Minutes of the Meeting of the Board of Studies in Bio Science and Biotechnology held on 20th & 21st March, 1996 at 10.30 a.m. in Vidya Mandir, Banasthali Vidyapith.

(1)

Present

1.	Dr. S. Mishra	External Member
2.	Dr. (Miss) Vijya L. Tandon	Convener
3.	Dr.(Mrs) Savita Pareek	Member
4.	Mrs. Venna Garg	Member
5.	Dr. Smita Chaudhary	Member
6.	Dr. Veena Pareek	Member
7.	Miss Sushma Kumari	Special Invitee
8.	Miss Sonia Raghav	Special Invitee
9.	Dr. (Miss) Jyoti Saxena	Special Invitee
10.	Dr. (Miss) Binita Nautiyal	Special Invitee
11.	Miss Mamta Dabral	Special Invitee
12.	Mrs. Anubhuti Sharma	Special Invitee

Note : Prof. Murlidharan, Dr. R.R. Unithan and Dr. Anil Kumar could not attend the meeting.

1. The Board confirmed the minutes of the last meeting held on 29th January, 1995.
2. The Board recommonded no change in the panel of examiners.
3. The Board persued the reports of the examiners of different examinnations of 1995 and was satisfied with the performance of candidates based on the pass percentage as well as the number of students securing I division.
4. In case the proposal of starting semester scheme is approved, the Board recommonded following 20 courses for M.Sc. Bio Science and 18 courses for M.Sc. Biotechnology, since in M.Sc. Biotechnology group, a dissertation is recommonded and this is treated as equivalent to two courses of the semester (Appendix I). If annual scheme is retained minor rearrangement are suggested. The suggested changes in paper I M.Sc. (Pre) Bio Science Unit IV and in paper III Unit III may now be read as given in Appendix IIA. A tantative list of experiments with slightly altered scheme of examination is also suggested for for M.Sc. (Pre) Bio Science students. The present practical syllabi page 41 may be read as given in **Appendix III**. In M.Sc. (Final) Bio Science (Animal Science) Unit IV of paper II and Unit I of paper IV be read as given in **Appendix II B**.

5. In M.Sc. (Pre) Biotechnology if the annual scheme is retained the changes in paper IV Unit I, II may be made as given in **Appendix IV-a** and Unit III as in **Appendix IV-b**. Similarly in M.Sc. Bio Science (Pre) Unit I and II of paper IV may be read as given in Appendix IV-a. In practicals a tentative list of experiments in lab I, II & lab III & IV is also specified (Appendix V) for M.Sc. (Pre) & Final Biotechnology. No change is recommended for M.Sc. final Biotechnology theory papers except with paper VII, Unit V-in the end of unit 'Recombinat DNA safety guidelines and intellectual property rights' be added.
6. The Board resolved to recommond that in M.Sc. (Final) Bio Science as far as possible 50% students should offer Animal Science and 50% Plant Science. The criteria for the same may be decided in the faculty.
7. The Board also recommonded that the students offering Main Hons. course at B.Sc. level should opt the same subject in M.Sc. (Final) Bio Science.

Appenix I

Courses recommonded for M.Sc. Bio Science & Biotecnnology in se
scheme.

