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.

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	4	0	0	4
	Alternate online core course Plant Physiology and Taxonomy https://www.acs.edu.au/courses/botany-i-plant-physiology-and-taxonomy-199.aspx				
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* (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. **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/proteintraffick ing ➢ **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	

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				➢ **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:**	

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				➢ **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

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			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.	**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*	

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, ~~eross 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* (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.	

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* (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* (5thed.). 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, carcinogenecity~~. - ~~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	

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				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	

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				➢ **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	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			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	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		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 , CO2 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:	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				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. o *Agrobacterium*, Ti plasmids, ~~co-integrate and binary vectors~~. Other vectors - viral vectors. o 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.	

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				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*.	

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				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	

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				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)	

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		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**	

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				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 (26th ed.). US: Lange Medical Books, McGraw-Hill. ➢ Madigan, M., Martinko, J., Stahl, D. and Clark, D. (2010). *Brock Biology of Microorganisms* (13th ed.). 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/PMC3470069/	

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			➢ 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 (2nd ed.). UK: Oxford University Press. ➢ Primrose, S.B., Twyman R.H. and 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. and 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. and 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		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.

Verified

Offg. Secretary
Banasthali Vidyapith
P.O. Banasthali Vidyapith
Distt. Tonk (Raj.)-304022

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**

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

Appendix-IVC

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	

Appendix-IVC

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* (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. **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	

Appendix-IVC

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. - Biopesticides~~, 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* (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:**	

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.	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				➢ 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/	

S. No	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				➢ **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* (11thed.). 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* (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. ➢ 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, 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~~	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* (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*.	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.

Appendix-IVC

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, carcinogenecity~~. - ~~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* (8th 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* (3rd ed.). Sunderland, USA: Sinauer Associates, Inc. ➢ Strikberger M.W. (2005). *Evolution* (3rd 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/bsc420520lect2.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*. (7th 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* (2nd 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* (3rd 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* (2nd 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, rhynococephalia, 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 exoskeletion 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 exoskeletion 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 CO_2 and O_2 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*	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				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.	

Appendix-IVC

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	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
			~~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* (9th ed.). Sunderland, USA: Sinauer Associates ➢ Hall, J. E. (2011). *Guyton and Hall Textbook of Medical Physiology* (6th 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*	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				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	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				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	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
		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*	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				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, ichthyosporidium, 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.	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				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 (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** ➢ **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).	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				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/SafetyHealth/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	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
		• 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 (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)	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				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.	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				• 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	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
				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.	

S. No.	Course	Learning Outcomes	Existing Syllabus	Suggested syllabus	Remarks
		patenting • Discuss the role of WTO and WIPO on IPR		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.**	

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				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, 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	**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 (26th ed.). US: Lange Medical Books, McGraw-Hill. ➢ Madigan, M., Martinko, J., Stahl, D. & Clark, D. (2010). *Brock Biology of Microorganisms* (13th ed.). UK: Pearson Education. ➢ Pelczar Jr., M.J., Chan, E.C.S. & Krieg, N.R. (2011). *Microbiology*. New York, USA:Tata	This course was earlier run as a core course in AMBT IIIrd sem.

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			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/	

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			➢ 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*	

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				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	

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		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	

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				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	

Verified

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