crossing over, gene conversion is important consequence of recombination.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		mapping in bacteria, virus and eukaryotes • Understand the scope of cytogenetics and its applications.	• Extensions of Mendelian Genetics Principles: Modification of dominance relationships, Gene interactions and modified Mendelian ratios, Multiple alleles, Essential and lethal genes. • Non Mendelian inheritance: Extrachromosomal inheritance; Genomic imprinting; isodisomy; Complex inheritance-genetic and environmental variation; Heritability; Twin studies; Behavioral traits; Analysis of quantitative traits. Linkage & Crossing over: Tetrad analysis, mapping of gene order and centromere location in fungi **Section-B** • Genome organization: Organization of bacterial genome; Structure of eukaryotic chromosomes, organization of DNA into chromosomes; Heterochromatin and euchromatin. • ~~Regulation of gene expression in prokaryotes: transcriptional regulation-Positive and negative; Operon concept- lac, trp and ara operons; transcriptional control in phage.~~ • ~~Regulation of gene expression in eukaryotes~~. • Mutations: Nonsense, missense and point mutations; Intragenic and intergenicsuppression; Frameshift mutations; Mutagens; Molecular mechanism of mutations. • ~~Transposable genetic elements in prokaryotes and eukaryotes: Insertion sequences, composite and complex transposons, replicative and non-replicative transposons; Mechanism of transposition; Role of transposons in mutation; Genetic analysis using transposons.~~ **Section-C** • Cytogenetics: Cell division and errors in cell division; Non disjunction; Structural and numerical	• Extensions of Mendelian Genetics: Modification of dominance relationships, gene interactions and modified Mendelian ratios, multiple alleles, essential and lethal genes. • Non Mendelian inheritance: Extrachromosomal inheritance. • Genomic imprinting. • Complex inheritance-genetic and environmental variation; Heritability; Twin studies; Behavioral traits; Analysis of quantitative traits. **Section-B** Linkage & crossing over, models of genetic recombination, gene conversion, Tetrad analysis, mapping of gene order & centromere location in fungi. • Genome organization: Organization of bacterial genome. • Structure of eukaryotic chromosomes, organization of DNA into chromosomes; Heterochromatin and euchromatin • Mutations: Nonsense, missense & point mutations; Frameshift mutations; Mutagens; Molecular mechanism of mutations; Suppressor mutation. • Transposon mutagenesis, transposons as genetic tools: signature tagging mutagenesis, insertional inactivation, P- elements as genetic tool. **Section-C** • Cytogenetics: Cytogenetics introduction,	Gene regulation can be deleted because this content is covered in Cell and Molecular Biology After modification students will have basic understanding of cytogenetics and its application

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			chromosomal abnormalities-deletion; duplication; translocation; Sex determination; Lyon hypothesis; Role of Y chromosome; Genetic recombination; Disorders of sex chromosomes and autosomes; • Molecular cytogenetics-Fluorescence In Situ Hybridization (FISH); Comparative Genomic Hybridization (CGH). • Genetics of bacteria and bacteriophages: Genetic analysis of Bacteria; Genetic mapping in bacteria by conjugation, transformation and transduction; Mapping of bacteriophage gene. • Population genetics: the Hardy-Weinberg law; Genetic variation in natural populations; Forces that change gene frequency in populations; Genetic basis of speciation. **Books Recommended :** ➢ Principles of Genetics 4th Ed :Snustad& Simmons, John Wiley & Sons. ➢ i-Genetics : P.J. Russel, Pearson Education. ➢ Principles of Genetics 8th Ed : Gardner, Simmons, Snustad, John Wiley & Sons. ➢ Genetics : P.K. Gupta, Rastogi Publications. ➢ Genetics - A molecular approach : T.A. Brown, Chapman and Hall. ➢ Concepts of Genetics 7th Ed. : William S. Klug, Pearson Education. ➢ Principles of Genetics : R.H. Tamarin, Tata McGraw Hill. ➢ Genetics-From Genes to Genomes : Hartwell, McGraw Hill.	karyotype analysis, chromosome banding techniques. • Cell division & errors in cell division; Non disjunction. • Structural and numerical chromosomal abnormalities- deletion, duplication, translocation; Sex determination; Lyon hypothesis; Role of Y chromosome; Disorders of sex chromosomes & autosomes. • Molecular cytogenetics-Fluorescence in Situ Hybridization (FISH); Comparative Genomic Hybridization (CGH). • Genetics of bacteria and bacteriophages; Genetic mapping in bacteria by conjugation, transformation and transduction. • Mapping of bacteriophage gene. • Population genetics: Hardy-Weinberg law; Genetic variation in natural populations; Forces that change gene frequency in populations; Genetic basis of speciation. **Suggested Books:** ➢ Klug, W. S., Cummings, M.R., Spencer, C.A. & Palladine, M.A. (2015). *Concepts of Genetics* (11th ed.). UK: Pearson Education. ➢ Gardner, E.J., Simmons, M.J., & Snustad, D.P. (2005). *Principles of Genetics* (8th ed.). New Jersey, USA: John Wiley & Sons Ltd. ➢ Benjamin, A.P. (2003). *Genetics: A conceptual approach*. New York, USA: W. H. Freeman and Company. ➢ Russel, P.J. (2010). *iGenetics* (3rd ed.). UK: Pearson Education. ➢ Brown, T.A. (1992). *Genetics- A Molecular Approach*. London, UK: Chapman & Hall.	

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			➢ Genetics 5th Eds. : D.L. Hartl and E.W. Jones, Jones and Barlett Publishers, Canada. ➢ An Introduction to Genetic Ananlysis : Suzuki, Griffith, Miller &Lewonith. ➢ Molecular Biology : Weaver, WCB McGraw Hill.	➢ Gupta, P.K. (2010).*Genetics*. Meerut, India: Rastogi Publications. **Suggested e- Resources:** ➢ **Cytogenetic methods and Disease** www.nature.com/scitable/topicpage/cytogenetic-methods-and-disease-flow-cytometry-cgh-772 ➢ **CGH Analysis** www.cs.cmu.edu/~epxing/Class/10810-05/Lecture11.pdf ➢ **Population Genetics** https://biomed.brown.edu/Courses/BIO48/6.PopGen1.HW.drift.HTML	
10.	**BIO 411:** Immunology	After successful completion of the course, students should be able to: • Evaluate and compare the role of various components and mechanisms of the immune system. • Describe various immune response mechanisms • Develop concept of antibody generation and various immunological techniques	**Section-A** • Basic concepts of immunology: specific and nonspecific defense mechanisms (innate and acquired immunity), organs and cells of immune system. • Antigen and Antigenicity: concept of immunogens, antigens, heptans, mitogens and superantigens. Properties of antigens, ~~cross reactivity~~, special group of antigens: bacterial antigens, viral antigens, cell surface antigens (MHC), autoantigens, isoantigens and frossman antigens (Heterophilic antigens). • Immunoglobulins: structure and properties of immunoglobulins, immunoglobulin isotypes and their significance.Immunoglobulins as antigens: isotypes, allotypes and idiotypes. • Complement System. **Section-B**	**Section-A** • Basic concepts of immunology: Historical background of immunology, specific and nonspecific defense mechanisms (innate and acquired immunity), cells and organs of immune system. • Antigen and Antigenicity: Concept of immunogens, antigens, haptens, mitogens and superantigens. Properties of antigens, special group of antigens: bacterial antigens, viral antigens, cell surface antigens (MHC), autoantigens, isoantigens and frossman antigens (Heterophilic antigens). • Immunoglobulins: Structure and properties of immunoglobulins, immunoglobulin isotypes and their significance. Immunoglobulins as antigens: isotypes, allotypes and idiotypes, brief idea about instructive, selective & clonal selection theory of antibody formation. • Complement system. **Section-B** • Cell - mediated immune responses: origin,	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• Cell - mediated immune responses : origin, maturation and characterization of T-Lymphocytes, monocytes and macrophages, characteristics of antigen presentation and its significance, concepts of memory cell, mode of action and functioning of TH, TC, CTLS and NK cells, lymphokines, the product of T cell activation. • Humoral immune responses: Origin, maturation and characterisation of B Lymphocytes, activation and proliferation of B and T cells, antibody generation in vivo. • Immunological tolerance ~~and Autoimmunity~~: characteristics and mechanism of immunologic tolerance, factors affecting immunologic tolerance and ~~mechanisms of autoimmunity~~. • Hypersensitivity: Type I, II, III and IV. **Section-C** • Hybrid and Chimeric monoclonal antibodies, catalytic antibodies • Surface plasmon resonance, Biosensor assay for assessing ligand-receptor interaction. • ~~Measurement of low molecular weight non-immunogenic compounds (such as secondary metabolites); phytohormones immunoassays.~~ • Advanced immunological techniques: Immunofluorescent and Immunogoldlabelling **Books Recommended:** ➢ Abbas, A.K.,&Lichtman, A.H. (2001). *Basic immunology: Functions and Disorders of Immune System*. US: W.B. Saunders. ➢ Delves, P.J., Martin, S.J., Burton, D.R.,&Roitt,	maturation and characterization of T-Lymphocytes, monocytes and macrophages, characteristics of antigen presentation and its significance, concepts of memory cell, mode of action and functioning of TH, TC, CTLS and NK cells, lymphokines, the product of T-cell activation. • Humoral immune responses: Origin, maturation and characterization of B-Lymphocytes, activation and proliferation of B and T cells, antibody generation *in vivo*. • Immunological tolerance and characteristics and mechanism of immunologic tolerance, factors affecting immunologic tolerance of autoimmunity. Immune regulation, positive, negative selection, apoptosis. **Section-C** • Hypersensitivity: Type I, II, III and IV. • Hybrid and Chimeric monoclonal antibodies, catalytic antibodies. • Surface plasmon resonance, biosensor assay for assessing ligand-receptor interaction. • Advanced immunological techniques: Immunofluorescent and immunogold labelling. **Suggested Books:** ➢ Abbas, A.K. & Lichtman, A.H. (2001). *Basic Immunology: Functions and Disorders of Immune System*. US: W.B. Saunders. ➢ Delves, P.J., Martin, S.J., Burton, D.R., & Roitt, I.M (2011). *Roitt's Essential Immunology* (12th ed.). New Jersey, USA: John Wiley & Sons	

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			I.M (2011). *Roitt's Essential Immunology* (12th ed.). New Jersey, USA: John Wiley & Sons Ltd. ➢ Goldsby, R. A., Kindt, T.J., & Osborne, B. A. (2006). *Kuby Immunology* (6th ed.). New York, USA: W.H. Freeman & Co. Ltd. ➢ Paul, W.E. (1999). *Fundamental Immunology* (14th ed.). USA: Lippincott-Raven. ➢ Peakman, M.,&Vergani, D. (2009). *Basic and Clinical Immunology* (2nd ed.). US: Elsevier Health Sciences. ➢ Tizard, I.R. (2017). *Veterinary Immunology* (10th ed.). US: Elsevier Health Sciences.	Ltd. ➢ Goldsby, R. A., Kindt, T.J. & Osborne, B. A. (2006). *Kuby Immunology* (6th ed.). New York, USA: W.H. Freeman & Co. Ltd. ➢ Paul, W.E. (1999). *Fundamental Immunology* (14th ed.). USA: Lippincott-Raven. ➢ Peakman, M. &Vergani, D. (2009). *Basic and Clinical Immunology* (2nd ed.). US: Elsevier Health Sciences. ➢ Tizard, I.R. (2017).*Veterinary Immunology* (10th ed.). US: Elsevier Health Sciences. **Suggested e- Resources:** ➢ **Basic Immunology** https://bit. y/2E6Zz16l ➢ **Monoclonal Antibodies** https://www.genscript.com/how-to-make-monoclonal-antibodies.html ➢ **Complement system** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3956958/	
11.	**BT 406:** Enzymology and Enzyme Technology	At the end of this course, the students will have fundamental knowledge of enzymes and varioustechniques involved in their production and purification. They would also learn about theirapplication in different fields such as medical, textile, chemical processes, etc. They can applythis knowledge for better understanding of other basic and advanced courses in biologicalsciences as well as to solve research based problems.	**Section-A** • History and introduction to enzymes: ~~Classification of enzymes. IUPAC system, nomenclature, E.C. numbers.~~ • ~~Enzyme kinetics (Michaelis – Menten laws), importance and determination of Vmax and Km values, Hofstee's plot, L & B plots.~~ • Bisubstrate reactions-ordered & random sequential mechanism. Theorell chance mechanism, ping pong mechanism, products of inhibition in bisubstrate reactions. • ~~Enzyme inhibition: competitive, non-competitive and other types.~~ **Section-B**	This course is proposed to be discontinued from II Semester.	Some part of the syllabus is integrated with I Semester course "Biochemistry". Remaining part of the syllabus is revised as per the present need and proposed as an elective course named as "Enzyme Technology" in the III Semester.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• Extraction of soluble and membrane bound enzymes from microbial, plant and animal tissues. • Purification of enzymes: salt precipitation, gel filtration, ion exchange and affinity chromatography. Regulation of enzyme activity, various controls (metabolic compartmentation, covalent modifications and others), feedback regulation, allosteric enzymes ~~Coenzymes, Isozymes and~~ Multienzyme complexes • Methods of storing enzymes. **Section-C** • Large scale production of enzymes including genetic engineering approaches for their over production. • Enzyme engineering; identification of active sites, approaches for modification of catalytic properties. ~~•~~ Techniques of enzyme immobilization ~~and their applications in:~~ ~~i.~~ Food industry- ~~High fructose syrup, cheese making and beer industry.~~ ii. Antibiotics and other Pharamaceuticals iii. Medical applications ~~iv.~~ Analysis of substances, ~~enzyme electrodes, enzyme thermistors.~~ ~~• Basic idea of proteomics~~ **Suggested Books:** ➢ Understanding Enzymes : T. Palmer. ➢ Fundamentals of Enzymology : Price and Stevenson. ➢ The Enzyme : Dixon and Webb, Academic Press, London. ➢ Methods in Enzymology : Academic Press.		

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			➢ The Enzyme Molecule: W. Ferdinan, John Wiley and sons. ➢ Protein Methods: D.M. Bollag and S.J. Edelstein, Wiley-Liss. ➢ The Nature of Enzymology : F.L. Foster, John Wiley and sons. ➢ Enzyme technology, biotechnology Vol7 : John Wiley and sons. ➢ Enzyme, Biomass, Food and Feed Biotechnology Vol. 9 : John Wiley and Sons.		
12.	**Environmental Biology and Biotechnology**	After successful completion of the course, students should be able to: • Identify key factors responsible for ecosystem balance and explain different efforts which can be undertaken for restoration and environmental remediation. • Comprehend the toxicity of various environmental pollutants and their influence on ecosystem. • Understand different waste management processes and generation of energy from waste. • Describe various roles played by microbes in biodegradation, bioremediation and plant growth promotion.	**M.Sc. III Semester Bioscience core course** **BIO 408: Environmental Biology and Toxicology** **Section-A** • ~~Concept of energy, conventional & non-conventional energy sources. Fossil fuels, hydro, wind and nuclear power, geothermal, solar and bioenergy.~~ • Energy flow in organisms, energy pathways & models, energy efficiencies, ~~conservation of energy.~~ • ~~Classification & characteristics of resources~~: water, soil, forest, wild life, ~~land use.~~ • Conservation of natural resources: water, soil, forest and wild life. **Section-B** • ~~Origin of pollutants : industrial, agricultural, domestic and vehicular sources.~~ • ~~Pollutant & their toxicology :~~ Heavy metals ~~and trace elements~~. Agrochemicals ~~(Pesticides, herbicides, rodenticides & fungicides, detergents) & particulate matter.~~ • ~~Types of radiations including ionizing & non-ionizing radiations & their interaction with matter.~~	**Environmental Biology and Biotechnology** **Section A** ➢ Structure and functions of ecosystem. ➢ Energy flow in organisms, energy pathways & models, energy efficiencies. ➢ Basic concept of Population Ecology – Inter & intra-specific interactions among populations. ➢ Community structure & dynamics: Ecological succession. ➢ Natural resources & conservation: water, soil, forest, wild life. ➢ Environmental challenges & sustainable development; Environmental Laws & Acts. **Section B** ➢ Heavy metal toxicity, agrochemical pollutants. ➢ Bioremediation of heavy metal pollution and oil spills, phytoremediation. ➢ Radiations—as environmental pollutants. Effects of radiations at cellular, molecular & genetic level. Disposal of radioactive waste.	"Environmental Biology and Biotechnology" is proposed to be included as a new core course in the second semester instead of the existing core course "Enzymology and Enzyme Technology". The syllabus of "Environmental Biology and Biotechnology" is designed by updating and merging the contents of existing courses BIO 408 "Environmental Biology and Toxicology" which is running as a core course in third semester of M.Sc. Bioscience programme and another course BT 509 "Environmental Biotechnology" which is running as a core course in the third semester of M.Sc. Biotechnology programme.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• Radiations as environmental pollutants. • Effects of radiations at cellular, molecular & genetic level. **Section-C** • ~~Mutagenecity, carcinogenecity~~. • ~~Green house effect, acid rains~~. • ~~Ozone layer depletion, photochemical smog~~. • Types of solid wastes, transport, reuse & recycling. **M.Sc. III Semester Biotechnology core course** **BT 509: Environmental Biotechnology** **Section-A** • ~~Current status of biotechnology in environmental protection.~~ • ~~Sewage &~~ waste water treatment: ~~Physical, Chemical and biological treaments; Aerobic processes & anaerobic processes,~~ Primary, secondary and tertiary treatments; ~~Sludge dewatering & its disposal;~~ Water reclamation. Solid waste management: Methods & disposal ~~of non hazardous and hazardous solid wastes, recycling,~~ methods of disposal of radioactive waste. • ~~Conservation of Biodiversity: *Ex situ & in situ* methods.~~ **Section-B** • ~~Environmental Biotechnology in Agriculture~~: Biofertilizers ~~and microbial inoculants~~, Biopesticides. • Biodegradation of xenobiotic compounds: Simple aromatics, chlorinated polyaromatic petroleum products, Pesticides ~~and surfactants.~~ • Bioremediation ~~& Biorestoration: Reforestation~~	➢ Waste water treatment- sources of waste water, strategies used in primary, secondary & tertiary treatments, water reclamation. **Section C** ➢ Biofertilizers, biopesticides, compost & vermicompost. ➢ Biofuels: Biogas, bioethanol, biodiesel, biohydrogen. Biodegradable plastics. ➢ Biodegradation of xenobiotic compounds: Simple aromatics, chlorinated polyaromatic petroleum products & pesticides; role of degradative plasmids. ➢ Solid waste management: types, treatment & disposal strategies. ➢ Bioleaching of metals, microbially enhanced oil recovery. Bioindicators. **Suggested Books** ➢ Allen, K. (2016). *Environmental Biotechnology*. New Delhi, India: CBS Publishers. ➢ Miller, G.T. (2004). *Environmental Science: Working With The Earth* (10^{th} ed.). Singapore: Thomson Asia. ➢ Milton, W. (Ed.). (1999). *An Introduction to Environmental Biotechnology*. USA: Springer. ➢ Milton, W. (Ed.). (1999). *An Introduction to Environmental Biotechnology*. USA: Springer. ➢ Modi, P. N. (2015). *Sewage treatment & disposal and waste water engineering*. New Delhi, India: Rajsons Publications Pvt. Ltd.	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			~~through micro-propagation, development of stress tolerant plants, and use of mycorrhiza in reforestation of soil contaminated with heavy metals.~~ **Section-C** • Biofuels: ~~Energy crops, Conventional sources of biofuel, Second and third generation of biofuel,~~ Biogas, Bioethanol, Biohydrogen. Biodegradable plastics. • Bioindicators ~~and Biosensers for detection of environmental pollution.~~ • Environmental genetics: Degradative plasmids, ~~release of GE microbes in environment.~~	➢ Odum E. P. (2006). *Fundamentals of Ecology* (5th ed.). Boston, US: Cengage. ➢ Sharma, P.D. (2008). *Environmental Biology and Toxicology*. Meerut, India: Rastogi Publications. ➢ Sodhi, G.S. (2002). *Fundamental Concepts of Environmental Chemistry*. New Delhi, India: Narosa Publishing House. ➢ Tripathi, B. N., Shekhawat, G. S., & Sharma, V. (Ed.). (2009). *Applications of Biotechnology*. Jaipur, India: Aavishkar Publishers. ➢ Vallero, D.A. (2016). *Environmental Biotechnology: Abiosystems approach*. US: Elsevier. ➢ Wright, R. T. (2015). *Environmental Science: Toward a Sustainable Future.* UK: Pearson Education. **Suggested e-resources** ➢ **Ecosystem structure** http://www.biologydiscussion.com/ecosystem/ecosystem-its-structure-and-functions-with-diagram/6666 ➢ **Radioactive waste treatment** https://ehs.unc.edu › Manuals › Radiation Safety Manual ➢ **Environmental Remediation** https://www.iaea.org/sites/default/files/18/05/environmental_remediation.pdf ➢ **Biological treatment of wastewater** http://www.neoakruthi.com/blog/biological-treatment-of-wastewater.html ➢ **Biogas** http://www.biologydiscussion.com/biomass/pr	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				oduction-of-biogas-from-biomass/10436 ➢ **Biofuel** http://uru.ac.in/uruonlinelibrary/BioFuels/Biomass%20and%20biofuels.pdf ➢ **Biological treatment of wastewater** http://www.neoakruthi.com/blog/biological-treatment-of-wastewater.html ➢ **Xenobiotic compound biodegradation** https://bit.ly/2GHRoMj	
13.	**BT 408:** Genetic Engineering	After successful completion of the course, students should be able to: • Develop comprehensive understanding of gene manipulation techniques • Describe various cloning and expression vectors • Develop skills for primer designing, gene amplification and expression	**Section-A** • Basic concepts of DNA structure and properties, restriction enzymes, DNA ligase, Klenow enzyme, T4 DNA polymerase, Polynucleotide kinase, Alkaline phosphatase, Cohesive and blunt end ligation, Linkers, Adapters, Homopolymeric tailing, Labeling of DNA, Nick translation, Random priming, Radioactive and non-radioactive probes, Hybridization techniques, Northern, Southern and Colony Hybridization, ~~Fluorescence in situ hybridization~~, Chromatin immunoprecipitation, DNA-Protein Interaction-Electromobility shift assay, DNaseIfootprinting, Methyl interference assay, Isolation of genomic DNA from prokaryotes and eukaryotes, Isolation of Plasmid DNA and Bacteriophage DNA. Isolation of total RNA and mRNA. **Section-B**	**Section-A** • Basic concepts of DNA structure and properties, restriction enzymes, DNA ligase, Klenow enzyme, T_4 DNA polymerase, polynucleotide kinase, alkaline phosphatase. • Cohesive & blunt end ligation, linkers, adapters, homopolymeric tailing, labeling of DNA, nick translation, random priming, radioactive & non-radioactive probes. • Hybridization techniques: Colony hybridization, Northern, Southern,South-Western & far-western blotting. • DNA-Protein Interaction: Chromatin immunoprecipitation, electromobility shift assay, DNaseI footprinting, methyl interference assay. • Protein-protein interaction: Yeast two hybrid system, split ubiquitin system, co-immunoprecipitation, Forster Resonance Energy Transfer, phage display. • Isolation of genomic DNA from prokaryotes and eukaryotes, isolation of Plasmid DNA and Bacteriophage DNA. Isolation of total RNA and mRNA. **Section-B**	Already covered in the Genetics course Yeast vectors have been covered in **Recombinant DNA Technology** paper. Relevant vectors have been added.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• Plasmids, Bacteriophages, pBR322 and pUC series of vectors, M13 and P2 phage based vectors, High capacity vectors: Cosmids, phagemid, ~~phasemid, YAC~~, BAC, Animal and Plant virus based cloning vectors, Shuttle vectors, Expression vectors, pMal, GST, pET-based vectors, ~~Insertion of foreign DNA into Host Cells, Transformation~~, Constructions of libraries, cDNA and genomic libraries, cDNA and genomic cloning, Expression cloning, Jumping and hopping libraries, South-western and Far-western cloning, Protein-protein interactive cloning and Yeast two hybrid system, Phage display. **Section-C** • Primer designing, Fidelity of thermostable enzymes, ~~DNA polymerase~~, Types of PCR- multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, in situ PCR, cloning of PCR products, T-vectors, ~~Proof reading enzymes~~, Principles in maximizing gene expression, Gene expression analyses, differential gene expression methods, Introduction of DNA into mammalian cells, ~~transfection techniques.~~ **Books Recommended :** ➢ Molecular Cloning Vol. 1, 2 and 3 :Sambrook, Russell and Maniatis, Cold Spring Harber laboratory, 2001. ➢ Molecular Biology of Gene : J.D. Watson, Pearson Education. ➢ An Introduction to Gene Technology-From genes to clones :Winnacker, VCH. ➢ Principles of Gene Manipulation : Old and Primrose. ➢ MoleculerBiotechnology : B.R. Glick and J.J. Pasternak, ASM Press Washington, USA.	• Plasmids, Bacteriophages, pBR322 & pUCseries of vectors, M13 based vectors. [redacted]High capacity vectors: cosmids, phagemids, BAC, animal & plant virus based cloning vectors, shuttle vectors; expression vectors: pMal, GST, pET-based vectors; *Baculovirus* and *Pichia* vectors.Introduction of DNA into mammalian cells. • cDNA& genomic libraries, expression, cloning, jumping & hopping libraries. **Section-C** • Primer designing, fidelity of thermostable enzymes. • Types of PCR- multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, *in situ* PCR, T-vectors. • Principles in maximizing gene expression, gene expression analyses, differential gene expression methods. **Suggested Books:** ➢ Brown, T. A. (2006). *Genomes* (3rd ed.). New York: Garland Science. ➢ Glick, B.R. & Pasternak, J.J. (1998). *Molecular Biotech: Principles and Application of Recombinant DNA*. US: ASM Press. ➢ Green, M. R. & Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. ➢ Old, R. W., Primrose, S. B. & Twyman, R. M. (2001). *Principles of Gene Manipulation: an*	Repeating topics have been removed Repeating topics have been removed

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Genetic Engineering : Science and ethics on new frontier : Michael Boylan, Pearson Education. ➢ An Introduction to Genetic Engineering : S.T. Nicholl, Cambridge University Press. ➢ Recombinant DNA Methodology : Grossman and Noldave, Academic Press.	*Introduction to Genetic Engineering*. Oxford: Blackwell Scientific Publications. ➢ Richard J. R. (2004). *Analysis of Genes and Genome*. New Jersey, USA: John Wiley & Sons Ltd. **Suggested e- Resources:** ➢ **Genetic engineering – Basics, New Applications and Responsibilities** http://library.umac.mo/ebooks/b28055287.pdf ➢ **Construction of genomic libraries** https://nptel.ac.in/courses/102103013/20 ➢ **Enzymes in genetic engineering** https://nptel.ac.in/courses/102103013/7	
M. Sc. Biotechnology III Semester					
14.	**BT 522**: Recombinant DNA Technology				The course BT 522: Recombinant DNA Technology which is offered as a core course in the existing syllabus but now contents of this course have been modified and proposed to be offered as an elective course.
15.	**BT504:** Bioprocess Engineering and Technology	After successful completion of the course, students should be able to: • Identify bioreactor design and differentiate between types • Explain kinetics of scale up and sterilization along with processes of downstreaming. • Demonstrate large scale production of biomolecules	**Section-A** • Microbial growth and ~~death kinetics.~~ • Mass balance, ~~maintenance coefficient~~ and yield concepts in bioprocesses engineering. • Substrate utilization and product formation kinetics. • Basic concept of volumetric mass transfer coefficient (kLa) and Medium Rheology. • Sterilization.	**Section – A** General concept of Fermentation, Types of bioreactors (CSTR, Bubble driven bioreactor, Packed bed bioreactor, Fluidized Bed bioreactor). • Basic concept of mass balance & yield coefficient. • Unstructured & structured growth model. Batch, continuous & fed batch processes with substrate utilization & product formation	The syllabus has been remodeled to include more relevant topics which are of current significance. Certain topics have been accommodated in different sections of the paper and other courses as per to their suitability. In Section C, the numbers of

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Section-B • Batch, continuous and fed batch processes. • ~~Brief overview of~~ different bioreactor configurations (Stirred tank, ~~Air lift~~ and Bubble columns). • Downstream processing: Bioseparation- ~~filtration,centrifugation,sedimentation, flocculation~~; Cell disruption; Liquid-liquid extraction; ~~Purification by~~chromatographic techniques; Reverse osmosis and ultra filtration; Drying; Crystallization. **Section-C** • Analysis of a few industrially important bioprocesses/products such as (taking into consideration, the raw material, media, organism metabolic pathway, bioreactor, product separation and uses). ~~a.~~ Organic acids (acetic acid, citric acid, ~~lactic acid and propionic acid).~~ b. Solvents (Butanol, Acetone, Ethanol). c. Industrial enzymes (a-amylase, proteases~~,~~ ~~rennin~~, lipase) and d. Antibiotics (Penicillin, Streptomycin, ~~Cephalosporin~~, Tetracycline, ~~Bacitracin~~). **Books Recommended :** ➢ Biochemical Engineering : J.M. Lee. Prentice Hall. ➢ Bioprocess Engineering : M. Shuler and F. Kargi, Prentice Hall. ➢ Comprehensive Biotechnology : M. Moo Young, Editor. ➢ Biotechnology : H.J. Rehm and G. Reed, VCH.	kinetics. • Sterilization kinetics. **Section-B** Volumetric mass transfer coefficient (kLa). • Medium Rheology in bioprocesses engineering. • Downstream processing: Bioseparation- ultrafiltration, precipitation, Cell disruption, Liquid-liquid extraction, chromatography, drying, crystallization. • Upscaling of bioprocess. • Enzyme immobilization & immobilized cell systems. **Section-C** • Screening, maintenance & strain improvement of industrially important microbes. • Analysis of a few industrially important bioprocesses/products (taking into consideration- the raw material, media, organism metabolic pathway, bioreactor, product separation and uses): a. Organic acids (acetic acid, citric acid). b. Solvents (butanol, acetone, ethanol). c. Enzymes (α amylases, proteases, lipases) d. Antibiotics (penicillin, streptomycin). e. Recombinant product (humulin, erythropoietin) **Suggested Books:** ➢ Stanbury, P.F., Whitaker, A. & Hall, S.J. (1995). *Principles of Fermentation Technology* (2^{nd}& 3^{rd}ed.). US: Elsevier Science Ltd. ➢ Crueger, W. & Crueger, A. (1990). *Biotechnology, A Text Book of Industrial Microbiology* (2^{nd} ed.). US.: Sinauer Associates	examples have been limited in order to generate a balance between sections.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Inc. ➢ Bailey, J.E. & Ollis, D.F. (1986). *Biochemical Engineering Fundamentals* (2nd ed.). New York, USA: McGraw-Hill Education. ➢ Clark, D.S. & Blanch, H.W. (1997). *Biochemical Engineering*. USA: CRC Press. ➢ Shuler, M.L., & Kargi, F. (2002). *Bioprocess Engineering Basic Concepts* (2nd ed.). New Jersey, USA: Prentice Hall PTR Upper Saddle River. **Suggested e- Resources:** ➢ **Microbial Enzymes** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5387804/pdf/BMRI2017-2195808.pdf ➢ **Acetone-Butanol Fermentation** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4894279/pdf/fnw134.pdf ➢ **Microbial culture fermentation** https://pdfs.semanticscholar.org/b4d3/7ed66ef2e37ce22ff7a3be09e3df7568fe49.pdf ➢ **Reverse Osmosis** https://www.oas.org/dsd/publications/unit/oea59e/ch20.htm	
16.	**BT 505L:** Biotechnology Lab-I	After successful completion of the course, students should be able to: • Perform production and scale up of some industrially relevant bioactive molecules from microbes • Demonstrate gene transfer techniques • Perform cell and tissue culture techniques	~~1. Determination of total hardness of water.~~ ~~2. Degradation of pesticide in soil and estimation of its residue.~~ ~~3. Determination of fluoride in water/soil/biosamples.~~ ~~4. Determination of BOD values.~~ ~~5. Determination of LD50 for common pesticides/weedicides.~~ ~~6. Bacteriological analysis of waste water.~~ ~~7. Detection of mutagens by Ames test.~~ 8. Isolation and determination of plasmid DNA from	**Bioprocess Engineering and Technology** 1. Production of citric acid from *Aspergillus* sp.and its estimation by titration. 2. Estimation of K_{La} by sodium sulphite method. 3. Production of alpha amylase from *Bacillus* sp. and its estimation. 4. Scale up of alpha amylase production from100 ml to 1 L. 5. Immobilization of enzyme by sodium alginate method.	The experiments have been reframed and modified keeping in consideration, the suggested syllabus.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			E. coli. 9. Electrophoretic separation of plasmid DNA. 10. Restriction digestion of plasmid DNA. 11. ~~To obtain transposon Tn5 insertion into the genome of AK 631 strain of *Rhizobium meliloti* using suicide plasmid vector PGS 9.~~ 12. To transfer plasmid PJB3JI from J53 strain of *E. coli* to HB101 strain of *E.coli*. 13. ~~Estimation of Biomass.~~ 14. Estimation of growth and product yield in a Bioconversion process. 15. Comparison between aerobic and anaerobic process. 16. Enzyme biosynthesis and measurement of its activity. ~~17. Culture of stem explants.~~ ~~18.~~ . Embryo culture.	6. Estimation of growth and product yield in a Bioconversion process. 7. Comparison between aerobic and anaerobic process **Genetic Engineering** 8. Preparation of competent cells (*E. coli* DH5α strain). 9. Transformation of *E. coli* with plasmid and calculation of transformation efficiency. 10. Isolation of plasmid DNA from *E. coli* by alkaline lysis method. 11. Restriction digestion of plasmid DNA and its electrophoretic separation. 12. To transfer plasmid PJB3JI from J53 strain of *E. coli* to HB101 strain of *E.coli*. **Cell and Tissue Culture Technology** 13. To perform embryo culture from germinated mung bean seeds. 14. Shoot tip culture. 15. Protoplast culture and somatic hybridization. 16. Blood cell culture and determination of cell viability using Trypan blue method. 17. Preparation of metaphase chromosome from whole blood culture. **Suggested Books:** ➢ Kulandaivel, S. & Janarthanan, S. (2012). *Practical Manual of Fermentation Technology*. New Delhi, India: I.K. International Publishing House Pvt. Ltd. ➢ Cappuccino, J. G., & Welsh, C. (2016). *Microbiology: A laboratory Manual*. USA: Benjamin-Cummings Publishing Company. ➢ Collins, C. H., Lyne, P. M., Grange, J. M., & Falkinham, J.O. (2004). *Collins and Lyne's*	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Microbiological Methods (8th ed.). London, UK: Arnold. ➢ Green, M. R., & Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual.* Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. **Suggested e- Resources:** ➢ **Harisha, S. Biotechnology procedures and experiments handbook** https://bit.ly/2U0e39D ➢ **Introduction to biotechnology** https://bit.ly/2IICkzE	
17.	**BT 507:** Cell and Tissue Culture Technology	After successful completion of the course, students should be able to: • Develop comprehensive concepts of cell and tissue culture techniques and methodology • Demonstrate use of various plant and animal tissue culture techniques • Explain applications of cell and tissue culture in agriculture, horticulture, medicine and pharmaceutical industry	**Section-A** • Historical background and terminologies used in cell & tissue culture. • Basic techniques of cell and tissue culture, sterilization, aseptic tissue transfer, concept of totipotency. • Nutritional requirement of cell in vitro, various types of nutrient media. • Contamination and cytotoxicity • Cryopreservation and cell storage. • Isolation of plant cells, single cell cultures and cloning. **Section-B** • Organogenesis and somatic embryogenesis, applications in agriculture, horticulture & forestry. • Haploid production: androgenesis, gynogenesis various techniques, applications. • Production of disease free plants by tissue culture methods. • Protoplast isolation and culture, fusion of protoplasts.	No change in syllabus, suggested books and E resources added ➢ Bhojwani, S.S. & Razdan, M.K. (1996). *Plant Tissue Culture*. USA: Elsevier Science. ➢ Chawla, H. S. (2000). *Introduction to Plant Biotechnology*. US: Science Publishers. ➢ Razdan, M. K. (2006). *Introduction to Plant Tissue Culture*. New Delhi, India: Oxford and IBH Pub. ➢ Smith, R. H (Ed.). (2013). *Plant tissue culture: Techniques and experiments*. Amsterdam: Academic Press. ➢ Buler, M. (2003). *Animal Cell Culture and Technology* (2nd ed.). UK: Taylor & Francis. ➢ Mathur, S. (2006). *Animal Cell and Tissue Culture*. India: Agrobios. ➢ Clynes, M. (Ed.) (1998). *Animal Cell Culture Techniques*. Germany: Springer-Verlag Berlin Heidelberg. ➢ Pollard, J.W., & Walker, J.M. (Eds.). (1990). *Animal Cell Culture*. USA: Humana Press ➢ John, R. W. (2000). *Animal Cell Culture: A*	No Modification. c.w. M.Sc. Bioscience

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• Somatic hybrids, selection methods, gene expression in somatic hybrids. **Section-C** • Disaggregation of animal tissue, isolation of cells, single cell culture, routine maintenance of animal cell lines. • Cloning & selection of specific animal cell types. • Transfection: gene transfer methods for adherent and non-adherent cell culture. • Cell fusion: fusogen, animal somatic cell fusion and selection of cybrids. • Animal organ culture. • Elementary idea about animal cell culture products. **Recommended Books:** ➢ Bhojwani, S.S. &Razdan, M.K. (1996). *Plant Tissue Culture*.USA: Elsevier Science. ➢ Chawla, H. S. (2000). *Introduction to Plant Biotechnology*. US: Science Publishers. ➢ Razdan, M. K. (2006). *Introduction to Plant Tissue Culture*. New Delhi, India: Oxford and IBH Pub. ➢ Smith, R. H (Ed.). (2013). *Plant tissue culture: Techniques and experiments*. Amsterdam: Academic Press. ➢ Butler, M. (2003).*Animal Cell Culture and Technology* (2nded.). UK: Taylor & Francis. ➢ Mathur, S. (2006). *Animal Cell and Tissue Culture*. India: Agrobios. ➢ Clynes, M. (Ed.) (1998). *Animal Cell Culture Techniques*. Germany: Springer-Verlag Berlin Heidelberg. ➢ Pollard, J.W.,&Walker, J.M. (Eds.). (1990). *Animal Cell Culture*. USA: Humana Press	*Practical Approach* (3rded.). UK: Oxford University Press. ➢ Freshney, R. I. (2011). *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications* (6thed.). USA: Wiley-Blackwell. ➢ Davis, J. M. (2011). *Animal Cell Culture: Essential Methods*. New Jersey, USA: John Wiley & Sons Ltd. **Suggested e- Resources:** ➢ **Background of Tissue Culture Technology** http://www.biologydiscussion.com/botany/tissue-culture/tissue-culture-definition-history-and-importance/42944 ➢ **Embryogenesis and organogenesis** https://nptel.ac.in/courses/102103016/module1/lec8/3.html ➢ **Single cell cultures and cloning** http://www.biologydiscussion.com/botany/tissue-culture/methods-for-obtaining-single-cell-clones-from-callus-culture-plant-tissue-culture/43004 ➢ **Protoplasm isolation and regeneration** https://nptel.ac.in/courses/102103016/12 ➢ **Haploid plant production** http://www.biologydiscussion.com/plants/haploid-plants/production-of-haploid-plants-with-diagram/10700 ➢ **Preservation of cell lines** https://www.ukessays.com/essays/biology/techniques-for-cell-preservation-biology-essay.php ➢ **Somatic hybridization** http://www.biologydiscussion.com/somatic-	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			➢ John, R. W. (2000). *Animal Cell Culture: A Practical Approach* (3rded.). UK: Oxford University Press. ➢ Freshney, R. I. (2011). *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications* (6thed.). USA: Wiley-Blackwell. ➢ Davis, J. M. (2011). *Animal Cell Culture: Essential Methods*. New Jersey, USA: John Wiley & Sons Ltd.	hybridization/somatic-hybridization-aspects-applications-and-limitations/10686 ➢ **Animal cell culture products** http://www.biologydiscussion.com/biotechnology/animal-biotechnology/applications-of-animal-cell-cultures/10457 ➢ **Cell Culture Technology** https://onlinecourses.nptel.ac.in/noc17_bt21/preview	
18.	**BT 509** ~~**Environmental Biotechnology**~~	After successful completion of the course, students should be able to: • Understand different waste management processes and generation of energy from waste • Explain impact of GMOs on environment. • Describe various roles played by microbes in biodegradation, bioremediation and plant growth promotion.	**BT 509: Environmental Biotechnology** **Section-A** - ~~Current status of biotechnology in environmental protection.~~ - ~~Sewage &~~ waste water treatment: ~~Physical, Chemical and biological treaments; Aerobic processes & anaerobic processes,~~ Primary, secondary and tertiary treatments; ~~Sludge dewatering & its disposal;~~ Water reclamation. - Solid waste management: Methods & disposal ~~of non hazardous and hazardous solid wastes, recycling,~~ methods of disposal of radioactive waste. - ~~Conservation of Biodiversity: *Ex-situ* & *in-situ* methods.~~ **Section-B** - ~~Environmental Biotechnology in Agriculture~~: Biofertilizers ~~and microbial inoculants~~, Biopesticides. - Biodegradation of xenobiotic compounds: Simple aromatics, chlorinated polyaromatic petroleum products, Pesticides ~~and surfactants.~~ - Bioremediation ~~& Biorestoration:~~	This course is proposed to be discontinued in the present form from the III Semester. **Suggested Books:** ➢ Jogdand, S. N. (2010). *Environmental Biotechnology (Industrial pollution management)* (3rded.). Mumbai, India: Himalaya Publishing House. ➢ Srinivasan, D. (2009). *Environmental Engineering*. New Delhi, India: PHI Learning Pvt. Ltd. ➢ Thakur, I. S. (2012). *Environmental Biotechnology: Basic concepts and Application* (2nded.). New Delhi: I K International Publishing House. ➢ Modi, P. N. (2015). *Sewage treatment & disposal and waste water engineering*. New Delhi, India: Rajsons Publications Pvt. Ltd. ➢ Milton, W. (Ed.). (1999). *An Introduction to Environmental Biotechnology*. USA: Springer. ➢ Tripathi, B. N., Shekhawat, G. S., & Sharma, V. (Ed.). (2009). *Applications of Biotechnology*. Jaipur, India: Aavishkar	The course contents are proposed to be revised and merged with the M.Sc. Bioscience III Semester core course BIO 408 “Environmental Biology and Toxicology” to propose a new core course i.e. “Environmental Biology and Biotechnology in the II Semester.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			~~Reforestation through micro-propagation, development of stress tolerant plants, and use of mycorrhiza in reforestation of soil contaminated with heavy metals.~~ **Section-C** - Biofuels: ~~Energy crops, Conventional sources of biofuel, Second and third generation of biofuel,~~ Biogas, Bioethanol, Biohydrogen. Biodegradable plastics. - Bioindicators ~~and Biosensers for detection of environmental pollution.~~ - Environmental genetics: Degradative plasmids, ~~release of GE microbes in environment.~~ **Books Recommended :** ➢ Environmental Impact Assessment : Clark, Bissel&Watham. ➢ Introduction to Toxicology : J.A. Timberell. ➢ Fundamentals of Ecology :Eugen P. Odum. ➢ Field Biology : R.L. Smith. ➢ Encyclopedia of Pollution & its Control :Vol.I-VI. ➢ Environmental Chemistry : B.K. Sharma and H. Kaue, Goel Publishing House, Meerut. ➢ Environmental Biotechnology : S.K. Aggarwal, APH Publishing Corporation. ➢ Environmental Chemistry : A.K. Bhagi and G.R. Chatwal, Himalaya Publishing House, New Delhi.	Publishers. ➢ Tchobanoglous, G., Burton, F. L., Stensel, H. D., & Metcalf & Eddy. (2014). *Wastewater engineering: Treatment and reuse*. New Delhi, India: Tata McGraw Hill Edition. **Suggested e- Resources:** ➢ **Biological treatment of wastewater** http://www.neoakruthi.com/blog/biological-treatment-of-wastewater.html ➢ **Biogas** http://www.biologydiscussion.com/biomass/production-of-biogas-from-biomass/10436 ➢ **Biofuel** http://uru.ac.in/uruonlinelibrary/BioFuels/Biomass%20and%20biofuels.pdf ➢ **Biosensor** https://www.edgefx.in/biosensors-types-its-working-and-applications/ ➢ **Xenobiotic compound biodegradation** https://bit.ly/2GHRoMj	
19.	Critical Analysis of classical papers/ Landmark Discoveries	After successful completion of the course, students should be able to: • Analyze and give a critical description of the papers studied.		**Suggested Reading:** • Studies on the chemical nature of the substance inducing transformation of Pneumococcal types: Induction of transformation by a desoxyribonucleic acid	Seminar mode Proposed to be introduced