No of Semster Semester	Courses for M.Sc. Bio Science	Courses for M.Sc. Biotechnology	Marks each c
Semster I	1. Cell Biology	1. Cell Biology	10
	2. Biochemistry	2. Biochemistry	10
	3. Micro Biology	3. Micro Biology	10
	4. Biostatistics & Bioinformatics	4. Biostatistics & Bioinformatics	10
	6. Lab I	6. Lab I	10
	5.Tools and Techniques	5. Tool and Techniques	10
Semester II	7. Genetics	7. Genetics	10
	8. Molecular Biology	8. Molecular Biology &	10
	9. Genetics Engineering	9. Genetics Engineering	10
	10. Immunology	10. Immunology	10
	11. Environmental Biology	11. Environmental Biology	10
	12. Lab II	12. Lab II	100
Semester III	13.Enzymology	13. Enzymology	100
	14. Animal & Plant Tissue Culture	14. Animal & Plant Tissue Culture	100
	15.Diversity in Animal Life-I	15. Environmental Biotechnology	100
	16.Reproductive Biology	16. Recobinant DNA Technology	100
	17.Endocrinology	17. Biophysics	100
	18. Lab III	18. Lab III	100
Semester IV	19. Diversity in Animal life-II	19. Enzyme Technology & fermentation	100
	20. Animal Physiology	20. Elective-I/II/III	100
	21. Ethology and Neurobiology	21. Dissertation	400
	22. Medical Pathology		
	23. Toxicology		

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Elective I - Advanced Immunology & its Application in Biological Science.
Elective II - Plant Biotechnology.
Elective III - Food Biotechnology.

Appendix - II A

M.Sc. Previous Bioscience

Paper I: Microbiology, Genetic Engineering and Biotechnology:

Unit 4 may be read as follows:

(i) Prokaryotes - Mode of gene transfers: conjugation Transformation, Transduction, Transfection and Sexduction.

(ii) Plasmids - Phenotypes, classification, Organization and distribution of plasmid borne genes.

(iii) Nature of viruses, organisation of virion. bacterial viruses & their replicat

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. Biotechnology Programme

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

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

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

Proposed Courses					
M.Sc. Biotechnology Sem. II		**L**	**T**	**P**	**C**
BIO 406	Biostatistics and Research Methodology	4	0	0	4
BIO	Genetics	4	0	0	4
BIO 411	Immunology	4	0	0	4
BIO 408	Environmental Biology and Biotechnology	4	0	0	4
BT	Genetic Engineering	4	0	0	4
BIO	Bioscience Lab-II	0	0	12	6
		20	**0**	**12**	**26**

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

Existing Courses					
M.Sc. Biotechnology Sem. III		**L**	**T**	**P**	**C**
BT 522	Recombinant DNA Technology	4	0	0	4
BT 504	Bioprocess Engineering and Technology	4	0	0	4
BT 507	Cell and Tissue Culture Technology	4	0	0	4
BT 509	Environmental Biotechnology	4	0	0	4
BT 505L	Biotechnology Lab-I	0	0	12	6
	Elective	4	0	0	4
	Total	**20**	**0**	**12**	**26**
	List of Electives				
BIO 503	Fundamentals of Bioentrepreneurship				
BIO 505	Microbial Technology				
BT 513	Food Process and Biotechnology				
BT 515	Genomics and Proteomics				
BT 516	Immunotechnology				
BT 521	Plant Biotechnology				

Proposed Courses					
M.Sc. Biotechnology Sem. III		**L**	**T**	**P**	**C**
BT	Bioprocess Engineering and Technology	4	0	0	4
BT 507	Cell and Tissue Culture Technology	4	0	0	4
BIO	Critical Analysis of Classical Papers/ Landmark Discoveries (Seminar)	0	2	0	2
BT	Biotechnology Lab-I	0	0	12	6
	Discipline Elective	4	0	0	4
	Open Elective	4	0	0	4
BT	Reading Elective-I/ II	0	0	0	2
	Total	**16**	**2**	**12**	**26**

Existing Courses					
M.Sc. Biotechnology Sem. IV					
BT 508D	Dissertation	0	0	52	26
	Total	**0**	**0**	**52**	**26**

Proposed Courses					
M.Sc. Biotechnology Sem. IV					
	Reading Elective-I/ II	0	0	0	2
BT 508D	Dissertation	0	0	48	24
	Total	**0**	**0**	**48**	**26**