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		• Discuss the significance of the research work.		fraction isolated from *Pneumococcus type* III. Avery OT, Macleod CM, McCarty M.; J Exp Med. 1944 Feb 1;79(2):137-58. • Independent functions of viral protein and nucleic acid in growth of bacteriophage Hershey AD and Chase M.; J Gen Physiol. 1952 May;36(1):39-56. • Molecular structure of nucleic acids; a structure for deoxyribose nucleic acid Watson JD and Crick FH; Nature. 1953 Apr 25;171(4356):737-8. Transposable mating type genes in *Saccharomyces cerevisiae* James Hicks, Jeffrey N. Strathern& Amar J.S. Klar; Nature 282, 478-483,1979. • Messelson& Stahl experiment demonstrating semi-conservative replication of DNA. Meselson M and Stahl FW.; Proc Natl Acad Sci U S A. 1958 Jul 15;44(7):671-82 • In vivo alteration of telomere sequences and senescence caused by mutated Tetrahymena telomerase RNAs Guo-Liang Yu, John D. Bradley, Laura D. Attardi& Elizabeth H. Blackburn; Nature 344, 126-132, 1990 • A protein-conducting channel in the endoplasmic reticulum Simon SM AND BlobelG.; Cell. 1991 May 3;65(3):371-80 • Identification of 23 complementation groups required for post-translational events in the yeast secretory pathway Novick P, Field C, Schekman R.; Cell. 1980 Aug;21(1):205-15 • A yeast mutant defective at an early stage in import of secretory protein precursors	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				into the endoplasmic reticulum Deshaies RJ and Schekman R.; J Cell Biol. 1987 Aug;105(2):633-45 • Reconstitution of the Transport of Protein between Successive Compartments of the Golgi Balch WE, Dunphy WG, Braell WA, Rothman JE.; Cell. 1984 Dec;39(2 Pt 1):405-16 • A complete immunoglobulin gene is created by somatic recombination Brack C, Hirama M, Lenhard-Schuller R, Tonegawa S.; Cell. 1978 Sep;15(1):1- • A novel multigene family may encode odorant receptors: a molecular basis for odor recognition Buck L and Axel R; Cell. 1991 Apr 5;65(1):175-87 • Kinesin walks hand-over-hand Yildiz A, Tomishige M, Vale RD, Selvin PR.; Science. 2004 Jan 30;303(5658):676-8 • Mutations affecting segment number and polarity in Drosophila Christiane Nusslein-Volhard and Eric Weischaus; Nature 287, 795-801, • Information for the dorsal--ventral pattern of the *Drosophila* embryo is stored as maternal mRNA Anderson KV and Nüsslein-Volhard C; Nature. 1984 Sep 20-26;311(5983):223-7 • Hedgehog signalling in the mouse requires intraflagellar transport proteins Huangfu D, Liu A, Rakeman AS, Murcia NS, Niswander L, Anderson KV.; Nature. 2003 Nov 6;426(6962):83-7	
Elective Courses to be offered in III Semester					**(Common with M.Sc.**

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
					AMBT III Sem.)
1)	**BT:** Enzyme Technology	After successful completion of the course, students should be able to: • Develop understanding of enzymes and their mechanism of action and regulation. • Explain the production of enzymes. • Learn wide applications of enzymes and their future potential.	**BT 406: Enzymology and Enzyme Technology** **Section-A** • History and introduction to enzymes: ~~Classification of enzymes. IUPAC system, nomenclature, E.C. numbers.~~ • ~~Enzyme kinetics (Michaelis - Menten laws), importance and determination of Vmax and Km values, Hofstee's plot, L & B plots.~~ • Bisubstrate reactions-ordered & random sequential mechanism. Theorell chance mechanism, ping pong mechanism, products of inhibition in bisubstrate reactions. • ~~Enzyme inhibition: competitive, non-competitive and other types.~~ **Section-B** • Extraction of soluble and membrane bound enzymes from microbial, plant and animal tissues. • Purification of enzymes: salt precipitation, gel filtration, ion exchange and affinity chromatography. Regulation of enzyme activity, various controls (metabolic compartmentation, covalent modifications and others), feedback regulation, allosteric enzymes ~~Coenzymes, Isozymes and~~ Multienzyme complexes • Methods of storing enzymes. **Section-C** • Large scale production of enzymes including genetic engineering approaches for their over production. • Enzyme engineering; identification of active sites,	**Enzyme Technology** **Section-A** • Enzymes: Scope, historical developments, distinguishing features. • Mechanisms of enzyme action: Concept of active site, specificity of enzyme action. • Methods of characterization of enzymes – Development of enzymatic assays • Bisubstrate reactions-ordered & random sequential mechanism. Theorell chance mechanism, ping pong mechanism, products of inhibition in bisubstrate reactions. Regulation of enzyme activity, various controls (metabolic compartmentation, covalent modifications and others), feedback regulation, allosteric enzymes. **Section-B** • Extraction of soluble and membrane bound enzymes from microbial, plant and animal tissues. • Purification of enzymes: salt precipitation, gel filtration, ion exchange, affinity chromatography, enzyme crystallization, drying and freeze drying. • Large scale production of enzymes including genetic engineering approaches for their over production. • Methods of storing enzymes. • Multienzyme complexes. • Designer enzymes, Thermophilic enzymes, Metal degrading enzymes.	The course "Enzyme Technology" is proposed as a new elective course by updating and shifting the existing core course BT 406 "Enzymology and Enzyme Technology" from the II Semester to III Semester.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			approaches for modification of catalytic properties. ~~•~~ Techniques of enzyme immobilization ~~and their applications in:~~ ~~v.~~ Food industry- ~~High fructose syrup, cheese making and beer industry.~~ vi. Antibiotics and other Pharamaceuticals vii. Medical applications ~~viii.~~ Analysis of substances, ~~enzyme electrodes, enzyme thermistors.~~ ~~• Basic idea of proteomics~~	**Section-C** • Enzyme engineering; identification of active sites, approaches for modification of catalytic properties. Synzymes. • Techniques of enzyme immobilization: Adsorbtion, Covalent bonding, Gel Entrapment and Microencapsulation. • Applications of enzymes in: i. Food industry- Baking industry, Dairy industry, Beverage industry ii. Antibiotics and other pharamaceuticals iii. Medical applications iv. Analysis of substances v. Leather industry vi. Textile industry • Enzyme biosensors. **Suggested Books:** ➢ Palmer, T. & Bonner, P. (2014). *Enzymes: Biochemistry*, *Biotechnology and Clinical Chemistry*. UK: Woodhead Publishing Limited. ➢ Buchholz, K., Kasche, V. and Bornscheuer, U. (2005). *Biocatalysts and Enzyme Technology*, WILEY–VCH. ➢ Pandey A., Webb C., Soccol, C. R. and Larroche, C. (2006). *Enzyme Technology.* Springer. ➢ Price N. & Stevenson L. (1999). *Fundamentals of Enzymology: Cell and Molecular Biology of catalytic Proteins*, Oxford University Press. ➢ Daniel L. Purich (2009). *Contemporary*	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Enzyme Kinetics and Mechanism. Atlantic Publishers and Distributers. ➢ Blanch, H.W., & Clark, D.S. (1997). *Biochemical Engineering*, Marcel Dekker. ➢ Drauz K., Gröger, H. and May, O. (2012). *Enzyme Catalysis in Organic Synthesis: A Comprehensive Handbook*, Volume 1, Wiley-VCH Verlag & Co. **Suggested e-resources:** ➢ **Enzymes: properties and mechanisms** http://www.biologydiscussion.com/enzymes/enzymes-properties-and-mechanism-of-enzyme-action/6145 ➢ **Enzyme technology: metagenomics, evolution and biocatalysis** https://searchworks.stanford.edu/view/8775255	
2)	**BIO 503:** Fundamentals of Bioentrepreneurship	After successful completion of the course, students should be able to: • Understand role of entrepreneurship in promoting innovation and wealth generation. • Develop skills for writing business models for new ideas and market segments. • Explain various financial, marketing, sales and legal issues associated with entrepreneurship.	**Section-A** • ~~Accounting and Finance: Taking decision on starting a venture; Assessment of feasibility of a given venture/new venture; Approach a bank for a loan; Sources of financial assistance~~; Making a business proposal/~~Plan for seeking loans from financial institution and banks; Funds from bank for capital expenditure and for working; Statutory and legal requirements for starting a company/venture; Budget planning and cash flow management.~~ • ~~Basics in accounting practices: concepts of balance sheet, P &~~ L ~~account and double entry book keeping; Estimation of income, expenditure, income tax etc.~~ **Section-B** • Marketing: Assessment of market demand for	**Section-A** • Concept of entrepreneurship; Classification and types of entrepreneurship, Myths about entrepreneurship; Role of entrepreneurship in wealth building and creating an impact; Society, Technology and Entrepreneurship. • Creativity and Innovation; Types and forms of Innovation; Sources of innovative opportunity; Entrepreneurship as a career option. **Section-B** • Introduction to the Design Thinking Process;	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			potential product (s) of interest; Market conditions, segments; prediction of market changes; Identifying needs of customers including gaps in the market, packaging the product; Market linkages, branding issues; Developing distribution channels; Pricing/Policies/Competition; Promotion/Advertising; Services Marketing. • ~~Negotiations/Strategy: with financiers, bankers etc; with government/law enforcement authorities: with companies/Institutions for technology transfer; Dispute resolution skills; External environment/changes; Crisis/Avoiding/Managing; Broader version-Global thinking.~~ **Section-C** • ~~Information Technology: How to use IT for business administration; Use of IT in improving business performance; Available software for better financial management; E-business setup, management.~~ • ~~Human Resource Development (HRD): Leadership skills; Managerial skills; Organization structure, pros & cons of different structures; Team building, teamwork; Appraisal; Rewards in small scale set up.~~ • Fundamentals of Entrepreneurship, Support mechanism for ~~entrepreneurship in India, Role of knowledge centre and R & D, knowledge centres like universities and research institutions; Role of technology and upgradation; Managing Technology Transfer; Regulations for transfer of foreign technologies; Technology transfer agencies.~~ **Recommended Books:** ➢ Patzelt, H., &Bernner, T. (Eds.). (2008).	Problem identification; Idea Generation; Value Proposition; Lean Canvas. • Identifying Customer Segments; Idea Validation; Developing Business Model; Sizing the opportunity; Building MVP; Concept of Start-up, Importance of Incubation. **Section-C** • Financial and Non financial support**:** Revenue streams; Pricing and Costs; Sources of funds; Importance of project management. • Marketing and Sales: Positioning; Channels and Strategy; Sales Planning. • Team: Importance of teambuilding; Complementary skill sets. • Legal issues: Brief overview of- intellectual property rights, patents, trademarks, copy rights, trade secrets, licensing and GI. • Business Plan writing. • Policies and Initiatives to promote Entrepreneurship in India. **Suggested Books:** ➢ Jain, P.C. (2001). *Hand Book for New*	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Handbook of Bioentrepreneurship. Berlin, Germany: Springer. ➢ Robert, D. H., & Peters, M. P. (2002). *Entrepreneurship*. New York, USA: McGraw-Hill Education ➢ Shane, S. (2004). *Academic Entrepreneurship: University Spinoffs and Wealth Creation*. Northampton, M.A.: Edward Elgar	*Entrepreneurs*. UK: Oxford University Press. ➢ Hisrich R. D., Manimala M. J., Peters Michael P. & Shepherd D. A. *Entrepreneurship* (9th ed.). McGraw Hill Publication. ➢ Roy, R. (2011). Entrepreneurship (2nd ed.). UK: Oxford University Press. ➢ Drucker, P. (2015). *Innovation and Entrepreneurship* (1st ed.). Routledge Classics. ➢ Kotler, P & Keller, K.L. (2017).*Marketing Management* (15th ed.). Pearson Publications ➢ Desai, V. (2011) *Dynamics of Entrepreneurial Development & Management* (6t ed.). Mumbai: Himalaya Publishing House. ➢ Khanka, S.S. (2007) *Entrepreneurial Development*. New Delhi: S. Chand & Company Ltd. ➢ Mohanty, S K. (2005). *Fundamentals of Entrepreneurship*. EEE Prentice Hall India Learning Private Limited. ➢ Gupta C.B. & Srinivasan N.P. (2013). *Entrepreneurship Development in India.* Sultan Chand & Sons. ➢ Gupta A.K. (2016).*Grassroots Innovations (Minds On the Margin Are Not Marginal Minds).* Random House. ➢ Patzelt, H., &Bernner, T. (Eds.). (2008). *Handbook of Bioentrepreneurship*. Berlin, Germany: Springer. ➢ Robert, D. H., & Peters, M. P. (2002). *Entrepreneurship*. New York, USA: McGraw-Hill Education ➢ Shane, S. (2004). *Academic Entrepreneurship: University Spinoffs and Wealth Creation*. Northampton, M.A.: Edward	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Elgar **Suggested e-Resources:** ➢ **Entrepreneurship** https://www.startupcommons.org/what-is-startup-ecosystem.html https://getproductmarketfit.com/how-to-select-test-to-get-market-validation-for-new-product-or-business-idea/ https://www.coursera.org/learn/wharton-launching-startup https://www.coursera.org/learn/wharton-entrepreneurship-opportunity http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.463.4354&rep=rep1&type=pdf ➢ **Accounts and Bioentrepreneur** https://www.nature.com/bioent/2003/031101/full/bioent779.html ➢ **Bioentrepreneurship** www.birac.nic.in/webcontent/jk.pdf ➢ **Biotechnology and entrepreneurship** http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.463.4354&rep=rep1&type=pdf	
3)	**BIO 505:** Microbial Technology	After successful completion of the course, students should be able to: • Utilize various strategies for strain improvement, overexpression, maintenance and containment of microbes • Describe strategies used for large scale production of various industrially relevant bioactive molecules from microorganisms .	**Section-A** • Biotechnological innovation in pharmaceutical, health, agricultural and industrial sectors. • Strategies for selection and improvement of industrial strains. • Measurement and control of bioprocess parameters. • Genetic and environmental control of metabolic pathways. **Section-B** • Industrial production of Biofuel,	**Section-A** • Biotechnological innovation in pharmaceutical, health, agricultural & industrial sectors. • Strategies for selection & improvement of industrial strains. • Measurement & control of bioprocess parameters. • Genetic & environmental control of metabolic pathways. **Section-B** • Industrial production of Biofuel,	Typological corrections have been made.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Biotransformation of Steroids, Single Cell Protein. • Biofertilizers (Rhizobium and BGA); Biopesticides (Bt toxin) • Biosensors (NH4, Sulphide); Biofilms. • Biopolymers (-PHB, Xanthum gum) **Section-C** • Microbial overproduction of recombinant molecules: Selection of suitable promoter sequences, ribosome binding sites, fusion protein tags, purification tags, protease cleavage sites and enzymes, inducible expression systems, limitations of metabolic engineering. • Large scale production using recombinant microorganisms: peptic hormones (secretin), metabolic engineering of antibiotics, basic ides of biohydrometallury. • Maintenance and containment of recombinant microorganisms. **Books Recommended :** ➢ Biotechnological Innovations in Chemical Synthesis, BIOTOL, Butterworth - Heinemann. ➢ Industrial Microbiology, G. Reed (editor), CBS Publishers (A VI Publishing Company) ➢ Genetics and Biotechnology of Industrial Microorganisms. C.L. I-le' -shnergev, S.W. Queener and Q Hegen. American Society of Microbiology. ➢ Protein Expression A Practical Approach: Edited by S.J. Higgins and B.D. Hames (OUP).	Biotransformation of Steroids, Single Cell Protein. • Biofertilizers (*Rhizobium* and BGA); Biopesticides (Bt toxin). • Biosensors (NH_4, Sulphide); Biofilms. • Biopolymers (PHB, Xanthum gum). **Section-C** • Microbial overproduction of recombinant molecules: Selection of suitable promoter sequences, ribosome binding sites, fusion protein tags, purification tags, protease cleavage sites and enzymes, inducible expression systems, limitations of metabolic engineering. • Large scale production using recombinant microorganisms: peptic hormones (secretin), metabolic engineering of antibiotics, basic idea of biohydrometallurgy. • Maintenance and containment of recombinant microorganisms. **Suggested Books:** ➢ BIOTOL, Currell, B.C., & Dam-Miera, R.C.E. (1997). *Biotechnological Innovations in Chemical Synthesis (BiotolSer)*. Oxford, UK: Butterworth-Heinemann, Elsevier. ➢ Reed, G. (2004). Prescott and Dunn's Industrial Microbiology. New Delhi, India: CBS Publishers. ➢ Glazer, A.N., & Nikaido, H. (2008). *Microbial Biotechnology*. UK: Cambridge University Press. ➢ Kun, L.Y. (Ed.) (2003). *Microbial Biotechnology: Principles and Applications*.	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Singapore: World Scientific Publication Co.Ptv. Ltd. ➢ Braun,V. & Gotz, F. (Eds.). (2002). *Microbial Fundamentals of Biotechnology*. Germany: Wiley-Vch. ➢ Gupta, V.K. (Ed.), Sharma, G.D. (Ed.),Tuohy, M.G. (Ed.), Gaur, R. (Ed.). (2016). *The Handbook of Microbial Bioresources* (1st ed.). New Delhi, India: CABI Publishing. ➢ Crueger, W. & Crueger, A. (1990). *Biotechnology, A Text Book of Industrial Microbiology* (2nd ed.). U.S: Sinauer Associates Inc. **Suggested e- Resources:** ➢ **Microbial Biotechnology** https://bit.ly/2XmRZs2 ➢ **Biosensor** https://www.edgefx.in/biosensors-types-its-working-and-applications/ ➢ **Biofertilizer** www.krishisewa.com/articles/organic-agriculture/115-biofertilizers.html ➢ **Biopesticide** www.agriinfo.in/default.aspx?page=topic&superid=3&topicid=1950	
4)	**BT 513:** Food Process and Biotechnology	After successful completion of the course, students should be able to: • Explain strategies of food preservation, spoilage and quality assessment • Understand various policies related to GM food and its safety assessment • Demonstrate the principles for	**Section-A** • Introduction and development of food biotechnology; Current status of Transgenic crops for crop improvement and enhanced agronmic performance. • International and National guidelines for safety assessment of genetically modified (GM) foods. • Contemporary food related policy issue and their implications.	**Section-A** • Introduction and development of food biotechnology; Current status of transgenic crops for crop improvement & enhanced agronomic performance. • International and National guidelines for safety assessment of genetically modified (GM) foods. • Contemporary food related policy issue & their	Some typological errors have been corrected. Butter has been replaced by kefir as it is a more important fermentation product of milk. Also food yeasts have been deleted as it is more relevant in fermentation.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		production of various processed food	• General principals of Food spoilage, factors affecting spoilage; Methods of food preservation. Food products with enhanced shelf-life. **Section-B** • Mechanism of enzyme function and reactions in Food processing; Enzymic bioconversions e.g. starch and sugar conversion process; HFCS; Interesterified fat, hydrolysed protein etc. and their downstream processing. • Baking by amylases; Deoxygenation and desugaring by glucose oxidases; Beer mashing and chill proofing. • ~~Cheese making by proteases and~~ various other enzyme catalytic actions in food processing.- Fermented dairy products: cheese, yogurt, ~~butter~~; Bacteriocin from lactic acid bacteria and Alcoholic beverages. • Fermented vegetables, oriental foods, meat products, Fish& poultry products. **Section-C** • Process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products. • Biotechnology applications in the production of additives/ingredients: Enzymes. • Carotenoids, amino acids, organic acids, vitamins, colouringflavours and nutraceuticals. • Production of new protein foods-Single cell proteins (SCP), mushroom, ~~food yeasts~~, algal proteins. • Quality control of food-Detection system, Enzyme	implications. • General principles of food spoilage, factors affecting spoilage; Methods of food preservation. Food products with enhanced shelf-life. **Section-B** • Mechanism of enzyme function and reactions in food processing; Enzymic bioconversions e.g. starch and sugar conversion process; HFCS; Interesterified fat, hydrolysed protein etc. and their downstream processing. • Baking by amylases; Deoxygenation and desugaring by glucose oxidases; Beer mashing and chill proofing. • Various enzyme catalysed actions in food processing- fermented dairy products (cheese, yogurt, kefir), alcoholic beverages, fermented vegetables, oriental foods, meat products, fish & poultry products. Bacteriocin from lactic acid bacteria. **Section-C** • Bioconversion of process wastes to useful products -whey, molasses, starch substrates and other food wastes. • Biotechnology applications in the production of additives/ingredients: enzymes, carotenoids, amino acids, organic acids, vitamins, colouring flavours and nutraceuticals. • Production of new protein foods- Single cell proteins (SCP), mushroom, algal proteins. • Quality control of food- detection system, Enzyme Immunoassay and Radio-immunoassay.	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Immunoassay and Radio-immunoassay. **Books Recommended :** ➢ Food Microbiology: W.C. Fragier, D.C. 1995. Westhoft 3rd Ed. Tata McGraw Hill. ➢ Food Microbiology : M.R. Adams, M.O. Moss, 1998 New Age International (P) Ltd. ➢ Principles of Fermentation Technology: P.F. Stanbury, A. Whittaker, S.J. Hall 1995. 2nd Edn. Pergamon Press. ➢ Basic Food Microbiology: G.J. Banwart (1898) CBS Publishers and Distributors, Delhi. ➢ Dairy Microbiology: R.K. Robinson (1990) Elsevier Applied Sciences, London.	**Suggested Books:** ➢ Frazier, W.C. & Westhoff, D.C. (2003). *Food Microbiology*. New York, USA: Tata McGraw Hill. ➢ Adams, M. R. & Moss, M. O. (2007). *Food Microbiology*. UK: Royal Society of Chemistry. ➢ Stanbury, P.F., Hall, S. J. & Whitaker, A. (1999). *Principles of Fermentation Technology*. Oxford, UK: Butterworth-Heinemann, Elsevier. ➢ Banwart, G.J. (1989). *Basic Food Microbiology*. New Delhi, India: CBS Publishers. ➢ Robinson, R.K. (1990). *Dairy Microbiology*. London, UK: Elsevier Applied Sciences. ➢ Pandey, A., Larroche, C., Soccol, C. R. & Dussap, C. (2008). *Advances in Fermentation Technology*. New Delhi, India: Asiatech Publishers, Inc. ➢ Joshi, V. K. & Pandey, A. (1999). *Biotechnology: Food Fermentation*. New Delhi, India: Asia tech Publishers Inc. **Suggested e- Resources:** ➢ **Quality control of food detection system** https://www.engineersgarage.com/Contribution/Arduino-based-Smart-IoT-Food-Quality-Monitoring-System ➢ **Food Preservation** https://sciencesamhita.com/methods-of-food-preservation/ ➢ **History of microorganisms in food** https://faculty.weber.edu/coberg/class/3853/3853%20HistoryofFood.htm	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				➢ **Genetically modified food** http://anrcatalog.ucdavis.edu/pdf/8180.pdf	
5)	**BT 515:** Genomics and Proteomics	After successful completion of the course, students should be able to: • Describe principles of functional genomics • Develop an understanding of proteomics and associated techniques • Understand comprehensive concept of nucleotide and protein sequencing.	**Section-A** • ~~Whole genome analysis: preparation of ordered cosmid libraries, bacterial artificial chromosome libraries. Shotgun libraries and sequencing, YAC.~~ • ~~Sequence analysis: computational methods, homology algorithms (BLAST) for proteins and nucleic acids, open reading frames, annotation of genes, EST.~~ • ~~Conserved protein motifs related structure/function (PROSITE, PI'-AM, Profilescan).~~ • ~~Physical and Genetic mapping.~~ **Section-B** • ~~DNA microarray: printing of oligonucleotides and PCR products on glass slides, nitrocellulose paper.~~ • ~~Analysis of SNP using DNA chips.~~ • ~~Whole genome analysis for global patterns of gene expression using fluorescent labeled cDNA or end labeled RNA probes.~~	**Section – A** • Genomics – Introduction to genome & genomics; genetics *vs.* genomics. DNA microarray; preparation, understanding of microarray data, normalizing microarray data, detecting differential gene expression, correlation of gene expression data to biological process & analysis tools. Gene Expression Omnibus (GEO). • Large scale genome sequencing strategies. Genome assembly & annotation. Genome databases of plants, animals & pathogens. • Metagenomics: Gene networks: basic concepts, computational model such as Lambda receptor & lac operon. • Prediction of genes, promoters, splices sites, regulatory regions: basic principles, application of methods to prokaryotic & eukaryotic genomes. **Section – B** • Introduction to proteome and proteomics; protein chemistry *vs.* proteomics. Analytical techniques of proteomics; working principles of 2D – gel electrophoresis, mass spectrometry with their merits and demerits. • Mass spectrometers for protein and peptide sequencing; MALDI – TOF, electospray ionization coupled tandem Mass spectrometry. Tandem mass analyzer, triple quadrupole mass analyzer, ion – trap mass analyzer and FT – ion cyclotron resonance MS. Peptide Mass Fingerprinting.	The syllabus has been remodeled keeping in mind the current advances in technology.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Section-C • ~~Proteomics Technology - Separation & isolation of protein, acquisition of protein structure database utilization.~~ • ~~Applications of Mass spectroscopy in proteomics : Isolation and sequence analysis of individual protein spots.~~ • ~~Types of Proteomics.~~ • ~~Proteomics Applications.~~ • ~~Protein and Peptide microarray.~~ • ~~Advantages & disadvantages of DNA & Protein microarrays~~. **Books Recommended :** ➢ Introduction to Bioinformatics - Parrysmith and Attwood. ➢ Introduction to Bioinformatics - Baxevenis and Oulette	• Sequencing the protein fragments: Scoring Algorithm for Spectral analysis. Application of SALSA in amino acid – Motif searching. **Section – C** • Next generation sequencing & assembly: elements of big data analysis, NGS Platforms based on pyrosequencing, sequencing by synthesis, emulsion PCR approach with small magnetic beads & single molecule real time (SMRT) sequencing. • Genome assembly algorithms, De-novo assembly algorithms. • Sequence Alignment formats: Sequence Alignment/Map (SAM) format, Binary Alignment/Map (BAM) format. Protein function prediction using Machine learning tools: supervised/unsupervised learning, neural network, SVM. • Protein-protein interactions: databases such as STRINGS, DIP, PPI server & tools for analysis of protein-protein interactions. **Suggested Books:** ➢ Brown, S.M. (2015). *Next-generation DNA sequencing Informatics* (2nd ed.). Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. ➢ Liebler, D. C. (2001). *Introduction to proteomics tools for the new biology*. US: Humana Press. ➢ Lesk, A.M. (2015). *Introduction to Genomics* (2nd ed.). Oxford, UK: Oxford University Press. ➢ Pevsner, J. (2017). *Bioinformatics and Functional Genomics* (3rd ed.). New Jersey,	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				USA: John Wiley & Sons Ltd. ➢ Twyman, R.M. (2004). *Principles of Proteomics*. New Delhi, India: CBS Publishers. ➢ Thangadurai, D. & Sangeetha, J. (2015). *Genomics and Proteomics: Principles, Technologies, and Applications*. USA: CRC Press. ➢ Pennington, S. R. & Dunn, M. J. (Eds.). (2000). *Proteomics: From protein sequence to function*. Oxford, UK: Bios Scientific Pub Ltd. **Suggested e- Resources:** ➢ **Proteomics** https://nptel.ac.in/courses/102101055/4 ➢ **Genomics** https://bit.ly/2Nq86jQ	
6)	**BT 516:** Immunotechnology	After successful completion of the course, students should be able to: • Describe various theories describing antibody formation • Explain the mechanism of immune response to various stimuli • Elucidate on vaccines and their development.	**Section-A** • Structure, genomic organisation, expression and functions of major histocompatibility complex. • Organisation and expression of immunoglobulin genes ~~and antibody diversity~~. • T cell receptors - genomic organisation, structure and isolation of TCR. • ~~Immune regulation, positive and negative selection in thymus, apoptosis.~~ **Section-B** • ~~Immunity to infectious diseases.~~ • Immunodeficiency and AIDS. • ~~Transplantation Immunology.~~ • ~~Tumor Biology.~~	**Section- A** • Structure, genomic organization, expression and functions of major histocompatibility complex (MHC). • Organization and expression of immunoglobulin genes. • T-cell receptors- genomic organization, structure and isolation of TCR. • Antibody diversity- mini gene theory, mutation theory, germ line theory, somatic recombination, V(D) J recombination. Combinatorial diversity, junctional diversity. **Section-B** • ABO Blood groups, blood transfusion, Bombay phenotype, Rh blood group, DAT test, MN blood group. • Immunity to infectious diseases: Viral, bacterial, fungal and parasitic infections.	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Section-C • ~~Various approaches to vaccines.~~ • ~~T cell cloning,engineered antibodies production~~. • ~~Radioimmunoassay, Enzyme linked immunosorbant assay, ELISPOT, Immunoblotting (western blotting).~~ • ~~Immunofluroescence, Immunoelectron microscopy, cell cytotoxicity assays and flow cytom~~etry. **Books Recommended:** ➢ Abbas, A. K., Lichtman, A. H., &Pillai, S. (2017). *Cellular and Molecular Immunology* (9th ed.). Amsterdam, Netherlands: Elsevier. ➢ Delves, P. J., Martin, S. J., Burton, D. R., &Roitt, I. M. (2006). *Roitt's Essential Immunology* (11thed.). New Jersey, USA: Wiley-Blackwell. ➢ Punt, J., Stranford, S., Jones, P., & Owen, J. (2018). *Kuby Immunology (*8th ed.). New York, USA: W. H. Freeman and Company. ➢ Tizard, I. R. (1995). *Immunology: Introduction*, (4th ed.). Philadelphia, USA: Saunders College Publishing.	• Immunodeficiency disease: Primary and secondary immunodeficiency disease (AIDS). **Section –C** • History of vaccination, immunization types and vaccination properties. • Types of vaccines: Live, killed, subunit, recombinant viral, synthetic peptide, anti-idiotype, DNA, toxoid, conjugate, recombinant vector & plant based vaccines. • Stages of vaccine development and some common vaccines used in human MMR, poliovaccine & BCG vaccines. **Suggested Books:** ➢ Austyn, J.M. &Wood, K.J. (1993). *Principles Of Cellular and Molecular Immunology*. London, U.K: Oxford University Press. ➢ Benjaminin, E., Coico, R. & Sunshine, G. (2000).*im*: A short course (4th ed.). New York, USA: Wiley-Liss. ➢ Cunnigham, A.J. (1978).*Understanding Immunology*. London, U.K.: Academic Press Inc. ➢ Hildemann, W.H. (1984). *Essentials of Immunology*. USA: Elsevier Science Ltd. ➢ Johnstone, A. & Thorpe, R. (1996) *Immunochemistry In Practice* (3rded.). US: Wiley-Blackwell. ➢ Joshi, K.R. & Osama, N.O. (2004). *Immunology and Serology*. India: Agrobios. ➢ Khan, F.H. (2009). *The Elements Of Immunology*. India: Pearson Education. ➢ Punt, J., Stranford, S., Jones, P. & Owen,	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				J. (2018). *Kuby Immunology (*8th ed.). New York, USA: W. H. Freeman and Company. ➢ Reeves, G. & Todd, I. (2001). *Lecture Notes on Immunology* (4th ed.). US: Wiley-Blackwell. ➢ Rich, R.R., Fleisher, T. A, Shearer, W.T., Schroeder, H., Frew, A.J. & Weyand, C.M. (2018). *Clinical Immunology: Principles and Practice* (5th ed.). USA: Elsevier Science Ltd. ➢ Tizard, I. R. (1995). *Immunology: Introduction*, (4th ed.). Philadelphia, USA: Saunders College Publishing. **Suggested e- Resources:** ➢ **Antibodies and antigens** https://nptel.ac.in/courses/102103038/download/module2.pdf ➢ **Vaccines** https://nptel.ac.in/courses/104108055/37 ➢ **DNA vaccines** https://nptel.ac.in/courses/102103041/18 ➢ **Transplantation immunology** https://nptel.ac.in/courses/102103038/31	
7)	**BT 521:** Plant Biotechnology	After successful completion of the course, students should be able to: • Demonstrate principles for development of various stress resistant plants • Understand various techniques used in plant biotechnology	**Section-A** • Introduction, examples of current use of plant biotechnology. • Development of pathogen resistant plants (virus & insect resistance). • Development of plants of improved seed quality. • Artificial seeds. • Development of plants resistant to environmental stress. • Development of herbicide resistant plants. • Future outlook.	**Section A** • Introduction, examples of current use of plant biotechnology. • Development of pathogen resistant plants (virus & insect resistance). • Development of plants of improved seed quality; Artificial seeds. • Development of plants resistant to environmental stress and herbicides. • Future outlook.	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks

			Section-B
			• Immobilization of cells.
			• Gene delivery methods in intact and cultured tissues and cells.
			  ○ *Agrobacterium*, Ti plasmids, ~~co-integrate and binary vectors~~. Other vectors - viral vectors.
			  ~~○~~ Direct DNA uptake~~, microprojectile delivery, electroporation, microinjection, Liposomes.~~
			• Chloroplast engineering : Advantages of ~~chloroplast transgenics~~, applications in production of biopharmaceuticals, introduction of agronomic traits, viz. disease resistance, herbicide resistance, salt and drought resistance; phytoremediation etc.
			• Biotechnology of Biological Nitrogen fixation : *nif* genes
			Section-C
			• Production of metabolites; metabolic engineering and industrial products : plant secondary metabolites; control mechanisms and manipulation of phenyl propanoids and shikimate pathways; general strategy towards production of plant cell products.
			• Biotransformation using plant cells.
			• Cryobiology of plant cell cultures~~and establishment of gene banks.~~
			• Edible vaccines.
			• ~~Radiobiology of cultured plant cells.~~
			
			Books Recommended :
			➢ Biotechnology - A Laboratory Course : J. M. Becker, G.A. Coldwell and E.A. Zachgo, Academic Press, New York.
			➢ Genetic Engineering Technology in Industrial
				Section-B
				• Immobilization of cells.
				• Direct gene delivery methods.
				• Vector based gene delivery methods: *Agrobacterium*, Ti plasmid based vectors, viral vectors.
				• Chloroplast engineering: Advantages of transplastomics, applications in production of biopharmaceuticals, introduction of agronomic traits, viz. disease resistance, herbicide resistance, salt and drought resistance; phytoremediation etc.
				• Biotechnology of biological nitrogen fixation: *nif* genes.
				
				Section-C
				• Production of metabolites; metabolic engineering and industrial products: Overview of plant secondary metabolites; control mechanisms and manipulation of phenyl propanoids and shikimate pathways; general strategy to regulate the production of plant cell products.
				• Biotransformation using plant cells.
				• Cryobiology of plant cell cultures.
				• Edible vaccines.
				• Molecular markers - hybridization and PCR based markers RFLP, RAPD, STS, SSR, AFLP, SNP markers.
				Suggested Books:
				➢ Singh, B.D. (2011). *Plant Biotechnology* (2^{nd}ed.). New Delhi, India: Kalyani Publisher.
				➢ Chawla, H.S. (2009). *Plant Biotechnology*
					Modifications have been done in the light of current technologies.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Pharmacy : Ed. - J.M. Tabor. ➢ Tissue Culture, Methods and Applications : P.F. Kruse. ➢ Plant Tissue Culture : Sharma and Alam; IK International Publiser Pvt. Ltd.	(3^{rd}ed.). New Delhi, India: Oxford & IBH Publishing Co. Pvt. Ltd. ➢ Slater, A. (2008). *Plant Biotechnology: The Genetic Manipulation of Plants* (2^{nd}ed.). Oxford, UK: Oxford Publisher. ➢ Peter, K.V., & Keshavachandran, R. (2008). Plant Biotechnology: Methods in Tissue Culture and Gene Transfer. India: Universities Press. ➢ Murphy, D. (2007). *Plant Breeding and Biotechnology: Societal Context and the Future of Agriculture* (1^{st}ed.). UK: Cambridge University Press. ➢ Singh, B.S. (2007). *Fundamentals of Plant Biotechnology*. New Delhi, India: Satish Serial Publishing House. **Suggested e- Resources:** ➢ **Chloroplast Biotechnology** https://onlinelibrary.wiley.com/page/journal/14677652/homepage/chloroplast_biotechnology_special_issue.htm ➢ **Plant transformation technologies** http://repository.ias.ac.in/57240/1/23-pub.pdf ➢ **Abiotic stress and transgenics** http://repository.ias.ac.in/89833/1/1-pub.pdf	
8)	**BT 522:** Recombinant DNA Technology	After successful completion of the course, students should be able to: • Explain techniques used for DNA synthesis, amplification and sequencing • Describe strategies of cloning in both prokaryotes and eukaryotes. • Identify novel diagnostic tools	**Section-A** • Chemical synthesis of DNA: Phosphodiester, triester approaches, ~~amidite method~~, solid phase automated synthesis of DNA. • Sequencing of DNA : ~~Chemical and dideoxy methods~~, ~~random and directed approaches~~, automated DNA sequencing, improved gel based sequencers, mass spectrometry based sequencing, pyrosequencing, 454 sequencing technologies.	**Section-A** • Chemical synthesis of DNA: phosphodiester, phosphotriester, phosphite triester approaches, phosphoramidite solid phase automated synthesis of DNA, post-synthetic processing. • Sequencing of DNA: Maxam-Gilbert method, Sanger sequencing technique, automated DNA sequencing, improved gel based sequencers, primer walking method, whole genome shotgun	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		of rDNA and gene therapy	• PCR in gene recombination, Deletion, Addition, Overlap extension. PCR in molecular diagnostics. Viral and bacterial detection, PCR based mutagenesis~~,~~ Mutation detection: SSCP, DGGE, RFLP, Oligo ligation assay (OLA), Mismatch chemical cleavage (MCC), High resolution melt analyses, Allele-specific amplification (ASA). • Applications of Transposons in genetic engineering : construction of R plasmids, gene tagging and isolation, mutagenesis genome characterization etc. **Section-B** • ~~Vectors expressing cloned DNA in *E. coli*.~~ • Molecular cloning in ~~*E. coli* &~~ *Bacillus subtilis*. • Cloning in yeast. • DNA cloning in mammalian cells with SV-40 vector. • Cloning in plants: Direct and vector based approaches. **Section-C** • Site directed mutagenesis. • New Diagnostics in rDNA technology: Detection of genetic disorders, ~~test for pathogens,~~ DNA finger printing. • Gene Silencing techniques, ~~Introduction of siRNA and~~ siRNA technology, Micro RNA, Construction of siRNA vectors, ~~Principle and~~ application of gene silencing, ~~Gene~~ knockouts, ~~Gene replacement, Gene targeting, Transgenics~~, gene	sequencing, mass spectrometry based sequencing, pyrosequencing, 454 sequencing technologies. • Overlap-extension PCR in gene recombination, deletion & addition. • Mutation detection: SSCP, DGGE, RFLP, Oligo ligation assay (OLA), Mismatch chemical cleavage (MCC), High resolution melt analyses, Allele-specific amplification (ASA). • Applications of Transposons in genetic engineering: construction of R plasmids, gene tagging and isolation, mutagenesis, genome characterization etc. **Section-B** • Molecular cloning in *Bacillus subtilis*. • Cloning in yeast. • DNA cloning in mammalian cells with SV-40 vector. • Cloning in plants: Direct and vector based approaches. • Site directed mutagenesis: Oligonucleotide directed mutagenesis, PCR based mutagenesis. • Introduction to genome editing by CRISPR-CAS and its applications. **Section-C** • New diagnostics in rDNA technology: detection of genetic disorders, PCR in molecular diagnostics: Viral and bacterial detection, DNA finger printing. • Gene silencing techniques: RNAi, siRNA technology, construction of siRNA vectors, micro RNA, ribozymes, applications of gene silencing. • Knockout mice.	"Gene cloning and expression in *E. coli*," is a repetition of the paper Genetic Engineering taught in M.Sc. II Semester. The same has been replaced with recent genome editing technique "CRISPR-CAS"

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			therapy. ~~Basic idea of~~ drug designing. • Cloning and expression of human interferon gene **Books recommended :** ➢ Molecular Cloning Vol. 1, 2 and 3 :Sambrook and Russell, Cold Spring Harberlaboratory, 2001. ➢ Molecular Biology of Gene : J.D. Watson, Pearson Education. ➢ An Introduction to Gene Technology-From genes to clones :Winnacker, VCH. ➢ Principles of Gene Manipulation : Old and Primrose. ➢ Molecular Biotechnology : B.R. Glick and J.J. Pasternak, ASM Press, Washington, USA. ➢ Genetic Engineering : Science and ethics on new frontier : Michael Boylan, Pearson Education. ➢ An Introduction to Genetic Engineering : S.T. Nicholl, Cambridge University Press. ➢ Recombinant DNA : J.D. Watson, W.H. Freeman. ➢ Nucleic acid and biotechnology : H.D. Kumar. ➢ Understanding DNA and Gene Cloning :Darlica, John Wiley and Sons.	• Gene therapy: types, viral and non viral vectors. An overview of structure and ligand based drug designing. • Cloning and expression of human interferon gene. **Suggested Books:** ➢ Sambrook, J.F. & Russell, D.W. (2001). *Molecular Cloning: A Laboratory Manual* (3rd ed.) Vol. 1, 2 and 3. Cold Spring Harbor laboratory. NY: Cold Spring Harbor Laboratory Press. ➢ Watson, J. D., Baker, T.A. & Bell, S.P. (2014). *Molecular Biology of the Gene* (7th ed.). US: Pearson. ➢ Winnacker, E.L. (1987). *From Genes to Clones: Introduction to Gene Technology*. Germany: Wiley VCH. ➢ Primrose, S. B. & Old, R.W. (2001). *Principles of Gene Manipulation* (6th ed.). New Jersey, USA: Wiley-Blackwell. ➢ Glick, B.R., Pasternak, J.J. & Patten, C.L. (2010). *Molecular Biotechnology: Principles and Applications of Recombinant DNA* (4th ed.). US: American Society for Microbiology. ➢ Boylan, M. & Brown, K.E. (2001). *Genetic Engineering: Science and Ethics on New Frontier*. UK: Pearson Education. ➢ Nicholl, D.S.T. (2008). *An Introduction to Genetic Engineering* (3rd ed.). UK: Cambridge University Press. ➢ Watson, J.D., Meyers, R.M., Caudy, A.A. & Witkowski, J.A. (2007). *Recombinant DNA: Genes and Enomes-A short Course* (3rd ed.).	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. ➢ Kumar, H.D. (1990). *Nucleic Acid And Biotechnology*. New Delhi, India: Vikas Publication. ➢ Drlica, K. (2003). *Understanding DNA and Gene Cloning* (4^{th}ed.). New Jersey, USA: John Wiley & Sons Ltd. **Suggested e-Resources :** ➢ **Solid phase oligonucleotide** synthesis:https://www.atdbio.com/content/17/Solid-phase-oligonucleotide-synthesis ➢ **DNA sequencing** approaches:https://www.ncbi.nlm.nih.gov/books/NBK21117/CRISPR/ ➢ **Cas technology** https://bit.ly/2Edvm06 ➢ **Construction of siRNA expression vectors** https://bit.ly/2EqNLI8 ➢ **Gene knockout and transgenic mice** https://www.ncbi.nlm.nih.gov/books/NBK21632/	
9)	Bio Physics-I	After completion of this course, the students will be able to- • Understand the concepts of physical principles in the biomolecular systems. • Know properties and conformations of biomolecules • Understand the interaction between physics and biology		**Section A** • Introduction: Brief introduction to all aspects of Biology, cellular automata, Conway's Game of life. • Cell structure and function: Cell theory, cell membrane and transport, membranous organelles, Non-membranous organelles, Nuclear components and major cell types, viruses. • Molecules in the cell: carbohydrates, lipids, proteins and nucleic acids, their structure and function.	(New Introduced Elective Course, cw M.Sc. Physics)

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				• Code of life: Central dogma, DNA replication, transcription and translation. • Energy in life forms: Cellular Respiration, Glycolysis, Krebs cycle, Electron transport chain, ATP calculation, Photosynthesis, C4 pathway. **Section B** • Intermolecular interactions: Covalent interactions, disulphide bonds, van der Waals interactions, bond angles and torsions. Role of hydrogen bonding and hydrophobicinteraction in biomolecular structures. Examples of α-helices and β-sheets in proteins, Watson-Crick pairs in DNA, stacking interactions in DNA and RNA. • Protein Conformation: Conformational properties of polypeptides, Ramachandran plot, Helical parameters and conformation, organization as secondary and supersecondary structures in proteins, domains and motifs. Protein folding in vivo and in vitro of globular proteins, basic idea. **Section C** • Molecular Mechanics: Force field equation, Lennard Jones Potential, Potential energy surface, Z-matrix, Molecular modeling, Energy minimization techniques, Exhaustive search method, steepest descent and conjugate gradient methods, Molecular dynamics simulation, Verlet algorithm and simulated annealing protocol. • Experimental techniques used to determine biomolecular structure: Principles and application of UV-visible,	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				circular dichroism and fluorescence spectroscopy. • Case studies on Helix to coil transitions, melting curves in proteins and DNA structures. X-ray crystallography of biomolecules: Obtaining single crystals of biomolecules, Single crystal data collection, Determination of point group, space group from symmetry of diffraction patterns, deducing cell parameters, interpretation of intensity data, Calculation of electron density, Solving the phase problem, Structure validation. **Suggested Books:** ➢ Tuszynski, J.A. & Kurzynski, M. (2003). *Introduction to molecular biophysics*. CRC press. ➢ Schlick, T. (2010). *Molecular modeling and Simulation: An Interdisciplinary Guide: An Interdisciplinary Guide* (Vol. 21). Springer Science & Business Media. ➢ Voet, D., Voet, J. G. & Pratt, C. W. (2013). *Fundamentals of Biochemistry: Life At The Molecular Level* (No. 577.1 VOE). Hoboken: Wiley. ➢ Cantor, C. R., & Schimmel, P. R. (1980). *Biophysical CHEMISTRY: PART III: The Behavior Of Biological Macromolecules*. Macmillan. ➢ Van Holde, K. E. J. W. *Principles of Physical Biochemistry*/ Kensal E. Van Holde, W. Curtis Johnson, P. Shing Ho. ➢ Jensen, J. H. (2010). *Molecular Modeling Basics*. CRC Press. ➢ Nelson, P. (2004). *Biological Physics*. New	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				York: WH Freeman. **Suggested e-Resources:** ➢ **Non-Conventional Energy Systems** https://nptel.ac.in/syllabus/1021 • **Quantum-mechanics of molecular structure** https://bit.ly/2SoEqof https://bit.ly/2SoEqof	
10)	Animal Biotechnology-I	At successful completion of this course students will be able to: • Comprehend tools of molecular biology and biotechnology for the improved production and protection of animals. • Evaluate and discuss public and ethical concerns over the use of animal biotechnology. • Demonstrate an understanding of the key topics in tissue engineering		**Section-A** • History and importance of animal biotechnology, cryopreservation of gametes & embryos in mammals, artificial insemination (AI) techniques & their development: estrus synchronization; semen collection, evaluation & storage. • *In Vitro* fertilization and embryo transfer; superovulation, Microinjection & macroinjection: introduction, procedure, applications advantages and limitations. Ethical, social & moral issues related to cloning, in situ & ex situ preservation of germplasm. **Section-B** • Introduction to stem cell-definition, classification, characteristics, differentiation and dedifferentiation, stem cell niche, stem cells vs somatic cells, mechanism of pleuripotency in stem cells, different kinds of stem cells: adult stem cells, embryonic stem cells, fetal tissue stem cell, umbilical cord blood stem cells. • Human embryonic stem cells and society: The religious, legal, ethical and scientific debate, stem cell banking and ethical approaches on	New proposed elective

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				stem cells. • Stem cell therapies: Clinical applications of stem cell therapy, parkinsons and alzheimers disease, diabetes, kidney failure, lymphoma and leukemic malignancies requiring stem cell therapy. **Section-C** • Principles of Tissue Engineering- History & scope, basics of tissue engineering, cell- ecm interaction, wound healing mechanism, tissue engineering bioreactors, models of tissue engineering, biomaterials in tissue engineering, bioartificial organs: source of cells, choosing the right scaffold material, mode of transplantation. • Tissue Engineering & future perspectives: commercial products. **Suggested Books:** ➢ Portner, R. (2007). *Animal Cell Biotechnology*. New York, USA: Humana Press. ➢ Butler, M. (Ed.). (1991). *Mammalian Cell Biotechnology; A Practical Approach*, London, UK: Oxford university press ➢ Lanza, R., Gearhart, J., & Hogan, B. (2009). *Essentials of Stem Cell Biology* (2nd ed.).London, UK: Academic Press. ➢ Lanza, R., Langer, R. & Vacanti, J.(2013). *Principles of Tissue Engineering* (4th ed.). London, UK: Academic Press. ➢ Kumaresan, V. (2008). *Applied Animal Biotechnology*. Tamil Nadu, India: Saras Publication. ➢ Singh, B., Gautam, S.K., & Chauhan, M.S. (2015). *Textbook of Animal Biotechnology*.	

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				New Delhi, India:Teri Publication. **Suggested e-Resources** ➢ **Cryopreservation of gametes and embryos in mammals** https://www.glowm.com/section_view/heading /Gamete and Embryo Cryopreservation ➢ **Human embryonic stem cell** https://bit.ly/2GX5SXW ➢ **Stem cell therapies** https://www.closerlookatstemcells.org/stem-cells-medicine ➢ **History and scope of Tissue Engineering** https://www.stoodnt.com/blog/tissue-engineering-applications-scopes/	
Proposed Reading Elective –I & II to be offered in III & IV Semester					common with Applied Microbiology and Biotechnology for Sem III and IV, Bioscience Sem IV
1)	**Drug Discovery**	On completion of this course, students should be able to: • Understand basics of R&D in drug discovery and should be able to apply knowledge gained in respective fields of pharmaceutical industry. • Understand the role of synthetic chemistry in the development of pharmaceutical agents; and the modification of chemical structures to develop new drug molecules. • Have an advanced understanding of the chemical structure of a pharmaceutical		Modern drug discovery involves the identification of a target or drug lead using different techniques including molecular modeling, combinatorial libraries and high-throughput screening (HTS). Rational drug design is based on the understanding of the three-dimensional structures and physicochemical properties of drugs and receptors. Knowledge of molecular mechanisms, molecular dynamics simulations and homology modeling is necessary for studying drug/receptor interactions. The different conformational sampling techniques, fitness functions used in molecular docking and computational receptor-based and ligand-based drug design approaches are mostly used to design compounds with improved biological activity in rational drug	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		agent and determine the chemical group/s responsible for a given biological effect. • Demonstrate a basic understanding of pharmacogenomics and bioinformatics as it relates to drug design and discovery. • Develop an understanding of drug targets as a recognition site for pharmaceutical agents; how the chemical structure of a substance influences interaction with a drug target; and the identification of new drug targets for future drug discovery.		design. Quantitative drug design using QSAR models are used to correlate structural molecular properties (descriptors) with functions (i.e. physicochemical properties, biological activities, toxicity, etc.) of the compounds. Understanding the structure activity relationship between the 3D structure of a molecule and its biological activity may act as the basis for the prediction of compounds with improved biological activities. Different bio-analytical assays (LC/MS/MS, GC/MS and ELISA) could be developed further in support of *in vitro* and *in vivo* studies. Understanding the principles as well as an early characterization of drug toxicity, adsorption, distribution, metabolism and excretion (ADME) along with drug-drug interactions, plasma protein binding assays and metabolite profile studies helps in eliminating compounds with unacceptable pharmacokinetic characteristics, which is critical to successful drug discovery programs. **Suggested Books:** ➢ Krogsgaard-Larsen *et. al.* (2016). *Textbook of Drug Design and Discovery*. 5th Edition. CRC Press. ➢ Satyanarayanajois, S. D. (2011). *Drug Design and Discovery: Methods and Protocols*. Humana Press. ➢ Rahman, A. U., Caldwell, G. W. & Choudhary, M. I. (2007). *Frontiers in Drug Design and Discovery*. Bentham Science publishers Limited. ➢ Dastmalchi, S. *et. al.* (2016). *Methods and Algorithms for Molecular Docking-Based*	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Drug Design and Discovery. IGI Global. **Suggested e- Resources:** ➢ **Drug Discovery** https://bit.ly/2tCqdtE ➢ **Peptide therapeutics** https://www.sciencedirect.com/science/article/pii/S1359644614003997 ➢ **Bio-analytical techniques** https://www.pharmatutor.org/articles/bioanalytical-techniques-overview	
2)	**Human Genetics and Diseases**	After successful completion of the course students will be able to: • Understand hereditary and molecular genetics with a strong human disease perspective. • Describe genetic abnormalities underlying human disease and disorders • Develop interest in biomedical research, genetic counseling, medicine, and clinical genetics		Since the rediscovery of Mendel's work in 1900, investigations on the genetic nature of human traits have gained significant importance. Understanding the genetic basis behind human disease is one of the most important reasons to study human chromosome structure, human karyotype, banding techniques, chromosome identification and nomenclature (ISCN)**.** Classical genetics has considerable importance in constructing genetic hypothesis from pedigree data analysis in monogenetic traits, autosomal dominant, autosomal recessive, sex linked dominant, sex linked recessive and sex influenced traits. The impact of consanguinity in causing sex linked anomalies (haemophilia, colour blindness and Duchenne Muscular Dystrophy) has been observed in human population. Current knowledge on genetic variations across populations is applied to study human health and diseases which include chromosomal disorders, structural and numerical chromosomal anomalies (Klinefelter syndrome, Down's syndrome, Turner syndrome, Achondroplasia), inborn errors of metabolism (Phenylketonuria (PKU), Alkaptonuria, Albinism,	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Galactosemia), haemoglobinopathies, Thalassemia syndromes, multifactorial disorders (diabetes, schizophrenia, huntington disease). Medical genetics involves ethical issues therefore serious discussion is required for prenatal/adult diagnosis of genetic disorders, medical ethics, risks and benefits, informed consent and right of choice. **Suggested Books:** ➢ Strachan T. & Read. A. (2011). *Human Molecular Genetics* (4th ed.). Garland Science ➢ Pasternak J. Fitzgerald. (1999). *An introduction to Human Molecular Genetics-Mechanism of Inherited Diseases*. Science Press. ➢ Thompson and Thompson.(2007).*Genetics in Medicine (7th Ed.*).Saunders **Suggested e- Resources** ➢ **Chromosome identification and nomenclature (ISCN)** http://www.cydas.org/Resources/ISCN_Discussion.html ➢ **Pedigree data analysis** https://learn.genetics.utah.edu/content/disorders/ ➢ **Genetic disorders** https://www.genome.gov/10001204/specific-genetic-disorders/ ➢ **Prenatal/ adult diagnosis of genetic disorders, medical ethics** https://www.michiganallianceforfamilies.org/all/#sectionD	
3)	**Intellectual Property Rights**	After completing this course, students will be able to:		Intellectual property rights (IPR) have an old history and are very relevant for economic	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		• Understand the concept of IPR and its types • Describe the steps for patenting • Discuss the role of WTO and WIPO on IPR		development. Various types of IPR (patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications) are recognized with specific uses. There is currently an emergence of specific IP pertaining to plants and animals (UPOV, Plant Breeder's rights and plant variety protection and farmers rights act, patent protection of plant and animal inventions (WTO) and Law on the protection of New plant varieties and animal breeds (WIPO)). It is important to know about types of patent applications and the process of patenting with special emphasis to India. The role of WTO (GATT and TRIPS) and WIPO in implementation of IPR is significant as is understanding the relevance of Patent Cooperation Treaty (PCT) in patenting. IPR also are associated with certain ethical dilemma and there are some interesting case studies which highlight its relevance. **Suggested Books:** ➢ Sateesh, M.K. (2008). *Bioethics and Biosafet*y. I.K. International Publishing House. ➢ Goel D. & Parashar S. (2013). *IPR, Biosafety and Bioethics* (1st ed.) Pearson Education India. ➢ Pandey, N. & Dharni, K. (2014). *Intellectual Property Rights*. PHI Learning ➢ Ramakrishna, B. & Kumar, A. (2017). *Fundamentals of Intellectual Property Rights: For Students, Industrialist and Patent Lawyers* (1st ed.). Notion Press **Suggested e-resources:** ➢ **World Trade Organisation**. http://www.wto.org	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				➢ **World Intellectual Property Organisation**. http://www.wipo.int ➢ **International Union for the Protection of New Varieties of Plants.** http://www.upov.int ➢ **National Portal of India**. http://www.archive.india.gov.in	
4)	**Medical Microbiology**	After successful completion of the course, students should be able to: • Identify various bacterial, fungal, viral and protozoan diseases and their epidemiology • Understand the relevance of emerging and reemerging diseases	**Medical Microbiology and Immunology** **Section-A** • Innate and Acquired Immunity • Antigens : types of Antigens, Antigen specificity, haptens, Antibody structure and functions • MHC, Complement System • Cell mediated cytotoxicity : Origin, maturation and characterization of T-lymphocytes, Monocytes & Macrophages, Mechanism of T cell and NK cell mediated lysis, ADCC, Macrophage mediated cytotoxicity, lymphokines - the product of T cell activation. • Humoral immune response : Origin, maturation and characterization of B-lymphocytes, Activation and proliferation of B-cells, Formation of plasmablast, Plasma cells and memory cells, Interaction of B and T cells. **Section-B** • Hypersensitivity, Monoclonal antibodies and its applications. • Radioimmunoassay, Enzyme linked immunosorbant assay, immunoblotting, immunofluorescence and flowcytometry • Characteristics of infectious diseases, Herd immunity. • Disease cycle (Source of disease, reservoir,	**Medical Microbiology** Medical Microbiology describes the cause, transmission, epidemiology, pathogenesis, symptoms, diagnosis and treatment of various bacterial (tuberculosis, typhoid, leprosy), fungal (superficial, subcutaneous, systemic mycosis), protozoan (Malaria, amoebiasis) and viral (AIDS, Influenza, measles) diseases. Currently, it is necessary to understand the impact of emerging and remerging diseases (cholera, dengue, multidrug resistant tuberculosis, H5N1 avian influenza, drug resistant malaria, chikungunya) on human health. Global assessment for various diseases also shows an increasing trend of nosocomial infections and opportunistic infections which cause significant mortality and health concerns.	This course was earlier run as a core course in AMBT IIIrd sem.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			carriers) • Transmission of pathogens (Air borne, contact transmission and vector transmission). **Section-C** • Bacterial Diseases : Epidemiology, Pathogenicity, Laboratory diagnosis, Prevention & control of the following diseases : Anthrax, Tuberculosis, Typhoid, Whooping cough, Tetanus, Diphtheria, Leprosy. • General Account of fungal diseases : Mycosis, Subcutaneous and deep. • General Account of viral & protozoan diseases : Pneumonia, Influenza, Mumps, Measles, Polio, Hepatitis B, Chickenpox, AIDS and Malaria, Leishmaniasis. • Brief account of sexually transmitted diseases. **Books Recommended :** ➢ Text Book of Microbiology : R. Ananthanarayanan and C.K. JayaramPanicker, Orient Longman, 1997. ➢ Medical Microbiology, Vol, 1 : Microbial infection : Mackie and MaCartney, Churchil Livingstone, 1996. ➢ Bailey and Scott's Diagnostic Microbiology : Baron EJ, Peterson LR and Finegold, SM Mosby, 1990. ➢ Essential immunology (1995) :Roitt, I.M. Black well Scientific Publications, Oxford. ➢ Fundamental immunology : W.E. Paul 1984, Raven Press, New York. ➢ Fundamentals of Immunology : R.M. Coleman, M.F. Lombord and R.E. Sicard (1992) - 2nd ed. C. Brown publishers. ➢ Immunology : D.M. Weir and J Steward 7th Ed. (1993).	**Suggested Books:** ➢ Brooks, G.F., Carroll, K.C., Butel, J.S., Morse, S.A. & Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's Medical Microbiology (26thed.). US: Lange Medical Books, McGraw-Hill. ➢ Madigan, M., Martinko, J., Stahl, D. & Clark, D. (2010). *Brock Biology of Microorganisms* (13thed.). UK: Pearson Education. ➢ Pelczar Jr., M.J., Chan, E.C.S. & Krieg, N.R. (2011). *Microbiology*. New York, USA:Tata McGraw-Hill. **Suggested e- resources:** ➢ **Emerging Diseases** ➢ https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3701702/ ➢ **Epidemiology** https://bit.ly/2SUmzum	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Broude A.I. (1981) : Medical "Microbiology" : and Infectious Diseases W.B. Saunders & Co. Philadelphia. ➢ Immunology : Janis Kuby. ➢ An Introduction to Immunology :lan R. Tizzard.	➢ **Nosocomial Infections** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3470069/	
5)	**Molecular Plant Breeding**	After completing this course, students will be able to: • Understand strategies and applications of plant breeding technologies. • Comprehend the knowledge of different plat molecular markers • Plan a research career in the area of plant biotechnology		Plant breeding study involves breeding methods for self and cross pollinated crops. There are several limitations of conventional breeding. Thus, there is need to have a better breeding approaches to overcome this limitation. Development of molecular markers (RFLP, RAPD, SSRs, ISSRs, SNPs), construction of molecular maps and linkage analysis, mapping populations for QTLs using molecular markers play an important role in plant breeding. In order to develop potential plant having better qualities, Marker Assisted Selection (MAS) is also a viable approach which can be done by using selection of traits and markers, trait association, marker assisted backcrossing and recurrent selection, marker assisted hybrid breeding and marker assisted improved varieties/germplasm. **Suggested Books:** ➢ Chawla, H. S. (2000). *Introduction to Plant Biotechnology*. USA: Science Publishers. ➢ Slater, A., Scott, N. & Fowler, M. (2008). *Plant Biotechnology: The Genetic Manipulation of Plants* (2^{nd}ed.). UK: Oxford University Press. ➢ Primrose, S.B., Twyman R.H. & Old R.W. (2001). *Principles of Gene Manipulation* (6^{th}ed.). Wiley-Blackwell. ➢ Nicholl, D.S.T. (2008). *An introduction to Genetic Engineering* (3^{rd}ed). Cambridge:	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Cambridge University Press. ➢ Glick, B.R., Pasternak, J.J. & Patten C.L. (2010). *Molecular Biotechnology: Principles and Applications of Recombinant DNA* (4thed.). American Society for Microbiology. ➢ Watson, J.D., Gilman, M., Witkowski J. & Zoller, M. (1992). *Recombinant DNA* (2nded.). W. H. Freeman publisher. **Suggested e- Resources:** ➢ **Plant breeding** https://nptel.ac.in/courses/102103013/pdf/mod6.pdf ➢ **Molecular marker** https://bit.ly/2XmNm0M ➢ **Gene mapping in plant** https://bit.ly/2TaegKm	
6)	**Protein Engineering**	On completion of this course, students should be able to: • Analyse structure and construction of proteins by computer-based methods • Describe structure and classification of proteins • Analyse and compare the amino acid sequence and structure of proteins, and relate this information to the function of proteins • Explain how proteins can be used for different industrial and academic purposes such as structure determination, organic synthesis and drug design.		An introduction to protein engineering for developing proteins with desired functions. Various methods (rational design and directed evolution) of protein engineering are employed to manipulate the different features or characteristics (affinity, specificity and stability etc) of proteins. Engineering various physicochemical and biological properties (stability to changes in parameters as pH, temperature, amino acid sequence and aggregation propensities etc) of the proteins could be important in their use as protein drugs and/or catalysts in bioreactors. The insight into the fundamental understanding of the mechanisms and forces (Van der waals, electrostatic, hydrogen bonding, weakly polar interactions, and hydrophobic effects), by which protein stabilizes, will help in the formulation of protein based pharmaceuticals. Protein	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		• Plan and carry out activity measurements of isolated proteins and characterize their purity and stability.		engineering with site-specifically incorporation of unnatural or non-canonical amino acids has been used to improve protein function for medical and industrial applications. Different computational approaches (sequence and 3D structure analysis, data mining, Ramachandran map etc) to protein engineering would help to address the requirements in order to find amino acid sequences that will optimize a desired property (physicochemical property and/or biological function) of a protein. Determination of the physicochemical properties of proteins using various spectroscopic methods (Far-UV and Near-UV CD, Fluorescence, UV absorbance and Optical rotatory dispersion) would further support the drug development process. Yeast surface display (YSD)has become a valuable protein engineering tool for modifying the affinity, specificity, and stability of antibodies, as well as other proteins. YSD could be successfully used for protein epitope mapping, identification of protein-protein interactions, and uses of displayed proteins in industry and medicine. Developing vaccines and peptidomimetics will further allow the investigators to identify novel therapeutic leads for numerous unmet clinical needs. **Suggested Books:** ➢ Walsh, G. (2014). *Proteins: biochemistry and biotechnology*, Second edition. Chichester, West Sussex: Wiley Blackwell. ➢ Creighton, T. E. (1997). *Protein Structure: a Practical Approach*, 2nd Edition. Oxford University press. ➢ Cleland, J. L. & Craik, C. S. (2006). *Protein*	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Engineering, Principles and Practice, Vol 7. Springer Netherlands. ➢ Mueller, K., & Arndt, K. (2006). *Protein Engineering Protocols*, 1st Edition. Humana Press. ➢ Robertson, D., & Noel, J. P. (2004). *Protein Engineering Methods in Enzymology*, Vol 388. Elsevier Academic Press. ➢ Kyte, J. (2006). *Structure in Protein Chemistry*, 2nd Edition. Garland publishers. ➢ Williamson, M. P. (2012). *How proteins Work*. New York: Garland Science. **Suggested e- Resources:** ➢ **Protein Engineering**: https://nptel.ac.in/courses/102103017/pdf/lecture%2022.pdf ➢ **Conformational stability of proteins**: https://bit.ly/2y85mid ➢ **Protein Engineering with Non-Natural Amino Acids:** https://library.umac.mo/ebooks/b2805488x.pdf	

* Matter in contrast (black background & white letters) is shifted to some other units, and material brought as a result of shift is also in contrast.
# Matter in square brackets, bold, italic and crossed is deleted.
@ Proposed added materials are shaded in grey.

List of online courses in M.Sc. Biotechnology Programme

S. No.	Portal	Name of course	Duration	Core/Elective/ Reading elective (Additional/ Alternate)	Credit point(s)	URL	Paid/ Free	Fee (course/ examination)	Remarks
	III Semester Elective Courses								
1	**SWAYAM** Dr. Adarsh Kumar Additional Professor, Department of Forensic Medicine & Toxicology AIIMS, New Delhi.	Forensic Biology and Serology	15 weeks (2 weeks for revision and assessment)	Elective	4	https://swayam.gov.in/course/264-forensic-biology-and-serology	Free	-	
2	**edX** TsinghuaX	Water and waste treatment engineering: Biochemical Technology	10 weeks 5-6 h/week	Elective	4	https://www.edx.org/course/water-wastewater-treatment-engineering-tsinghuax-40050455-2x-0	Paid	Add a Verified Certificate for $49	
3	**NPTEL**	Industrial Biotechnology	12 weeks	Elective	4	https://onlinecourses.nptel.ac.in/noc17_bt23/preview https://swayam.gov.in/search?keyword=Industrial%20Biotechnology	Paid	Certificate exam fee	
4	**Harvard**	Fundamentals of Ecology for Sustainable Ecosystem	-	Elective	4	https://www.extension.harvard.edu/academics/courses/fundamentals-ecology/12779	Paid	$1550	

S. No.	Portal	Name of course	Duration	Core/Elective/ Reading elective (Additional/ Alternate)	Credit point(s)	URL	Paid/ Free	Fee (course/ examination)	Remarks
	III/IV Semester Reading elective								
1	**NPTEL**	Bio- organic Chemistry	56 h	Reading	4	http://nptel.ac.in/courses/104103018/#	Paid	Certification exam fee	
2	**IIT, Delhi**	Enzyme Science and Engineering	28 videos	Reading Elective	2	http://freevideolectures.com/Course/85/Enzyme-Science-and-Engineering/1	Free	-	
3	**NPTEL**	Biocatalysis in organic synthesis	46 h	Reading Elective	3	http://nptel.ac.in/courses/104105032/	Paid	Rs. 1000 for certification exam fee	
4	**National Institute of Disaster Management** (Ministry of Home Affairs, New Delhi)	Comprehensive Disaster Risk Management Framework	6 weeks Run in batches throughout the year	Reading Elective	2	www.nidm.gov.in/online.asp	Paid	Rs. 1500 Exam fee	
5	**WIPO Academy** - [DL] Distance Learning Program	DL101E - DL-101 General Course on Intellectual Property	55 h	Reading Elective	4	https://welc.wipo.int/acc/index.jsf?page=courseCatalog.xhtml	Free	-	

S. No.	Portal	Name of course	Duration	Core/Elective/ Reading elective (Additional/ Alternate)	Credit point(s)	URL	Paid/ Free	Fee (course/ examination)	Remarks
6	**Algonquin college**	Environmental Management - An Introduction		Reading Elective	-	http://www.algonquincollege.com/ccol/courses/environmental-management-an-i			

BANASTHALI VIDYAPITH
Department of Bioscience and Biotechnology
M.Sc. BIOINFORMATICS
PROGRAMME EDUCATIONAL OBJECTIVES

The M.Sc Bioinformatics programme aims for the holistic development of the students through the unique and innovative fivefold education ideology of Banasthali Vidyapith.

Bioinformatics is an interdisciplinary approach to study of biological processes including gene expression, protein modifications or interactions as well as the molecular evolution. The programme focuses on specific knowledge of computational biology and the associated academic disciplines including molecular cell biology, structural biology, mathematics and statistics, computer programming, drug designing, database management systems and genetic engineering. The program fulfills the requirements of the students to become familiar with basic and advanced concepts of the subject thus providing them the scientific background they need to find career opportunities in any related field of bioinformatics.

Main objectives of M.Sc Bioinformatics programme are to:

- develop interdisciplinary approach for learning about the biological processes and their significance ranging from single cell to multicellular system.
- enable students to solve complex biological questions by developing the the mathematical and computational skills.
- decipher the process of molecular evolution and phylogenetic reconstruction.
- develop understanding of organisms functioning at the molecular level of the gene, genome, cell.
- apply bioinformatics for biological database management, exploring behavior of the biomacromolecules and drug discovery programs.
- gain the ability to work as computational biophysicist, computational chemist in chemical biology projects, medical bioinformatician and evolutionary biologist.
- access the primary literature, recognize relevant works for a particular topic, and evaluate the scientific content of these works.
- demonstrate ability in the experimental and computational techniques and methods of analysis appropriate for their area of specialization within bioinformatics.

BANASTHALI VIDYAPITH
Department of Bioscience and Biotechnology
M.Sc. BIOINFORMATICS
PROGRAMME OUTCOMES

PO1: Knowledge: Equipped with an in-depth knowledge in the area of basic and applied bioinformatics including molecular evolution, computational structural molecular biology, cell biology, computer programming and database management system. Enable them to specialize in one of the many branches of bioinformatics through dissertation work.

PO2: Planning abilities: Develop efficient planning abilities with time management, analytical and decisive skills to reach achievable goals.

PO3: Problem analysis: Devise and sustain logical thinking to tackle detailed problem-solving and analytical tasks associated with questions in core and applied bioinformatics.

PO4: Bioinformatics tool usage: Learn, select, and apply statistical, mathematical and computational tools of bioinformatics. Develop competence in the handling of research facilities and work in a laboratory environment, both individually and as a team member.

PO5: Leadership skill: Develop leadership skills to work in a team and take initiative for fulfillment of professional and societal responsibilities.

PO6: Professional Identity: Understand, analyze and communicate the value of their professional roles in different research and development laboratories, information technology, pharmaceutical industries etc.

PO7: Communication: Develop skills used in reasoning and communication with scientific community and society. To synthesize information from literature and its communication in form of scientific papers, reports, poster and oral presentations.

PO8: The Bioinformatics and society: Contribute to society, in the realms of the agriculture, biological resource management, human and animal health well being.

PO9: Environment and sustainability: Development of efficient predictive bioinformatics methods for sustainable development conservation and preservation of biodiversity.

PO10: Life-long learning: Develop independent, critical and creative thinker who has a self-motivated passion for life-long learning.

Appendix -VIIIC

Department of Bioscience and Biotechnology, Banasthali Vidyapith

M.Sc. Bioinformatics

Existing						**Proposed**					
	M.Sc. Bioinformatics Ist Sem	**L**	**T**	**P**	**C**		**M.Sc. Bioinformatics Ist Sem**	**L**	**T**	**P**	**C**
BIO 402	Basic Cell, Molecular Biology and Biological Databases	4	0	0	4		Cell & Molecular Biology (c.w. - MSc AMBT, BT, Biosci I Sm)	4	0	0	4
BIO 417	Structural Biology	4	0	0	4	BIO	Structural Biology	4	0	0	4
CS 410	Computer Fundamentals and Perl Programming	4	0	0	4	CS	Fundamentals of Computer and Programming	2	0	0	2
CS 410L	Computer Fundamentals and Perl Programming Lab	0	0	8	4	CS	Fundamentals of Computer and Programming Lab	0	0	4	2
MATH 406	Introductory Mathematics	4	0	0	4	MATH	Introductory Mathematics	4	0	0	4
STAT 405	Statistical Techniques	4	0	0	4	BIN	Biological Databases	4	0	0	4
STAT 405L	Statistical Techniques Lab	0	0	4	2	BIO404 L	Bioscience Lab I (c.w. - MSc AMBT, BT, Biosci I Sm)	0	0	12	6
	Total				**26**		**Total**				**26**

Existing						**Proposed**					
	M.Sc. Bioinformatics IInd Sem	**L**	**T**	**P**	**C**		**M.Sc. Bioinformatics IInd Sem**	**L**	**T**	**P**	**C**
BIN402	Computational Biology and Molecular Modeling	4	0	0	4		Algorithms in Computational Biology	4	0	0	4
BIN402L	Computational Biology and Molecular Modeling Lab	0	0	4	2		Sequence analysis and Phylogenetics	4	0	0	4
BIN 403	Proteomics, Sequence Analysis and Systems Biology	4	0	0	4		Programming with Perl and R	4	0	0	4
BIO413	Medical Microbiology and Immunology	4	0	0	4		Programming with Perl and R Lab	0	0	8	4
CS 418	Database Management Systems	4	0	0	4		Genetic Engineering (c.w.- MSc,AMBT, BT, Biosci II Sem)	4	0	0	4
CS 418L	Database Management Systems Lab	0	0	4	2	CS 418	Database Management System	4	0	0	4
CS412	Computer Networks and Web Technologies	4	0	0	4	CS 418L	Database Management System Lab	0	0	4	2
CS412L	Computer Networks and Web Technologies Lab	0	0	4	2		-	-	-	-	-
	Total				**26**		**Total**				**26**

	Course proposed to be discontinued		Course content modified
	Common course with other programmes		New course proposed

Existing					
	M.Sc. Bioinformatics IIIrd Sem	**L**	**T**	**P**	**C**
BIN 502	Computer Aided Drug Designing	4	0	0	4
BIN 505	Functional and Comparative Genomics	4	0	0	4
BIN 505L	Functional and Comparative Genomics Lab	4	0	0	4
BIN504	Evolutionary Computing	0	0	4	2
BIN 507	Mining and Warehousing of Biological Data	4	0	0	4
BIN 508	Molecular Structure Prediction and Visualization	4	0	0	4
BIN 508	Molecular Structure Prediction and Visualization Lab	0	0	4	2
	Total				**24**

Proposed					
	M.Sc. Bioinformatics IIIrd Sem	**L**	**T**	**P**	**C**
	Biomolecular Modeling and Computational Drug Design	4	0	0	4
	Biomolecular Modeling and Computational Drug Design Lab	0	0	8	4
BT	Genomics and Proteomics (c.w.- MSc AMBT, BT III Sem)	4	0	0	4
	Python Programming	4	0	0	4
	Python Programming Lab	0	0	4	2
	RNA Structure Function and Transcriptomics	4	0	0	4
	Elective	4	0	0	4
	Total				**26**
	List of Electives				
BIN507	Mining and Warehousing of Biological Data				
CS512	Cloud Computing				
CS530	Neural Networks				
	Artificial Intelligence				
BIO 503	Fundamentals of Bioentrepreneurship (c.w.- MSc AMBT, BT III Sem)				
BIN	Systems Biology				

Existing					
	M.Sc. Bioinformatics IVth Sem	**L**	**T**	**P**	**C**
BT514	Genetic Manipulation Technology	4	0	0	4
BIN 510	Transcriptomics and Metabolomics	4	0	0	4
BIN 506L	In silico Studies Lab	0	0	8	4
CS 518	Data Structure and Java Programming	4	0	0	4
CS 518L	Data Structure and Java Programming Lab	0	0	4	2
	Elective	4	0	0	4
	Total				**22**
	List of Elective				
BIO 501	Bioentrepreneurship	4	0	0	4
CS 512	Cloud Computing	4	0	0	4
CS 530	Neural Networks	4	0	0	4
CS427	Parallel Computing	4	0	0	4
CS507	Artificial Intelligence	4	0	0	4

Proposed					
	M.Sc. Bioinformatics IVth Sem	**L**	**T**	**P**	**C**
BIN	Dissertation	0	0	48	24
	Reading Elective	0	0	0	2
	Total				**26**
	List of Reading Elective				
BIN601R	Chemoinformatics	0	0	0	2
BIN602R	Immunoinformatics	0	0	0	2
	Human Genetics and Diseases	0	0	0	2
	Drug Discovery	0	0	0	2
	Protein Engineering	0	0	0	2

	Course proposed to be discontinued		Course content modified
	Common course with other programmes		New course proposed

Comparative Table: M.Sc. Bioinformatics: Existing and Modified syllabus, Suggested Books and Suggested E-Resources

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
	Ist Semester				
1.	**BIO 407:** **Cell and Molecular Biology** (c.w.– M.Sc. BT/ AMBT /Bot/ Zoo I Sem BIO407)	After successful completion of the course, students should be able to: • Understand membrane transport and cell signalling mechanisms. • Develop comprehensive understanding of endo-membrane system. • Understand molecular mechanisms of prokaryotes and eukaryotes	~~**Basic Cell, Molecular Biology and Biological Databases**~~ ~~**Section A**~~ ~~Cell Biology: Prokaryotic & Eukaryotic Cells, Introduction of cell organelles (Mitochondria, Chloroplast, ER, Golgi, Lysosomes & Peroxisomes, Nucleus & Nucleolus) Cellular Membrane: Structure and function of membranes, Cell-Cell interactions & signal transduction: signaling by hormones and neurotransmitters, receptors, G proteins, protein kinases & second messengers, Concepts of Signal hypothesis and protein targeting.~~ ~~**Section B**~~ ~~Prokaryotic and Eukaryotic genomes, structure, organization, function, Evolution of Genomes. Prokaryotic gene expression, Operons – Positive & Negative regulation. Mechanism of Gene Expression in Eukaryotes, Promoter & regulatory sequences, transcription factors. Processing of RNA, Basic mechanism involved in translation & its regulation~~.	**Cell & Molecular Biology** **Section-A** • Molecular structure and function of plasma membrane; Transport of ions and macromolecules; Pumps, carriers and channels; Membrane carbohydrates and their significance in cellular recognition; Cellular junctions and adhesions. • Endocytosis and exocytosis, clathrin coated vesicles, SNARE proteins. • Cell to cell signalling: autocrine, paracrine and endocrine stimulation. • Signaling via G-protein linked cellsurface receptors, adenylatecyclase system, inositol phosphate pathway, role of Ca^{2+} ions. • Signaling via enzyme-linked surface receptors, tyrosine kinases. • Steroid receptors. **Section-B** • Protein sorting and targeting: Signal hypothesis, SRP, SRP Receptor, ER Resident proteins, ER chaperone proteins and their functions, glycosylation of proteins in ER. • Golgi apparatus, role in protein glycosylation and transport. • Lysosomes, intracellular digestion, sorting of lysosomal enzymes in Golgi, lysosomal storage diseases. • Transport of proteins into mitochondria and chloroplasts. • Cell Cycle and its regulation, apoptosis.	1. The ultrastructure of plasma membrane is introduced. 2. Cellular trafficking and different signaling approaches are introduced. 3. Structure and functions of various cellular organelles are defined clearly. 4. Cell cycle regulation and Cancer Biology DNA repair mechanisms is introduced. 5. Databases are being introduced in a separate paper. 6. This paper is being proposed to be common with MSc. BT/AMBT/Bioscience 7. Section C of the existing course is proposed to be part of the new course Biological Databases.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Section C ~~Biological Databases: Primary Secondary, Composite Databases & their file format. Nucleic Acids (GenBank, DDBJ, EMBL), Proteins (SWISS-PROT, PIR, PDB), Specialized (KEGG, Transfac, ReBase), NCBI, Entry & Retrieval of data from public databases.~~	**Section-C** • Replication of genetic material in prokaryotes and eukaryotes: initiation, elongation and termination; Replication of single stranded circular DNA. • Prokaryotic transcription: Transcription units; RNA polymerase structure and assembly; Promotors; Rho-dependent and Rho-independent termination; Anti-termination. • Eukaryotic transcription: RNA polymerase structure and assembly; RNA polymerase I, II, III; eukaryotic promoters and enhancers; general transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF). • Post transcriptional modifications: processing of hnRNA, tRNA and rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; Splicing; RNA editing; Nuclear export of mRNA; Catalytic RNA. • Genetic code, Isoaccepting tRNA; Translation: Translation machinery; initiation, elongation and termination; Co- and post-translational modifications. **Suggested Books:** ➢ De Robertis, E.D.R., & De Robertis, E.M.F. (2017) *Cell and Molecular Biology*. Lippincott Williams & Wilkins. ➢ Hardin, J., Bertoni, G., & Lewis, K.J. (2011) *Becker's World of the Cell*. Pearson. ➢ Karp, G., Lwasa, J., & Larshall, W. (2015) *Cell and Molecular Biology: Concepts and Experiments*. John Wiley & Sons. ➢ Cooper, G., M., & Hausman, R., E. (2013) *The Cell :A Molecular Approach*. Sinauer Associates ➢ Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretsher, A., Ploegh, H., Amon, A., & Martin, K.	

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				C. (2007). *Molecular Cell Biology*. W.H.Freeman & Co Ltd. ➢ Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2007). *Molecular Biology of the Cell*. Garland Science. ➢ Freifelder , D. M. (1986). *Molecular Biology*. Jones & Bartlett Publishers. **Suggested e-Resources:** ➢ **Cell Biology resources** https://www.nature.com/scitable ➢ **Sorting and trafficking of proteins** http://www.vcell.science/project/proteintraffickin g ➢ **RNA editing** study.com/academy/lesson/rna-editing-definition-processes.html	
2.	**BIO 417**: Structural Biolgy	After the successful completion of the course, students should be able to: • understand the biophysical processes working at molecular level. • develop analytical understanding of macromolecular folding and interactions.	**Structural Biology** **Section A** Introduction to protein ~~structure~~: ~~Physical and chemical properties of amino acids and polypeptides~~, secondary, super secondary, tertiary and quaternary structure of proteins, ~~Helix-coil transition,~~ and Ramachandran ~~plot~~. ~~Protein structure determination: Isolation and purification of proteins,~~ Methods for determination of size of proteins, Basic principles of X-ray diffraction studies, Electron crystallography of proteins. **Section B** ~~Protein secondary structure prediction methods: Chou and Fasman, Garnier-Osguthorpe-~~	**Structural Biology** **Section A** • Introduction to proteins: – Amino acids classification and their physicochemical properties. • Hierarchical organization of protein structures – primary, secondary, tertiary and quaternary structure of proteins. • Ramachandran Map. Motifs and domains. • Packing of protein structure Structures of oligomeric proteins and study of interaction interfaces • Base pairing in nucleic acids – Watson-Crick and Hoogstein; geometrical and structural properties of A, B, & Z DNA. • Secondary and Tertiary structures of RNA. **Section B** • Principles and practices in Centrifugation, Chromatography and Electrophoresis for isolation	1. The Section A is covers the structural features of all the three biological macromolecules associated to biological information. 2. The Section B focuses on the purification and structure determination experimental techniques for biomolecules. 3. The CD spectroscopy is being proposed to be introduced as part of experimental

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			~~Robson.Classification of three-dimensional structure of protein: Prediction of structural classes, motifs, folds and domains~~, ~~classification of three-dimensional structures in Protein Data Bank (HSSP, SCOP, FSSP, CATH).~~ **Section C** ~~Nucleic acid structure: Nucleic acid conformation, A-DNA, B-DNA, Z-DNA and C-DNA, their geometrical and structural features~~, RNA secondary and tertiary structures~~, idea about local doublet parameters.~~ Molecular interactions: Protein-Protein interactions, Protein-DNA interactions. Techniques for the studies of these interactions. Forces that stabilize bimolecular structure. **Recommended Books** ➢ Principles of Biochemistry-Lehninger. ➢ Biochemistry-Stryer. ➢ Biophysical Chemistry-Cantor and Schimmel. ➢ Practical Biochemistry-Wilson and Walker. ➢ Bioinformatics –Sequence and Genome analysis-David W. mount. ➢ Structural Bioinformatics-Philip E.Bourne and Helge Weissig	& purification of biomacromolecules. • Circular Dichroism Spectroscopy. • X-Ray crystallography: Introduction, Bragg's law; Crystal system, Bravais Lattices, Space group, symmetry. Protein crystallization, Phase problem and its solutions. Calculation and analysis of electron density map. • Nuclear magnetic resonance: Introduction, chemical shift, NOE and coupling constant, spin – spin coupling and relaxation; 2D – NMR spectroscopy (COSY, NOESY). **Section C** • Three dimensional structure comparison and classification of proteins (VAST, DALI). • Assignment of protein secondary structural elements; DSSP and STRIDE methods. • Various types of weak interactions and their roles in stabilizing the biomolecular structures and their interactions. Macromolecular interactions. • Protein-Protein, Protein – DNA and Protein – Ligand interactions **Suggested Books:** ➢ Cantor, C.R. & Schimmel, P.R. (1980). *Biophysical Chemistry* (1st Ed.). W. H. Freeman. ➢ Nelson, D.L. & Cox, M.M. (2017) *Lehninger's Principles of Biochemistry* (7^{th} Ed.). W.H. Freeman. ➢ Schulz, G.E.& Schirmer, R.H. (1979). *Principles of Protein Structure*. Springer. ➢ Schwede, T. & Peitsch, M. (2008). *Computational Structural Biology: methods and applications*. World Scientific Press. ➢ Wilson, K. & Walker, J. (2010). *Practical Biochemistry* (7^{th} Ed.). Cambridge University Press	technique of protein secondary structure prediction. 4. NMR being more suitable experimental technique is being put here instead of III semester course Molecular Structure Prediction and Visualization since it is more suitable for structural biology course. 5. More advanced computational methods are introduced to study the macromolecular structures.