Proposed List of Elective courses to be offered in III Semester	
BIO	Fundamentals of Bioentrepreneurship
BIO 505	Microbial Technology
BT	Food Process and Biotechnology
BT	Genomics and Proteomics
BT	Immunotechnology
BT	Plant Biotechnology
BT	Recombinant DNA Technology
BT	Animal Biotechnology-I
PHY	Biophysics-I
BT	Enzyme Technology
BT	Forensic Biology and Serology https://swayam.gov.in/course/264-forensic-biology-and-serology
BT	Water and Waste Treatment Engineering: Biochemical Technology https://www.edx.org/course/water-wastewater-treatment-engineering-tsinghuax-40050455-2x-0
BT	Industrial Biotechnology https://onlinecourses.nptel.ac.in/noc17_bt23/preview https://swayam.gov.in/search?keyword=Industrial%20Biotechnology
BT	Fundamentals of Ecology for Sustainable Ecosystem https://www.extension.harvard.edu/academics/courses/fundamentals-ecology/12779

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

Comparative Table: M.Sc. Biotechnology: Existing and Modified syllabus, Suggested Books and Suggested E-Resources

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

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• ~~Statistical significance of alignment,~~ ~~Substitution Scores and Gap penalties.~~ • Multiple Sequence alignment: ~~CLUSTAL W~~. [redacted] ~~EMBOSS~~. **Books Recommended :** ➢ A textbook of Bioinformatics : Sharma, Munjal&Shanker, Rastogi Publication, Meerut ➢ Fundamental of computer : P.K. Sinha ➢ Introduction to Bioinformatics : Parrysmith and Attwood ➢ Introduction to Bioinformatics : Baxevenis and Oulette ➢ Internet for Molecular Biologist : Swindell ➢ Molecular databases for protein sequences and structure studies - An Introduction Silence : J., Sillince M., Springerberlagd, Berlin 1972 ➢ Leaping from Basic to C++ : Robert J. Traister, A.P. Professional Cambridge ➢ Perl 5 Unleashed : Kamran Husain & Robert F Breedlore SAMS Publishing. ➢ Bioinformatics : David, Mount.	• Forces stabilizing biomolecular interaction. • Principle of Molecular Docking. Types of molecular docking, its advantage and limits. **Suggested Books:** ➢ Rastogi, S.C. & Rastogi, P. (2013). *Bioinformatics Methods and Applications* (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	**Section-A** • Chromatographic methods for macromolecule separation- TLC and Paper chromatography, gel	**Section-A** • Chromatographic methods for macromolecule separation:	