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				Suggested e-Resourses: ➢ **X-ray crystallography** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1186895/ ➢ **VAST** ➢ https://structure.ncbi.nlm.nih.gov/Structure/VAST/vast.shtml ➢ **DALI** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2896194/.	
3.	Fundamentals of Computer and Programming	The candidates should be able to: • understand working of computation. • write simple programs to carry out bioinformatics analyses.	~~**Computer Fundamentals and Perl Programming**~~ **Section A** Block diagram of computer, Its components and functions, Representation of data, ~~Number System Conversion~~, ~~Introductory~~ Boolean algebra, Concept of program, Programming languages, Introduction to Operating Systems; Linux OS, Compilers, Interpreters, Algorithms and flowcharts. **Section B** ~~Overview of Perl language: Perl language and syntax, strings, arrays, hashes, pattern matching, file handling.~~ ~~**Section C**~~ ~~Perl language: Directories, subroutines, references, packages, libraries, modules, classes, objects, introduction to Bioperl.~~	**Fundamentals of Computer and Programming** **Section A** • Block diagram of computers, its components and functions. Data representation. • Boolean algebra, Basic defintions and theorems of boolean algebra, logic gates and circuits. Sum of products and product of sums, truth tables and Boolean functions. • History of computer evolution. • Concept of program, programming language, algorithms and flowcharts, compilers, interpreters. **Section B** • Operating Systems: Unix, Linux and Windows. • Basic Utilities commands. Pipe and Filters: Grep, SED, AWK, Shell scripting. • Introduction to HPC systems. • Communication technology; Network basics; LAN, WAN & MAN, Intranet, Wireless, and Internet services. Web Services; WWW, URL. **Section C** • Introduction to MATLAB; understanding the MATLAB environment. • Data types in MATLAB; Local and Global variables in MATLAB.	1. Keeping in view that most of bioinformatics tools require basic understanding of scientific computing and working of Linux operating systems, this course is being proposed with primary focus on Linux operating systems and scientific computations. 2. Introduction of MatLab programming to enable students, without any programming background, with programming skills and learn data analysis methods with MatLab

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			Recommended Books ➢ Sinha P.K Computer Fundamentals, BPB publication, New Delhi ➢ Tom Christian Sen, Nathan Torkington, Perl Cook book, 2nd Edition, O'REILLY ➢ James D. Tisdall, Beginning Perl for Bioinformatics, 2001, O'REILLY ➢ James D. Tisdall, Mastering Perl for Bioinformatics, 2003, O'REILLY ➢ Larry Wall, John Orwant, Tom Christian Sen, Programming Perl, O'REILLY	• Programming with MATLAB Relational and Logic operators, Control structure of MATLAB, conditional and Loops; Creating user – defined functions and function files. • 2D and 3D graph plotting with MATLAB. • Introduction to Bioinformatics Toolbox. **Suggested Books:** ➢ Sinha, P.K & Sinha, P. (2016). *Computer Fundamentals* (6th Ed.). BPB publication, New Delhi. ➢ Barret, D.G.(2016). *Linux Pocket Guide* (3rd Ed.). OReilly Media. ➢ Gilat, A. (2012). *MATLAB® An Introduction with Applications* (4rd Ed.). John Wiley and Sons. **Suggested e-Resources:** ➢ **Matlab tutorial** https://www.tutorialspoint.com/matlab/	
4.	Fundamentals of Computer and Programming Lab	The candidates should be able to: • Write programs to analyze biological and statistical data. • Understand different statistical distributions		**Fundamentals of Computer and Programming Lab** 1. MatLab working environment. 2. Constructing vectors and Matrices. 3. Diagrammatic representation of data by : Simple Bar, pie-diagrams, Histogram 4. File handling in MatLab. 5. Computation of : (i) Range, standard deviation, Mean deviation, Quartile deviation and coefficient of variation. (ii) Combined mean and combined standard deviation. 6. Introduction to Bioinformatics Toolbox. 7. Fitting of following curves by the method of least square: (i) Straight line (ii) Parabola (iii) Exponential curve (iv) Power Curve 8. Computation of coefficient of correlation and rank	1. This laboratory course aims to provide the hands experience of programming, writing simple codes for biological data analysis. 2. Relevant exercises from Statistical Techniques Laboratory are being proposed to be part of this course as MatLab enables to write codes for Statistical analysis of Biological data. 3. This laboratory course also aims to provide

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				correlation. 9. Fitting of regression lines. 10. Probability distributions curves : (i) binomial (ii) Poison and (iii) Normal Distribution. 11. Comparative studies of different database file formats: GenBank, FASTA and PIR. 12. Survey of various genomic, proteomic and evolutionary tools available at ExPasy server. 13. Study of Databases: Uniprot, Unigene, PDB and KEGG	the hands on Experiences with Biological Databases.
5.	**MATH 406** Introductory Mathematics	After successful completion the candidates should be able to: • understand the principles of algebra. • Solve the complex biological problems using calculus methods. • Understand the geometrical properties. • Develop a basic understanding of statistics and statistical distributions.	**Introductory Mathematics** **Section A** ~~Sequences and series, finite and infinite series. Arithmetic and geometrical progressions. Sum to n terms, arithmetic and geometric means between two numbers, sum of an infinite G.P. Permutation and combination simple problems under restrictions.~~ Logarithms- Definition and laws regarding product, quotient power and change of base. Application of exponential theorem and logarithmic series in summation of infinite series. Matrices- Definition, order of a matrix, types of matrices rectangular matrix, square matrix, row matrix, column matrix, triangular matrix, diagonal matrix, unit matrix, null matrix, transpose of a matrix, symmetric and skew- symmetric and subtraction of matrices, matrix multiplication commutative, associative and distributive laws for matrix addition and multiplication. Inverse of matrix, determinant of a matrix, Characteristic equation of matrix, Eigen values and Eigen vectors.	**Introductory Mathematics** **Section A** • Set Theory; Introduction to sets and elements, Universal, and empty sets, subsets. Venn diagrams, Set operations and algebra of sets, ordered sets, cartesian product of sets, Classes of sets, power sets and partition. Relations; product sets, equivalence relations, partial ordering relations. • Logarithms- Definition and laws regarding product, quotient, power and change of base. • Introduction to complex numbers; algebra of complex number, modulus and conjugate of a complex number. • Introduction to Matrix: types, Order and transpose of matrix. Operations on matrix; addition, subtraction, multiplication. Associative and distributive laws of matrix, Inverse of Matrix and matrix division; determinant of a matrix, Eigen values and Eigenvectors of matrix.	1. Mathematics and Statistics are integral part of Bioinformatics. 2. All essential ingredients of mathematics and statistics are being introduced here. 3. Probability theory and probability distributions, measure of central tendency and correlation analyses are included here. 4. Repeated terms have been removed.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Section B Co-ordinate Geometry: Rectangular co-ordinates, quadrants, Distance between two points. ~~The section formula, Area of a triangle. Locus of a point, equation to the locus, graph of a linear function, Equations to straight lines- Parallel to axes, the slope form the intercept form, normal form, general linear form, point slope form, two points form, Point of intersection of two straight lines, angle between two lines, relation between the slopes of two lines, which are (i) Parallel and (ii) Perpendicular. Line through the point of intersection of two given lines, concurrency of lines, co-linearity of points.~~ **Section C** Differential Calculus: Functions, limit of function evaluation of limits of functions, derivative of a function, ~~differentiation of algebraic, circular, exponential and logarithmic functions, differentiation of sum, difference, product and quotient of two functions, differential coefficient of a function of a function.~~ Derivative of second order, partial differentiation (simple problems) maxima and minima of functions of one independent variable. Introduction to integration. Differential Equations: ~~Formation of differential equation order and degree of a differential equation, solution of a differential equation, General solution, particular solution and singular solution, Solution of differential equations of first order and first degree- variables separable from only.~~	**Section B** • Differential Calculus- Derivative of a function, Concept of limit, Continuity, Differentiation, Maxima and Minima of a function. • Introduction to Partial Differentiation. • Integral Calculus: The Idea of the Integral, The Definite Integrals, Indefinite Integrals, Area under curve. • Trigonometric ratios, De Moivre's theorem. • The general equation of a Straight line, slope of a line, intercepts of a line, Angle between two lines, Intersection of two lines, The general equations of a Circle, Parabola, Ellipse, Hyperbola, Cylinder, Cone and Sphere. **Section C** • Probability theory and probability distributions; Concepts of random experiment, sample space and events, definition of probability and some elementary results of probability. • Conditional probability and Bayes theorem. • Random variable, probability mass function and probability distribution function, cumulative distribution function, Binomial, Poisson and Normal(Gaussian) distribution. • Measures of central tendency- Mean, Median, Mode. Measures of dispersion- range, mean deviation, variance, standard deviation, skewness and kurtosis. Bivariate data: Correlation and regression analysis. **Suggested Books:** ➢ Artin M. (2015) *Algebra* (2nd Ed.). Pearson Education. ➢ Aitken, M., Broadhurst, B. & Hladky, S. B. (2009). *Mathematics for Biological Scientists*. Garland Science.	

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				➢ Thomas, G.B. (2013). *Thomas Calculus* (12th Ed.) Pearson education. ➢ Spiegel, M.R. & Stephens, L. J. (2014). *Schaum's Outline Statistics* (4th Ed.) McGraw-Hills Education. ➢ Spiegel, M., Schiller, J., Srinivasan, R.A.& Goswami, D. (2017). *Schaum's Outline Probability and Statistic* (3rd Ed.). McGraw-Hills Education.	
6.	**STAT 405** Statistical Techniques		**~~Statistical Techniques~~** **Section A** ~~Concept of variable, attribute, statistical population and sample Treatment of data-collection of primary and secondary data, representation of data (tabular, diagrammatic and graphical methods) Sample survey verses census survey-procedure, advantages and limitations Curve fitting through principle of least squares fitting of straight line, parabola, exponential and power curves Bi-variate distribution~~ correlation and regression **Section B** Theory of probability- Random experiment, mutually exclusive and independent events, classical and axiomatic approaches of probability, conditional probability, simple applications of addition and multiplication laws of probability, Bayes Theorem. Probability Distributions-Binomial, Multinomial, Poisson and normal distributions with their properties, applications and fitting **Section C** ~~Testing of hypothesis- Meaning and need, one tail and two tail tests, large and small sample tests. Test of significance of mean, variance, proportion~~	Course proposed to be discontinued	1. The section A of the existing syllabus is graphical representation of the data therefore is not required for Bioinformatics. The Correlation and regression techniques are useful and therefore included into section C of Proposed course **MATH 406:** Introductory Mathematics 2. Section B is merged with **MATH 406:** Introductory Mathematics. 3. Remaining parts of the existing syllabus either very basic or not required for the bioinformatics students.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			~~and correlation coefficient, Chi-square test of goodness of fit and independence of attributes. Analysis of variance of one way and two way (one observation per cell) classified data. Design of experiment- layout and analysis of completely randomized design (CRD) and randomized block design (RBD), Basic idea of Cluster analysis and Principle component analysis.~~		
7.	**BIN** Biological Database	After successful completion of the course the candidates should be able to: • understand the architecture of different sequence and structure database. • mine and analyze the biological information from different database.		**Biological Databases** **Section A** • Bioinformatics Sequence Databases–Primary Databases- GenBank, EMBL, DDBJ. • Composite Databases- UniProt. • Secondary databases - Prosite, ProDom, Pfam, InterPro, gene ontology; sequence file formats:- GenBank, FASTA, PIR, ALN/ClustalW2. • Literature Databases- Open access and open sources, PubMed, PLoS, Biomed Central, NAR databases; • Bioinformatics Resources- NCBI, EBI, ExPASy. **Section B** • Structure database – Primary structure databases - PDB, NDB, MMDB. • Secondary databases-Structural Classification of Proteins – SCOP, Class Architecture Topology Homology –CATH. • Families of Structurally Similar Proteins –FSSP. • Specialized Databases – Viral genome database-ICTVdb; Microbial genome database-MBGD; Genome browsers- Ensembl, VEGA genome browser, NCBI-NCBI map viewer, KEGG, MIPS, UCSC Genome Browser; Archeal Genomics, Eukaryotic genomes with special reference to model organisms-Yeast (SGD), Drosophila (FlyBase), C.elegans (WormBase), Mouse, Human	1. The biological databases are integral components of Bioinformatics; therefore it is necessary to introduce them together. 2. Primary, Secondary and Specialized databases are introduced here.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				(OMIM / OMIA), plants – Arabidopsis (TAIR). **Section C** • Derived Databases- Catalytic Site Atlas –CSA; Databases of molecular functions /enzymatic catalysis databases - KEGG ENZYME database; • Protein-Protein interaction database - STRING; chemical structure database - Pubchem; gene expression database - GEO, SAGE. • Database search engines – Text-based search engines (Entrez, DBGET /LinkDB). Sequence similarity based search engines (BLAST and FASTA). Motif-based search engines (Scan Prosite and eMOTIF). Structure similarity based search engines (combinatorial extension, VAST and DALI). • Proteomics tools- ExPASy server, EMBOSS. **Suggested Books:** ➢ Baxevanis, A.D. & Ouellette, B.F.F. (2004). *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins* (3rd Ed.). John Wiley. ➢ Bosu, O. & Thukral, S.K.(2007). *Bioinformatics: database, tools and algorithms* (1st Ed.). Oxford University Press. **Suggested e-Resources** ➢ **NCBI** https://www.ncbi.nlm.nih.gov/ ➢ **EBI** https://www.ebi.ac.uk/ ➢ **UNIPORT** https://www.uniprot.org/ ➢ **EXPASY** https://www.expasy.org/ ➢ **Biomed Central** https://www.biomedcentral.com/ ➢ **Databases Journal**	

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				➢ https://academic.oup.com/database	
8.	**BIO 404L:** Bioscience Lab-I	After successful completion of the course, students should be able to: • Demonstrate use of various tools and techniques for detection and quantification of biomolecules. • Perform various biochemical assays for fats, carbohydrate, protein and enzymes • Demonstrate microbiological techniques • Access, retrieve, and analyze nucleotide and protein sequences using bioinformatics tools		**Bioscience Lab-I** **BIO 404L** **Analytical Techniques** 1. Demonstration: Working principle & applications of 2. Centrifuges (high speed refrigerated centrifuge & ultracentrifuge), 3. Fluorescence microscope. 4. Atomic absorption spectrophotometer, 5. HPLC, FPLC, GC-MS 6. Separation of amino acids by TLC and Paper Chromatography. **Cell And Molecular Biology** 7. Study of different stages of mitosis (onion root tip) and meiosis (onion buds/grasshopper testis) and determine the mitotic index. 8. Separation of chloroplast by sucrose density gradient centrifugation **Biochemistry** 9. To prepare an Acetic-Na Acetate Buffer and validate the Henderson-Hasselbach equation. 10. Extraction of crude enzyme from germinating mung bean seeds. 11. Estimation of total protein content by Lowry's method 12. Separation of protein by SDS PAGE. 13. Estimation of acid phosphatase activity using standard curve of p-nitrophenol. 14. Purification of the crude enzyme extract (from Expt. 6) using ammonium sulphate precipitation and ion exchange/ affinity chromatography (demonstration). 15. Determination of kinetic properties (K_m and V_{max} values) of acid phosphatase.	1. This course is being proposed to provide the hands on experiences of Wetlab techniques to study cells and Biomacromolecules.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				16. Estimation of total carbohydrates using Anthrone method. 17. Estimation of reducing sugar by Nelson-Somogyi method. 18. Estimation of fats (cholesterol). **Microbiology** 19. Isolation and enumeration of microbes from soil and water. 20. Staining of selected bacterial and fungal strains 21. Estimation of bacterial growth by turbidometric method. 22. Antibiotic sensitivity test. 23. Estimation of infectivity titre of a virus sample using Plaque assay **Bioinformatics** 24. Database Search: Use and analysis of BLAST tool for protein and DNA sequences. 25. Molecular Evolution: Multiple sequence alignment and phylogenetic analysis. (Clustal X/ Mega/ Tree-View) 26. Structure Prediction: Protein secondary and tertiary structure prediction using online tools. 27. Molecular Visualization: Structural analysis of PDB entries for active and inactive states of protein(Pymol). **Suggested Books:** ➢ Aneja, K.R. (1996). *Experiments in Microbiology, Plant Pathology, Tissue Culture and Mushroom Cultivation* (II Ed.). New Delhi: Wishwa Prakashan. ➢ Cappuccino, J. G. & Sherman, N. (2014). *Microbiology – A laboratory manual* (10^{th} ed). Pearson **Suggested e-Resources:** ➢ **Harisha, S. Biotechnology procedures and**	

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				experiments handbook: http://site.iugaza.edu.ps/mwhindi/files/BIOTECHNOLOGY-PROCEDURES-AND-EXPERIMENTS-HANDBOOK.pdf ➢ **Introduction to Biotechnology :** http://www.austincc.edu/awheeler/Files/BIOL%201414%20Fall%202011/BIOL1414_Lab%20Manual_Fall%202011.pdf	
	IInd Sem				2.
9.	**BIN402** Computational Biology and Molecular Modeling		~~**Computational Biology and Molecular Modeling**~~ ~~**Section A**~~ ~~Sequence alignment: Scoring matrices PAM and BLOSUM- Local and Global alignment concepts, Dynamic programming methodology- Needleman- Wunsch algorithm, Smith-Waterman algorithm, Databases similarity searching: Algorithms of FASTA, BLAST and their variants, Multiple sequence alignment, Progressive alignment.~~ ~~**Section B**~~ ~~Gene finding methods: content and signal methods, Background of transform techniques, Fourier transform and gene prediction. Probabilistic models: Markov chain, Random Walk, Hidden Markov models. Molecular modeling: Quantum mechanical and molecular orbital methods.~~ ~~**Section C**~~ ~~Introduction to semi-empirical, molecular mechanics and ab intio techniques, potential energy surfaces, docking and modeling substrate receptor interactions. Software tools for modeling bimolecular, molecular electrostatic potentials, charge analysis. Protein conformations, folding~~	Course is proposed to be dropped	1. Section A is being proposed as part of Sequence Analysis and Phyogenetics. 2. Section B of the existing syllabus is being proposed to be part of Algorithms in Computational Biology. 3. Section C is being proposed as part of Biomolecular Modeling and Computational Drug Design.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			~~and mutation through modeling.~~		
10.	**BIN403** Proteomics, Sequence Analysis and Systems Biology		**~~Proteomics, Sequence Analysis and Systems Biology~~** **~~Section A~~** ~~Molecular Biology based Sequence Analysis: Alignment, Primer Selection, Phylogeny, Molecular Phylogenetic analysis using NJ, UPGMA methods. Introduction to Functional and Comparative genomics, Genome Comparison & Analysis: Homologues, Orthologues and Paralogues, Horizontal gene transfer.~~ **~~Section B~~** ~~Proteomics: Basic concepts of Proteomics and analytical look, 2D-Gel Electrophoresis, Mass Spectroscopy, Peptide Sequencing. Global expression analysis, Serial analysis of gene expression (SAGE), Technique of Micro array, Micro array design, Analysis of Microarray data using, K-Means Clustering, Nearest Neighbor and Hierarchical Clustering. Application of Micro array, Protein Arrays.~~ **~~Section C~~** ~~Genome Sequencing, Genome Assembly. Introduction to Systems Biology, Metabolomics: Metabolic pathways (Shikimate Pathway), Drug target identification method, Biological System: Molecular networks, Ecosystems, Elements of Systems modeling. Gene Regulatory Network and the models (logical, continuous, stochastic etc.).~~	Course is proposed to be discontinued	1. Section A is repletion and is being proposed as part of Sequence Analysis and Phylogenetics. 2. Section B is being proposed as part of Genomics and Proteomics in IIIrd Semester (c.w. MSc. AMBT and BT III Sem)
11.	**BIO413** **Medical Microbiology and Immunology**		**~~Medical Microbiology and Immunology~~** **~~Section A~~** ~~Innate and Acquired Immunity, Antigens : types of Antigens, Antigen specificity, haptens,~~	Course is proposed to be discontinued	Course irrelevant to the programme

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			~~Antibody structure and functions, MHC, Complement System Cell mediated cytotoxicity : Origin, maturation and characterization of T-lymphocytes, Monocytes & Macrophages, Mechanism of T cell and NK cell mediated lysis, ADCC, Macrophage mediated cytotoxicity, lymphokines - the product of T cell activation. Humoral immune response : Origin, maturation and characterization of B lymphocytes, Activation and proliferation of B cells, Formation of plasmablast, Plasma cells and memory cells, Interaction of B and T cells.~~ **~~Section B~~** ~~Hypersensitivity, Monoclonal antibodies and its applications. Radioimmunoassay, Enzyme linked immunosorbant assay, immunoblotting, immunofluorescence and flowcytometry Characteristics of infectious diseases, Herd immunity.Disease cycle (Source of disease, reservoir, carriers) Transmission of pathogens (Air borne, contact transmission and vector transmission).~~ **~~Section C~~** ~~Bacterial Diseases : Epidemiology, Pathogenicity, Laboratory diagnosis, Prevention & control of the following diseases : Anthrax, Tuberculosis, Typhoid, Whooping cough, Tetanus, Diphtheria, Leprosy.General Account of fungal diseases : Mycosis, Subcutaneous and deep. General Account of viral & protozoan diseases : Pneumonia, Influenza, Mumps, Measles, Polio, Hepatitis B, Chickenpox, AIDS and Malaria, Leishmaniasis. Brief account of sexually transmitted diseases.~~		

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
12.	**CS 412** Computer Networks and Web Technologies		~~**Computer Networks and Web Technologies**~~ ~~**Section A**~~ ~~Components of a data communication system, modulation concepts. Computer Networks, Advantages, Transmission media, Local Area Networks. Types of LAN (Star, Ethernet, Bus, EPABX) , Wide Area Networks (WAN), requirements, advantages.~~ ~~**Section B**~~ ~~ISO-OSI model of Networking, different layers and their functions, definition of protocol, introduction to TCP/IP, Network devices (Hub, Switch, Router, Gateway, Bridge) Internet, intranet, internet services.~~ ~~Internet connection methods (Dialup, DSL, Leased Line, ISDN, Broadband) Introduction to HTML; Structure of HTML code, various tags, embedding images in websites.~~ ~~**Section C**~~ ~~Web Development: Web design, Meaning of web design and building of websites, Web Document, Web Server, Web Browser, characteristics of good website, Publishing & Registering web sites, CSS, Web Scripting: VBScript, JavaScript, ASP : Introduction, features, ASP objects, Database Connectivity.~~	Course is proposed to be discontinued	1. This course is being proposed to discontinue as it is not relevant to bioinformatics. 2. Appropriate contents such as networking protocols are being proprosed to be part of Fundamentals of Computer and Programming.
13.	**BIN** Algorithms in Computational Biology	After successful completion of the course the candidates should be able to: • Develop understanding on the efficiency and speed of computer algorithm. • Understand the		**Algorithms in Computational Biology** **Section A** Algorithms and Data structures in Bioinformatics Algorithms and complexity, Iterative and recursive algorithms, Fast versus slow algorithms, Big-O Notation, Algorithm design and analysis techniques, Greedy Algorithms, Randomized Algorithms, Divide-and-Conquer approach, Searching and Sorting algorithms, Linear and non-linear data structure, Stack,	1. Algorithms are critically important for bioinformatics studies, therefore, all the relevant algorithm along with their computational complexity are put in this course.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		stochastic process and sampling methods. • Understand the system optimization using computational tools.		Queues, Linked list, Trees-Terminologies, Binary trees, Tree traversal (Pre-order, In-order, post-order). **Section B** Brute Force, Dynamic programming: Shortest Superstring Problem, Random Walk (1D & 2D), Markov chain; Hidden markov models – Forward, Backward, Viterbi and Baum – Welch algorithm. Population dynamics algorithms; Intraspecies, Interspecies, and Pre – Predator (two species Lotka – Voltera). Fibonacci series, golden ratio. Introduction to chaos and fractals; Lorenz equation. Random sampling; Monte Carlo, Metropolis algorithms. **Section C** Introduction to optimization problem, methods of optimization: Newton – Raphson, Quasi – Newton methods, Genetic algorithm, Particle – Swarm algorithm and Ant – colony optimization. Introduction to data clustering; definitions of distance, similarity, cluster, centre and modes. Measure of distances; Euclidean, Maximum, Mahalanobis and average. The EM Algorithm, Center-based Clustering Algorithms; The k-means Algorithm. Hierarchical Clustering; Agglomerative clustering methods; Single link, complete link, group average, centroid and median methods. **Suggested Books:** ➢ Jones, N.C. & Pevzner, P.A. (2000). *An Introduction to Bioinformatics Algorithms*. The MIT Press. ➢ Dediu, A. H., Hernández-Quiroz, F., Martín-Vide, C. & Rosenblueth, D.A. (2015). (Eds.) *Algorithms for Computational Biology*. Springer. ➢ Baxevanis, A.D., Davison, D.B., Page, R. D. M. & Petsko, G.A. (2004). *Current Protocols in Bioinformatics*. John Wiley & Sons Inc.	2. The first unit introduces data structure and working of computer algorithms and their complexities. 3. Second unit introduces stochastic and random processes. 4. The third unit introduces various optimization methods useful in bioinformatics studies.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				➢ Gibas, C. & Jambeck, P. (2001). *Developing Bioinformatics Computer Skills*. O'Reilly Media, Inc., ➢ Parida, L. (2008). *Pattern Discovery in Bioinformatics: Theory & Algorithms*. Chapman and Hall/CRC. **Suggested E – Resources:** ➢ **Bio-Informatics:Algorithms and Applications** https://onlinecourses.nptel.ac.in/noc19_bt01/preview ➢ **Markovian Processes:** https://www.coursera.org/learn/dna-analysis	
14.	**BIN** Sequence analysis and Phylogeny	After successful completion of the course the candidates should be able to: • Understand the biological sequence analysis. • Identify similar sequences in the database. • Understand the phylogenetic analyses		**Sequence Analysis and Phylogeny** **Section A** • Sequence Analysis – concepts of sequence similarity, Sequence identity vs homology. Definitions of homologues, orthologues, paralogues and xenologues. Basic methods of sequence analysis; Dot plot method, sequence distance calculation (Hamming and Levinshtein), their merits and demerits. Scoring matrices: basic concept and construction of a scoring matrix; PAM and BLOSUM matrix and their derivatives. Pairwise sequence alignment: Global and Local alignment algorithms; gap penalties, ends free alignment. Statistical significance of alignment score. **Section B** • Sequence-based database searches: algorithm of BLAST and FASTA and interpretation of results. Algorithms for generation of sequence profiles; profile-based database searches using PSI-BLAST, analysis and interpretation of profile-based searches. Multiple sequence alignments (MSA): the need for MSA. Theory and application of various approaches for MSA; progressive and	1. Sequence analysis and phylogenetics are core courses of Bioinformatics to study the sequence based characteristics and molecular evolution. 2. Section A introduces the fundamentals of sequence analysis along with the mathematical and statistical rational. 3. Section B focuses on the database search methods and the MSA. 4. The section C introduces the Phylogenetics methods and their applications in studying the evolution.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				hierarchical. Algorithm of CLUSTAL and PileUp and their application for sequence analysis. **Section C** • The concept of evolutionary tree; types of phylogenetic trees (rooted vs. unrooted trees), Molecular Clock Newick format of tree representation. Introduction to evolutionary models; Jukes Cantor and Kimura two parameter. Algorithms of Phylogenetic Tree Construction: UPGMA, Neighbor-Joining, Maximum Parsimony, Maximum likelihood, and Bayesian Inference. Statistical assessments of phylogenetic methods (Consistency, Efficiency, Robustness, & Computational speed). Evaluation of phylogenetic tree: Bootstrapping, Randomized and jack-knifing methods. **Suggested Books:** ➢ Mount, D.W. (2004). *Bioinformatics: Sequence and Genome Analysis*. (2nd Ed.). Cold Spring Harbor Press. ➢ Durbin, R., Eddy, S.R., Anders, K. & Graeme, M (2002). *Biological Sequence Analysis: Probabilistic models of protein and Nucleic acids*. Cambridge University Press. ➢ Nei M. & Kumar, S. (2004). *Molecular Evolution and Phylogenetics*. Oxford University Press **Suggested E Resources** ➢ **Sequence Analysis** https://www.coursera.org/learn/undefined ➢ **Molecular Evolution:** https://www.ebi.ac.uk/training/online/course/introduction-phylogenetics	
15.	**BIN** Programming with Perl and R	After successful completion of the course the candidates should be		**Programming with Perl and R** **Section A** Perl Data types: Scalar variables, scalar operations and	1. Perl Programming of existing syllabus CS410: computer

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		able to: • Understand the perl scripting for string manipulations. • Understand using the perl modules. • Understand the environment of R and Bioconductors.		functions, array variables, array representation, array operations and functions, hash variables and its representation, hash functions. Application of hashes to write genetic code and gene expression data. Perl regular expression: Concepts and use of regular expression for biological data. Metacharacters, Pattern-matching, Substitutions, Transliteration, split and join functions. Subroutines and its advantage, arguments, passing data to subroutines. Concept of file handling, opening, rading editing and closing a File. Directory handling: opening reading and closing a directory. **Section B** Bioperl: Introduction to Bioperl and its installation. Bioperl architecture: general classes, Sequences - Bio::Seq Class, sequence manipulation, alignments - AlignIO, Analysis -Blast, Databases- Database Classes. Introduction to common gateway interface module (CGI.pm), CGI program in Context, Perl and the Web. Introduction to R language; R Objects and data structures – Variable classes, Vectors and matrices, Data frames and lists, Data sets included in R packages, Summarizing and exploring data, Reading data from external files, Storing data to external files, Creating and storing R workspaces. **Section C** Object Manipulating using R – Mathematical operations (recycling rules, propagation of names, dimensional attributes, NA handling), Basic matrix computation (element-wise multiplication, matrix multiplication, outer product, transpose, eigenvalues, eigenvectors), Textual operations, Basic graphics (high-level plotting, low-level plotting, interacting with graphics).	fundamentals and Perl Programming is being adopted here, since, Perl scripting is powerful string manipulation language and therefore is not suitable for candidates without any programming background. 2. R programming is being proposed here to understand develop skills of analyzing big data from molecular biology.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Introduction to Big data in Bioinformatics: Characteristics, data structures and data repositories; exploratory analysis of big data in R environment, Bioconductor, Microarray and next-generation sequencing (NGS) data analysis in R environment. **Suggested Books:** ➢ Schwartz RL et al.; Learning Perl (2008, 5th Ed.) O'Reilly. ➢ Wall L et al.; Programming Perl (2012, 4th Ed.) O'Reilly. ➢ Gerrard P and Johnson RM.; Mastering Scientific Computing with R (2015), Packt Publishing, UK. ➢ Hahne F. et al.; Bioconductor case studies (2008), Springer. ➢ Lewis PD.;R for Medicine and Biology (2010), Jones and Bartlett Series. **Suggested E Resources** ➢ **Perl Programming** https://www.learn-perl.org/ ➢ **R Programming** https://www.rstudio.com/online-learning/	
16.	**BIN** Programming with Perl and R Lab	After successful completion of the course the candidates should be able to: • Write the perl programs for string manipulations. • Develop and use simple perl modules. • Install and use the Bioconductor packages from R for statistical analyses of biological data.		**Programming with Perl and R Lab** 1. Use of various arithmetic and logical operators. 2. Programming based on string manipulation (concatenation, splitting etc.) 3. Regular expression and its applications. Use of s/// and tr/// operators. 4. Pattern matching to locate and count motifs in a string. 5. Constructing arrays. addition and removal of elements from array, exploring array. 6. Use hashes in conversion of three letter code to one letter code and proteing translation. 7. Perl subroutines. 8. File handling, reading data from a file writing data	1. R exercises are included with Perl exercise.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				to a file and editing a file. 9. Directory handling, make a directory, change present working directory, reading files from a directory. 10. Introduction to Perl modules, construction of simple module 11. Basic statistical analyses in R. 12. Using R for simple problems of molecular biology. 13. Use of Bioconductor for analyzing biological data. **Suggested Books:** ➢ Wall L et al.; Programming Perl (2012, 4th Ed.) O'Reilly. ➢ Gerrard P and Johnson RM.; Mastering Scientific Computing with R (2015), Packt Publishing, UK. **Suggested E-Resources** ➢ **Perl Programming** https://www.learn-perl.org/ ➢ **R Programming** https://www.rstudio.com/online-learning/	
17.	**CS418:** Database Management Systems	After successful completion of the course the candidates should be able to: • Understand relational database systems • Calling, processing and optimizing the databases. • Mining data from open access biological databases.	**Database Management Systems** **Section A** Introduction: - Data base system concepts, Comparison between traditional file system and DBMS, Database Users, Data models, schemas and instances, Data independence, 3-level architecture of DBMS, Overall data base structure. Data modeling using Entity Relationship Model: - ER model, mapping constraints, Concept of super key, candidate key, primary key, Generalization, aggregation, reducing ER diagrams to tables. Relational Data Model: concepts, integrity constraints, relational	**Suggested Books:** ➢ Hanery, K. & Abraham, S. (1997). *Database System Concepts*. New York, Tata Mac- Graw Hill. ➢ Date, C. J. (1999). *An Introduction to Database Systems*(6th Ed.). Addison Wesley. ➢ Hanery, K. & Abraham, S. (1997). *Database System Concepts*. New York, Tata Mac-Graw Hill. ➢ Baxevanis, A.D. & Ouellette, B.F.F. (2004). *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins* (3rd Ed.). John Wiley. ➢ Bayross, I. (2003). *SQL, PL/SQL The Programming Language of Oracle* (2nd Ed.). BPB New Delhi. 2003	**No Change**

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			algebra, SQL queries. **Section B** Data Base design: - Functional Dependency and its types, normal forms: first, second, third and BCNF, multi-valued dependency, fourth normal form, join dependency and fifth normal form. Steps in database design. Transaction processing: Introduction, ACID properties, Concurrency control techniques: Locking techniques, Time stamping, Optimistic approach, Multi-version. Management of deadlocks, Query processing and optimization. **Section C** Recovery, Integrity and security of Databases. Distributed Database systems: Introduction, Fragmentation, Replication, Transparency, Consistency and Concurrency control, Homogeneous Vs Heterogeneous systems. Advanced topic in databases: temporal database, spatial database, data mining, data warehousing and its applications. Case studies using NCBI, SwissProt and PDB.		
18.	**CS418:** Database Management Systems lab	After successful completion of the course the candidates should be able to: • Create relational databases. • Manage databases for biological purposes.	**Database Management System Lab** 1. Basic DDL commands (creat, drop, alter) with integrity constraints. 2. DML and DCL commands (Insert, Update, Delete, Select, Commit, Rollback) 3. Operators (Arithmatic, Logical, Relational etc.) 4. Assignment based on DDL and DML with conditions also join (Self join, inner join, outer join, equi join) 5. Complex queries (Retrieval of data from more than one table)		No Change

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
19.	**BT408** Genetic Engineering	After successful completion of the course, students should be able to: • Develop comprehensive understanding of gene manipulation techniques • Describe various cloning and expression vectors • Develop skills for primer designing, gene amplification and expression		**Genetic Engineering** **Section-A** • Basic concepts of DNA structure and properties, restriction enzymes, DNA ligase, Klenow enzyme, T_4 DNA polymerase, polynucleotide kinase, alkaline phosphatase. • Cohesive & blunt end ligation, linkers, adapters, homopolymeric tailing, labeling of DNA, nick translation, random priming, radioactive & non-radioactive probes. • Hybridization techniques: Colony hybridization, Northern, Southern,South-Western & far-western blotting. • DNA-Protein Interaction: Chromatin immunoprecipitation, electromobility shift assay, DNaseIfootprinting, methyl interference assay. • Protein-protein interaction: Yeast two hybrid system, split ubiquitin system, co-immunoprecipitation, Forster Resonance Energy Transfer, phage display. • Isolation of genomic DNA from prokaryotes and eukaryotes, isolation of Plasmid DNA and Bacteriophage DNA.Isolation of total RNA and mRNA. **Section-B** • Plasmids, Bacteriophages, pBR322 & pUCseries of vectors, M13 based vectors. • High capacity vectors:cosmids, phagemids, BAC, animal & plant virus based cloning vectors, shuttle vectors; expression vectors: pMal, GST, pET-based vectors; *Baculovirus* and *Pichia* vectors. Introduction of DNA into mammalian cells. • cDNA& genomic libraries, expression, cloning, jumping & hopping libraries.	This course is being introduced to provide the core knowledge of biotechnological methods of gene manipulation. The course is already running in M.Sc. Biotechnology, AMBT and Bioscience.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Section-C • Primer designing, fidelity of thermostable enzymes. • Types of PCR- multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, *in situ* PCR, T-vectors. • Principles in maximizing gene expression, gene expression analyses, differential gene expression methods. **Suggested Books:** ➢ Old, R. W., Primrose, S. B. & Twyman, R. M. (2001). *Principles of Gene Manipulation: an Introduction to Genetic Engineering*. Oxford: Blackwell Scientific Publications. ➢ Brown, T. A. (2006). *Genomes* (3rd ed.). New York: Garland Science. ➢ Glick, B.R. & Pasternak, J.J. (1998). *Molecular Biotech: Principles and Application of Recombinant DNA*. US: ASM Press. ➢ Richard J. R. (2004). *Analysis of Genes and Genome*. New Jersey, USA: John Wiley & Sons Ltd. ➢ Green, M. R. & Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. **Suggested e- Resources:** ➢ **Genetic engineering – Basics, New Applications and Responsibilities** http://library.umac.mo/ebooks/b28055287.pdf ➢ **Construction of genomic libraries** https://nptel.ac.in/courses/102103013/20 ➢ **Enzymes in genetic engineering** https://nptel.ac.in/courses/102103013/7	
	IIIrd Semester				
20.	**BIN 502 :** Computer Aided		~~**Computer Aided Drug Designing**~~	Course is proposed to be discontinued	1. This course is being proposed to

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
	Drug Designing		~~**Section A**~~ ~~Introduction to Pharmacogenomics and Pharmacogenetics, Clinical trials in Pharmacogenomics, Polymorphism of CYP450 enzymes affecting drug response, Role of SNP in Pharmacogenomics, The Multi Drug Resistance proteins: drug carriers affecting drug response.~~ ~~**Section B**~~ ~~Basics of Drug Pharmacokinetics and Pharmacodynamics, Molecular descriptors, QSAR methodologies 3D QSAR. Structure based drug designing, Ligand based drug designing, Different docking methodologies, success stories in docking.~~ ~~**Section C**~~ ~~Pharmacophore modeling, Pharmacophore generation (Hiphop and HypoGen theories), Combinatorial libraries, High throughput screening, Virtual screening, Lipinski's rule of five and its applications. Chemoinformatics: Introduction, Chemical Databases (ACD, MDDR and WDI), Application of Chemoinformatics in CADD.~~		discontinued, however, the contents from section B and Pharmacophore Modeling from section C are being proposed to be part of Biomolecular Modelling and Computaitonal Drug Design. 2. Section A of this course is not relevant from the Bioinformatics View point.
21.	**BIN 508:** Molecular Structure Prediction and Visualization		~~**Molecular Structure Prediction and Visualization**~~ ~~**Section A**~~ ~~**Protein 3Dstructure determination:** Basic principles of NMR, chemical shift, The Nuclear Overhauser Effect (NOE), Correlation Spectroscopy (COSY), Nuclear Overhauser Effect Spectroscopy (NOESY), Protein 3D structure determination using NMR. Structural features of RNA, RNA structure prediction algorithms.~~ ~~**Section B**~~	Course is proposed to be discontinued	1. Section A is an experimental method of Structural Biology therefore is being proposed to be part of BIO417: Structural biology. 2. Algorithmic parts of section C is being proposed to be part of Algorithms in Computational

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			~~**Protein structure prediction:** Steps in Homology modeling, Threading; Contact potential, structural profile and segment matching method, Abinitio method. Protein structure comparison, Purpose of structure comparison and algorithms (dynamic programming, distance matrix), Predicting Protein Function from Structure.~~ ~~**Section C**~~ ~~Applications of the visualization softwares like Rasmol and SWISS PDB Viewer. Application of Hidden Markov Model, Support Vector Machine and Artificial Neural Network in structure prediction. Optimization methods: Montecarlo and Simulated annealing.~~		Biology. 3. Section B is now part of Biomolecular Modelling and Computation Drug Design.
22.	**BIN 505** Functional and Comparative Genomics		~~**Functional and Comparative Genomics**~~ ~~Section A~~ ~~Introduction to Functional and Comparative Genomics, Application of molecular markers with references to RAPD, RFLP, AFLP, STS, SSR etc., Protein Profiling, Transgenic Animals & Plants, Knockouts.~~ ~~Section B~~ ~~Strategies for generating Expressed Sequence Tags, EST Clustering (TIGR Gene Indices, STACK), ESTs and gene discovery, ESTs and sequence polymorphisms, EST databases (DbEST, UNIGene), The nature of Single Nucleotide Polymorphisms (SNP), distribution of SNPs, Applications of SNP technology.~~ ~~Section C~~ ~~Comparative genomics of prokaryotes and eukaryotes, Protein evolution by exon shuffling. General purpose databases for comparative genomics, in silico gene prediction, Phylogenetic~~	Course is proposed to be discontinued	1. This course is being proposed as part of Genomics and Proteomics. 2. All the contents of relevant to Genomics are being proposed to be part of Genomics and Proteomics. 3. The databases from this course are being proposed to be part of Biological Databases in the first semester.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			~~Analysis, MUMMER~~		
23.	**BIN 504**Evolutionary Computing		**Section A** ~~Overview of natural evolution, Evolutionary algorithm and its application, Genetic algorithm, Examples of Evolutionary Computing such as Artificial Immune Systems, Computational Embryology, Artificial Life, Ant colony optimization and Swarm intelligence.~~ ~~**Section B**~~ ~~Introduction to Artificial neural network, Neuron model, neural network architectures, Learning Rules (Hebbian, Competitive, Baltzmann) Supervised and unsupervised learning, Types of neural networks: Perceptron, MLP, recurrent network, self organizing Feature maps, Applications of NN.~~ ~~**Section C**~~ ~~Science of genetics – objectives, terminologies, methods, Mendelian principles of inheritance, sex linked inheritance, Concept of linkage, linkage maps and recombination, Mutations – molecular, gene/point and chromosomal, Phenotype and genotype relationships, gene interactions, Genetics of populations, genetics and evolution, Genetics and diseases, cancer.~~	Course is proposed to be discontinued	1. Section C of this course is basic genetics which essentially irrelevant to Bioinformatics and is part of many undergraduate and school courses. 2. Algorithms from section B are being proposed to be part of Algorithms in Computational Biology. 3. Section A is part of Phylogenetics in the proposed course of Sequence analysis and Phylogenetics.
24.	**BIN** Biomolecular Modeling and Computational Drug Design	After successful completion of the course the candidates should be able to: • Understand the principles of statistical thermodynamics. • Develop understanding of principles of biomolecular modelling and		**Biomolecular Modeling and Computational Drug Design** **Section – A** Basic Thermodynamics - The Laws of Thermodynamics, the Maxwell Relations, the Gibbs-Duhem Equation and Extensive Functions, Intensive Functions. Lagrangian Formulation, Hamiltonian Formulation and Canonical Transformations Classical approach to Ensembles: Ensembles and Phase Space. Partition Function: Review of rotational, vibrational and translational partition functions. Application of	1. Section A introduces basics of molecular thermodynamics along with statistical mechanics. 2. Section B introduces updated techniques of molecular modeling employed in theoretical study of biomolecules.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		simulations. • Understand the computational methods for drug designing and development.		partition functions to specific heat of solids and chemical equilibrium. **Section – B** Homology modeling, Protein Threading and abinitio methods. Introduction to Molecular mechanics. Optimization of modeled protein 3D structure. Energy minimization (steepest descent, conjugate gradient and Newton-Raphson methods). Molecular dynamics simulation: Equation of motion, integration schemes; Introduction to force fields, its popular variants; Ergodic Hypothesis, Ensembles (Canonical and Micro-Canonical) and their control in MD simulation, periodic boundary conditions and calculation of long range potentials (Particle – Mesh and Ewald summation methods). Potential energy surface: Convergence Criteria, Characterizing Stationary Points, Search for Transition States. **Section – C** Computational Drug design; Drug likeness: Lipinski's rules, ligand efficiency and lipophilic ligand efficiency. Molecular recognition: affinity determination, intermolecular binding free energy. Ligand based drug design: - pharmacophore, constrained systematic search and genetic algorithm. Structure based drug design: Molecular docking and virtual screening. Introduction to QSPR and QSAR. Molecular descriptors used in QSAR studies: electronic; topological and quantum chemical. QSAR models: Free Wilson and Hansch equation. Statistical methods for QSAR modeling: regression, principle component and partial least squares analysis. Bioisosteres, Hammet substituent constant. **Suggested Books:** ➢ Cramer, C. (2004) *Essentials of Computational Chemistry* (2nd Ed); John Wiley.	3. Section C provides computational methods to study drug designing and discovery.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				➢ Leach, A. R. (2001). *Molecular Modeling-Principles and applications*. Pearson Education. ➢ Thomas G. (2003) Fundamentals of Medicinal Chemistry; John Wiley. ➢ Alvarez J. and Shoichet B. (Ed.) (2004). *Virtual Screening in Drug Discovery*. Taylor and Francis. ➢ Kukol, A. (Ed.) (2015). *Molecular Modeling of Proteins* (2^{nd} Ed.). Springer Nature. Young, D.C. (2009). *Computational Drug Design*. John Wiley. **Suggested e-Resources:** ➢ **Statistical Mechanics** https://onlinecourses.nptel.ac.in/noc19_ph06/preview ➢ **MD Simulation and SBDD** https://nptel.ac.in/courses/103103036/13 https://onlinecourses.nptel.ac.in/noc18_bt28/preview	
25.	**BIN** Biomolecular Modeling and Computational Drug Design Lab	After successful completion of the course the candidates should be able to: • Model the 3D structure of the biomolecules. • Carry out biomolecular interaction studies. • Perform MD simulations to study the biomolecular dynamics.		**Biomolecular Modeling and Computational Drug Design Lab** 1. Molecular visualization tool (applications such as molecular interaction, Molecular surface visualization, electrostatics, H-bond calculation etc.) 2. Identification of different structural motifs in proteins.A 3. Analysis of PDB (NMR and X-ray) structures (Quality of structure, analyzing molecular interactions, protein-ligand/protein-protein if any, from PDB). 4. Homology based protein structure prediction. 5. Quality estimation of modeled protein structure (ProCheck, PROSA, Verify 3D, Errat etc.). 6. Contact map based protein structure comparison. 7. Energy minimization based mutational analysis of proteins (using SwissPDB-Viewer). 8. Protein-Ligand docking Autodock and MGL Tools and Pharmacophore analysis.	1. This laboratory course provides hands on experience to various softwares used in studying biomolecules.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				9. Carry out molecular dynamics simulation. 10. Simple analyses of MD data such RMSF, RDF movie making etc.	
26.	**BIN** Genomics and Proteomics	After successful completion of the course the candidates should be able to: • Understand the experimental methods available to study the genome and proteomes. • Develop understanding of computational tools of genomics and proteomics. • Understand the next generation sequencing methods.		**Genomics and Proteomics** **Section – A** Genomics – Introduction to genome and genomics; genetics vs genomics. DNA microarray; prepration, understanding of microarray data, normalizing microarray data, detecting differential gene expression, correlation of gene expression data to biological process and analysis tools. Gene Expression Omnibus (GEO). Genomics and Metagenomics – Large scale genome sequencing strategies. Genome assembly and annotation. Genome databases of Plants, animals and pathogens. Metagenomics: Gene networks: basic concepts, computational model such as Lambda receptor and lac operon. Prediction of genes, promoters, splice sites, regulatory regions: basic principles, application of methods to prokaryotic and eukaryotic genomes. **Section – B** Proteomics – Introduction to proteome and proteomics; protein chemistry vs proteomics. Analytical techniques of proteomics; working principles of 2D – gel electrophoresis, mass spectrometry with their merits and demerits. Mass spectrometers for protein and peptide sequencing; MALDI – TOF, Electospray Ionization coupled tendem Mass spectrometry.Tendem mass analyzer, triple quadrupole mass analyzer, ion – trap mass analyzer and FT – ion cyclotron resonance MS. Peptide Mass Fingerprinting. Sequencing the protein fragments: Scoring Algorithm for Spetral Analysis. Application of SALSA in amino acid – Motif searching. **Section – C**	Course already running in M.Sc. Biotechnology, M.Sc. AMBT as a elective course 1. Section A of this course provides description of techniques and databases used in genomics. 2. Section B discusses about the techniques of proteomics studies. 3. Section C provides applications of genomics and proteomics tools and techniques along with the databases.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Next Generation sequencing & assembly: Elements of big data analysis, NGS Platforms based on pyrosequencing, sequencing by synthesis, emulsion PCR approach with small magnetic beads and single molecule real time (SMRT) sequencing; Genome assembly algorithms, De-novo assembly algorithms, Sequence Alignment formats: Sequence Alignment/Map (SAM) format, Binary Alignment/Map (BAM) format. Protein function prediction using Machine learning tools: supervised/unsupervised learning, Neural network, SVM. Protein-protein interactions: databases such as STRINGS, DIP, PPI server and tools for analysis of protein-protein interactions **Suggested Books:** ➢ Brown, S.M. (2015). *Next-generation DNA Sequencing Informatics* (2nd Ed.). Cold Spring Harbor Press. ➢ Liebler, D. C. (2001). *Introduction to Proteomics Tools for the New Biology*. Humana Press. ➢ Lesk, A.M. (2015). *Introduction to Genomics* (2nd Ed). Oxford University Press. ➢ Pevsner, J. (2017). *Bioinformatics and Functional Genomics* (3rd Ed). John Wiley. ➢ Twyman, R.M. (2004). *Principles of Proteomics*; CBS Publishers. ➢ Thangadurai, D. & Sangeetha, J. (2015). *Genomics and Proteomics: Principles, Technologies, and Applications*. CRC Press. **Suggested e-Resources:** ➢ **Proteomics** https://nptel.ac.in/courses/102101055/4 ➢ **Genomics** https://edu.t-bio.info/course-category/omics/ https://ocw.mit.edu/courses/biology/7-012-	

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				introduction-to-biology-fall-2004/video-lectures/lecture-25-genomics/	
27.	**BIN** Python Programming	After the successful completion of course the candidates should be able to: • Understand the python programming environment. • Understand using the python libraries. • Learn file and directory handling in python.		**Python Programming** **Section A** Python interpreter and interactive mode; values and types: int, float, boolean, string, and list; variables, expressions, statements, tuple assignment, precedence of operators, comments; modules and functions, function definition and use, flow of execution, parameters and arguments; Illustrative programs: exchange the values of two variables, circulate the values of n variables, distance between two points. **Section B** Conditionals: Boolean values and operators, conditional (if), alternative (if-else), chained conditional (if-elif-else); Iteration: state, while, for, break, continue, pass; Fruitful functions: return values, parameters, local and global scope, function composition, recursion; Strings: string slices, immutability, string functions and methods, string module; Lists as arrays. Illustrative programs: square root, gcd, exponentiation, sum an array of numbers, linear search, binary search. **Section C** Lists: list operations, list slices, list methods, list loop, mutability, aliasing, cloning lists, list parameters; Tuples: tuple assignment, tuple as return value; Dictionaries: operations and methods; advanced list processing – list comprehension; Illustrative programs: selection sort, insertion sort, mergesort, histogram. Files and exception: text files, reading and writing files, format operator; command line arguments, errors and exceptions, handling exceptions, modules, packages; Illustrative programs: word count, copy file. **Suggested Books:**	1. To meet the requirements of current developments in Bioinformatics python programming is a must and therefore being proposed here.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				➢ Sedgewick, R., Wayne, K. & Dondero R. (2015). *Introduction to Programming in Python: An Inter-disciplinary Approach*. Addison – Wesley Professional. ➢ Lambert, K.A. (2011). *Fundamentals of Python: First Programs*, Cengage Learning. ➢ Goodrich, M.T., Tamassia, R. & Goldwasser M.H. (2016). Data structure and Algorithms in Python. Wiley India Pvt.Ltd. ➢ Bassi, S. (2017). *Python for Bioinformatics* (2nd Ed.). Chapman and Hall/ CRC press. **Suggested e-Resources:** ➢ Python tutorials https://www.tutorialspoint.com/execute_python_online.php https://onlinecourses.nptel.ac.in/noc16_cs11/preview	
28.	**BIN** Python Programming Lab	After the successful completion of course the candidates should be able to: Write python programs for studying biological samples.		**Python Programming Lab** 1. Introduction to variables and various arithmetic & logic operations. 2. Introduction to strings and lists 3. Conditionals and Loops in python. 4. Working with files and directories in python. 5. Working with Molecular biology problems such as transcription, translation, GC island identification. 6. Working with sequence analysis problems such as global alignment, local alignment Parsing Blast output etc. 7. Accessing biological databases with Python.	1. To provide hands on experience with Python programming this laboratory course is being proposed.
29.	**BIN** RNA Structure Function and Transcriptomics	After the successful completion of course the candidates should be able to: • Understand the		**RNA Structure Function and Transcriptomics** **Section A** The biology, chemistry, structure and function of the RNA molecule in prokaryotic and eukaryotic systems including their viruses. Interaction between RNA	1. The Section A of this course introduces the description of noncoding RNAs which are essential part of

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		structure of various non-coding RNAs and their functions • Learn techniques of genome wide expression studies.		molecules. Interaction between RNA and proteins. Interaction between RNA and small ligands. The role of RNA in an evolutionary perspective. Description of non coding RNA and their functions and possible mechanism of action. (SnRNA, SnoRNA, siRNA, miRNA, Catelytic RNA and Ribozymes) **Section B** Transcriptome and Transcriptomics; Genome Wide Gene Expression Analysis: Microarrays: experiments to annotation. Expressed sequence tags: EST Genration, EST Clustering importance in gene identification. Serial analysis of gene expression (SAGE), SAGE data and its importance. Tools for Transcriptomics and Transcriptome Analysis. **Section C** Database and web tools for ESTs project. Tissue Specific Transcriptomics and Expression Pattern Analysis. Transcriptional Regulation of Gene Expression in Prokaryotes and Eukaryotes. The Transcriptome Projects. Impact of Transcriptomics on functional genomics, Diseases and drug discovery, Evolutionary analyses and Pharmaceutical Research. **Suggested Books:** ➢ Meister G. (2011), *RNA Biology*; Wiley – VCH. ➢ Gesteland, R. F., Cech, T & Atkins, J. (2005). *The RNA World* (3rd Ed.), CSHL – press. ➢ Wu J. (Ed.) (2016),*Transcriptomics and Gene Regulation*; Springer – Nature. ➢ Passos G.A. (Ed.) (2014). *Transcriptomics in Health and Disease*; Springer Publications. **Suggested e-Resources:** ➢ **Genomics 1 - T-BioInfo in Education** https://edu.t-bio.info/course-category/omics/ ➢ **Non coding RNA** https://www.nature.com/collections/sqtqxdnvdz	genome regulators. 2. Section B and C are adopted from the previously existing course Transcriptomics and Metabolomics, with slight update.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				➢ **Epigenetics** https://www.whatisepigenetics.com/non-coding-rna/	
30.	**BIN** Systems Biology	After the successful completion of course the candidates should be able to: • Understand the different types and properties of biological networks.. • Understand using the various databases of biological networks. • Learn to model the metabolic processes.		**Systems Biology** **Section A** Introduction to Graph, forest & Network. Parameters of networks: degree of node, degree distribution and power law behaviour, shortest path, mean path, clustering coefficient, node centrality and network centrality. Types of networks: random, small world, scale-free networks, and Hierarchical networks. Robustness of a Network: Topological, Functional and dynamical robustness. **Section B** Introduction to biological networks, properties and importance of biological networks. Types of biological networks. Protein interaction network, Types of Protein-Protein interactions (PPI): Stable, Transient, Physical, and Genetic interactions. Prediction of Protein-Protein interactions: experimental and computational methods. Databases of biological networks (STRING, BioGRID, STITCH and KEEG), Designing of network circuitry (CYTOSCAPE), Network layouts. **Section C** Gene Regulatory network: Methods for regulatory network reconstruction, Boolean and Bayesian network model. Multi-layer hierarchical structure of regulatory networks.Metabolic Network, Signaling networks and their identification methods Methods in system Biology: Interaction based method, Construction based methods, and Mechanism based methods. Visual representations and notations for systems biology, Metabolic Pathway visualization and editing software (MyBioNet, MetaViz, Cytoscape). Future for system	1. This course is being proposed to develop the holistic understanding of the biological systems. 2. Section A introduces the theory of networks. 3. Section B and C provides description of various regulatory networks of proteins and genes.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Biology. Synthetic biology and artificial gene circuits. **Suggested Books:** ➢ Klipp, E., Liebermeister W., Wierling C., Kowald A. & Herwig R. (2016). *Systems Biology: A Textbook*. Wiley – Blackwell. ➢ Covert, M.W. (2014). *Fundamental of Systems Biology: From Synthetic Circuits to Whole – Cell Models*. CRC press. ➢ Helms, V. (2008). *Principles of Computational Cell Biology*. Wiley – Blackwell. ➢ Panchenko, A. & Przytycka T.M. (Ed.) (2008). *Protein-protein Interactions and Networks: Identification, Computer Analysis, and Prediction*. Springer – Verlag London. ➢ Vadyanathan, S., Harrigan G.G. & Goodacre R. (2005). Metabolome analyses: Strategies for Systems Biology. Springer – Verlag. ➢ Alon, U. (2006). *An Introduction to Systems Biology: Design Principles of Biological Circuits.* Chapman & Hall/CRC, Tailor & Francis. **Suggested e-Resources:** ➢ **Network Biology** https://www.coursera.org/learn/network-biology ➢ **System Biology** https://www.coursera.org/learn/systems-biology ➢ **Synthetic Biology** https://www.edx.org/course/principles-of-synthetic-biology	
31.	**BIN 507** Mining and Warehousing of Biological Data	After successful completion of the course the candidates should be able to: • Understand the knowledge discovery from the databases.	**Mining and Warehousing of Biological Data** **Section A** **Fundamentals of Data Mining** – concept, definitions, why data mining, kind of data for data mining, knowledge discovery in databases (KDD), data mining functionalities, data mining primitives, classification of data mining systems,	**Suggested Books:** ➢ Han, J., Kamber, M. & Pei, J. (2012). *Data mining concept and technique* (3rd Ed.). Elsevier. ➢ Chen, J.Y. & Lonardi, S. (Eds.) (2017). *Biological Data Mining* (1st Ed.). Chapman and Hall/CRC. ➢ Elayidom, M. S. (2014). *Data Mining and Warehousing.* Cengage Learning.	No Change

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		• Categorizing the biological data based on various parameters. • Learn to use data mining tools.	data mining techniques, major issues in data mining. **Data Preprocessing** – Needs for preprocessing the data, data cleaning, data integration and transformation, data reduction, data discretization and concept hierarchy generation. **Data Warehousing** – need, definitions, characteristics, data marts, metadata, operational versus analytical databases, data warehouse architecture, multi dimensional data model, schemas for multidimensional databases, introduction to DMQL, implementation of data warehouse, OLAP, OLTP, ROLAP, MOLAP, HOLAP. **Section B** **Association Rules Mining** – market basket analysis, apriori algorithm, FP-growth method, Mining Multilevel Association Rules from Transaction Databases, Mining Multidimensional Association Rules **Classification and Prediction** – classification by decision tree induction, classification by back propagation, linear and non-linear regression, classifier accuracy. **Clustering** – types of data in clustering, categorization of clustering methods, Major Clustering Methods (K-means, Hierarchal clustering, DBSCAN). **Section C** **Mining Complex Types of Data -** Spatial databases, multimedia databases, time-series and sequence data, text mining, web mining, trends in data mining, Introduction to various data mining tools (SAS Enterprise Miner 5.1, Oracle Data Mining, SPSS Clementine 8.5).	➢ Baxevanis, A.D. & Ouellette, B.F.F. (2004). *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins* (3^{rd} Ed.). John Wiley. ➢ Morey, D., Maybury, M. & Thuraisinghan, B. (Eds) (2002). *Knowledge Management, Classic and Contemporary Works*; The MIT Press. **Suggested e-Resources:** ➢ **Data Mining** https://nptel.ac.in/courses/106105174/ ➢ **Data Mining: Concepts and Techniques** https://hanj.cs.illinois.edu/bk3/bk3_slidesindex.htm	

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Biological databases, Application of data mining in DNA/protein sequence analysis, protein structure analysis, gene expression analysis, application of specific examples of designing biological databases, application of mining and warehousing in bioinformatics.		
32.	**CS512** Cloud Computing	After successful completion of the course the candidates should be able to: • Understand virtualization of machines. • Learn to use various cloud platforms.	**Cloud Computing** **Section A** Introduction to Cloud Computing, Definition, Characteristics, Components, Administering & Monitoring cloud services, benefits and limitations, Deploy application over cloud, Cloud computing platforms: Infrastructure as service: Platform as Service: Google App Engine, Introduction to Cloud Technologies, Study of Hypervisors, Compare SOAP and REST, Web services, AJAX and mashups-Web services: SOAP and REST, SOAP versus REST, AJAX: asynchronous 'rich' interfaces, Mashups: user interface services. **Section B** Virtualization Technology: Virtual machine technology, virtualization applications in enterprises, Pitfalls of virtualization, Multitenant software: Multi-entity support, Multi-schema approach, Multitenance using cloud data stores, Data access control for enterprise applications. Data in the cloud: Relational databases, Cloud file systems: GFS and HDFS, Map-Reduce and extensions: Parallel computing. **Section C** Cloud security fundamentals, Vulnerability assessment tool for cloud, Privacy and Security in cloud, Cloud computing security architecture: Architectural Considerations- General Issues,	**Suggested Books:** ➢ Puttini, R., Erl, T. & Mahmood, Z. (2013) *Cloud Computing: Concepts, Technology & Architecture*. ➢ Rittinghouse, J.W. & Ransome, J.F. (2010).*Cloud Computing, Implementation, Management, and Security*. CRC Press. ➢ Hurwitz, J., Bloor, R., Kanfman, M. & Halper, F. (2009) *Cloud Computing for Dummies*.Wiley India Edition. ➢ Rafaels, R. (2015). *Cloud Computing from Beginning to End*. Createspace Independent Publishing. **Suggested e-Resources:** ➢ **Cloud Computing** https://nptel.ac.in/courses/106105167/1 ➢ **Cloud Computing Specialization** https://www.coursera.org/specializations/cloud-computing	No change

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Trusted Cloud computing, Secure Execution Environments and Communications, Micro-architectures; Identity Management and Access control Identity management, Access control, Autonomic Security Cloud computing security challenges: Virtualization security management virtual threats, VM Security Recommendations, VM-Specific Security techniques, Secure Execution Environments and Communications in cloud. Issues in cloud computing, Implementing real time application over cloud platform.		
33.	**BIO 503** Fundamentals of Bioentrepreneurship	After successful completion of the course, students should be able to: • Understand role of entrepreneurship in promoting innovation and wealth generation. • Develop skills for writing business models for new ideas and market segments. • Explain various financial, marketing, sales and legal issues associated with entrepreneurship.		**Fundamentals of Bioentrepreneurship** **Section-A** • Concept of entrepreneurship; Classification and types of entrepreneurship, Myths about entrepreneurship; Role of entrepreneurship in wealth building and creating an impact; Society, Technology and Entrepreneurship. • Creativity and Innovation; Types and forms of Innovation; Sources of innovative opportunity; Entrepreneurship as a career option. **Section-B** • Introduction to the Design Thinking Process; Problem identification; Idea Generation; Value Proposition; Lean Canvas. • Identifying Customer Segments; Idea Validation; Developing Business Model; Sizing the opportunity; Building MVP; Concept of Start-up, Importance of Incubation. **Section-C** • Financial and Non financial support: Revenue streams; Pricing and Costs; Sources of funds; Importance of project management. • Marketing and Sales: Positioning; Channels and	New elective proposed which is c.w. M.Sc BT, AMBT 3rd sem.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Strategy; Sales Planning. • Team: Importance of teambuilding; Complementary skill sets. • Legal issues: Brief overview of- intellectual property rights, patents, trademarks, copy rights, trade secrets, licensing and GI. • Business Plan writing. • Policies and Initiatives to promote Entrepreneurship in India. **Suggested Books:** ➢ Jain, P.C. (2001). Hand Book for New Entrepreneurs. UK: Oxford University Press. ➢ Hisrich R. D., Manimala M. J., Peters Michael P. & Shepherd D. A. Entrepreneurship (9th ed.). McGraw Hill Publication. ➢ Roy, R. (2011). Entrepreneurship (2nd ed.). UK: Oxford University Press. ➢ Drucker, P. (2015). Innovation and Entrepreneurship (1st ed.). Routledge Classics. ➢ Kotler, P & Keller, K.L. (2017).Marketing Management (15th ed.). Pearson Publications ➢ Desai, V. (2011) Dynamics of Entrepreneurial Development & Management (6t ed.). Mumbai: Himalaya Publishing House. ➢ Khanka, S.S. (2007) Entrepreneurial Development. New Delhi: S. Chand & Company Ltd. ➢ Mohanty, S K. (2005). Fundamentals of Entrepreneurship. EEE Prentice Hall India Learning Private Limited. ➢ Gupta C.B. & Srinivasan N.P. (2013). Entrepreneurship Development in India. Sultan Chand & Sons. ➢ Gupta A.K. (2016).Grassroots Innovations	

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				(Minds On the Margin Are Not Marginal Minds). Random House. ➢ Patzelt, H., &Bernner, T. (Eds.). (2008). Handbook of Bioentrepreneurship. Berlin, Germany: Springer. ➢ Robert, D. H., & Peters, M. P. (2002). Entrepreneurship. New York, USA: McGraw-Hill Education ➢ Shane, S. (2004). Academic Entrepreneurship: University Spinoffs and Wealth Creation. Northampton, M.A.: Edward Elgar **Suggested e-Resources:** ➢ https://www.startupcommons.org/what-is-startup-ecosystem.html ➢ https://getproductmarketfit.com/how-to-select-test-to-get-market-validation-for-new-product-or-business-idea/ ➢ https://www.coursera.org/learn/wharton-launching-startup ➢ https://www.coursera.org/learn/wharton-entrepreneurship-opportunity ➢ **Bioentrepreneurship** www.birac.nic.in/webcontent/jk.pdf ➢ **Biotechnology and entrepreneurship** http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.463.4354&rep=rep1&type=pdf ➢ **Accounts and Bioentrepreneur** https://www.nature.com/bioent/2003/031101/full/bioent779.html ➢ **Bioentrepreneurship** ➢ www.birac.nic.in/webcontent/jk.pdf	
34.	**CS530** Neural Networks	After successful completion of the course the candidates should be	**Neural Networks** **Section A** Introduction to Neural Networks, Models of a	**Suggested Books:** ➢ Bishop, C.M. (1995). *Neural Networks For Pattern Recognition*. Oxford University Press.	No Change

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		able to: • Understand the automated classification methods. • Learn the basic theory of artificial intelligence.	Neuron, Network architectures, feedback, learning process - error correction, learning, Hebbian, Competitive, Boltzman, Supervised and unsupervised learning, the perceptron model, Multilayer perceptrons. **Section B** Recurrent Networks, the Hopfield Network, the Boltzmann machine, its Markov Chain model, self organizing systems : Hebbian learning, Competitive learning. **Section C** Moduler Networks, associative Model, Stochastic Model, Temporal processing : Back propagation learning, real time recurrent networks. VLSI implementations of Neural Networks : Design considerations, Neurocomputing hardware.	➢ Fausett L.V. (2004). *Fundamentals of neural networks*. Pearson Education ➢ Gurney, K. (1997) *An introduction to neural networks* . CRC press. **Suggested e- Resources:** ➢ **Introduction to Neural Networks** http://www.cs.bham.ac.uk/~jxb/NN/ ➢ **Neural Networks and Deep Learning** https://www.coursera.org/learn/neural-networks-deep-learning	
35.	**BIN 510** Transcriptomics and Metabolomics		~~**Transcriptomics and Metabolomics**~~ ~~**Section A**~~ ~~Transcriptome and Transcriptomics, The Insights of Transcriptomics (mRNA regulation), Transcriptome Project (Human, Mouse, Cancer, Fungal). Genome Wide Gene Expression Analysis: cDNA Microarrays - Analysis of Microarray data, Application of Micro array. EST-expressed sequence tags, EST Genration, EST Clustering, ESTs and gene discovery, database and web tools for ESTs project. Serial analysis of gene expression (SAGE), SAGE data and its role in gene discovery, Tissue Specific Transcriptomics and Expression Pattern Analysis.~~ ~~**Section B**~~ ~~Transcriptomics in functional genomics, Transcriptomics and Disorders, Transcriptomics in drug design, Transcriptomics in Human cancer~~	Course is proposed to be discontinued	Course is proposed to be discontinued as the genetic engineering is being introduced in the second semester that fulfills the requirements of this course.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			~~hazard assessment, Transcriptomes and Phylogenetics applications, Impact of transcriptomics on Pharmaceutical Research. Tools for Transcriptomics and Transcriptome Analysis, Bioconductor. Introduction to Systems Biology, Computational Challenge in system Biology. Systems biology in drug discovery and pathway analysis.~~ ~~**Section C**~~ ~~Metabolome and Metabolomics, Metabolic profiling and fingerprinting, Metabolic pathway analysis and metabolic networks, Single Cell Metabolomics, Metabotype Concept. Computational Methods to Interpret and Integrate Metabolomic Data, Metabolomics data processing workflow, Online metabolic databases (Human Metabolome Databases, KEGG, BioCyc) and pipelines. Applications of Metabolomics: Drug screning, human health etc. Plant metabolomics.~~		
36.	**BT 514** Genetic Manipulation Technology		~~**Genetic Manipulation Technology**~~ ~~**Section A**~~ ~~Genetic engineering tools: Introduction, Historical perspective of Genetic Manipulation, Enzymes used in genetic engineering, Vectors used in genetic engineering pBR322 and pUC series, Lambda and M13 based vectors, Expression vectors, T-vectors, Animal and plant virus based cloning vectors, Gene cloning and expression in *E.coli* and yeast (*Saccharomyces cerevisia*). Construction of gene libraries, cDNA, PCR based cDNA, subtractive cDNA, normalized cDNA, Genomic DNA, BAC and YAC library.~~ ~~**Section B**~~ ~~Screening and identification of libraries.~~	Course is proposed to be discontinued	Course is proposed to be discontinud as the genetic engineering is being introduced in the second semester that fulfills the requirements of this course.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			~~Automated DNA sequencing, Illumina and Pyrosequencing based Next Generation Sequencing.Primer design, PCR: Nested PCR, 5' and 3' RACE PCR, inverse PCR, hybrid PCR, TAIL PCR, Real Time PCR, Cloning of PCR product. Promoters, Analysis of Gene Expression at transcription and translation level, Hybridization techniques, Transformation and transfection assays, In vitro mutagenesis, Antisense technology.~~ ~~**Section C**~~ ~~Genetically Modified Organisms: Introduction, Genetic transformation methods (*Agrobacterium* and virus mediated methods, Direct gene transfer by gene gun, electroporation, microinjection, Embryonic stem cells method). Choloroplast genetic engineering: Methodologies, foreign gene expression, advantages over nuclear transgenics, limitations, production of biopharmaceuticals. Applications of GMO (Agriculture, Pharmaceutical, Food, Beverages, Dairy, Poultry), Ethical, legal and social issues, IPR in transgenic technology, Biosafety guidelines.~~		
37.	**CS 518** Data Structure and Java Programming		~~**Data Structure and Java Programming**~~ ~~**Section A**~~ ~~Java Introduction: Evolution, features, concepts of Java Virtual Machine (JVM) and its task, Java and Internet, Environment (JRE, JDK, JSDK, APIs), Application & Applet, Java Programming: Structure of program, Data Types, Variables, Operators, Expressions, Control statements(sequencing, alteration, looping), Object oriented Concepts, Objects, Classes, data encapsulation & abstraction, Recursion, Constructors, Method Overloading, Arrays,~~	Course is proposed to be discontinued	1. This course is proposed to be discontinued. 2. To fulfill the requirement of Object Oriented Programming a new updated course on Python Programming is being proposed in third semester.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			~~String handling, , Access Specifier, Inheritance, Method Overriding, Interfaces.~~ ~~**Section B**~~ ~~Inner class, Anonymous classes, Wrapper classes, Vector, packages, Exception handling, Streams and I/O programming, Collection framework (List, Vector, tree), iterator, list iterator, Utility Classes.~~ ~~Concept of data structures, Abstract data type, and linear data structures: stack, queue, circular queue and their array implementations, application of stack and queue.~~ ~~**Section C**~~ ~~Linked list, implementation of singly, doubly & circular linked list, linked implementation of stack and queue. Non linear data structures: tree, basic terminology, binary tree, binary search tree (tree traversal, searching, insertion, and deletion), application of tree. Searching and sorting techniques: linear search, binary search, selection sort, bubble sort, insertion sort.~~		
38.	**BIO 501** Bioentrepreneurship		~~**Bioentrepreneurship**~~ ~~**Section A**~~ ~~Entrepreneurship: meaning and definition; fundamentals of entrepreneurship; development of entrepreneurship through training, achievement motivation training- theory and concept, Kakinada experiment: developing achievement motivation, experiential exercises, scoring and coding; Entrepreneurship in area of Biotechnology; MSMEs: definition, role in India's Economic development, regulations covering MSMEs, sources of information and non financial support, Incentives and benefits available to MSMEs entrepreneurs; schemes for~~	Course is proposed to be discontinued	Relevant portions merged with other courses.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			~~women entrepreneurs, psychological stress encountered by women in the light of her dual role and managing it.~~ ~~**Section B**~~ ~~Business Opportunity sensing and idea generation, Idea Feasibility testing through market research, Developing Vision and Mission statements, Deciding the offering and identifying target market, Positioning the offering, Designing Sales Process, Marketing mix and promotional strategies, Maintaining and hiring team, Knowing Competitors; preparing revenue model up to break-even point, Projecting future moves of business, Product Road Map, writing a detailed Business Plan, Basics of finance & accounting, Raising Funds- banks, financial institutions, venture capitalists, angel investors, bootstrapping; Role of incubation centres~~ ~~**Section C**~~ ~~Role of Knowledge centres like universities and institutions and R & D; Role of Technology and Upgradation; Managing technology transfer; Regulation for transfer of foreign Technology; Technology Transfer agencies; Business Crisis and its management; Ethical Entrepreneurship; Social Entrepreneurship; Use of IT in business administration, Available Software for better financial management; Setting an E-Business; Key Leadership and Management skills.~~		
39.	**CS 427** Parallel Computing		~~**Parallel Computing**~~ ~~Section A~~ ~~Introduction to parallel computing, advantages of parallel computing. Solving problems in parallel : Temporal parallelism, Data parallelism and their comparison. Intertask dependency and task~~	Course is proposed to be discontinued	This course is being proposed to discontinue as it is of no relevance to Bioinformatics.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			~~graphs. Structures of parallel computers: Pipelined~~ ~~Papralle computers, Array processors, Shared memory multi-processor, message passing multiprocesors, MMC systems. Integer Arithmetic : Carry look-ahead addition and carry-save addition on binary tree, integer multiplication and convolution on a linear array. Elementary sorting algorithm.~~ ~~Section B~~ ~~Matrix Algorithms : Matrix-Vector multiplication and solving lower triangular system of equations on a linear array, matrix multiplication, LU decomposition, matrix inversion, Guassian elimination on a mesh.~~ ~~Graph Algorithms : Mesh algorithm for tranisitive closure, connected component, shortest path, breadth first search and minimum spanning tree. Mesh of trees and its applications such as Matrix-Vector multiplication, Convolution and integer multiplication.~~ ~~Section C~~ ~~More fancier networks : r-dimensional mesh of trees, shuffle trees, shuffle-exchange network, hypercube, De-bruijn network and butterfly. Some examples on these networks, sorting and FFT on butterfly.~~ ~~Introduction to dataflow computers. Parallelism in logic programming. Programming parallel computers~~		
40.	**CS 507** Artificial Intelligence		**Artificial Intelligence** Section A Introduction to Artificial Intelligence, General	**Suggested Books:** ➢ Elaine, R., & , Kevin, K. (1991) *Artificial Intelligence*. Mc-Graw Hill. ➢ Patterson, D.W. (1990) *Introduction to Artificial*	No Change

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			problem solving, state space and graph model techniques, Heuristic designs, Aim-oriented heuristic algorithms versus solution guaranted algorithms, Game playing strategies. Knowledge representation : Knowledge representation tools, First order predicate calculus. The language PROLOG - sementic nets, partitioned nets, Minsky's frames, case grammer theory, production rules, knowledge base, the inference system, forward and backward deduction. Section B Understanding Natural Language, Parsing techniques, context free and transformational grammer, transition net, augumented transition nets, Fillmore's grammer, Shanks conceptual dependency. Grammer free analysers, Sentence generation, Translation. Expert systems : Structure, development tools, uncertainty considerations, domain exploration, meta knowledge, expertize transfer, existing systems (DENDRAL, MYCIN) , self explaining systems. Section C Pattern recognition : Structured description, symbolic description; machine perception: Vision & Speech; techniques used in solving preceptual problems, analysing visual clues (edge detection) ; speech recognition : Problems in speech recognition, analyzing speech, Introduction to machine **Recommended Books** 1. Rich Elaine & Knight Kevin, Artificial Intelligence, Mc-Graw Hill, 1991. 2. Patterson Dan W, Introduction to Artificial Intelligence and Expert Systems, PHI., India,	*Intelligence and Expert Systems*. PHI., India. ➢ Barr, A. & Feigenbauen, E.A. 1982. *The Handbook of Artificial Intelligence*. Addison-Wesley Pub, Vol I, Vol II, Vol III. ➢ Allen, J. (1995) *Natural Language Understanding*. 2nd Edition, Pearson Education India. ➢ Nilsson, N.J. (1991) *Principles of Artificial Intelligence.* Narosa Publishing. ➢ Nilsson, N.J. (1998) *AI: A New Synthesis*. Morgan Kaufmann Inc. ➢ Russell, S. & Norvig, P. (2002) *Artificial Intelligence: A Modern Approach*, Prentice Hall. ➢ Luger, G.F. (2002) *Artificial Intelligence: Structures and Strategies for Complex Problem Solving.* Addison-Wesley. ➢ Jackson, P. (1998) Introduction to Expert Systems. Addison Wesley. ➢ Charniak E. & McDermott D. (1985) Introduction to Artificial Intelligence, Addison Wesley. ➢ Tau & Genzales (1994) Pattern Recognition Principles. Addison-Wesley.	

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			1990. 3. Avron Barr & Edward A. Feigenbauen, The Handbook of Artificial Intelligence., Addison-Wesley Pub, Vol I, Vol II, Vol III, 1982 4. James Allen, Natural Language Understanding, 2nd Edition, Pearson Education India, 1995. 5. Nilsson N.J., Principles of Artificial Intelligence, Narosa Publishing, 1991. 6. Nils J. Nilsson , "AI: A New Synthesis", by, Morgan Kaufmann Inc., 1998 7. Stuart Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach", Prentice Hall, 2002 8. George F. Luger, "Artificial Intelligence: Structures and Strategies for Complex Problem Solving", Addison-Wesley, 2002 9. Jackson Peter, Introduction to Expert Systems, Addison Wesley, 1998. 10. Charniak E. & McDermott D., Introduction to Artificial Intelligence, Addison Wesley, 1985. 11. Tau & Genzales, Pattern Recognition Principles, Addison-Wesley, 1974.		
41.	**BIN601R** Chemoinformatics	On completion of this course, students should be able to: • Understand the computational methods implemented for the chemistry. • Learn about different databases and techniques of chemoinformatics.	**Chemoinformatics** ~~Introduction to cheminformatics, History and Evolution of cheminformatics, Use of cheminformatics, Molecular Modeling and Structure Elucidation.~~ ~~Nomenclature; Different types of Notations; SMILES coding; Matrix Representations; Structure of Molfiles and Sdfiles; Libraries and toolkits; Different electronic effects; Reaction classification.~~ ~~Design of Chemical Databases, Metadatabases, Structure databases; Reaction Databases; Literature Databases; Medline; GenBank; PIR; CAS Registry; National Cancer Institute (NCI) Database.~~	**Chemoinformatics** The informatics has influenced the fate of chemical sciences since last quarter of the 20th century, with evolution of computational methods such as combinatorial libraries, virtual screening and molecular modeling has led the medicinal chemists to speed up the drug discovery. To store the data computational chemists uses different nomenclatures such as SMILES and variety of file formats like MOL, MOL2 and SDF. The entire chemical space has been maintained in various databases such as PUBCHEM, DRUGBANK, NCI and ZINC. Further, the details of chemical reactions and novelty of the chemical species are maintained at chemical abstract service (CAS).	New reading elective is being proposed.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			~~Searching Chemical Structure: Full structure search; sub structure search; basic ideas; similarity search; Three dimensional search methods; Basics of Computation of Physical and Chemical Data and structure descriptors; Data visualization and Non-linear Mapping.~~ ~~Prediction of Properties of Compounds; Model Building; Modeling Toxicity; Structure-Spectra correlations, Computer Assisted Structure elucidations; Computer Assisted Synthesis Design, Application of Cheminformatics in Drug Design~~**.**	Searching full or fragments of chemical structures involves pharmacophore methods, that forms the ground for ligand based drug discovery programs. The methods involve 3D searching of chemical space; Predicting different physico-chemical properties, toxicity of compounds has been a challenging task since the inception of chemoinformatics. **Suggested Books:** ➢ Leach A.R. Gillet V.J. (2007), An Introduction to Chemoinformatics. Springer Netherlands. ➢ Goodman J.M. (1998), Chemical Applications of Molecular Modelling, RSC Publications. ➢ Varnek A. (Ed.) (2017) Tutorials in Chemoinformatics. John Wiley and Sons Ltd. ➢ Bunin B.A., Siesel B., Morales G. & Bajorath J. (2007), Chemoinformatics: theory, practice and products. Springer Netherlands **Suggested E-resources** ➢ **Chemoinformatics** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6146447/ ➢ **Databases and tools of medicinal chemistry** https://core.ac.uk/download/pdf/82152489.pdf	
42.	**BIN602R** Immunoinformatics	On completion of this course, students should be able to: • Develop an understanding of immunology. • Understand the computational methods implemented for the immunology. • Learn about different databases of	**Immunoinformatics** ~~Concepts in Immunology: Classification of Immunity, Antigens, Antibodies, The Compliment System, Antigen-Antibody Reactions, The Major Histocompatibility Comples, Antigen Presentation, TAP, T and B cell receptors.~~ ~~Immune Effector Mechanisms: Cytokines and Chemokines, Hypersensitive Reactions.~~ ~~The Immune system in Health and Disease: Autoimmunity, Transplantation Immunology, Classification of Vaccine Haptens, Carrier~~	**Immunoinformatics** Immunology is a core biological science course that deals with the immunity, classification of Immunity, antigens, Immunoglobulins and biochemical processes in antigen – antibody reactions. The antigen representation is a challenging task to understand the antigen – antibody reactions, which are followed by th major histocompatibility complexes and variety of receptors such as T and B cell receptors. The immunology has played a great role in human health improvement by development of vaccines and organ transplantation. However, hyper-activation of immune	New reading elective is being proposed.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		immunological importance.	~~Proteins, and Anti-Hapten Antibodies.~~ ~~Databases searching: Databases related with immunology (eg.dbMHC, IMGT, IPD, SYFPEITHI, Bcipep etc.)~~ ~~Predicting Preptide-MHC Binding: Peptide-MHC Binding Using Profiles, Machine Learning Techniques for MHC Binders, Artificial Intellingence Methods for Predicting T-Cell Epitopes, MHC-Class I and II Binding Affinity MHC-Molecular Affinity and QSAR Models, Support Vector Machine for MHC-Binding Peptides.~~	system may result in the autoimmune disorders such as psoriasis. The informatics is currently playing great role in immunological sciences such as by developing databases dbMHC, IMGT, IPD, SYFPEITHI, Bcipep etc.). Bioinformatics methods such as molecular modeling, Protein – Protein/Peptide interactions are routinely being used to understand the Preptide-MHC Binding. Further the machine learning techniques are also being used to predict the MHC Binders, T-Cell Epitopes, MHC-Class I and II Binding Affinity. **Suggested Books:** Punt J., Stranford S., Jones P. & Owens J.A. (2018), Kuby Immunology (8th Ed.); W.H. Freeman & Company. ➢ Roitt I.M. & Delves P.J. (2001) Roitt's Essential Immunology(10th Ed.) Blackwell Science Ltd. ➢ Flower D.R. (Ed.) (2007) Immunoinformatics: Predicting Immunogenicity in-silico. Humana Press: Methods in Molecular Biology. **Suggested E-Resources:** ➢ **Immunoinformatics** http://www.imgt.org/about/immunoinformatics.php	
43.	**Drug Discovery**	On completion of this course, students should be able to: • Understand basics of R&D in drug discovery and should be able to apply knowledge gained in respective fields of pharmaceutical industry. • Understand the role of		Modern drug discovery involves the identification of a target or drug lead using different techniques including molecular modeling, combinatorial libraries and high-throughput screening (HTS). Rational drug design is based on the understanding of the three-dimensional structures and physicochemical properties of drugs and receptors. Knowledge of molecular mechanisms, molecular dynamics simulations and homology modeling is necessary for studying drug/receptor interactions. The different conformational sampling techniques, fitness functions used in molecular docking and computational	New Course Proposed. c.w. M.Sc BT, AMBT 3rd/4th sem.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		synthetic chemistry in the development of pharmaceutical agents; and the modification of chemical structures to develop new drug molecules. • Have an advanced understanding of the chemical structure of a pharmaceutical agent and determine the chemical group/s responsible for a given biological effect. • Demonstrate a basic understanding of pharmacogenomics and bioinformatics as it relates to drug design and discovery. • Develop an understanding of drug targets as a recognition site for pharmaceutical agents; how the chemical structure of a substance influences interaction with a drug target; and the identification of new drug targets for future drug discovery.		receptor-based and ligand-based drug design approaches are mostly used to design compounds with improved biological activity in rational drug design. Quantitative drug design using QSAR models are used to correlate structural molecular properties (descriptors) with functions (i.e. physicochemical properties, biological activities, toxicity, etc.) of the compounds. Understanding the structure activity relationship between the 3D structure of a molecule and its biological activity may act as the basis for the prediction of compounds with improved biological activities. Different bio-analytical assays (LC/MS/MS, GC/MS and ELISA) could be developed further in support of *in vitro* and *in vivo* studies. Understanding the principles as well as an early characterization of drug toxicity, adsorption, distribution, metabolism and excretion (ADME) along with drug-drug interactions, plasma protein binding assays and metabolite profile studies helps in eliminating compounds with unacceptable pharmacokinetic characteristics, which is critical to successful drug discovery programs. **Suggested Books:** ➢ Krogsgaard-Larsen *et. al.* (2016). *Textbook of Drug Design and Discovery*. 5th Edition. CRC Press. ➢ Satyanarayanajois, S. D. (2011). *Drug Design and Discovery: Methods and Protocols*. Humana Press. ➢ Rahman, A. U., Caldwell, G. W., and Choudhary, M. I. (2007). *Frontiers in Drug Design and Discovery*. Bentham Science publishers Limited. ➢ Dastmalchi, S. *et. al.* (2016). *Methods and Algorithms for Molecular Docking-Based Drug Design and Discovery*. IGI Global. **Suggested e- Resources:**	

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				➢ **Drug Discovery** https://bit.ly/2tCqdtE ➢ **Peptide therapeutics** https://www.sciencedirect.com/science/article/pii/S1359644614003997 ➢ **Bio-analytical techniques** https://www.pharmatutor.org/articles/bioanalytical-techniques-overview	
44.	**Human Genetics and Diseases**	After successful completion of the course students will be able to: • Understand hereditary and molecular genetics with a strong human disease perspective. • Describe genetic abnormalities underlying human disease and disorders • Develop interest in biomedical research, genetic counseling, medicine, and clinical genetics		Since the rediscovery of Mendel's work in 1900, investigations on the genetic nature of human traits have gained significant importance. Understanding the genetic basis behind human disease is one of the most important reasons to study human chromosome structure, human karyotype, banding techniques, chromosome identification and nomenclature (ISCN)**.** Classical genetics has considerable importance in constructing genetic hypothesis from pedigree data analysis in monogenetic traits, autosomal dominant, autosomal recessive, sex linked dominant, sex linked recessive and sex influenced traits. The impact of consanguinity in causing sex linked anomalies (haemophilia, colour blindness and Duchenne Muscular Dystrophy) has been observed in human population. Current knowledge on genetic variations across populations is applied to study human health and diseases which include chromosomal disorders, structural and numerical chromosomal anomalies (Klinefelter syndrome, Down's syndrome, Turner syndrome, Achondroplasia), inborn errors of metabolism (Phenylketonuria (PKU), Alkaptonuria, Albinism, Galactosemia), haemoglobinopathies, Thalassemia syndromes, multifactorial disorders (diabetes, schizophrenia, huntington disease). Medical genetics involves ethical issues therefore serious discussion is required for prenatal/adult diagnosis of	New Course Proposed. c.w. M.Sc BT, AMBT 3rd/4th sem.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				genetic disorders, medical ethics, risks and benefits, informed consent and right of choice. **Suggested Books: Suggested Books:** ➢ Strachan T. & Read. A. (2011). *Human Molecular Genetics*(4th ed.). Garland Science ➢ Pasternak J. Fitzgerald. (1999). *An introduction to Human Molecular Genetics-Mechanism of Inherited Diseases*. Science Press. ➢ Thompson and Thompson.(2007).*Genetics in Medicine (7th Ed.*).Saunders **Suggested e- Resources** ➢ **Chromosome identification and nomenclature (ISCN)** http://www.cydas.org/Resources/ISCN_Discussion.html ➢ **Pedigree data analysis** https://learn.genetics.utah.edu/content/disorders/ ➢ **Genetic disorders** https://www.genome.gov/10001204/specific-genetic-disorders/ ➢ **Prenatal/ adult diagnosis of genetic disorders, medical ethics** https://www.michiganallianceforfamilies.org/all/#sectionD	
45.	**Protein Engineering**	On completion of this course, students should be able to: • Analyse structure and construction of proteins by computer-based methods • Describe structure and classification of proteins • Analyse and compare		An introduction to protein engineering for developing proteins with desired functions. Various methods (rational design and directed evolution) of protein engineering are employed to manipulate the different features or characteristics (affinity, specificity and stability etc) of proteins. Engineering various physicochemical and biological properties (stability to changes in parameters as pH, temperature, amino acid sequence and aggregation propensities etc) of the proteins could be important in their use as protein drugs and/or catalysts in bioreactors. The insight into	New Course Proposed. c.w. M.Sc BT, AMBT 3rd/4th sem.

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		the amino acid sequence and structure of proteins, and relate this information to the function of proteins • Explain how proteins can be used for different industrial and academic purposes such as structure determination, organic synthesis and drug design. • Plan and carry out activity measurements of isolated proteins and characterize their purity and stability.		the fundamental understanding of the mechanisms and forces (Van der waals, electrostatic, hydrogen bonding, weakly polar interactions, and hydrophobic effects), by which protein stabilizes, will help in the formulation of protein based pharmaceuticals. Protein engineering with site-specifically incorporation of unnatural or non-canonical amino acids has been used to improve protein function for medical and industrial applications. Different computational approaches (sequence and 3D structure analysis, data mining, Ramachandran map etc) to protein engineering would help to address the requirements in order to find amino acid sequences that will optimize a desired property (physicochemical property and/or biological function) of a protein. Determination of the physicochemical properties of proteins using various spectroscopic methods (Far-UV and Near-UV CD, Fluorescence, UV absorbance and Optical rotatory dispersion) would further support the drug development process. Yeast surface display (YSD)has become a valuable protein engineering tool for modifying the affinity, specificity, and stability of antibodies, as well as other proteins. YSD could be successfully used for protein epitope mapping, identification of protein-protein interactions, and uses of displayed proteins in industry and medicine. Developing vaccines and peptidomimetics will further allow the investigators to identify novel therapeutic leads for numerous unmet clinical needs. **Suggested Books:** ➢ Walsh, G.(2014). *Proteins: Biochemistry and Biotechnology*, Second edition. Chichester, West Sussex: Wiley Blackwell. ➢ Creighton, T. E. (1997). *Protein Structure: a Practical Approach*, 2nd Edition. Oxford	

S.No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				University press. ➢ Cleland, J. L., and Craik, C. S. (2006). *Protein Engineering, Principles and Practice*, Vol 7. Springer Netherlands. ➢ Mueller, K., and Arndt, K. (2006). *Protein Engineering Protocols*, 1st Edition. Humana Press. ➢ Robertson, D., and Noel, J. P. (2004). *Protein Engineering Methods in Enzymology*, Vol 388. Elsevier Academic Press. ➢ Kyte, J. (2006). *Structure in Protein Chemistry*, 2nd Edition. Garland publishers. ➢ Williamson, M. P. (2012). *How proteins work*. New York: Garland Science. **Suggested E- Resources:** ➢ **Protein Engineering**: https://nptel.ac.in/courses/102103017/pdf/lecture%2022.pdf ➢ **Conformational stability of proteins**: https://bit.ly/2ViS7GQ ➢ **Protein Engineering with Non-Natural Amino Acids:** https://library.umac.mo/ebooks/b2805488x.pdf	

BANASTHALI VIDYAPITH

Department of Bioscience and Biotechnology

M. Tech PROGRAMME EDUCATIONAL OBJECTIVES

The M. Tech. Biotechnology programme aims at overall growth and development of the students considering the exclusive five fold Educational ideology of Banasthali Vidyapith.

Biotechnology is a broad discipline of biological science dealing with commercial exploitation of living organisms and their products for the welfare of mankind. Past few decades have witnessed a steady growth towards invention and innovation oriented research. Thus, the M. Tech Biotechnology programme has been designed to provide knowledge, which can be applied by the students in various related R & D sectors and industries, to find solutions pertaining to bioproduct, bioprocesses, and technology development. It will also help them to inculcate the spirit of teamwork together with leadership qualities. The key objectives of the programme are:

- To provide expertise in various tools and techniques of biotechnology
- To facilitate postgraduates to identify, formulate and analyze complex biotechnological challenges
- To address the societal, ethical and environmental issues that a biotechnologist is facing
- To nurture competence in digital literacy that would support professional needs in biotechnology
- To nurture a temperament that would enable students to develop technical proficiency that can be used to cater the performance driven needs of industry, academia, research and startups
- To strengthen communication, entrepreneurial and leadership skills, which will promote a lifelong learning.

BANASTHALI VIDYAPITH
Department of Bioscience and Biotechnology
M.Tech. BIOTECHNOLOGY PROGRAMME OUTCOMES

PO1: Knowledge: Enriched with the knowledge of core domain like cytology, microbiology, genetics, biochemistry along with applied field including genetic engineering, cell culture, immunology, bioinformatics, bioprocess engineering, food engineering.

PO2: Planning ability: Instill effective time and resource management skill accompanied with good team practices and organizational abilities

PO3: Problem analysis: Utilize technical skills to design, conduct experiments, analyze and interpret data for investigating problems in biotechnology.

PO4: Modern tool usage: Apply appropriate methodologies, resources, and techniques for biological manipulation and data interpretation.

PO5: Leadership skills: Work as effective leader by applying his reasoning skill to assess societal, environmental, safety and legal issues of biotechnology sectors..

PO6: Professional Identity: Understand their responsibility for biotechnology engineering practices and work efficiently with multi-disciplinary team in research lab and industry

PO7: Bitechnology ethics : Understand the regulatory norms and ethics for production of various products and process development in biotechnology sectors.

PO8: Communication: Work as impressive personality in industry and research lab with eloquent communication skill of both oral and written form.

PO9: The Biotechnology and society: Acquire the technical skills in solving societal challenges related to healthcare, food and environmental sectors through Biotechnological approaches.

PO10: Environment and sustainability: Understand the impact of the biotechnology solutions on societal and environmental contexts and need for sustainable development.

PO11: Life-long learning: Develop confidence for self education and ability for life-long learning of latest development of technology.

Appendix-VIIIC

Department of Bioscience and Biotechnology, Banasthali Vidyapith
M. Tech Biotechnology

Existing Courses					
M. Tech. Biotechnology Sem. I		**L**	**T**	**P**	**C**
BT 501	Advanced Cell Biology	4	0	0	4
BT 502	Bioprocess Engineering-I	4	0	0	4
BIN 501	Biological Databases and Computational Biology	4	0	0	4
BT 511	Enzyme Technology	4	0	0	4
BT 505L	Biotechnology Lab-I	0	0	12	6
MATH 506	Engineering Mathematics	4	0	0	4
	Total	**20**	**0**	**12**	**26**

Proposed Courses					
M. Tech. Biotechnology Sem. I		**L**	**T**	**P**	**C**
BT	Advanced Cell Biology	4	0	0	4
BIN	Biological Databases and Computational Biology	4	0	0	4
MATH 506	Engineering Mathematics	4	0	0	4
BT	Term Paper-I/Minor Project	0	0	8	4
BT	Elective I	4	0	0	4
BT L	Biotechnology Lab-I	0	0	12	6
	Total	**16**	**0**	**20**	**26**

Existing Courses					
M. Tech. Biotechnology Sem. II		**L**	**T**	**P**	**C**
BT 503	Bioprocess Engineering-II	4	0	0	4
BT 514	Genetic Manipulation Technology (C.W. M.Sc. Sem IV Bioinfo BT 514)	4	0	0	4
BT 516	Immunotechnology	4	0	0	4
BT 520	Plant and Animal Cell Culture Technology	4	0	0	4
BT 512	Elective*	4	0	0	4
BT 506L	Biotechnology Lab-II	0	0	12	6
	Total	**20**	**0**	**12**	**26**
	Electives*				
BIN 502	Computer Aided Drug Designing	4	0	0	4
BIN 503	Elements of Bioinformatics	4	0	0	4
BIO 417	Structural Biology	4	0	0	4
BIO 501	Bioentrepreneurship	4	0	0	4
BIO 502	Cancer Biology	4	0	0	4
BT 510	Environmental Biotechnology	4	0	0	4
BT 512	Food Biotechnology	4	0	0	4
BT 517	Medical Biotechnology	4	0	0	4
BT 519	Nanobiotechnology	4	0	0	4

Proposed Courses					
M. Tech. Biotechnology Sem. II		**L**	**T**	**P**	**C**
BT 503	Bioprocess Engineering	4	0	0	4
BT 514	Genetic Manipulation Technology	4	0	0	4
BT	Term paper-II/Minor project	0	0	8	4
BT	Elective-II	4	0	0	4
	Open Elective	4	0	0	4
BT 506L	Biotechnology Lab-II	0	0	12	6
	Total	**16**	**0**	**20**	**26**

Existing Courses					
M. Tech. Biotechnology Sem. III		**L**	**T**	**P**	**C**
	Reading Electives - I*	0	0	4	2
BT 602P	Project Part - I	0	0	48	24
	Total	**0**	**0**	**52**	**26**

Proposed Courses					
M. Tech. Biotechnology Sem. III		**L**	**T**	**P**	**C**
	Reading Elective - I	0	0	0	2
BT 602P	Project Part - I	0	0	48	24
	Total	**0**	**0**	48	**26**

Existing Courses					
M. Tech. Biotechnology Sem. IV		**L**	**T**	**P**	**C**
	Reading Electives - II	0	0	4	2
BT 603P	Project Part - II	0	0	48	24
	Total	**0**	**0**	**52**	**26**
Reading Electives I/ II					
BIO 601R	Biodiversity and Conservation	0	0	4	2
BIO 602R	Bioethics, Biosafety and IPR	0	0	4	2
BT 604R	Renewable Energy Sources	0	0	4	2

Proposed Courses					
M. Tech. Biotechnology Sem. IV		**L**	**T**	**P**	**C**
	Reading Elective - II	0	0	0	2
BT 603P	Project Part - II	0	0	48	24
	Total	**0**	**0**	48	**26**

(red)	Course proposed to be discontinued
(yellow)	Course content modified
(peach)	Course shifted to different semester
(green)	New course proposed
(purple)	Course shifted from different programme
(light green)	Course shifted from core to elective course

	Proposed List of Electives proposed to be offered in I & II Semester
BIN 502	Computer Aided Drug Designing
BIN 503	Elements of Bioinformatics
BIO 417	Structural Biology
BIO 501	Bioentrepreneurship
BIO 502	Cancer Biology
BT 510	Environmental Biotechnology
BT	Food Biotechnology
BT 517	Medical Biotechnology
BT 519	Nanobiotechnology
BT	Enzyme Technology
BT	Immunotechnology
	Proposed List of Reading Elective-I & II proposed to be offered in III & IV Semester
BT	Molecular Plant Breeding
	Intellectual Property Rights
BT	Human Genetics and Diseases
BT	Medical Microbiology
BT	Protein Engineering
BT	Drug Discovery
BT	Downstream Processing http://nptel.ac.in/syllabus/102106022
BT	Bioreactor https://swayam.gov.in/course/1339-bioreactors
BT	Mass Spectrometry based Proteomics https://onlinecourses.nptel.ac.in/noc15_bt05/preview https://swayam.gov.in/search?keyword=Mass%20spectrometry%20based%20proteomics

Comparative Table: M. Tech. Biotechnology: Existing and Modified syllabus, Suggested Books and Suggested e-Resources

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
M. Tech. Biotechnology I Semester					
1)	**BT 501** Advanced Cell Biology	After successful completion of the course, students should be able to: • Describe processes in cell biology • Compare the role of various characteristic bio-molecules of living organisms. • Apply concepts of cell biology to relevant and specific problems	**Section A** ~~Basic overview of cell organelles, cell cycle, cell membrane, cytoskeleton, cell motility and shape. Mitochondria: membrane organization, transport of proteins into mitochondria and chloroplasts. Semiautonomous organelles concept, cell-cell signaling. DNA~~ replication, Transcription and Translation. **Section B** Lysosomes: intracellular digestion, sorting of lysosomal enzymes in Golgi, lysosomal storage diseases. ~~Signal hypothesis:~~ Concept of signal peptide, SRP, SRP Receptor, transport of soluble and membrane bound proteins in Endoplasmic Reticulum, ER Resident proteins, ER chaperone proteins and their functions, protein glycosylation. **Section C** ~~DNA -protein interaction: Mobility shift DNA binding assay, Methylation and Uracil interference assay, DNase I foot printing, UV cross linking of protein to nucleic acid. Yeast one and two hybrid system for DNA -protein/ protein-protein interaction .Expression of~~	**Section-A** • Replication of genetic material in prokaryotes and eukaryotes, Replication of single stranded circular DNA. • Prokaryotic transcription and Anti-termination; Eukaryotic transcription • Post transcriptional modifications: processing of hnRNA, tRNA and rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; Splicing; RNA editing; Nuclear export of mRNA; Catalytic RNA. • Translation: Genetic code; Translation machinery; Isoaccepting tRNA; Mechanism of initiation, elongation and termination; post-translational modifications. **Section B** • Molecular structure and function: Structural models, Composition and dynamics; Transport of ions and macromolecules; Pumps, carriers and channels; Membrane carbohydrates and their significance in cellular recognition; cellular junctions and adhesions; structure and functional significance of plasmodesmata. • Endocytosis and exocytosis, clathrin & coatomer coated vesicles, SNARE proteins. • Cell to cell signalling : autocrine, paracrine and endocrine stimulation. Signaling via G-protein linked cell-surface receptors, adenylate cyclase system, inositol phosphate pathway, role of Ca^{2+} -ions; signalling via enzyme-linked surface receptors, tyrosine kinases. Steroid receptors. **Section C** • Cell cycle and its regulation, apoptosis. • Transport of proteins into mitochondria and chloroplasts. • Concept of signal peptide, SRP, SRP Receptor, transport of soluble and membrane bound proteins in Endoplasmic Reticulum, ER Resident proteins, ER chaperone proteins and	The contents have been rearranged with incorporation of new and relevant topics in all the sections.

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			~~proteins in E.coli, insect cell and Mammalian cell, GST- fusion protein purification, Far western analysis, FISH & GISH techniques.~~ **Books Recommended:** ➢ Cell and Molecular Biology : De Robertis & De Robertis, B.I. Waverly Pvt. Ltd., New Delhi. ➢ The world of the cell : W.M. Becker, Pearson Education. ➢ Cell and Molecular Biology : G. Karp, John Wiley & Sons. ➢ The Cell - A Molecular Approach : Cooper, Sinauer. ➢ Cell and Molecular Biology : P.K. Gupta, Rastogi Publications. ➢ Molecular Cell Biology : Lodish, Baltimore, W. H. Freeman & Co. ➢ Molecular Biology of the Cell : Bruce Albert, Garland Publication, NY. ➢ Essentials of Cytology : C.B. Powar, Himalaya Publications. ➢ Principles of Genetics : Gardner, Simmons, Snustad, John Wiley & Sons. ➢ Gene VIII : Lewin, Pearson Education.	their functions, glycosylation of proteins in ER. Golgi apparatus, role in protein glycosylation and transport. • Lysosomes, intracellular digestion, sorting of lysosomal enzymes in Golgi, lysosomal storage diseases. **Suggested Books:** ➢ Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008). *Molecular Biology of the Cell* (5th Ed.). New York: Garland Science. ➢ Cooper, G. M., & Hausman, R. E. (2013). *The Cell: a Molecular Approach* (6th Ed.). Washington: ASM ; Sunderland. ➢ Gardner, E. J., Simmons, M. J., & Snustad, D. P. (1991). *Principles of genetics*. New York: J. Wiley. ➢ Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2012). *Becker's World of the Cell*. Boston (8th Ed.). Benjamin Cummings. ➢ Karp, G. (2008). *Cell and molecular biology: Concepts and experiments*. *John New Jersey: Wiley and Sons* ➢ Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014). *Lewin's Genes XI*. Burlington, MA: Jones & Bartlett Learning. ➢ Lodish, H. F. (2016). *Molecular Cell Biology* (8th Ed.). New York: W.H. Freeman. ➢ Watson, J. D. (2008). *Molecular Biology of the Gene* (5th ed.). Menlo Park, CA: Benjamin/Cummings. **Suggested e-Resources:** ➢ **mRNA export** https://www.researchgate.net/profile/Evelina_Tutucci/publication/51156486_Keeping_mRNPs_in_check_during_assembly_and_nuclear_export/links/02e7e5213704c24e86000000/Keeping-mRNPs-in-check-during-assembly-and-nuclear-export.pdf ➢ **ER chaperons and folding enzymes** https://iubmb.onlinelibrary.wiley.com/doi/full/10.1002/iub.1272	

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				➢ **Lysosomal storage disorders** https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1365-2141.2004.05293.x	
2)	**BT 502:** ~~Bioprocess Engineering-I~~				The contents of the first semester core course BT 502: “Bioprocess Engineering-I” and second semester core course BT 503: “Bioprocess engineering-II” are proposed to be merged, modified and offered as new common course named as “Bioprocess engineering” in the second semester of the programme.
3)	**BIN 5** Biological Databases and Computational Biology	After successful completion of the course, students should be able to: • Mine the biological databases to identify relevant sequence/structure for studies • Carry out sequence based evolutionary	**Section A** Biological Databases: Primary Secondary, Composite Databases ~~& their file formats~~. Nucleic Acids (GenBank, DDBJ, EMBL), Proteins (SWISS-PROT, PIR), Structures (PDB, ~~HSSP,~~ SCOP, ~~FSSP~~, CATH), Specialized (KEGG, Transfac, ReBase), Submission & Retrieval of data from public databases. **Section B** Sequence alignment: Local and Global alignment concepts, Scoring matrices - PAM and BLOSUM, Gap penalties, Dot Plot, Dynamic programming ~~methodology-~~ Needleman- Wunsch algorithm, Smith-	**Section A** • Introduction to biological Databases: primary, secondary, composite databases. • Sequence databases: Nucleic Acids (GenBank, DDBJ, EMBL), Proteins (SWISS-PROT, PIR) • Structures Databases: PDB, SCOP, CATH. • Specialized databases: KEGG, Transfac, ReBase • Submission and retrieval of data to/from public databases. **Section B** • Introduction to Sequence alignment: dot plot, scoring matrices (PAM and BLOSUM), gap penalties, ends free alignment.	HSSP and FSSP are part of PDB annotation system Local is SW algorithm and Global is NW algorithm therefore

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		studies • Perform molecular modeling studies with biological macromolecules and explain the results	Waterman algorithm, Databases similarity searching: Algorithms of FASTA, BLAST ~~and their variants~~, Multiple sequence alignment, Progressive alignment. **Section C** ~~Detecting~~ ORF's, Gene ~~finding methods~~: ~~content and signal methods,~~ ~~Genome comparison~~, ~~Markov chain, Random Walk, Hidden Markov models,~~ Docking and modeling substrate receptor interactions. Methods for Phylogenetic analysis: Distance and Character based methods. **Books Recommended:** ➢ Bioinformatics –Sequence and Genome analysis- David W. mount. ➢ Bioinformatics-from Genomes to drugs- Thomas lengauer. ➢ Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids, Richard Durbin, S. Eddy, A. Krogh, G. Mitchison. ➢ David Mount (2001) Bioinformatics – Sequence and Genome analysis, CSHL Press. ➢ Introduction to Bioinformatics-Terasa K. Attwood. ➢ Bioinformatics –A practical guide to the analysis of genes and proteins-Baxevanis and Ouellette.	• Concept of dynamic programming: Needleman- Wunsch (global alignment) algorithm, Smith-Waterman (local alignment) algorithm. • Databases similarity search: algorithms of FASTA, BLAST. Statistical significance of alignment scores. • Concept of multiple sequence alignment: Progressive alignment. **Section C** • Computational approaches of ORF and Gene identification. • Models of evolution, methods of Phylogenetic analysis Distance based (UPGMA and NJ method) and Character based (Maximum parsimony). • Homology based modeling three dimensional structure of proteins. • Concept of molecular docking: modeling substrate - receptor interaction and its applications. **Suggested Books:** ➢ Baxevanis, A.D. & Ouellette, B.F.F. (2004). *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins* (3rd ed.). Wiley. ➢ Bosu, O. & Thukral, S.K. (2007). *Bioinformatics: database, tools and algorithms* (1st ed.). Oxford University Press. ➢ Sharma, V., Munjal, A., & Shanker, A. (2017). *A Text Book of Bioinformatics* (2nd ed.). Meerut: Rastogi Publications. ➢ Sinha, P.K & Sinha, P. (2016). *Computer Fundamentals* (6th ed.). New Delhi: BPB publication. **Suggested e-Resources:** ➢ **Chou-Fasman Method for protein secondary structure prediction** https://pdfs.semanticscholar.org/fd8c/c95aec2d7af19ed28eea3688b3c231d0e745.pdf ➢ **Homology modeling** https://proteinstructures.com/Modeling/homology-modeling.html ➢ **Bioinformatic tools**	repetitions are deleted. Markov chain, random walk and HMM are not relevant to this paper as these statistical techniques are of

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				https://nptel.ac.in/courses/102103044/pdf/mod6.pdf ➢ **Essential bioinformatics** http://www.aun.edu.eg/molecular_biology/Procedure%20Bioinformatics22.23-4-2015/Xiong%20-%20Essential%20Bioinformatics%20send%20by%20Amira.pdf	
4)	**BT 511** ~~Enzyme Technology~~				The core course BT 511: 'Enzyme Technology' of the first semester is proposed to be offered as an elective course.
5)	**BT:** Term Paper-I/Minor Project				**Newly Introduced**
6)	**BT 505L** Biotechnology Lab - I	After successful completion of the course, students should be able to: • Demonstrate an understanding of microbial production of biomolecules • Gain hands on training on extraction and bio-separation techniques for various metabolites • Learn basic tools of bioinformatics • Analyze and	1. Reductase test for milk~~; dye reduction test~~. 2. Extraction and determination of protein content by Lowry's method. 3. ~~To~~ determine the peroxide value in oil/fat sample. 4. Separation of secondary metabolites/ sugars/ phenolic acids/ fatty acids by Thin Layer chromatography. 5. Engineering Mathematics/Statistical problems-I. 6. Engineering Mathematics/Statistical problems-II. 7. Estimation of amylase activity in germinating seeds. 8. Determination of the optimum temperature and effect of pH on amylase enzyme activity. 9. Buccal smear – Identification of Barr Body. 10. Isolation of cell organelles, viz. chloroplast/ mitochondria/ amyloplast. 11. Production of penicillin. 12. Lipase production and estimation. 13. Filtration/Mass balance based problems. 14. Energy balance based problems. 15. To determine inhibition constant (K_i) for various	**Biological Databases and Computational Biology** 1. Molecular Evolution: Multiple sequence alignment alignment and phylogenetic analysis (Clustal X/ Mega/ Tree-View). 2. Database Search: Use and analysis of BLAST tool for protein and DNA sequences. 3. Structure Prediction: Protein secondary and tertiary structure prediction using online ExPASy tools. 4. Molecular Visualization: Structural analysis of PDB entries for active and inactive states of protein (Pymol/Chimera/DeepView). **Advanced Cell Biology** 5. Buccal smear – Identification of Barr Body. 6. Isolation of cell organelles, viz. chloroplast/ mitochondria/ amyloplast. 7. Determination of hydrogen peroxide scavenging activity of plant. 8. Separation of secondary metabolites/ sugars/ phenolic acids/ fatty acids by Thin Layer chromatography. **Enzymology and Bioprocess Engineering** 9. Reductase test for milk.	Repetition has been removed More relevant experiments have been added.

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		solve problems for statistics, mass balance and energy balance.	inhibitors of enzyme reactions. 16. Separation of isoenzymes by native gel electrophoresis. 17. Determination of hydrogen peroxide scavenging activity of plant. 18. ~~Database similarity search using online BLAST P, BLAST N and BLAST X.~~	10. Extraction and determination of protein content by Lowry's method. 11. Estimation of amylase activity in germinating seeds. 12. Determination of the optimum temperature and effect of pH on amylase activity. 13. To determine inhibition constant (K_i) for various inhibitors of enzyme reactions. 14. Separation of isoenzymes by native gel electrophoresis. 15. Lipase production and estimation 16. Production of penicillin. 17. Filtration/Mass balance based problems. 18. Energy balance based problems. 19. To determine the peroxide value in oil/fat sample. **Engineering Mathematics** 20. Engineering Mathematics/Statistical problems-I. 21. Engineering Mathematics/Statistical problems-II. **Suggested Books:** ➢ Datta, A.K. (2014). *Basic Biostatistics and Application*. Kolkata: New Central Book Agency. ➢ Kumar, V. (2011). *Laboratory Manual of Microbiology*. New Delhi: Scientific Publishers. ➢ Mahajan, R., Sharma, J., & Mahajan, R.K. (2010). *Practical Manual of Biotechnology* (1^{st} ed.). New Delhi: Vayu Education of India. ➢ Rao, P.H., & Janardhan, K. (2014). *Fundamentals of Biostatistics*. New Delhi: I. K. International Publishing House. ➢ Saxena, J., Baunthiyal., & Ravi, I. (2015). *Laboratory Manual of Microbiology, Biochemistry and Molecular Biology*. Jodhpur: Scientific Publishers. ➢ Shuler, M.L., & Kargi, F. (2002). *Bioprocess Engineering Basic Concepts* (2^{nd} ed,). Prentice Hall PTR Upper Saddle River, NJ, USA. ➢ Swamy, P.M. *Laboratory Manual on Biotechnology* (1^{st} ed.). Meerut: Rastogi Publication.	

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				➢ Yadav, V.K., & Yadav, N. (2018). *Biochemistry & Biotechnology: A Laboratory Manual*. Jaipur: Pointer Publisher. **Suggested e-Resources:** ➢ **Harisha, S. Biotechnology procedures and experiments handbook** http://site.iugaza.edu.ps/mwhindi/files/BIOTECHNOLOGY-PROCEDURES-AND-EXPERIMENTS-HANDBOOK.pdf ➢ **Introduction to biotechnology** http://www.austincc.edu/awheeler/Files/BIOL%201414%20Fall%202011/BIOL1414_Lab%20Manual_Fall%202011.pdf ➢ **Sequence Alignment** https://blast.ncbi.nlm.nih.gov/Blast.cgi	
M. Tech. Biotechnology II Semester					
7)	**BT 503:** ~~Bioprocess Engineering-II~~				The contents of the second semester core course "Bioprocess Engineering-II" and first semester core course "Bioprocess engineering-I" are proposed to be merged, modified and offered as new common course named as "Bioprocess engineering" in the second semester of the programme.
8)	**BT** Bioprocess	• After successful completion of	**Section A** Introduction to bioprocess, Steps in bioprocess	**Section A** Growth stoichiometry, Kinetics of Batch, Fed-batch and	"A typical new product from

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
	Engineering	the course, students should be able to: • Understand design of bioreactor and bioprocess parameters influencing production • Describe basic concepts of large scale production of industrially important bio-molecules • Plan a career in the biotechnology industry	development: ~~A typical new product from recombinant DNA~~ An overview, growth factors and precursors for microorganisms. Isolation, selection and improvement of cultures – screening methods, culture preservation, strain improvement. Kinetics of microbial growth, thermal death ~~kinetics of micro organisms~~, growth stoichiometry and elemental balances, kinetics of Batch, Fed-batch and Continuous operation of bioreactors, design of sterilization systems for liquids and gases. ~~Yields in cell culture.~~ **Section B** Heat transfer: General equipment for heat transfer, mechanisms of heat transfer, calculation of heat-transfer coefficients. Transport phenomena in bioprocess systems: Gas –liquid mass transfer in cellular systems, role of diffusion in bioprocessing, liquid- solid mass transfer, liquid –liquid mass transfer, gas-liquid mass transfer, measurement of kLa. Classification of fluids, fluids in motion, momentum transfer in fluids, viscosity measurement, effect of rheological properties on mixing. **Section C** Mechanical design and analysis of ~~biological reactors~~: Ideal bioreactors, bioreactor configurations of: plug-flow, packed bed, fluidized bed, trickle bed, photobioreactor, solid-state fermentation, on-line sensors for cell properties, off-line analytical methods, Immobilized biocatalysts: Formulation and characterization of immobilized cell biocatalysis, applications of immobilized cell biocatalysts. Animal and plant cell reactor technology: Environmental requirements for animal cell cultivation, reactors for large-scale production using animal cells, plant cell cultivation using bioreactors. **Books Recommended:**	Continuous operation of bioreactors, Gas –liquid mass transfer in cellular systems, role of diffusion in bioprocessing, measurement of volumetric mass transfer coefficient (K_La), Sterilization Kinetic, Fluid Rheology, Configuration of biological reactors: Plug-flow, packed bed, fluidized bed, photobioreactor, Stirred tank, Advanced cell bioreactor for cultivation of animal cells and plant cell culture. **Section B** Recovery and purification of products: strategies to recover and purify products, cell disruption, filtration, centrifugation, sedimentation, coagulation and flocculation, solid-liquid/liquid-liquid extraction, precipitation, adsorption, membrane separation- reverse osmosis, ultrafiltration, chromatography-FPLC,HPLC and HPTLC, affinity chromatography, electrophoresis, electrodialysis, crystallization, drying. **Section C** Importance of process flow sheeting in bioprocess engineering, development and utility of process flow diagrams, symbols for equipments, piping, instrumentation and controls, Scale up, Scale down, fermentation process economic, bioproduct regulation, medical applications of bioprocess engineering. Biological waste treatment: An example of the industrial utilization of mixed cultures. **Books Recommended:** ➢ Bailey, J.E., & Ollis, D.F. (1986). *Biochemical Engineering fundamentals* (2nd ed). McGraw-Hill College. ➢ Blanch, H.W., & Clark, D. S. (1997). *Biochemical Engineering*. CRC Press. ➢ Crueger, W., & Crueger, A. (2005). *Biotechnology- A Text Book of Industrial Microbiology*. Panima Publishing Corporation, New Delhi. ➢ Harrison, R. G., Todd, P. W., Rudge S. R., & Petrides, D. P. (2015). *Bioseparations Science and Engineering*. USA: Oxford University Press. ➢ Ogunnaike, B. A., & Ray, W. H. (1994). *Process Dynamics*,	recombinant DNA" has been already covered in section C of Bioprocess Engineering-II (BT 503). "thermal kinetic of microorganisms" has been rearranged as thermal cell death. Yield in cell culture has been rearranged. The word "bioreactor" has been already used for biological reactors.

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Shuler, M.L. and Kargi, F. Bioprocess Engineering : Basic concepts, 2 nd ed., Prentice- Hall, 2002. ➢ Doran Pauline M, Bioprocess Engineering Principles, Academic Press, 1995 ➢ Nielsen, J. and Villadsen, J. "Bioreaction Engineering Principles". Springer, 2007. ➢ Blanch, H.W and Clark D.S., "Biochemical Engineering", Marcel Dekker,1997 ➢ Bailey,J.E. and Ollis, D.F. Biochemical Engineering Fundamentals", 2nd ed.,McGraw Hill 1986. ➢ Stanbury, P.F., Stephen J. Hall & A. Whitaker, Principles of Fermentation Technology, Science & Technology Books. ➢ Thakore, S.B. and Bhatt, B.I. Introduction to process engineering and design, McGraw Hill 2009. ➢ Colin Ratledge, Bjorn Kristiansen, Basic Biotechnology, 2nd Edition, Cambridge University Press, 2001. ➢ Roger Harrison et al., Bioseparations Science and Engineering, Oxford University Press, 2003. ➢ W. Crueger and A.Crueger, Biotechnology- A Text Book of Industrial Microbiology.	*Modeling and Control*. Oxford University Press. ➢ Pandey, A., Larroche, C., Soccol, C. R., & Dussap, C. (2008). *Advances in Fermentation Technology*. Asiatech Publishers, Inc. ➢ Seader, J. D., & Henley, E. J. (2013). *Separation Process Principles*. Wiley India (P.) Ltd. ➢ Shuler, M.L., & Kargi, F. (2002). *Bioprocess Engineering Basic Concepts* (2nd ed). Prentice Hall PTR Upper Saddle River, NJ, USA. ➢ Stanbury, P.F., Whitaker, A., & Hall S.J. (1995).*Principles of Fermentation Technology* (2nd ed.). Elsevier Science Ltd. ➢ Stanbury, P.F., Whitaker, A., & Hall S.J. (2016).*Principles of Fermentation Technology* (3rd ed.). Elsevier Science Ltd. ➢ Thakore, S.B., & Bhatt, B.I. (2007). *Introduction to Process Engineering and Design*. Tata McGraw-Hill Publishing Company Limited ➢ Van Imp, J. F. M., Vanrollegham P. A., & Iserentant, D. I. (1998). *Advanced Instrumentation, Data Instrumentation, and Control of Biotechnological Processes*. Kluwer Academic Publishers ➢ Vogel, H.C., & Todaro, C. L. (1996). *Fermentation and Biochemical Engineering Handbook*. Elsevier. **Suggested e-Resources:** ➢ **Microbial culture fermentation** https://pdfs.semanticscholar.org/b4d3/7ed66ef2e37ce22ff7a3be09e3df7568fe49.pdf ➢ **Animal Cell Cutivation** https://nptel.ac.in/courses/102103012/pdf/mod6.pdf ➢ **Bioprocess Design** https://www.cri.or.th/en/mitthai/Announcement%20and%20Discussion%20Pages/BioprocessDesign.pdf ➢ **Bioprocess Control** http://cdn.intechopen.com/pdfs/44372/InTech-Bioprocess_modeling_and_control.pdf ➢ **Biotechnology- Downstream processing**	

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				https://nptel.ac.in/courses/102106022/	
9)	**BT 514** Genetic Manipulation Technology	After successful completion of the course, students should be able to: • Comprehend tools and techniques used for genetic manipulation of living organisms. • Familiarize with current genome editing techniques. • Develop research aptitude and technical skills to secure a job in genetic engineering labs.	**Section A** ~~Genetic engineering tools: Introduction, Historical perspective of Genetic Manipulation, Enzymes used in genetic engineering, Vectors used in genetic engineering pBR322 and pUC series~~, Lambda and M13 based vectors~~,~~ Expression vectors, ~~T-vectors, Animal and plant virus based cloning vectors, Gene cloning and expression in *E.coli* and yeast (*Saccharomyces cerevisia*). Construction of gene libraries~~, cDNA~~, PCR based cDNA, subtractive cDNA, normalized cDNA, Genomic DNA, BAC and YAC library.~~ **Section B** ~~Screening and identification of libraries.~~ Automated DNA sequencing~~, Illumina and~~ Pyrosequencing ~~based~~ Next Generation Sequencing. Primer design, PCR: Nested PCR~~, 5' and 3' RACE-PCR, inverse PCR, hybrid PCR, TAIL PCR, Real Time PCR, Cloning of PCR product. Promoters, Analysis of Gene Expression at transcription and translation level~~, Hybridization techniques~~, Transformation and transfection assays, In vitro mutagenesis, Antisense technology.~~ **Section C** ~~Genetically Modified Organisms: Introduction, Genetic transformation methods (*Agrobacterium* and virus mediated methods, Direct gene transfer by gene gun, electroporation, microinjection, Embryonic stem cells method). Choloroplast genetic engineering: Methodologies, foreign gene expression, advantages over nuclear transgenics, limitations, production of biopharmaceuticals. Applications of GMO (Agriculture,~~	• **Section A** • Concept of the structure of DNA, enzymes as tools of genetic engineering: restriction endonucleases, methylases, DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing; labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes • Hybridization techniques: northern, southern, south-western and far-western and colony hybridization, FISH and GISH. • Study of protein-DNA interactions: electrophoretic mobility shift assay, DNase footprinting, methyl interference assay, chromatin immunoprecipitation. • Protein-protein interactions using yeast two-hybrid system; phage display. **Section B** • Plasmid vectors; M13 mp vectors; PUC19 and Bluescript vectors, phagemids; Lambda vectors; Cosmids; YACs, BACs; Expression vectors (pMal; GST; pET-based vectors), Yeast vectors, Baculovirus and *Pichia* vectors, SV40 vectors, Ti and Ri vectors. • cDNA and genomic libraries, si RNA Technology, construction of siRNA vectors, chloroplast engineering, introduction to genome editing by CRISPR-CAS with its applications. **Section C** • Principles of PCR: primer design, fidelity of thermostable enzymes, types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR; T-vectors, PCR based site specific mutagenesis, PCR in molecular diagnostics (viral and bacterial detection). • Sequencing methods (enzymatic and chemical); automated DNA sequencing; Pyrosequencing and Next Generation	The contents have been rearranged in all the sections with incorporation of new and relevant topics.

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			~~Pharmaceutical, Food, Beverages, Dairy, Poultry), Ethical, legal and social issues, IPR in transgenic technology, Biosafety guidelines.~~ **Books Recommended:** ➢ Primrose S.B., Twyman R.H. and Old R.W. Principles of Gene Manipulation, 6th ed., Blackwell Science, 2001. ➢ Winnacker E.L. From Genes to clones: Introduction to Gene Technology, Panima, 2003. ➢ Glick B.R. and Pasternak J.J. Molecular Biotechnology: Principles and applications of recombinant DNA, 3rd ed., ASM Press, 2003. ➢ Lemonie, N.R. and Cooper, D.N. Gene therapy, BIOS Scientific, 1996. ➢ Allison LA . Fundamental Molecular Biology. Blackwell publishing. 2007 ➢ Watson et al. Recombinant DNA, 5th Ed, Freeman; 2006 ➢ Brown TA. Gene Cloning and DNA Analysis ; 5th Ed ; 2006 ➢ Reece RJ. Analysis of Genes and Genomes, Wiley; 2004. ➢ Kreuzer H and Massey A. Recombinant DNA and Biotechnology ; 2nd Ed; ASM; 2006. ➢ Korf BR. Human Genetics and Genomics; 3rd Ed; Blackwell; 2007. ➢ Sambrook & Russel. Molecular Cloning; 3rd Ed; Cold Spring Harbour Laboratory press, NY; 2001.	Sequencing; mutation detection: SSCP, DGGE, RFLP. **Suggested Books:** ➢ Brown, T.A. (2010). *Gene Cloning and DNA analysis: An Introduction.* Oxford: Wiley-Blackwell. ➢ Glick, B.R., Pasternak, J.J., & *Patten C.L.* (2010). *Molecular Biotechnology: Principles and applications of recombinant DNA* (4th ed). American Society for Microbiology. ➢ Lemonic, N.R., & Cooper, D.N. (1996). *Gene therapy*. BIOS Scientific publisher. ➢ Nicholl, D.S.T. (2008). *An introduction to Genetic Engineering* (3rd ed). Cambridge: Cambridge University Press. ➢ Primrose, S.B., Twyman R.H., & Old R.W. (2001). *Principles of Gene Manipulation* (6th ed). Wiley-Blackwell. ➢ Watson, J.D., Gilman, M., Witkowski J., & Zoller, M. (1992). *Recombinant DNA* (2nd ed.). W. H. Freeman publisher. **Suggested e-Resources:** ➢ **Next Generation Sequencing** file:///C:/Users/all/Downloads/49602.pdf ➢ **DNA sequencing- approaches** https://www.ncbi.nlm.nih.gov/books/NBK21117/CRISPR/ ➢ **CRISPR-CAS technology** https://www.ucll.be/sites/default/files/documents/gezondheid/crispr_cas_technology_-_manetsberger.pdf https://www.ncbi.nlm.nih.gov/pubmed/24584096 ➢ **Construction of siRNA expression vectors** https://www.thermofisher.com/us/en/home/references/ambion-tech-support/rnai-sirna/tech-notes/sirna-expression-vectors--with-selectable-markers.html ➢ **Gene knockout and transgenic mice** https://www.ncbi.nlm.nih.gov/books/NBK21632/	
10)	**BT 516:** ~~Immunotechno~~				The course BT 516: 'Immunotechnology'

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
	~~logy~~				which is offered as a core course in the second semester but now this course is proposed to be offered as an elective course.
11)	**BT:** Term Paper-II/Minor Project				**Newly Introduced**
12)	~~**BT 520**~~ ~~Plant and Animal Cell Culture Technology~~	~~After successful completion of the course, students should be able to:~~ • ~~Comprehend the tools and techniques used for animal and plant cell/tissue culture technology.~~ • ~~Develop skills for the production of commercially viable animal and plant products~~ • ~~Demonstrate the techniques learned for the future research~~	~~**Section A**~~ ~~Concept of cell culture, development of tissue culture, cellular totipotency, various terminologies associated with Plant tissue culture. Nutritional requirements and media preparation for plant and animal tissue culture. PGR's and their *in vitro* roles. Callus culture technique and applications. Suspension culture: Technique, growth measurement and applications. Organ culture techniques. Haploids and its application. Protoplast isolation, culture, Somatic hybridization: protoplast fusion, requirement and application. Micro propagation: Concept, stages, explants, Axillary bud proliferation.~~ ~~**Section B**~~ ~~Secondary metabolites production and biotransformations: Introduction, principal, optimization of yield. Somatic embryogenesis, somaclonal variation, Germplasm preservation. Basic concepts and essential steps for producing transgenic plants. Development of plants resistant to environmental stress and herbicides and pathogen resistant (Virus and insect). Introduction to animal cell cultures; animal cell growth characteristics, Disaggregation techniques, Primary cell cultures, Establishment and maintenance of primary cell cultures of adherent and non-adherent cell lines, . Secondary cell cultures, Establishment and maintenance of secondary~~		This course is discontinued

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			~~mammalian and insect cell lines, Organ and histotypic culture in animals. Preservation of cell lines: cryopreservation, cell banks, transporting cells.~~ ~~**Section C**~~ ~~Cell fusion: aim & requirement, fusogens, Somatic cell fusion, Selection of hybrids, Transfection: gene transfer methods for adherent & non- adherent animal cell cultures, Characterization of cell lines: Karyotyping, biochemical and genetic characterization of cell lines, cytotoxicity assays, cell viability assays. Production of vaccine in animal cells: use of Hybridoma for production of monoclonal antibodies, Bioreactors in animal cells: Bioreactors for large-scale culture of animal cells, Transplantation: tissue culturing, Transplantation techniques, General overview of animal cell culture products.~~ ~~**Books Recommended:**~~ ➢ ~~Plant Tissue Culture: Applications and Limitations. S.S. Bhojwani (1990), Elsevier, Amsterdam.~~ ➢ ~~Plant biotechnology In Agriculture: K. Lindsey and M.G.K. Jones (1990), Prentice hall, New Jersey.~~ ➢ ~~Dashek W.V. Methods in Plant Biochemistry and Molecular Biology, CRC Press, 1997.~~ ➢ ~~Kirsi-Marja Oksman-Caldentey and Barz W.H. Plant Biotechnology and Transgenic Plants, Marcel Dekker Inc., 2002.~~ ➢ ~~R.E. Spier and J.B Griffiths (1998). Animal cell Biotechnology, Academic Press.~~ ➢ ~~Living resources for Biotechnology, Animal cells ; a.Doyle, R.Hay and B.E. Kirsop (1990), Cambridge University Press, Cambridge.~~ ➢ ~~Freshney, R. Ian, "Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications,"~~		

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			~~6th ed., Wiley Blackwell.~~ ➢ ~~John R.W. (2006) Masters, Animal Cell Culture: Practical Approach, 3rd Edition, Oxford.~~ ➢ ~~M. Clynes (2006) Animal Cell Culture Techniques, 2ndt Edition, Springer.~~ ➢ ~~Basic Cell Culture Vol. 290 Protocols by Cheryl D Helgason, Cindy L~~ ➢ ~~Miller. Humanan Press~~ ➢ ~~Morgan, S.J. and Darling, D. C., "Animal Cell Culture," Bios Scientific Publishers in Association with the Biochemical society.~~ ➢ ~~In vitro Cultivation of Animal Cells: Biotechnology by Open Learning, Elsevier.~~ ➢ ~~Basic Cell Culture 2nd Edition by JM Davis Oxford Press~~ ➢ ~~Tissue Culture in Biological Research by G. Penso and D. Balduki.~~ ➢ ~~Biotechnology by B. D. Singh.~~ ➢ ~~Principle of Fermentation Technology by Whittaker.~~ ➢ ~~Gangal, Sudha, "Principles and Practice of Animal Tissue Culture, 2nd ed., Universities Press (India) Private Limited.~~ ➢ ~~In vitro Cultivation of Animal Cells: Biotechnology by Open Learning, Elsevier.~~ ➢ ~~Mathew, Jennie P., Roberts, Penelope E.,"Introduction to Cell and Tissue Culture: Theory & Techniques", Plenum Press, New York, 1998~~		
13)	**BT 506L** Biotechnology Lab - II	After successful completion of the course, students should be able to: • Gain hands on training on techniques related to	1. To study DNA amplification by PCR and resolution of PCR products on agarose gel. 2. Purification of amplified PCR Product by column purification. 3. Preparation of bacterial competent cells for transformation. 4. Transfer of recombinant vector into competent bacterial cells.	**Bioprocess Engineering** 1. Bioethanol production by immobilized *Saccharomyces cerevisiae* cells. 2. Separation of pigments from leaves or flowers by adsorption column chromatography. 3. To perform gel exclusion chromatography. 4. Lactic acid production. 5. Estimation of K_{La} by sodium sulphite method.	The practicals have been properly categorized Relevant practical has been introduced.

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		genetic engineering, plant tissue culture and immunology • Demonstrate an understanding of different methods for chromatography • Demonstrate a basic understanding of production and estimation of industrially important biofuel and acids. • Demonstrate a basic concept of in silico Primer designing	5. Preparation of stock media (RPMI 1640) from powder, preparation of complete media from stock and sterilization by filtration. 6. Preparation of metaphase chromosome from lymphocyte culture. 7. Isolation of single cells from intact plant organs by enzymatic method, single cell culture. 8. To isolate and inoculate anthers for haploid production. 9. To induce callus from the explants of Phaseolus mungo (Green Gram). 10. Rocket Immunoelectrophoresis. 11. Sandwich ELISA for the detection of an antigen. 12. Preparation of an immunoglobulin fraction from whole serum by ammonium sulphate precipitation. ~~13. To perform catalase test by using microorganism/plant.~~ 14. Bio ethanol production by immobilized Saccharomyces cerevisiae cells. 15. Separation of pigments from leaves or flowers by adsorption column chromatography. 16. To perform gel exclusion chromatography. 17. Lactic acid production. 18. in silico Primer designing.	**Cell Culture and Genetic Manipulation Technology** 6. Preparation of stock media (RPMI 1640) from powder, preparation of complete media from stock and sterilization by filtration. 7. Preparation of metaphase chromosome from lymphocyte culture. 8. Isolation of single cells from intact plant organs by enzymatic method, single cell culture. 9. To inoculate anthers for haploid production. 10. To induce callus from the explants of *Phaseolus mungo* (Green Gram). 11. To study DNA amplification by PCR and resolution of PCR products on agarose gel. 12. Purification of amplified PCR Product by column purification. 13. Preparation of bacterial competent cells for transformation. 14. Transfer of recombinant vector into competent bacterial cells. 15. *In silico* Primer designing. **Immunology** 16. Rocket Immunoelectrophoresis. 17. Sandwich ELISA for the detection of an antigen. 18. Preparation of an immunoglobulin fraction from whole serum by ammonium sulphate precipitation. **Suggested Books:** ➢ Saxena, J., Baunthiyal., & Ravi, I. (2015). *Laboratory Manual of Microbiology, Biochemistry and Molecular Biology*. Jodhpur: Scientific Publishers. ➢ Swamy, P.M. *Laboratory Manual on Biotechnology* (1st d.). Meerut: Rastogi Publication. ➢ Mahajan, R., Sharma, J., & Mahajan, R.K. (2010). *Practical Manual of Biotechnology* (1st ed.). New Delhi: Vayu Education of India. ➢ Sharma, R.K., Sangha, S.P.S. (2009). *Basic Techniques in Biochemistry & Molecular Biology*. New Delhi: I.K.	

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				International Publisher. ➢ Green, M. R., & Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual.*Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. **Suggested e-Resources** ➢ **Introduction to biotechnology** http://www.austincc.edu/awheeler/Files/BIOL%201414%20Fall%202011/BIOL1414_Lab%20Manual_Fall%202011.pdf ➢ **Harisha, S. Biotechnology procedures and experiments handbook** http://site.iugaza.edu.ps/mwhindi/files/BIOTECHNOLOGY-PROCEDURES-AND-EXPERIMENTS-HANDBOOK.pdf In silico primer design https://www.ncbi.nlm.nih.gov/tools/primer-blast/index.cgi	
Elective Courses proposed to be offered in I & II Semester					
1)	**BIN 502** Computer Aided Drug Designing	After successful completion of the course, students should be able to: • Understand the scope of pharmacogenomics and computer aided drug designing. • Identify and search potential drug leads using various tools of computational biology. • Develop data-mining skills	**Section A** Introduction to computer aided drug designing. Molecular descriptors, QSAR methodologies, Structure based drug designing, Ligand based drug designing, Different docking methodologies. **Section B** Pharmacophore identification, Pharmacophore generation (Hiphop and HypoGen theories), Combinatorial libraries, High throughput screening, Virtual screening, Lipinski's rule of five and its application in ADMET screening. Chemoinformatics: Introduction, Chemical Databases (ACD, MDDR and WDI), Application of Chemoinformatics in CADD. **Section C** Introduction to Pharmacogenomics and Pharmacogenetics, Clinical trials in Pharmacogenomics, Polymorphism of CYP450 enzymes affecting drug response, Role of SNP in Pharmacogenomics, The Multi	**Section A** • Introduction to computer aided drug designing. • Molecular descriptors, QSAR methodologies, structure based drug designing, ligand based drug designing, different docking methodologies. **Section B** • Pharmacophore identification, pharmacophore generation (Hiphop and HypoGen theories), combinatorial libraries, high throughput screening, virtual screening, Lipinski's rule of five and its application in ADMET screening. • Chemoinformatics: Introduction, Chemical Databases (ACD, MDDR and WDI), Application of Chemoinformatics in CADD. **Section C** • Introduction to pharmacogenomics and pharmacogenetics, clinical trials in Pharmacogenomics. • Polymorphism of CYP450 enzymes affecting drug response, role of SNP in pharmacogenomics.	Typographical corrections only

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		pertaining to drug discovery	Drug Resistance proteins: drug carriers affecting drug response. **Books Recommended:** ➢ Bioinformatics-from Genomes to drugs- Thomas lengauer. ➢ Molecular Modeling-Principles and applications-Andrew R. Leach. ➢ Fundamentals of Medicinal Chemistry by Gareth Thomas. ➢ Principles of Pharmacology: The Pathophysiologic Basis of Drug Therapy-David E. Golan. ➢ Pharmacogenomics: An Approach to New Drug Development: Chiranjib Chakraborty, Atanu Bhattacharyya.	• Multi Drug Resistance proteins: drug carriers affecting drug response. **Suggested Books:** ➢ Alvarez, J. & Shoichet, B. (2004). *Virtual Screening in Drug Discovery*. Taylor and Francis. ➢ Cramer, C. (2004). *Essentials of Computational Chemistry* (2 nd Ed). John Wiley. ➢ Thomas, G. (2003). *Fundamentals of Medicinal Chemistry*. John Wiley. ➢ Young, D.C. (2009). *Computational Drug Design*. John Wiley. **Suggested e-Resources:** ➢ **Personalized medicine** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2957753/ ➢ **Pharmacodynamics and pharmacokinetics** https://www.mheducation.co.uk/openup/chapters/9780335245659.pdf ➢ **Drug Discovery** http://www.kubinyi.de/lectures.html ➢ **Essential bioinformatics** http://www.aun.edu.eg/molecular_biology/Procedure%20Bioinformatics22.23-4-2015/Xiong%20-%20Essential%20Bioinformatics%20send%20by%20Amira.pdf	
2)	**BIN 503** Elements of Bioinformatics	After successful completion of the course, students should be able to: • Understand principles behind the genome wide coding region prediction and RNA folding.	**Section A** Genome comparison & analysis, Gene prediction, RNA structure prediction algorithms (Minimum free energy method, MFold, Coevolution method). Protein secondary structure prediction methods: Chou and Fasman, Garnier-Osguthorpe-Robson. Prediction of structural classes, motifs and domains. **Section B** Steps in Homology modeling, Threading; Contact potential, structural profile and segment matching method, Abinitio method, Protein structure comparison,	**Section A** • Genome comparison & analysis, Gene prediction, RNA structure prediction algorithms (Minimum free energy method, MFold, Coevolution method). • Protein secondary structure prediction methods: Chou and Fasman, Garnier-Osguthorpe-Robson, prediction of structural classes, motifs and domains. **Section B** • Steps in homology modeling, Threading, Contact potential, structural profile and segment matching method, *ab initio* method	Typographical corrections only

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		• Predict 3D structure of proteins and their regular structural elements for the integrity of the structure. • Analyze, interpret and understand the protein structure informatics. • Write perl program to solve the biological problems.	Structure comparison algorithms (dynamic programming, distance matrix). Perl language and syntax, scalars, arithmetic and logical operators, arrays, array functions, hashes, hash functions, conditional statements (if/else, elsif), control structures (for, foreach, while). **Section C** Pattern matching, substitutions, translations, splits and joins, file handling; opening, reading and closing a file, directory handling; opening, reading and closing a directory, subroutines, references, packages, modules, classes, objects, introduction to Bioperl. **Books Recommended:** ➢ Philip E. Bourne and Helge Weissig, Structural Bioinformatics-. ➢ David W. Mount, Bioinformatics - Sequence and Genome analysis. ➢ Tom Christian Sen, Nathan Torkington, Perl Cook book, 2nd Edition, O'REILLY ➢ James D. Tisdall, Beginning Perl for Bioinformatics, 2001, O'REILLY ➢ James D. Tisdall, Mastering Perl for Bioinformatics, 2003, O'REILLY ➢ Larry Wall, John Orwant, Tom Christian Sen, Programming Perl, O'REILLY	• Protein structure comparison, structure comparison algorithms (dynamic programming, distance matrix). • Perl language and syntax, scalars, arithmetic and logical operators, arrays, array functions, hashes, hash functions, conditional statements (if/else, elsif), control structures (for, foreach, while). **Section C** • Pattern matching, substitutions, translations, splits and joins, file handling, opening, reading and closing a file. • Directory handling, opening, reading and closing a directory, subroutines, references, packages, modules, classes, objects, introduction to Bioperl. **Suggested Books:** ➢ Christiansen, T., & Torkington, N. (2003). *Perl Cookbook: Solutions & Examples for Perl Programmers*. " O'Reilly Media, Inc.". ➢ Essen, L. O. (2003). *Structural Bioinformatics*. Edited by Philip E. Bourne and Helge Weissig. *Angewandte Chemie International Edition*. ➢ Mount, D. W. (2001). *Bioinformatics: Sequence and Genome analysis*. Cold Spring Harbor, N.Y: Cold Spring Harbor Laboratory Press. ➢ Tisdall, J. (2003). *Mastering Perl for Bioinformatics: Perl Programming for Bioinformatics*. " O'Reilly Media, Inc.". **Suggested e-Resources:** ➢ **Chou-Fasman Method for protein secondary structure prediction** https://pdfs.semanticscholar.org/fd8c/c95aec2d7af19ed28eea3688b3c231d0e745.pdf ➢ **Homology modeling** https://proteinstructures.com/Modeling/homology-modeling.html ➢ **Essential bioinformatics** http://www.aun.edu.eg/molecular_biology/Procedure%20Bioinformatics22.23-4-2015/Xiong%20-	

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				%20Essential%20Bioinformatics%20send%20by%20Amira.pdf ➢ **Bioinformatic tools** https://nptel.ac.in/courses/102103044/pdf/mod6.pdf	
3)	**BIO 417** Structural Biology	After the successful completion of the course, students should be able to: • Explain the biophysical processes working at molecular level. • Answer the biological questions of macromolecular folding and interactions • Understand the molecular processes behind locomotion, neuronal signaling and vision.	**Section A** Introduction to protein structure: Physical and chemical properties of amino acids and polypeptides, secondary, super secondary, tertiary and quaternary structure of proteins, Helix-coil transition, and Ramachandran plot. Protein structure determination: Isolation and purification of proteins, Methods for determination of size of proteins, Basic principles of X-ray diffraction studies, Phase determination, Calculation and interpretation of electron density map, Electron crystallography of proteins. **Section B** Protein secondary structure prediction methods: Chou and Fasman, Garnier-Osguthorpe-Robson.Classification of three-dimensional structure of protein: Prediction of structural classes, motifs, folds and domains, classification of three-dimensional structures in Protein Data Bank (HSSP, SCOP, FSSP, CATH). **Section C** Nucleic acid structure: Nucleic acid conformation, A-DNA, B-DNA, Z-DNA and C-DNA, their geometrical and structural features, RNA secondary and tertiary structures, idea about local doublet parameters.Molecular interactions: Protein-Protein interactions, Protein-DNA interactions. Techniques for the studies of these interactions. Forces that stabilize bimolecular structure. **Books Recommended:** ➢ Principles of Biochemistry-Lehninger. ➢ Biochemistry-Stryer. ➢ Biophysical Chemistry-Cantor and Schimmel.	**Section A** • Introduction to protein structure: Physical and chemical properties of amino acids and polypeptides, secondary, super secondary, tertiary and quaternary structure of proteins, Helix-coil transition, and Ramachandran plot. • Protein structure determination: Isolation and purification of proteins, Methods for determination of size of proteins, Basic principles of X-ray diffraction studies, Phase determination, Calculation and interpretation of electron density map, Electron crystallography of proteins. **Section B** • Protein secondary structure prediction methods: Chou and Fasman, Garnier-Osguthorpe-Robson. • Classification of three-dimensional structure of protein: Prediction of structural classes, motifs, folds and domains, classification of three-dimensional structures in Protein Data Bank (HSSP, SCOP, FSSP, CATH). **Section C** • Nucleic acid structure: Nucleic acid conformation, A-DNA, B-DNA, Z-DNA and C-DNA, their geometrical and structural features. • RNA secondary and tertiary structures, idea about local doublet parameters. • Molecular interactions: Protein-protein interactions, protein-DNA interactions, techniques for the studies of these interactions. Forces that stabilize bimolecular structure. **Suggested Books:** ➢ Berg, J. M., Tymoczko, J. L., Stryer, L., & Stryer, L. (2002). *Biochemistry*. New York: W.H. Freeman. ➢ Cantor, C. R., & Schimmel, P. R. (1980). *Biophysical*	Typographical corrections only

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Practical Biochemistry-Wilson and Walker. ➢ Bioinformatics –Sequence and Genome analysis-David W. mount. ➢ Structural Bioinformatics-Philip E.Bourne and Helge Weissig	*Chemistry Part I: The Conformation of Biological Macromolecules*. New York: W. H. Freeman & Company. ➢ Gu, J., & Bourne, P. E. (2011). *Structural Bioinformatics*. Chicester: Wiley. ➢ Hoffmann, A., Clokie, S., Wilson, K., & Walker, J. M. (2018). *Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology: Principles and Techniques of Biochemistry and Molecular Biology*. Cambridge: Cambridge University Press. ➢ Lehninger, A. L., Nelson, D. L., & Cox, M. M. (2000). *Lehninger Principles of Biochemistry*. New York: Worth Publishers. ➢ Mount, D. W., & Cold Spring Harbor Laboratory Press. (2006). *Bioinformatics: Sequence and Genome analysis*. Cold Spring Harbor, N.Y: Cold Spring Harbor Laboratory Press. **Suggested e-Resources:** ➢ **Chou-Fasman Method for protein secondary structure prediction** https://pdfs.semanticscholar.org/fd8c/c95aec2d7af19ed28eea3688b3c231d0e745.pdf ➢ **Homology modeling** ➢ https://proteinstructures.com/Modeling/homology-modeling.html ➢ **Essential bioinformatics** http://www.aun.edu.eg/molecular_biology/Procedure%20Bioinformatics22.23-4-2015/Xiong%20-%20Essential%20Bioinformatics%20send%20by%20Amira.pdf ➢ **Protein protein interaction** https://nptel.ac.in/courses/102103017/pdf/lecture%2020.pdf	
4)	**BIO 501** Bioentrepreneurship	After successful completion of the course, students should be able to:	**Section A** Entrepreneurship: meaning and definition; fundamentals of entrepreneurship; development of entrepreneurship through training, achievement motivation training- theory	**Section A** • Entrepreneurship: meaning and definition; fundamentals of entrepreneurship; development of entrepreneurship through training, achievement motivation training- theory and	Typographical corrections only

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		• Comprehend fundamental concepts of entrepreneurship • Identify and utilize various schemes promoting entrepreneurship • Develop skills to convert a viable idea into start ups	and concept, Kakinada experiment: developing achievement motivation, experiential exercises, scoring and coding; Entrepreneurship in area of Biotechnology; MSMEs: definition, role in India's Economic development, regulations covering MSMEs, sources of information and non financial support, Incentives and benefits available to MSMEs entrepreneurs; schemes for women entrepreneurs, psychological stress encountered by women in the light of her dual role and managing it. **Section B** Business Opportunity sensing and idea generation, Idea Feasibility testing through market research, Developing Vision and Mission statements, Deciding the offering and identifying target market, Positioning the offering, Designing Sales Process, Marketing mix and promotional strategies, Maintaining and hiring team, Knowing Competitors; preparing revenue model up to break-even point, Projecting future moves of business, Product Road Map, writing a detailed Business Plan, Basics of finance & accounting, Raising Funds- banks, financial institutions, venture capitalists, angel investors, bootstrapping; Role of incubation cntres **Section C** Role of Knowledge centres like universities and institutions and R & D; Role of Technology and Upgradation; Managing technology transfer; Regulation for transfer of foreign Technology; Technology Transfer agencies; Business Crisis and its management; Ethical Entrepreneurship; Social Entrepreneurship; Use of IT in business administration, Available Software for better financial management; Setting an E-Business; Key Leadership and Management skills. **Books Recommended:**	concept, Kakinada experiment: developing achievement motivation, experiential exercises, scoring and coding. • Entrepreneurship in area of Biotechnology; MSMEs: definition, role in India's economic development, regulations covering MSMEs, sources of information and non financial support, Incentives and benefits available to MSMEs entrepreneurs. • Schemes for women entrepreneurs, psychological stress encountered by women in the light of her dual role and managing it. **Section B** • Business opportunity sensing and idea generation, idea feasibility testing through market research, Developing Vision and mission statements, deciding the offering and identifying target market, positioning the offering. • Designing sales process, marketing mix and promotional strategies, maintaining and hiring team. • Knowing competitors, preparing revenue model up to break-even point, projecting future moves of business, product road map, writing a detailed business plan, basics of finance & accounting. • Raising funds: banks, financial institutions, venture capitalists, angel investors, bootstrapping; role of incubation centres **Section C** • Role of knowledge centres like universities and institutions and R & D, role of technology and upgradation, managing technology transfer, regulation for transfer of foreign technology, technology transfer agencies. • Business crisis and its management, ethical entrepreneurship, social entrepreneurship, use of IT in business administration, available software for better financial management; setting an E-business; key leadership and management skills. **Suggested Books:** ➢ Barringer, B. R., & Ireland, R. D. (2019). *Entrepreneurship:*	

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Jain P.C.: Hand book for new entrepreneurs: Oxford University Press. ➢ Lalitha D. Rani : Women Entrepreneurs, A.P.H. Publishing Corporation. ➢ Drucker Peter F : Innovation and Entrepreneurship, New Delhi Heineman, UBSPD ➢ David Holt : Entrepreneurship and New Venture Creation, Prentice Hall of India. ➢ Other Suggested readings apart from text books include motivational titles in air for instance, The Goal, Rich Dad Poor Dad, Count you Chicken Before they Hatch, The Winning, A Monk who sold his Ferrari, Stay Hungry Stay Foolish, 60 Keys to Success etc.	*Successfully launching new ventures*. New York, NY Pearson Education ➢ Drucker, P. F. (2015). *Innovation and entrepreneurship: Practice and principles*. London: Routledge. ➢ Holt, D. H. (1992). *Entrepreneurship: New venture creation*. Englewood Cliffs, N.J: Prentice Hall. ➢ Jain, P. C. (1998). *Handbook for new entrepreneurs*. New Delhi, India: Oxford University Press. ➢ Schaper, M., & Schaper, M. (2014). *Entrepreneurship and small business*. Milton, Qld: John Wiley and Sons Australia. **Suggested e-Resources:** ➢ **Start up and Technology news** https://techcrunch.com/ ➢ **Demo events** http://www.demo.com/ehome/DEMO/home/ ➢ **Entrepreunership in biotechnology** http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.463.4354&rep=rep1&type=pdf	
5)	**BIO 502** Cancer Biology	After successful completion of the course, students should be able to: • Explain mechanisms leading to cancer • Identify sources of cancer causing agents • Understand various therapies involved in cancer treatment	**Section-A** Basics of cancer biology, Cancer incidence and mortality, Cancer as a cellular disease, Tumor growth kinetics. Different forms of cancers, Diet and cancer. Regulation of cell cycle, Modulation of cell cycle in cancer. Oncogenes and tumor suppressor genes. Aberrant cell signaling in cancer, anti-apoptotic mechanisms for survival of cancer cells **Section-B** Environmental carcinogens, carcinogen metabolism. Chemical carcinogenesis, Targets of chemical carcinogenesis, initiation, promotion, and progression. Radiation induced carcinogenesis. Animal models of cancer research, athymic nude mice, syngeneic mouse model, transgenic mouse model **Section-C** Molecular mechanisms of tumor angiogenesis. Cancer	**Section-A** • Basics of cancer biology, cancer incidence and mortality, cancer as a cellular disease, tumor growth kinetics. • Different forms of cancers, diet and cancer. Regulation of cell cycle, modulation of cell cycle in cancer. • Oncogenes and tumor suppressor genes. Aberrant cell signaling in cancer, anti-apoptotic mechanisms for survival of cancer cells **Section-B** • Environmental carcinogens, carcinogen metabolism. Chemical carcinogenesis, targets of chemical carcinogenesis, initiation, promotion, and progression. • Radiation induced carcinogenesis. animal models of cancer research, athymic nude mice, syngeneic mouse model, transgenic mouse model. **Section-C** • Molecular mechanisms of tumor angiogenesis, cancer	Typographical corrections only

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			invasion and metastasis. Concept of stem cells in cancer. Advances in cancer detection. Different forms of therapy: chemotherapy, radiotherapy, and surgery. Chemoprevention of cancer. **Books Recommended:** ➢ Biology of Cancer by Robert Weinberg ➢ Cancer Biology, R.J.B. King ➢ Cancer Biology, R.W. Ruddon ➢ Molecular Biology of Human Cancers, W. A. Schulz ➢ Molecular Biology of Cancer, F. Macdonald, C.H.J. Ford, and A.G. Casson ➢ Chemoprevention of cancer and DNA damage by dietary factors, S. Knasmuller, D. M. DeMarini, I. Johnson, and C. Gerhauser.	invasion and metastasis. • Concept of stem cells in cancer, advances in cancer detection. Different forms of therapy: chemotherapy, radiotherapy, and surgery. **Suggested Books:** ➢ King, R., & Robins, M. (2006). *Cancer biology*. Harlow, England: Pearson/Prentice Hall. ➢ Macdonald, F., Ford, C. H. J., & Casson, A. G. (2004). *Molecular biology of cancer*. London: BIOS Scientific Publishers. ➢ Ruddon, R. W. (1995). *Cancer biology*. New York: Oxford University Press. ➢ Weinberg, R. A. (2007). *The biology of cancer*. New York: Garland Science. **Suggested e-Resources:** ➢ **Types of cancer** https://nptel.ac.in/courses/104103068/pdf/M4.pdf ➢ **Carcinogenes** http://www.prc.cnrs.fr/IMG/pdf/cmr-criteria-clp.pdf https://www.ilo.org/legacy/english/protection/safework/ghs/ghsfinal/ghsc10.pdf ➢ **Cancer Therapy** https://www.aafp.org/afp/2008/0201/p311.pdf	
6)	**BT 510** Environmental Biotechnology	After successful completion of the course, students should be able to: • Understand sources and role of environmental contaminants • Demonstrate various techniques involved in	**Section A** Definition and Scope of Environmental Biotechnology; Environmental Pollution; Types, Causes and Effects of Soil, air, water, oil and heavy metal. Pollution, control measures. Social Issues- Green House Gases, Global Warming, Acid Rain, Ozone depletion, nuclear accidents and holocaust. Purification of waste water; Aerobic and anaerobic treatments; Laboratory methods for the detection of coli form organisms in water; Water recycling methods; Management of radioactive pollutants in water, VOC, COD BOD and BOD sensors.	**Section A** • Definition and scope of environmental biotechnology, environmental pollution: Types, causes and effects on soil, air, water. • Control measures of pollution, social issues: Green house gases, global warming, acid rain, ozone depletion, nuclear accidents and holocaust. • Purification of waste water: Aerobic and anaerobic treatments, laboratory methods for the detection of coliform organisms in water. • Water recycling methods, management of radioactive pollutants in water, VOC, COD BOD and BOD sensors.	Typographical corrections only

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		bioremediation • Develop understanding of generation of energy from waste	**Section B** Molecular biology tools for Environmental management, rDNA technology in waste treatment, Genetically modified organisms in Waste management, Genetic Sensors, Metagenomics, Bioprospecting, Nanoscience in Environmental management, Phytoremediation for heavy metal pollution, Biosensors development to monitor pollution. Biomass waste as renewable source of energy, Cellulose and Hemi cellulose as source of energy Biocomposting, Vermiculture, Biofertilizers, Organic farming, Biofuels, Biomineralization, Bioethanol and Biohydrogen, **Section C** Bioelectricity through microbial fuel cell, Conversion of Solid Waste to Methane; Biogas production, Management of Sludge and Solid waste treatment- Land filling, lagooning, Ecofriendly agriculture. Definition, Types- Ex situ and In situ Bioremediation; genetically Engineered Microbes for Bioremediation; Bioremediation of Ground Water; Biodegradation of Hydrocarbons, Pesticides, Herbicides, Insecticides and Xenobiotics. **Books Recommended:** ➢ Indu shekhar Thakur, 2006. Environmental Biotechnology- Basic concepts and Applications. ➢ Foster C.F; Johnware D.A, 1987. Environmental Biotechnlogy.Ellis Harwood Ltd. ➢ Chakraborty K.D. Omen G.S. Biotechnology and Bio degradation, Advances in Applied Biotechnology series, Vol. 1, Gulf Publications Co. London 1989. ➢ Organic farming BY Dr. Sharma	**Section B** • Molecular biology tools for environmental management, rDNA technology in waste treatment, genetically modified organisms in Waste management, genetic sensors, metagenomics, bioprospecting, nanoscience in environmental management. • Phytoremediation for heavy metal pollution, biosensors development to monitor pollution. • Biomass waste as renewable source of energy, cellulose and hemi cellulose as source of energy, biocomposting, vermiculture, biofertilizers, organic farming, biofuels, biomineralization. **Section C** • Bioelectricity through microbial fuel cell, Conversion of Solid Waste to Methane. • Biogas production, management of sludge and solid waste treatment: Land filling, lagooning, ecofriendly agriculture. • *Ex situ* and i*n situ* bioremediation; genetically engineered microbes for bioremediation, bioremediation of ground water, biodegradation of hydrocarbons, pesticides, herbicides, insecticides and xenobiotics. **Suggested Books:** ➢ Jogdand, S. N. (2010). *Environmental Biotechnology (Industrial pollution management)* (3rd ed.). Mumbai, India: Himalaya Publishing House. ➢ Metcalf & Eddy. (Ed.). (1991). *Wastewater Engineering Treatment Disposal and Reuse* (3rd Edition). New Delhi, India: Tata McGraw Hill Edition. ➢ Milton, W. (Ed.). (1999). *An Introduction to Environmental Biotechnology*. USA: Springerlink, ➢ Modi, P. N. (2015). *Sewage treatment & disposal and waste water engineering*. New Delhi, India : Rajsons publications Pvt. Ltd. ➢ Srinivasan, D. (2009). *Environmental Engineering*. New Delhi, India: PHI Learning Pvt. Ltd.	

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				➢ Thakur, I. S. (2012). *Enviromental Biotechnology: Basic concepts and Application* (2nd ed.). New Delhi: I K International Publishing House. ➢ Tripathi, B. N., Shekhawat, G. S., & Sharma, V. (Ed.). (2009). *Applications of Biotechnology*. Jaipur, India: Aavishkar publishers. **Suggested e-Resources:** ➢ **Biological treatment of wastewater** http://www.neoakruthi.com/blog/biological-treatment-of-wastewater.html ➢ **Biogas** http://www.biologydiscussion.com/biomass/production-of-biogas-from-biomass/10436 ➢ **Biofuel** http://uru.ac.in/uruonlinelibrary/BioFuels/Biomass%20and%20biofuels.pdf ➢ **Biosensor** https://www.edgefx.in/biosensors-types-its-working-and-applications/ ➢ **Xenobiotic compound biodegradation** http://www.biologydiscussion.com/microbiology-2/bioremediation/xenobiotic-compounds-meaning-hazards-and-biodegradation/55625	
7)	**BT 512** Food Biotechnology	After successful completion of the course, students should be able to: • Learn processing and preparation of various food products. • Determine role of microbes in food spoilage and understand	**Section A** Constituent of food – contribution to texture, flavour and organoleptic properties of food, food additives – intentional and non-intentional and their functions. Enzymes in food processing. Physical Properties of Foods-Rheological, Thermal, Aerodynamic, hydrodynamic and Electrical properties of food. Raw material characteristics, cleaning, sorting and grading of foods; physical conversion operations – mixing, emulsification, extraction, filtration, centrifugation, membrane separation, crystallization, heat processing, evaporation, dehydration. Dehydration- Dehydration	**Section A** • Constituent of food – contribution to texture, flavour and organoleptic properties of food. • Food additives – intentional and non-intentional and their functions. • Enzymes in food processing. Physical Properties of Foods: Rheological, thermal, aerodynamic, hydrodynamic and electrical properties of food. • Raw material characteristics, cleaning, sorting and grading of foods; physical conversion operations – mixing, emulsification, extraction, filtration, centrifugation, membrane separation, crystallization, heat processing,	

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		the various methods used for food preservation • Understand the scope of food biotechnology for future endeavors	principles, Preparation of fruits and vegetables for dehydration. - Equipments used for drying with their principles, Packaging of Dried slices, Dices and powder. **Section B** Emerging technologies in food processing- High pressure processing of Foods, Pulsed electric field processing of Foods, Osmotic dehydration of Foods, ~~Ohmic and Ultrasound Processing of Foods,~~ Hurdle technology. Principles of food preservation; UHT, LTT, canning, frozen storage, irradiation, acidulants, salts and sugar. Factors leading to rancidity and reversion. Colloidal systems in food, stability of colloidal system. ~~Bread and baked goods, dairy products – milk processing, cheese, butter, vegetable fermentations, meat, poultry and fish products, sugar and distillation industries; Beverages – wine, beer;~~ food aroma compounds: microbial and enzymatic techniques. **Section C** Bread and baked goods, dairy products – milk ~~processing~~, cheese, butter, ice-cream, vegetable and fruit products; edible oils ~~and~~ fats; meat, poultry and fish products; confectionery, ~~beverages. Colloidal systems in food, stability of colloidal system~~. Types of Food Starches, Soluble Fibers: Pectin, Gums &Mucilages. Popular oils and fats in foods- pulses, dairy products and vegetable oils. ~~Factors leading to rancidity and reversion.~~ Properties of granular food and powders. **Books Recommended:** ➢ Coultate T.P. Food – The chemistry of its components, 2nd ed., Royal society, London, 1992. ➢ Sivasankar B. Food processing and preservation, Prentice Hall of India Pvt.Ltd., New Delhi, 2002. ➢ Fennema O.R. ed. Principles of food science: Part I, Food chemistry, Marcel Dekker, New York, 1976.	evaporation, dehydration. • Dehydration- Dehydration principles, Preparation of fruits and vegetables for dehydration. Equipments used for drying with their principles, packaging of dried slices, dices and powder. **Section B:** • Emerging technologies in food processing: High pressure processing, pulsed electric field processing, osmotic dehydration, hurdle technology. • Principles of food preservation: UHT, LTT, canning, frozen storage, irradiation, acidulants, salts and sugars. • Factors leading to rancidity and reversion. Colloidal systems in food, stability of colloidal system. • Food aroma compounds microbial and enzymatic techniques. Types of Food Starches, Soluble Fibers: Pectin, Gums &Mucilages. Properties of granular food and powders. **Section C:** • Food processing technology-Bread and baked goods, dairy products: milk, cheese, butter, ice-cream. Vegetable and food products. • Food processing technology: Edible oils, fats, meat, poultry and fish products, confectionary, beverages- wine, beer. • Popular oils and fats in foods-pulses, dairy products and vegetable oils. Sugar and distillation industries. **Suggested Books:** ➢ Adams, M. R., & Moss, M. O. (2007). *Food Microbiology*. Royal Society of Chemistry. ➢ Banwart, G.J. (1989). *Basic Food Microbiology*. CBS Publishers and Distributors, Delhi ➢ Frazier, W.C., &Westhoff, D.C. (2003). *Food Microbiology*. Tata McGraw Hill, Inc., New York. ➢ Joshi, V. K., &Pandey, A. (1999). *Biotechnology: Food Fermentation*. Asiatech Publishers Inc	The repetitive contents in the section B have been removed. The repetitive contents in the section C have been removed.

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Frazier W.C. and Westhoff D.C. Food Microbiology, 4th ed. McGram-Hill Book Co., New York, 1988. ➢ Brenner, J.G., Butters, J.R., Cowell, N.D. and Lilly, A.E.V. Food engineering operations, 2nd ed., Applied Sciences Pub.ltd., London,1979. ➢ Pyke, M. Food Science and Technology , 4th ed., John Murray, London, 1981 ➢ Food Biotechnology. Ed. Kalidas Shetty, Gopinadhan Paliyath, Anthony Pometto and Robert E. Levin. Taylor and Francis ➢ Banwart, George. J., “Basic Food Microbiology,” CBS Publishers and Distributors, New Delhi. ➢ Nuri N. Mohsenin: Physical Properties of Plant and Animal Materials Gordon and Reach Science Publishers (1970) ➢ Nuri N. Mohsenin: Thermal Properties of Food & Agricultutral materials Gordon and Reach Science Publishers (1970) ➢ Da-wen Sun: Emerging Technologies for Food Processing, Elsevier Academic PressMarcel Dekker Inc. NY (1995)	➢ Robinson, R.K. (1990).*Dairy Microbiology*. Elsevier Applied Sciences, London. **Suggested e-Resources:** ➢ **Quality control of food detection system** https://www.engineersgarage.com/Contribution/Arduino-based-Smart-IoT-Food-Quality-Monitoring-System ➢ **Food Preservation** https://sciencesamhita.com/methods-of-food-preservation/ ➢ **Genetically modified food** http://anrcatalog.ucdavis.edu/pdf/8180.pdf	
8)	**BT 517** Medical Biotechnology	After successful completion of the course, students should be able to: • Understand various in utero diagnostic techniques • Identify gene therapy techniques used for the treatment of diseases • Comprehend the	**Section A** Prenatal diagnosis - Invasive techniques - Amniocentesis, Fetoscopy, Chorionic Villi Sampling (CVS), Noninvasive techniques - Ultrasonography, X-ray, TIFA, maternal serum and fetal cells in maternal blood. Diagnosis using protein and enzyme markers, monoclonal antibodies. DNA/RNA based diagnosis Hepatitis, HIV - CD 4 receptor. Microarray technology-genomic and cDNA arrays, application to diseases. **Section B** Clinical management and Metabolic manipulation – PKU, Familial Hypercholesterolemia, Rickets, ADA, Congenital hypothyroidism. Gene therapy - Ex-vivo,	**Section A** • Prenatal diagnosis, invasive techniques: Amniocentesis, fetoscopy, chorionic villi sampling (CVS). • Noninvasive techniques: Ultrasonography, X-ray, TIFA, maternal serum and fetal cells in maternal blood. • Diagnosis using protein and enzyme markers, monoclonal antibodies. DNA/RNA based diagnosis Hepatitis, HIV - CD 4 receptor. • Microarray technology: genomic and cDNA arrays, application to diseases. **Section B** • Clinical management and metabolic manipulation: PKU, Familial Hypercholesterolemia, Rickets, ADA, Congenital hypothyroidism.	Typographical corrections only

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		applications of embryonic stem cells	Invivo, Insitu gene therapy, Stratagies of gene therapy: gene augmentation **Section C** Vectors used in gene therapy Biological vectors – retrovirus, adenoviruses, Herpes Synthetic vectors– liposomes, receptor mediated gene transfer. Gene therapy trials – Familial Hypercholesterolemia, Cystic Fibrosis, Solid tumors. Properties and application of embryonic stem cells and its potential, Nanomedicine. **Books Recommended:** ➢ Diagnostic and Therapeutic Antibodies (Methods in Molecular Medicine by Andrew J.T. George (Editor), Catherine E. Urch (Editor) Publisher: Humana Press; edition (2000) ➢ Molecular Diagnosis of Infectious Diseases (Methods in Molecular Medicine) by Jochen Decker, U. Reischl Amazon ➢ Human Molecular Genetics by T. Strachan, Andrew Read Amazon Sales Rank: ➢ Principles of Biostatistics by Marcello Pagano , Kimberlee Gauvreau ➢ Essentials of Epidemiology in Public Health, Second Edition by Ann Aschengrau , George R., III Seage ➢ Stem Cells: From Bench to Bedside- Ariff Bongso, Eng Hin Lee. ➢ Stem Cells-C S Potten.	• Gene therapy: Ex-vivo, in vivo, in situ gene therapy, strategies of gene therapy, gene augmentation **Section C** • Vectors used in gene therapy: retrovirus, adenoviruses, herpes synthetic vectors, liposomes, receptor mediated gene transfer. • Gene therapy trials, familial hypercholesterolemia, cystic fibrosis, solid tumors. • Properties and application of embryonic stem cells and its potential, nanomedicine. **Suggested Books:** ➢ Aschengrau, A., & Seage, G. R. (2014). *Essentials of epidemiology in public health*. ➢ Bongso, Ariff. & Lee, Eng Hin. (2005). *Stem cells : from bench to bedside*. Singapore : World Scientific Publishing ➢ George, A. J., & Urch, C. E. (Eds.). (2000). *Diagnostic and therapeutic antibodies* (Vol. 40). Springer Science & Business Media. ➢ Pagano, M., & Gauvreau, K. (2000). *Principles of biostatistics*. Australia: Duxbury. ➢ Strachan, T., Read, A. P., & Strachan, T. (2011). *Human molecular genetics*. New York: Garland Science. **Suggested e-Resources:** ➢ **Prenatal Diagnosis** http://semmelweis.hu/noi1/files/2017/02/Prenatal-diagnostic-methods.pdf ➢ https://www.health.wa.gov.au/docreg/Education/Prevention/Genetics/HP3131_prenatal.pdf ➢ **Gene Therapy** https://nptel.ac.in/courses/102103013/pdf/mod8.pdf http://uniqure.com/patients/Gene-Therapy-Information.pdf ➢ **Nanomedicine** https://noharm-europe.org/sites/default/files/documents-files/2462/HCWH%20Europe%20Nanoreport.pdf	
9)	**BT 519**	After successful	**Section A**	**Section A**	Typographical changes

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
	Nanobiotechnology	completion of the course, students should be able to: • Understand the fundamental concepts of nanobiotechnology • Apply engineering concepts to the nano-scale domain and design processing conditions • Plan research career in institute working on nanobiotechnology	Nanoscale and nanobiotechnology: Introduction to Nanoscience and Nanotechnology; Milestones in Nanotechnology; Overview of Nanobiotechnology and Nanoscale processes; Physicochemical properties of materials in Nanoscales. Fabrication and characterization of nanomaterials: Types of Nanomaterials (Quantum dots, Nanoparticles, Nanocrystals, Dendrimers, Buckyballs, Nanotubes); Gas, liquid, and solid –phase synthesis of nanomaterials. **Section B** Lithography techniques (Photolithography, Dip-pen and Electron beam lithography); Thin film deposition; Electrospinning. Bio-synthesis of nanomaterials. Properties and measurement of nanomaterials: Optical Properties: Absorption, Fluorescence, and Resonance; Methods for the measurement of nanomaterials; Microscopy measurements: SEM, TEM, AFM and STM. Confocal and TIRF imaging. Nanobiology and bioconjugation of nanomaterials: Properties of DNA and motor proteins; Lessons from nature on making nanodevices; Reactive groups on biomolecules (DNA & Proteins). **Section C** Surface modification and conjugation to nanomaterials. Fabrication and application of DNA nanowires; Nanofluidics to solve biological problems. Nano drug delivery and nanomedicine: Properties of nanocarriers; drug delivery systems used in nanomedicine; Enhanced Permeability and Retention effect; Blood-brain barrier; Active and passive targeting of diseased cells; Health and environmental impacts of nanotechnology. **Books Recommended:** ➢ Nanobiotechnology: Concepts, Applications and	• Nanoscale and nanobiotechnology: Introduction to nanoscience and nanotechnology, milestones in nanotechnology, overview of nanobiotechnology and nanoscale processes. • Physicochemical properties of materials in nanoscales. Fabrication and characterization of nanomaterials: Types of nanomaterials (quantum dots, nanoparticles, nanocrystals, dendrimers, buckyballs, nanotubes). • .Gas, liquid, and solid –phase synthesis of nanomaterials. **Section B** • Lithography techniques (photolithography, dip-pen and electron beam lithography), Thin film deposition, Electrospinning. • Bio-synthesis of nanomaterials, properties and measurement of nanomaterials, optical properties: absorption, fluorescence, and resonance. • Methods for the measurement of nanomaterials, microscopy measurements: SEM, TEM, AFM and STM, confocal and TIRF imaging. • Nanobiology and bioconjugation of nanomaterials: Properties of DNA and motor proteins, Lessons from nature on making nanodevices, reactive groups on biomolecules (DNA & Proteins). **Section C** • Surface modification and conjugation to nanomaterials. Fabrication and application of DNA nanowires. • Nanofluidics to solve biological problems. • Nano drug delivery and nanomedicine: Properties of nanocarriers, drug delivery systems used in nanomedicine, enhanced permeability and retention effect, blood-brain barrier, active and passive targeting of diseased cells, health and environmental impacts of nanotechnology. **Suggested Books:** ➢ Bhattacharya, S. (2013). *Introduction to nanotechnology*. New Delhi: Wisdom Press.	only

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			Perspectives, Christof M. Niemeyer (Editor), Chad A. Mirkin (Editor) , Wiley-VCH; 1 edition , 2004. ➢ NanoBioTechnology: BioInspired Devices and Materials of the Future by Oded Shoseyov and Ilan Levy, Humana Press; 1 edition 2007. ➢ NanoBiotechnology Protocols (Methods in Molecular Biology) by Sandra J Rosenthal and David W. Wright , Humana Press; 1 edition, 2005. ➢ Bio-Nanotechnology_ Concepts and applications. Madhuri Sharon, Maheshwar Sharon, Sunil Pandey and Goldie Oza, Ane Books Pvt Ltd, 1 edition 2012 ➢ Microscopy Techniques for Material Science. A. R. Clarke and C. N. Eberhardt (Editors) CRC Press. 1st Edition, 2002.	➢ Bhushan, B. (2017). *Springer Handbook of Nanotechnology*. Berlin, Heidelberg: Springer Berlin Heidelberg. ➢ Di, V. M. (2008). *Introduction to nanoscale science and technology*. New York, NY: Springer. ➢ Wilson, M. (2004). *Nanotechnology: Basic science and emerging technologies*. Boca Raton: Chapman & Hall/CRC. **Suggested e-Resources:** ➢ **Nanofluidic devices** https://aip.scitation.org/doi/pdf/10.1063/1.4794973?class=pdf ➢ **Quantam dot** file:///C:/Users/all/Downloads/9783642449093-c2.pdf ➢ **Preparation of Nanomaterial** https://nptel.ac.in/courses/103103033/module9/lecture2.pdf ➢ **Nanodrug delivery system** http://cdn.intechopen.com/pdfs/40262/InTech-Nanotechnology_in_drug_delivery.pdf http://iapc-obp.com/assets/files/883189NBDD.pdf	
10)	**BT 511** Enzyme Technology	After successful completion of the course, students should be able to: • Describe structure, functions and the mechanisms of action of enzymes • Get exposure of wide applications of enzymes and their future potential • Describe	**Section A** Introduction to enzymes, Classification, Sources, Mechanism of enzyme action. Strategies of purification of enzymes, criteria of purity, molecular weight determination and characterization of enzymes. Methods for investigating the kinetics of Enzyme catalysed reactions – Initial velocity Studies, Estimation of Michaelis Menten parameters, Effect of pH and temperature on enzyme activity, Modeling of rate equations for single and multiple substrate reactions. **Section B** Kinetics of inhibition- Reversible Inhibitors, Tight Binding Inhibitors, Time-Dependent Inhibition. Techniques of enzyme immobilization; kinetics of immobilized enzymes, effect of solute, Partition & diffusion on the kinetics of immobilized enzymes, design	**Section A** • Introduction to enzymes, classification, sources, mechanism of enzyme action. • Strategies of purification of enzymes, criteria of purity, molecular weight determination and characterization of enzymes. • Methods for investigating the kinetics of enzyme catalysed reactions – initial velocity studies, estimation of Michaelis Menten parameters, effect of pH and temperature on enzyme activity, modeling of rate equations for single and multiple substrate reactions. **Section B** • Kinetics of inhibition: Reversible Inhibitors, tight Binding Inhibitors, time-Dependent Inhibition. • Techniques of enzyme immobilization, kinetics of immobilized enzymes, effect of solute, partition & diffusion on the kinetics of immobilized enzymes, design and	Typographical corrections only

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		methods for enzyme mediated production of drugs, fine chemicals and other industrial intermediates	and configuration of immobilized enzyme reactors, applications of immobilized enzyme technology, Economic argument for immobilization. Functional group interconversion using enzymes (hydrolysis reaction, oxidation/reduction reactions, C-C bond formations). Cooperativity in Enzyme Catalysis. **Section C** Reaction engineering for enzyme-catalyzed biotransformations. Catalytic antibodies. Biocatalysts from extreme Thermophilic and Hyperthermophilic microorganisms (extremozymes). The design and construction of novel enzymes, artificial enzymes, Biotransformation of drugs (hydroxylation of Steroids), Host Guest Complexation chemistry, enzyme design using steroid templates, enzymes for production of drugs, fine chemicals and chiral intermediates. Enzymes of biological importance- Acetylcholinesterase, angiotensin converting enzyme (ACE), ACE Inhibitors, HMG Co A reductase inhibitors, pseudocholinesterase, 5-nucleotidase(5NT) and glucose-6-phosphate dehydrogenase(GPD). **Books Recommended:** ➢ Blanch, H.W., Clark, D.S. “Biochemical Engineering.” Marcel Dekker, 1997. ➢ Lee, James M. “Biochemical Engineering.” PHI, 1982. ➢ Bailey J.E. & Ollis, D.F. “Biochemical Engineering Fundamentals.” 2nd Edition. McGraw Hill, 1986. ➢ Faber, Kurt “Biotransformations in Organic Chemistry : A Textbook.” 5th Edition. Springer, 2008. ➢ Palmer, Trevor. “Enzymes : Biochemistry, Biotechnology, Clinical Chemistry.” 2nd Edition, East West Press, 2008.	configuration of immobilized enzyme reactors, applications of immobilized enzyme technology, Economic argument for immobilization. • Functional group interconversion using enzymes (hydrolysis reaction, oxidation/reduction reactions, C-C bond formations). Cooperativity in enzyme catalysis **Section C** • Reaction engineering for enzyme-catalyzed biotransformations. Catalytic antibodies. • Biocatalysts from extreme thermophilic and hyperthermophilic microorganisms (extremozymes). • The design and construction of novel enzymes, artificial enzymes • Biotransformation of drugs (hydroxylation of Steroids), host guest complexation chemistry, enzyme design using steroid templates, enzymes for production of drugs, fine chemicals and chiral intermediates. • Enzymes of biological importance: Acetylcholinesterase, angiotensin converting enzyme (ACE), ACE Inhibitors, HMG Co A reductase inhibitors, pseudocholinesterase, 5-nucleotidase (5NT) and glucose-6-phosphate dehydrogenase (GPD). **Suggested Books:** ➢ Bhaskar, A., Vidhya, V. G. (2014). *Enzyme Technology*. India: Mjp Publishers. ➢ Copeland, R. A. (2000). *Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis*. USA: John Wiley & Sons. ➢ Devasena, T. (2010). *Enzymology* (3^{rd} ed.). UK: Oxford University Press. ➢ Meena, M., & Chauhan, D. (2009). *Fundamentals of Enzymology*. Jaipur, India: Aavishkar publishers. ➢ Palmer, T., & Bonner, P. (2008). *Enzymes: Biochemistry, Biotechnology, Clinical Chemistry* (2^{nd} ed.). India: East West Publications.	

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Robert A. Copeland. "A Practical Introduction to Structure, Mechanosm, and Data Analysis." Second Edition, John Wiley & Sons Inc. Publication, 2000.	➢ Scopes, R. K. (2013). *Protein Purification: Principles and Practice* (3^{rd} ed.). USA: Springer. **Suggested e-Resources:** ➢ **Factors affecting rate of chemical reaction** https://www.adichemistry.com/physical/kinetics/factors/factors-affecting-rate-reaction.html ➢ **Extraction and purification of enzyme** http://chemsites.chem.rutgers.edu/~kyc/Teaching/Files/543-05/09%20544-10%20ppt.pdf ➢ **Catalytic antibodies** https://nptel.ac.in/courses/104103018/28	
11)	**BT 516** Immunotechnology	After successful completion of the course, students should be able to: • Compare and describe the different components of immune system and their functions. • Demonstrate and understand the principle techniques used for disease diagnostics. • Apply the knowledge of disease resistance and gene therapy in clinical research.	**Section A** Concept of immunity, cells and organs involved in the immune system, clonal selection theory, ubiquity of innate immunity, antigens, basic structure of antibodies, complementarity determining regions (CDRs) and antigenic determinants, multigene organization of Ig genes, assembly of TCR genes, antibody diversity and its generation **Section B** Antibody engineering, general organization and immune responsiveness of MHC, roles of APCs, components of immune effector mechanism (cytokines, chemokines, T cells and NKs), antigen antibody interactions and their diagnosis methods: cross reactivity, surface plasmon response (SPR), RIA, ELISA, western blotting, immunoprecipitation, immunofluorescence, flow cytometry, immunoelectron microscopy, **Section C** Mechanism of self tolerance and autoimmunity hypersensitivity, designing of vaccines, primary and secondary immunodeficiency, cancer immunotherapy, general and specific immunosuppressive therapy, hybridoma technology, SCID mice, SCID- human mice,	**Section A** • Concept of immunity, cells and organs involved in the immune system, clonal selection theory, ubiquity of innate immunity. • Antigens, basic structure of antibodies, complementarity determining regions (CDRs) and antigenic determinants. • Multigene organization of Ig genes, assembly of TCR genes, antibody diversity and its generation **Section B** • Antibody engineering, general organization and immune responsiveness of MHC, roles of APCs. • Components of immune effector mechanism (cytokines, chemokines, T cells and NKs). • Antigen antibody interactions and their diagnosis methods: cross reactivity, surface plasmon response (SPR), RIA, ELISA, western blotting, immunoprecipitation, immunofluorescence, flow cytometry, immunoelectron microscopy, **Section C** • Mechanism of self tolerance and autoimmunity, hypersensitivity. • Designing of vaccines, primary and secondary immunodeficiency, cancer immunotherapy. • General and specific immunosuppressive therapy, hybridoma	Typographical corrections only

<table>
<tr><th>S. No.</th><th>Course List</th><th>Learning Outcomes</th><th>Existing Syllabus</th><th>Suggested Syllabus</th><th>Remarks</th></tr>
<tr><td></td><td></td><td></td><td>technology for separation or identification of antigen

Books Recommended:
➢ Kuby Immunology (sixth edition) by Kindt, Goldsby, Osborne, Publisher Sara Tenney, 2007
➢ Immunology and Immunotechnology by Ashim K Chakravarty, Oxford University Press, 2006.
➢ Janeway’s Immunobiology (seventh edition) by Kenneth Murphy, Paul Travers , Mark Walport, Publisher Garland Science Taylor and Francis, 2008.
➢ The elements of Immunology by Fahim Halim Khan, Publisher Pearson education, 2009.</td><td>technology, SCID mice, SCID- human mice, technology for separation or identification of antigen.
Suggested Books:
➢ Abbas, A. K., Lichtman, A. H. &Pillai, S. (2017). Cellular and Molecular Immunology(9th ed.). Elsevier.
➢ Delves, P. J., Martin, S. J., Burton, D. R., &Roitt, I. M. (2006). Roitt's Essential Immunology, (11th ed.). Wiley-Blackwell.
➢ Punt, J., Stranford, S., Jones, P., & Owen, J. (2018). Kuby Immunology (8th ed.). W. H. Freeman and company.
➢ Tizard, I. R. (1995). Immunology: Introduction, (4th ed.). Philadelphia: Saunders College Publishing.
Suggested e-Resources:
➢ Cellular and Molecular Immunology
https://ocw.mit.edu/courses/health-sciences-and-technology/hst-176-cellular-and-molecular-immunology-fall-2005/lecture-notes/
➢ Immunology
https://study.com/academy/topic/immunology.html
➢ Antibodies
https://nptel.ac.in/courses/102103038/download/module2.pdf
https://nptel.ac.in/courses/102103047/PDF/mod5.pdf</td><td></td></tr>
<tr><td colspan="6">Reading Electives-I &II to be offered in III & IV Semester</td></tr>
<tr><td>1)</td><td><s>BIO 601R Biodiversity and Conservation</s></td><td><s>After successful completion of the course, students should be able to:</s>
• <s>Understand the concepts of biodiversity</s>
• <s>Comprehend ways to manama biodiversity and government bodies involved</s></td><td><s>Section A</s>
<s>General Account:</s>
<s>Concept and facts: ecological diversity; organism diversity (á, â, and ã); genetic diversity. Magnitude and distribution. Hot spots of biodiversity. India’s biodiversity. Factors that control species diversity. Generation of biodiversity.</s>
<s>Section B</s>
<s>Threats and management:</s>
<s>Species extinction (local, ecological, biological, background extinction, anthropogenic extinction); causes of extinction. Chain extinction. Key stone species.</s></td><td></td><td>This is removed and replaced with relevant reading elective paper</td></tr>
</table>

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		~~in making conservation strategies~~ • ~~Understand various biodiversity conservation strategies~~	~~Extinction vortex.~~ ~~IUCN and its major activities. IUCN status categories (extinct, extinct in wild, critically endangered, endangered, vulnerable, lower risk, data deficient, not evaluated). Red Data Book. Rare species. Indeterminate species.~~ ~~**Section C**~~ ~~**Conservation of biodiversity**~~ ~~Conservation strategies-~~ ~~*In situ*- biosphere reserve, national park, wildlife sanctuaries, sacred forests.~~ ~~*Ex situ* – cryo-preservation,Gene banks, DNA banks. Endangered species in India.~~ ~~**Books Recommended:**~~ ➢ ~~Textbook of Biodiversity, K V Krishnamurthy, Science Publishers~~ ➢ ~~Biodiversity, E.O. Wilson, editor,frances M. Peter, Associate Editor, National Academy press, Washington, D.C., 1988~~		
2)	~~**BIO 602R Bioethics, Biosafety and IPR**~~	~~After successful completion of the course, students should be able to:~~ • ~~Explain role of biotechnology in sustainable research and various ethical implications~~ • ~~Understand biosafety – objective, implementation, necessity and legislations~~	~~**Section A**~~ ~~History and principles of bioethics, ethical dimensions of medicine and biotechnology viz. organ transplant, human genome project, cloning, surrogacy, artificial insemination, egg donation abortion, euthanasia.~~ ~~Convention on biological diversity; Overview of Cartagena Protocol, Codex Alimentarius, FAO, OECD and their role in enforcing Biosafety; Role of NGOs in biotechnology.~~ ~~**Section B**~~ ~~Issues of Biosafety; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety guidelines - Government of India; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO~~		This is removed and replaced with relevant reading elective paper

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		~~• Develop preliminary understanding of Intellectual Property with emphasis on patents~~	~~applications in food and agriculture; Environmental release of GMOs; Biosafety management~~ ~~**Section C**~~ ~~History of IPR, types of IPR; Role of WIPO and WTO in IPR.~~ ~~Classification of patents; granting of patents and patenting authorities; rights and duties of patent owner; Patent infringement- meaning, scope and litigation; Invention in context of "prior art"; Patent databases; Country-wise patent searches (USPTO, EPO, India etc.)~~ ~~US Patent act; Indian Patent act. Filing of a patent application; Precautions before patenting-disclosure/non-disclosure; WIPO Treaties; Budapest Treaty; PCT and Implications; Role of a Country Patent Office; Case studies in IPR.s~~ ~~**Books Recommended:**~~ ~~➢ Bioethics and Biosafety by M.K. Sateesh. I.K. International~~ ~~➢ Biosafety and bioethics. Ed. Raj Mohan Joshi. Isha Books~~ ~~➢ Bioethics. An introduction to the history, methods and practice. By N. Jecker, A.R. Jonsen and R.A. Perlman. Jones and Bartlett publications and Bioethics by Deepa Goel and Shomini Parashar. Pearson~~ ~~➢ http:// Bioethics by S. Ignacimuthu s.j. Narosa Publishing House Pvt. Ltd.~~ ~~➢ IPR, Biosafety www.w3.org/IPR/~~ ~~➢ http://www.wipo.int/portal/index.html.en~~ ~~➢ http://www.ipr.co.uk/IP_conventions/ patent_cooperation_treaty.html~~ ~~➢ www.patentoffice.nic.in~~ ~~➢ www.iprlawindia.org/ - 31k - Cached - Similar page~~ ~~➢ http://www.cbd.int/biosafety/ background.shtml~~ ~~➢ http://www.cdc.gov/OD/ohs/ symp5/jyrtext.html~~		

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ ~~http://web.princeton.edu/sites/ehs/biosafety/biosafetypage/section3.html~~		
3)	~~**BT 604R Renewable Energy Sources**~~	~~After successful completion of the course, students will be able to:~~ • ~~Understand the various forms of conventional and non conventional energy resources~~ • ~~Design working models of renewable energy~~ • ~~Understand the applications and limitations of renewable energy sources~~	~~**Section A**~~ ~~Availability, importance, utilization, economics and growth rates of renewable energy sources. Combustion calculations, Conventional thermal power plant design and its operation, Superheat, reheat and regeneration, Other auxiliaries of thermal plant. High pressure boilers, Steam generator control. Biomass and its types, Biomass fuel characterization; thermo chemical and biochemical processes; reaction kinetics; energy and mass balance equations; studies of processes and system design for gasification, pyrolysis and liquefaction of biomass. Biochemical and thermochemical conversion of biomass. Design of biogas plants and gasifiers; Fuel related properties of biomass; planning and management of biomass collection, utilization, handling and pre-conditioning processes such as size reduction and densification; combustion, pyrolysis and gasification of biomass, photosynthetic efficiency, plant productivity and bio-energy yield, biomass waste.~~ ~~**Section B**~~ ~~Chemistry, process and performance analysis of biofuels; alcohol production: pre-treatment of biomass, fermentation with process details and dehydration; operational performance of I.C. engines on producer gas, biogas, alcohol, and plant oils and their esters. Solar radiation intensity and solar geometry. Analysis and design of non-concentrating and concentrating solar collectors. Solar energy storage techniques, Steady and transient heat transfer analysis of solar cookers, solar ponds, solar stills and solar dryers. Design of solar thermal systems; hot water systems, space heating and cooling systems, solar drying system for agricultural produce etc. Economic analysis of solar energy systems.~~		This is removed and replaced with relevant reading elective paper

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			~~Design of solar energy operated systems for heating, cooling, distillation, drying, dehydration, water pump and power generation for applications in agriculture.~~ ~~**Section C**~~ ~~Basic principles of wind energy conversion, site selection considerations, classification advantages and disadvantages of Wind Energy Conversion System (WECS), types of wind machines, performance of wind machines, Utilization of wind energy for generating electricity and mechanical power. Types of wind mill and their characteristics. Mechanics of wind mills. Introduction to geothermal energy and storage, hydrothermal resources, geo-pressured resources, petro-thermal resources, prime movers for geothermal energy conversion, applications of geothermal energy. Basic principle of tidal power, components of tidal power plant, site requirements, storage of tidal energy, advantages and limitations of tidal power generation. Photo-Voltaic devices. Applications of renewable energy sources.~~ ~~**Books Recommended:**~~ ➢ ~~Godfrey Boyle, Renewable Energy, Power for a Sustainable Future, Oxford University Press, U.K, 1996.~~ ➢ ~~G.D. Rai, Non-Conventional Energy Sources, Khanna Publishers~~ ➢ ~~H. P. Garg, J. Prakash, Solar Energy : Fundamentalsand Applications : Fundamentals and Applications 1 Edition, Tata Mcgraw Hill Education Private Limited (2000)~~ ➢ ~~Ching T. Hou and Jei-Fu Shaw, Biocatalysis and Bioenergy, John Wiley & Sons, 2008~~ ➢ ~~L.L. Freris, Wind Energy Conversion systems, Prentice Hall, UK, 1990.~~ ➢ ~~Johnson Gary, L., Wind Energy Systems, Prentice Hall, New York, 1985.~~		

<table>
<tr><th>S. No.</th><th>Course List</th><th>Learning Outcomes</th><th>Existing Syllabus</th><th>Suggested Syllabus</th><th>Remarks</th></tr>
<tr><td>4)</td><td>BT: Molecular Plant Breeding</td><td>After completing this course, students will be able to:
Understand strategies and applications of plant breeding technologies.
• Comprehend the knowledge of different plat molecular markers
• Plan a research career in the area of plant biotechnology</td><td></td><td>Plant breeding study involves breeding methods for self and cross pollinated crops. There are several limitations of conventional breeding. Thus, there is need to have a better breeding approaches to overcome this limitation. Development of molecular markers (RFLP, RAPD, SSRs, ISSRs, SNPs), construction of molecular maps and linkage analysis, mapping populations for QTLs using molecular markers play an important role in plant breeding. In order to develop potential plant having better qualities, Marker Assisted Selection (MAS) is also a viable approach which can be done by using selection of traits and markers, trait association, marker assisted backcrossing and recurrent selection, marker assisted hybrid breeding and marker assisted improved varieties/germplasm.
Suggested Books:
➢ Chawla, H. S. (2000). Introduction to Plant Biotechnology. USA: Science Publishers.
➢ Glick, B.R., Pasternak, J.J., & Patten C.L. (2010). Molecular Biotechnology: Principles and applications of recombinant DNA (4th ed). American Society for Microbiology.
➢ Nicholl, D.S.T. (2008). An introduction to Genetic Engineering (3rd ed). Cambridge: Cambridge University Press.
➢ Primrose, S.B., Twyman R.H., & Old R.W. (2001). Principles of Gene Manipulation (6th ed). Wiley-Blackwell.
➢ Slater, A., Scott, N., & Fowler, M. (2008). Plant Biotechnology: The Genetic Manipulation of Plants (2nd edition). UK: Oxford University Press.
➢ Watson, J.D., Gilman, M., Witkowski J., & Zoller, M. (1992). Recombinant DNA (2nd ed.). W. H. Freeman publisher.
Suggested e-resources:
➢ Plant breeding
https://nptel.ac.in/courses/102103013/pdf/mod6.pdf
➢ Molecular marker</td><td>c.w. M.Sc. AMBT, BT, Bioscience</td></tr>
</table>

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				http://eacharya.inflibnet.ac.in/data-server/eacharya documents/55d44ff9e41301fd23d8facc_INFIEP_203/734/ET/203-734-ET-V1-S1__lec_32.pdf ➢ **Gene mapping in plant** http://eacharya.inflibnet.ac.in/data-server/eacharya-documents/55d44ff9e41301fd23d8facc_INFIEP_203/733/ET/203-733-ET-V1-S1__lec_31.pdf	
5)	**Intellectual Property Rights**	After completing this course, students will be able to: • Understand the concept of IPR and its types • Describe the steps for patenting • Discuss the role of WTO and WIPO on IPR		Intellectual property rights (IPR) have an old history and are very relevant for economic development. Various types of IPR (patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications) are recognized with specific uses. There is currently an emergence of specific IP pertaining to plants and animals (UPOV, Plant Breeder's rights and plant variety protection and farmers rights act, patent protection of plant and animal inventions (WTO) and Law on the protection of new plant varieties and animal breeds (WIPO)). It is important to know about types of patent applications and the process of patenting with special emphasis to India. The role of WTO (GATT and TRIPS) and WIPO in implementation of IPR is significant as understands the relevance of Patent Cooperation Treaty (PCT) in patenting. IPR also are associated with certain ethical dilemma and there are some interesting case studies which highlight its relevance. **Suggested Books:** ➢ Goel D. & Parashar S. (2013). *IPR, Biosafety and Bioethics* (1st ed.) Pearson Education India. ➢ Pandey, N. & Dharni, K. (2014). *Intellectual Property Rights.* PHI Learning ➢ Ramakrishna, B., & Kumar, A. (2017). *Fundamentals of Intellectual Property Rights: For Students, Industrialist and Patent Lawyers* (1st ed.). Notion Press ➢ Sateesh, M.K. (2008). *Bioethics and Biosafety*. I.K. International Publishing House. **Suggested e-resource** ➢ **World Trade Organisation**	c.w. M.Sc. AMBT, BT, Bioscience

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				http://www.wto.org ➢ **World Intellectual Property Organisation** http://www.wipo.int ➢ **International Union for the Protection of New Varieties of Plants** http://www.upov.int ➢ **National Portal of India** http://www.archive.india.gov.in	
6)	**BT: Human Genetics and Diseases**	After successful completion of the course students will be able to: • Understand hereditary and molecular genetics with a strong human disease perspective • Describe genetic abnormalities underlying human disease and disorders • Develop interest in biomedical research, genetic counseling, medicine, and clinical genetics		Since the rediscovery of Mendel's work in 1900, investigations on the genetic nature of human traits have gained significant importance. Understanding the genetic basis behind human disease is one of the most important reasons to study human chromosome structure, human karyotype, banding techniques, chromosome identification and nomenclature (ISCN)**.** Classical genetics has considerable importance in constructing genetic hypothesis from pedigree data analysis in monogenetic traits, autosomal dominant, autosomal recessive, sex linked dominant, sex linked recessive and sex influenced traits. The impact of consanguinity in causing sex linked anomalies (haemophilia, colour blindness and Duchenne Muscular Dystrophy) has been observed in human population. Current knowledge on genetic variations across populations is applied to study human health and diseases which include chromosomal disorders, structural and numerical chromosomal anomalies (Klinefelter syndrome, Down's syndrome, Turner syndrome, Achondroplasia), inborn errors of metabolism (Phenylketonuria (PKU), Alkaptonuria, Albinism, Galactosemia), haemoglobinopathies, Thalassemia syndromes, multifactorial disorders (diabetes, schizophrenia, huntington disease). Medical genetics involves ethical issues therefore serious discussion is required for prenatal/adult diagnosis of genetic disorders, medical ethics, risks and benefits, informed consent and right of choice. **Suggested Books:** ➢ Nussbaum, R., McInnes, R., & Willard, H. (2007). *Thompson & Thompson-Genetics in Medicine* (7th ed.).	c.w. M.Sc. AMBT, BT, Bioscience

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				Elsevier. ➢ Pasternak, J. J. (2005). *An Introduction to Human Molecular Genetics: Mechanisms of Inherited Diseases* (2nd ed.). Wiley-Blackwell. ➢ Strachan, T., & Read, A. P. (2018). *Human Molecular Genetics* (5th ed.). Garland Science. **Suggested e-resources** ➢ **Chromosome identification and nomenclature (ISCN)** http://www.cydas.org/Resources/ISCN_Discussion.html ➢ **Pedigree data analysis** https://learn.genetics.utah.edu/content/disorders/ ➢ **Genetic disorders** https://www.genome.gov/10001204/specific-genetic-disorders/ ➢ **Prenatal/ adult diagnosis of genetic disorders, medical ethics** https://www.michiganallianceforfamilies.org/all/#sectionD	
7)	**BT: Medical Microbiology**	After successful completion of the course, students should be able to: • Identify various bacterial, fungal, viral and protozoan diseases and their epidemiology • Understand the relevance of emerging and reemerging diseases		Medical Microbiology describes the cause, transmission, epidemiology, pathogenesis, symptoms, diagnosis and treatment of various bacterial (tuberculosis, typhoid, leprosy), fungal (superficial, subcutaneous, systemic mycosis), protozoan (Malaria, amoebiasis) and viral (AIDS, Influenza, measles) diseases. Currently, it is necessary to understand the impact of emerging and remerging diseases (cholera, dengue, multidrug resistant tuberculosis, H5N1 avian influenza, drug resistant malaria, chikungunya) on human health. Global assessment for various diseases also shows an increasing trend of nosocomial infections and opportunistic infections which cause significant mortality and health concerns. **Suggested books:** ➢ Brooks, G.F., Carroll, K.C., Butel, J.S., Morse, S.A., & Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's Medical Mcirobiology (26th ed.). US: Lange Medical Books, Mc Graw-Hill. ➢ Madigan, M., Martinko, J., Stahl, D., & Clark, D. (2010).	c.w. M.Sc. AMBT, BT, Bioscience

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				Brock Biology of Microorganisms (13^{th}ed.). UK: Pearson Education. ➢ Pelczar Jr., M.J., Chan, E.C.S., & Krieg, N.R. (2011). *Microbiology*. New York, USA:Tata McGraw-Hill. **Suggested e- Resources:** ➢ **Emerging Diseases** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3701702/ ➢ **Epidemiology** https://www.bmj.com/about-bmj/resources-readers/publications/epidemiology-uninitiated/1-what-epidemiology ➢ **Nosocomial Infections** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3470069/	
8)	**BT: Protein Engineering**	On completion of this course, students should be able to: • Analyse structure and construction of proteins by computer-based methods • Describe structure and classification of proteins • Analyse and compare the amino acid sequence and structure of proteins, and relate this information to		An introduction to protein engineering for developing proteins with desired functions. Various methods (rational design and directed evolution) of protein engineering are employed to manipulate the different features or characteristics (affinity, specificity and stability etc) of proteins. Engineering various physicochemical and biological properties (stability to changes in parameters as pH, temperature, amino acid sequence and aggregation propensities etc) of the proteins could be important in their use as protein drugs and/or catalysts in bioreactors. The insight into the fundamental understanding of the mechanisms and forces (Van der waals, electrostatic, hydrogen bonding, weakly polar interactions, and hydrophobic effects), by which protein stabilizes, will help in the formulation of protein based pharmaceuticals. Protein engineering with site-specifically incorporation of unnatural or non-canonical amino acids has been used to improve protein function for medical and industrial applications. Different computational approaches (sequence and 3D structure analysis, data mining, Ramachandran map etc) to protein engineering would help to address the requirements in order to find amino acid sequences that will optimize a desired property (physicochemical property and/or biological function) of a protein. Determination of the	c.w. M.Sc. AMBT, BT, Bioscience

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		the function of proteins • Explain how proteins can be used for different industrial and academic purposes such as structure determination, organic synthesis and drug design. • Plan and carry out activity measurements of isolated proteins and characterize their purity and stability.		physicochemical properties of proteins using various spectroscopic methods (Far-UV and Near-UV CD, Fluorescence, UV absorbance and Optical rotatory dispersion) would further support the drug development process. Yeast surface display (YSD) has become a valuable protein engineering tool for modifying the affinity, specificity, and stability of antibodies, as well as other proteins. YSD could be successfully used for protein epitope mapping, identification of protein-protein interactions, and uses of displayed proteins in industry and medicine. Developing vaccines and peptidomimetics will further allow the investigators to identify novel therapeutic leads for numerous unmet clinical needs. **Suggested Books:** ➢ Cleland, J. L., and Craik, C. S. (2006). *Protein Engineering, Principles and Practice*, Vol 7. Springer Netherlands. ➢ Creighton, T. E. (1997). *Protein Structure: a Practical Approach*, 2nd Edition. Oxford University press. ➢ Kyte, J. (2006). *Structure in Protein Chemistry*, 2nd Edition. Garland publishers. ➢ Mueller, K., and Arndt, K. (2006). *Protein Engineering Protocols*, 1st Edition. Humana Press. ➢ Robertson, D., and Noel, J. P. (2004). *Protein Engineering Methods in Enzymology*, Vol 388. Elsevier Academic Press. ➢ Walsh, G. (2014). *Proteins: biochemistry and biotechnology*, Second edition. Chichester, West Sussex: Wiley Blackwell. ➢ Williamson, M. P. (2012). *How proteins work*. New York: Garland Science. **Suggested e-resources:** ➢ **Protein Engineering**: https://nptel.ac.in/courses/102103017/pdf/lecture%2022.pdf ➢ **Conformational stability of proteins**: https://www.khanacademy.org/test-prep/mcat/biomolecules/amino-acids-and-proteins1/v/conformational-stability-protein-folding-and-	

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				denaturation ➢ **Protein Engineering with Non-Natural Amino Acids:** https://library.umac.mo/ebooks/b2805488x.pdf	
9)	**BT: Drug discovery**	On completion of this course, students should be able to: • Understand basics of R&D in drug discovery and should be able to apply knowledge gained in respective fields of pharmaceutical industry. • Understand the role of synthetic chemistry in the development of pharmaceutical agents; and the modification of chemical structures to develop new drug molecules. • Have an advanced understanding of the chemical structure of a pharmaceutical		Modern drug discovery involves the identification of a target or drug lead using different techniques including molecular modeling, combinatorial libraries and high-throughput screening (HTS). Rational drug design is based on the understanding of the three-dimensional structures and physicochemical properties of drugs and receptors. Knowledge of molecular mechanisms, molecular dynamics simulations and homology modeling is necessary for studying drug/receptor interactions. The different conformational sampling techniques, fitness functions used in molecular docking and computational receptor-based and ligand-based drug design approaches are mostly used to design compounds with improved biological activity in rational drug design. Quantitative drug design using QSAR models are used to correlate structural molecular properties (descriptors) with functions (i.e. physicochemical properties, biological activities, toxicity, etc.) of the compounds. Understanding the structure activity relationship between the 3D structure of a molecule and its biological activity may act as the basis for the prediction of compounds with improved biological activities. Different bio-analytical assays (LC/MS/MS, GC/MS and ELISA) could be developed further in support of *in vitro* and *in vivo* studies. Understanding the principles as well as an early characterization of drug toxicity, adsorption, distribution, metabolism and excretion (ADME) along with drug-drug interactions, plasma protein binding assays and metabolite profile studies helps in eliminating compounds with unacceptable pharmacokinetic characteristics, which is critical to successful drug discovery programs. **Suggested Books:** ➢ Dastmalchi, S. *et. al.* (2016). *Methods and Algorithms for Molecular Docking-Based Drug Design and Discovery*. IGI	c.w. M.Sc. AMBT, BT, Bioscience

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		agent and determine the chemical group/s responsible for a given biological effect. • Demonstrate a basic understanding of pharmacogenomics and bioinformatics as it relates to drug design and discovery.		Global. ➢ Krogsgaard-Larsen *et. al.* (2016). *Textbook of Drug Design and Discovery*. 5th Edition. CRC Press. ➢ Rahman, A. U., Caldwell, G. W., and Choudhary, M. I. (2007). *Frontiers in Drug Design and Discovery*. Bentham Science publishers Limited. ➢ Satyanarayanajois, S. D. (2011). *Drug Design and Discovery: Methods and Protocols*. Humana Press. **Suggested e-resources:** ➢ **Drug Discovery** https://www.studocu.com/en/document/university-of-leeds/drug-development-pre-clinical-to-practice/lecture-notes/lecture-i-drug-discovery-lecture-notes-lectures-1-8/615380/view ➢ **Peptide therapeutics** https://www.sciencedirect.com/science/article/pii/S1359644614003997**Bio-analytical techniques** https://www.pharmatutor.org/articles/bioanalytical-techniques-overview	

[*] Matter in contrast (black background & white letters) is shifted to some other units, and material brought as a result of shift is also in contrast.
[#] Matter in square brackets, bold, italic and crossed is deleted.
[@] Proposed added materials are shaded in grey.

List of online elective courses of M.Tech Biotechnology Programme

S No	Portal	Name of course	Duration	Semester (Core/Elective/ Additional)	Credit point(s)	URL	Paid/ Free	Fee (course/ examination)	Reamrks
1	**NPTEL**: Indian Institute of Technology Madras;	Downstream Processing	12 weeks 36 lectures	Reading Elective course	2	http://nptel.ac.in/syllabus/102106022/	Paid	Rs. 2000 for online exam and certificate	-
2	**NPTEL**: Indian Institute of Technology Bombay; **SWAYAM, Created by** Sanjeeva Srivastava IIT Madras	Mass spectrometry based proteomics	8 weeks	Reading Elective course	2	https://onlinecourses.nptel.ac.in/noc15_bt05/preview https://swayam.gov.in/search?keyword=Mass%20spectrometry%20based%20proteomics	Free	-	-
3	**SWAYAM,** Created by GK Suraishkumar, IIT Madras	Bioreactor	8 weeks , 27 lectures	Reading Elective	2	https://swayam.gov.in/course/1339-bioreactors	Free	-	-

Certificate Course in Molecular Modelling and Drug Designing

Course Name	L	T	P	C
Molecular Modelling and Drug Designing	4	0	0	4
Laboratory	0	0	4	2
Total	**4**	**0**	**4**	**6**

Table: Proposed Examination Scheme – **Certificate Course in Molecular Modelling and Drug Designing**

	Exam Duration	Contact Hour/Week		Continuous Assessment Marks		Semester Assessment Marks		Total Marks		Min. Pass. Marks	
		T	**P**	**T**	**P**	**T**	**P**	**T**	**P**	**T**	**P**
Molecular Modelling and Drug Designing	3 Hours	4	0	20	0	40	0	60	0	24	0
Laboratory	4 Hours	0	4	0	10	0	20	0	30	0	12
Total		**4**	**4**	**20**	**10**	**40**	**20**	**60**	**30**	**24**	**12**

Eligibility: Students successfully qualified B.Sc. (Biotechnology, Bioscience, Applied Microbiology and Biotechnology, Chemistry, Mathematics group), B.Tech., B.Pharma examination.

Table: Proposed syllabus - **Certificate course in Molecular Modelling and Drug Designing**

S.No.	Course List	Learning Outcome	Existing Syllabus	Proposed	Remarks
1.	Molecular Modelling and Drug Designing	Upon successful completion of the course, students should be able to: • Understand the structural organization and of drugable targets. • Learn the drug discovery process and role of computational techniques. • Develop programming skills for analyzing the bioinformatics and chemoinformatics data.	-	**Section – A** • Protein: Structure of protein; Hierarchical organization of protein structure – primary, secondary, tertiary and quaternary structure. • Ramachandran map. Introduction to enzymes as drug targets; enzymatic activity and its inhibition (Case study of COX-1, HIV-protease and AChE). • Transcription factors as drug target, membrane proteins as drug targets. • DNA: Structure of DNA, types of base pairing – Watson-Crick and Hoogstein; Structural properties of A-, B- and Z- DNA. • DNA as drug target (Case study of Cis-platin). • Targeting Biomolecular Interactions: protein – protein interactions and DNA – protein interactions. • Introduction to receptors; Drug – receptor interaction; Forces involved in drug receptor interaction. **Section – B** • Drug discovery and design: Structure based drug discovery process. Methods and Tools in Computer-aided drug design. • Modeling drug - target interaction; molecular docking, and virtual screening. • Principles of Pharmacokinetics and Pharmacodynamics: ADME, Bioavailability of drugs - Lipinski's rule; Concept of	New course proposed

				Pharmacophore and QSAR. • Lead Optimization; functional group replacements: isosteres and bioisosteres. • Molecular modelling for drug discovery: Molecular mechanics: energy of a molecule under stretch, bend, torsional strain, van der Waals and dipole-diploe interactions. • Molecular dynamics simulations: introduction to Newtonian dynamics, Leapfrog Integrations. Implicit and explicit Solvation models, Periodic boundary conditions, Temperature and pressure control in molecular dynamics simulations. **Section – C** • Perl Programming: Data types: Scalar, Array and Hash Variables: their representation, applications and manipulations. • Perl Regular Expression: concepts and applications in biological data handling, Pattern-matching, Substitutions, Transliteration, split and join functions. • Concept on File handling, Opening, Closing and editing a File, Opening, Reading and Closing a Directory • Perl Subroutines: Advantage of Subroutines, Scoping and Subroutines, Arguments, Passing Data to Subroutines, Modules and Libraries of Subroutines. Introduction to Bioperl. **Suggested Books:** ➢ Berg J.M., Tymoczoko J.L. & Stryer L. (2006) Biochemistry (6th Ed.); W.H. Freeman and Co New York.	

				➢ Leach A.R. (2001) Molecular Modeling: Principles and Applications (2nd Ed.). Prentice Hall, USA. ➢ Gervasio F. L. & Spiwok V. (Ed.) (2019) Biomolecular Simulations in Structure-Based Drug Discovery. Wiley-VCH Verlag GmbH & Co. ➢ Riccardo B. (Ed) (2012) Computational Drug Discovery and Design Humana Press. ➢ Wall L., Christiansen T. & Orwant J. (2007) Programming Perl (3rd Ed). O'Reilly.	
2.	Laboratory	Upon successful completion of the course, students should be able to: • Write Perl programs to analyze and interpret biological data. • Model and analyze 3D structure of drug targets. • Handle sorftware for drug designing and virtual screening.		**Drug Designing Exercises** 1. Molecular visualization tool (applications such as molecular interaction, Molecular surface visualization, electrostatics, H-bond calculation etc. with PyMol) and Visualization of structural motifs. 2. Analysis of PDB (NMR and X – ray) structures (Quality of structure, analyzing molecular interactions, protein – ligand/ protein – protein if any, from PDB). 3. Homology based protein structure prediction. 4. Quality estimation of modeled protein structure (ProCheck, PROSA, Verify3D, Errat and MolProbity). 5. Contact map based protein structure comparison. 6. Energy minimization based mutational analysis of proteins. 7. Protein – Ligand docking using Autodock and MGLTools and Pharmacophore analysis. **Perl Exercises**	New Course proposed

				8. Use of various arithmetic and logical operators. 9. Programming based on string manipulation (concatenation, splitting etc.). 10. Regular expression and its applications, use of s/// and tr/// operators. 11. Pattern matching to locate and count motifs in a string. 12. Calculating nucleotide frequency and GC content., Hydropathy index calculation of proteins. 13. Constructing arrays, addition and removal of elements from array, exploring array. 14. Use hashes in conversion of three letter code to one letter code and protein translation. 15. Perl subroutines, generating random DNA and its comparison with real DNA. 16. File handling, reading data from a file writing data to a file and editing a file. 17. Directory handling, make a directory, change current working directory, reading files from a directory.	

Diploma Course in Computational Biology

First Semester				
Course Name	**L**	**T**	**P**	**C**
Molecular Modelling and Drug Designing	4	0	0	4
Laboratory I	0	0	4	2
Total	**4**	**0**	**4**	**6**
Second Semester				
Computational Biology	3	0	0	3
Laboratory II	0	0	4	2
Mini Project	0	0	2	1
Total	**3**	**0**	**6**	**6**

Table: Proposed Examination Scheme – Diploma in Computational Biology

		Exam Duration	**Contact Hour/Week**		**Cont. Ass. Marks**		**Ann. Ass. Marks**		**Total Marks**		**Min. Pass. Marks**	
			T	**P**	**T**	**P**	**T**	**P**	**T**	**P**	**T**	**P**
I Sem	Molecular Modelling and Drug Designing	3 Hours	4	0	20	0	40	0	60	0	24	0
	Laboratory – I	4 Hours	0	4	0	10	0	20	0	30	0	12
Total			**4**	**4**	**20**	**10**	**40**	**20**	**60**	**30**	**24**	**12**

		Exam Duration	**Contact Hour/Week**		**Cont. Ass. Marks**		**Ann. Ass. Marks**		**Total Marks**		**Min. Pass. Marks**	
			T	**P**	**T**	**P**	**T**	**P**	**T**	**P**	**T**	**P**
II Sem.	Computational Biology	3 Hours	3	0	15	0	30	0	45	0	18	0
	Laboratory – II	4 Hours	0	4	0	10	0	20	0	30	0	12
	Project	-	0	2	0	5	0	10	0	15	0	6
Total			**3**	**6**	**15**	**15**	**30**	**30**	**45**	**45**	**18**	**18**

Eligibility: Students successfully qualified B.Sc. (Biotechnology, Bioscience, Applied Microbiology and Biotechnology, Chemistry, Mathematics group), B.Tech., B.Pharma examination.

Table: Proposed syllabus - Diploma in Computational Biology

S.No.	Course List	Learning Outcome	Existing	Proposed	Remarks
	Ist Sem				
1	Molecular Modelling and Drug Designing	Upon successful completion of the course, students should be able to: • Understand the structural organization and of drugable targets. • Learn the drug discovery process and role of computational techniques. • Develop programming skills for analyzing the bioinformatics and chemoinformatics data.	-	**Section – A** • Protein: Structure of protein; Hierarchical organization of protein structure – primary, secondary, tertiary and quaternary structure. • Ramachandran map. Introduction to enzymes as drug targets; enzymatic activity and its inhibition (Case study of COX-1, HIV-protease and AChE). • Transcription factors as drug target, membrane proteins as drug targets. • DNA: Structure of DNA, types of base pairing – Watson-Crick and Hoogstein; Structural properties of A-, B- and Z- DNA. • DNA as drug target (Case study of Cis-platin). • Targeting Biomolecular Interactions: protein – protein interactions and DNA – protein interactions. • Introduction to receptors; Drug – receptor interaction; Forces involved in drug receptor interaction. **Section – B** • Drug discovery and design: Structure based drug discovery process. Methods and Tools in Computer-aided drug design. • Modeling drug - target interaction; molecular docking, and virtual screening. • Principles of Pharmacokinetics and Pharmacodynamics: ADME, Bioavailability of	New course introduced

S.No.	Course List	Learning Outcome	Existing	Proposed	Remarks
				drugs - Lipinski's rule; Concept of Pharmacophore and QSAR. • Lead Optimization; functional group replacements: isosteres and bioisosteres. • Molecular modelling for drug discovery: Molecular mechanics: energy of a molecule under stretch, bend, torsional strain, van der Waals and dipole-diploe interactions. • Molecular dynamics simulations: introduction to Newtonian dynamics, Leapfrog Integrations. Implicit and explicit Solvation models, Periodic boundary conditions, Temperature and pressure control in molecular dynamics simulations. **Section – C** • Perl Programming: Data types: Scalar, Array and Hash Variables: their representation, applications and manipulations. • Perl Regular Expression: concepts and applications in biological data handling, Pattern-matching, Substitutions, Transliteration, split and join functions. • Concept on File handling, Opening, Closing and editing a File, Opening, Reading and Closing a Directory • Perl Subroutines: Advantage of Subroutines, Scoping and Subroutines, Arguments, Passing Data to Subroutines, Modules and Libraries of Subroutines. Introduction to Bioperl. **Suggested Books:** ➢ Berg J.M., Tymoczoko J.L. & Stryer L. (2006) Biochemistry (6^{th} Ed.); W.H. Freeman and Co New York.	

S.No.	Course List	Learning Outcome	Existing	Proposed	Remarks
				➢ Leach A.R. (2001) Molecular Modeling: Principles and Applications (2nd Ed.). Prentice Hall, USA. ➢ Gervasio F. L. & Spiwok V. (Ed.) (2019) Biomolecular Simulations in Structure-Based Drug Discovery. Wiley-VCH Verlag GmbH & Co. ➢ Riccardo B. (Ed) (2012) Computational Drug Discovery and Design Humana Press. ➢ Wall L., Christiansen T. & Orwant J. (2007) Programming Perl (3^{rd} Ed). O'Reilly.	
2.	Laboratory I	Upon successful completion of the course, students should be able to: • Write Perl programs to analyze and interpret biological data. • Model and analyze 3D structure of drug targets. • Handle sorftware for drug designing and virtual screening.		**Drug Designing Exercises** 1. Molecular visualization tool (applications such as molecular interaction, Molecular surface visualization, electrostatics, H-bond calculation etc. with PyMol) and Visualization of structural motifs. 2. Analysis of PDB (NMR and X – ray) structures (Quality of structure, analyzing molecular interactions, protein – ligand/ protein – protein if any, from PDB). 3. Homology based protein structure prediction. 4. Quality estimation of modeled protein structure (ProCheck, PROSA, Verify3D, Errat and MolProbity). 5. Contact map based protein structure comparison. 6. Energy minimization based mutational analysis of proteins. 7. Protein – Ligand docking using Autodock and MGLTools and Pharmacophore analysis. **Perl Exercises** 8. Use of various arithmetic and logical operators. 9. Programming based on string manipulation	New course introduced

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				(concatenation, splitting etc.). 10. Regular expression and its applications, use of s/// and tr/// operators. 11. Pattern matching to locate and count motifs in a string. 12. Calculating nucleotide frequency and GC content., Hydropathy index calculation of proteins. 13. Constructing arrays, addition and removal of elements from array, exploring array. 14. Use hashes in conversion of three letter code to one letter code and protein translation. 15. Perl subroutines, generating random DNA and its comparison with real DNA 16. File handling, reading data from a file writing data to a file and editing a file. 17. Directory handling, make a directory, change current working directory, reading files from a directory.	
	IInd Sem				
1.	Computational Biology	After successful completion of the course students should be able to: • Solve problems of sequencing projects by applying the computational tools and understand the molecular evolution process. • Analyze the biological networks to identify potential node for various		**Section – A** • Sequence Analysis – Concepts of sequence comparison, identity and homology, definitions of homologues, orthologues, paralogues and xenologues. Scoring matrices: concept and applications of PAM. • Algorithms: Needleman and Wunsch, Smith and Waterman algorithms for pairwise alignments and application. • Concept and application of multiple sequence alignments. • Database searchin: introduction to BLAST.	New course introduced

S.No.	Course List	Learning Outcome	Existing	Proposed	Remarks
		application in molecular biology		**Section – A** • Molecular Evolution – Gene Phylogeny versus Species Phylogeny, Forms of Tree Representation. • Phylogenetic Tree Construction Methods and Programs: Distance-Based Methods, Character-Based Methods. • MatLab: Introduction to MatLab environment, vector and matrices, expression, subscripts and manipulating matrices. • Programming with MatLab: Flow control, script and function files. • Graphics: Plotting (2D and 3D) graphs. • Introduction to Bioinformatics toolbox. **Section – C** • Biological Networks - Basic properties of Network: Degree, average degree and degree distribution. • Network Models- Erdos-Renyi model, Small-world effect, clustering coefficient. Scale-free networks, Power laws, The Barabasi-Albert Model. • Biological networks, Intra-cellular networks: Gene-regulatory network, Protein-interaction network, Metabolic networks and Signaling network **Suggested Books:** ➢ Bromham L. (2016) An Introduction to Molecular Evolution and Phylogenetics. Oxford University Press. ➢ Newman M.E.J. (2010) Networks: An Introduction, Oxford University Press.	

S.No.	Course List	Learning Outcome	Existing	Proposed	Remarks
				➢ Selzer P. M., Marhöfer R. J. & Koch O. (2018) Applied Bioinformatics: An Introduction (2nd Ed.). Springer International Publishing AG. ➢ Gilat A. (2016) MATLAB: An introduction with application (6th Ed.). John-Wiley Publication.	
2.	Laboratory II	After successful completion of the course students should be able to: • Perform sequence alignment and utilise associated phyllogenetic tools • Have a working knowledge of MatLab.		**Computational Biology Exercises** 1. Pair wise sequence alignment (both global and local sequence alignments). 2. Blast tools. 3. Multiple sequence alignment. 4. Molecular Phylogeny (Phylogenetic tree reconstruction). 5. Prediction of coding region in given nucleotide sequence (GenemarkS). 6. Demonstration and analysis of Biological networks (Protein – Protein Interaction and Metabolic). **MatLab Exercises** 7. Introduction to MatLab working environment. 8. Working with matrices 9. Writing biology oriented simple programs. 10. Matlab Graphics (Plotting 2D and 3D Graphs). 11. Introduction to Bioinformatics Toolbox. 12. Data analysis and Statistics with Matlab	New course introduced

Verified

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