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

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

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				2.pdf ➢ **Microscopic techniques** www.nptel.ac.in/courses/102103015/pdf/mod3.pdf	
3.	**BIO 403:** Biochemistry &Biophysics	After successful completion of the course, students should be able to: • Understand the structure and role of various biomolecules • Identify, assess and explain various biochemical pathways • Develop understanding of enzymes and their mechanism of action	**Biochemistry & Biophysics** **Section-A** • ~~Hydrogen bonding and structure of water molecule, Ionization of water, pH and colligative properties of water~~. • Bioenergetics: First & second law of thermodynamics, concept of free energy, change in standard free energy, ~~ATP and its hydrolysis.~~ • Carbohydrates: general classification, Polysaccharides: ~~&proteoglycans~~: Starch, glycogen, cellulose, chitin ~~&bacterial cell wall~~. ~~Glycosaminoglycans& proteoglycans in extracellular matrix.~~ **Section-B** • Electron transport system in mitochondria & chloroplasts. Oxidative phosphorylation, P/O ratio, Uncouplers. • Lipids - Glycerophospholipids, sphingolipids, gangliosides, Eicosanoids & prostaglandins. ~~Cholesterol & its biosynthesis~~. • Proteins & amino acids - Zwitterionic properties of amino acids & titration curves. Peptide bonds, disulphide cross links, various levels of structural organization of proteins. • Ramachandran plot, Alpha-helix, Beta sheet, ~~Helix-coil transitions.~~ **Section-C** • Structure function relationship in model proteins like ribonuclease A, haemoglobin, chymotrypsin.	**Biochemistry** **Section-A** • Bioenergetics: First and Second law of thermodynamics, concept of free energy, change in standard free energy. • Carbohydrates: general classification, Polysaccharides: Starch, glycogen, cellulose & chitin. • Glycolysis, Citric acid cycle. Electron transport system in mitochondria & chloroplasts. Oxidative phosphorylation, Photosynthetic phosphorylation, P/O ratio, Uncouplers. **Section-B** • Lipids - glycerophospholipids, sphingolipids, gangliosides, eicosanoids & prostaglandins. • Proteins & amino acids – Zwitterionic properties of amino acids & titration curves. Peptide bonds, disulphide crosslinks, various levels of structural organization of proteins. • Ramachandran plot, Alpha-helix, Beta sheet, • Structure function relationship in model proteins like ribonuclease A, haemoglobin and chymotrypsin. • Biosynthesis of purines and pyrimidines, *de novo* and salvage pathway, **Section-C** • Introduction to enzymes: Classification of	The title is changed as Biophysics component has been removed as it does not fit in two year M.Sc. Biotechnology programme. Section B: Relevant topics, which were earlier not part of the syllabus, have been added. These topics are essential part of the carbohydrate metabolism, a key component of the living organisms. Section C: Biophysics topics have been deleted. Reshuffling done in order to coherently organize various topics of the syllabus.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• Biosynthesis of purines and pyrimidines, *de novo* and salvage pathway, ~~various confirmations of nucleotides,~~ glycosidic bond rotation, base-stacking. • ~~Mechano-Chemical Process: Molecular structure of musele-Actin, myosin, troponin, tropomyosin, Musele Contraction.~~ • ~~Action Potential and propagation of neuronal computation through nerve fibre.~~ **Books Recommended :** ➢ Principles of Biochemistry : A.L. Lehninger, Nelson and Cox, McMillan Worth Publishers. ➢ Biochemistry :Voet and Voet, John Wiley and Sons, Inc. USA. ➢ Biophysical Chemistry Vol. I, II &III : Cantor and Schimmel, Freeman. ➢ Biochemistry :Zubey, WCB. ➢ Biochemistry : Garrett and Grisham, Harcourt. ➢ Biochemistry :Stryer, W. H. Freeman. ➢ Understanding Enzymes : T. Palmer, Horwood. ➢ Harper's review of Biochemistry : R.K. Murray et al., Prentice-Hall International Inc. ➢ Fundamentals of Biochemistry : Cohn and Stumf. ➢ Molecular Biophysics-Structure in Motion :Michel Daune, Oxford University Press.	enzymes Nomenclature of enzymes, E.C. Number • Enzyme kinetics (Michaelis – Menten kinetics), importance and determination of Vmax and Km values, L & B plots. • Enzyme inhibition: competitive, non-competitive and un-competitive. • Coenzymes and Isozymes. **Suggested Books:** ➢ Nelson, D. L. & Cox, M.M. (2012). *Lehninger Principles of Biochemistry* (6th ed.). New York, USA: W. H. Freeman and Company. ➢ Rodwell, V.W., Bender, D., Botham, K.M., Kenelly, P.J.& Weil., P.A. (2018). *Harper's Illustrated Biochemistry* (31st ed.). New York, USA: McGraw-Hill Education. ➢ Voet, D. &Voet, J.G.(2010). *Biochemistry* (4th ed.). New Jersey, USA: Wiley. ➢ Berg, J.M., Tymoczko, J.L., Gatto Jr., G.J. & Stryer, L. (2015). *Biochemistry* (8th ed.). New York, USA: W. H. Freeman and Company. ➢ Garrett, R. H. & Grisham, C. M. (2012). *Biochemistry* (5th ed.). Belmont, USA: Wadsworth Publishing Co Inc. ➢ Palmer, T. & Bonner, P. (2014). *Enzymes: Biochemistry, Biotechnology and Clinical Chemistry*. UK: Woodhead Publishing Limited. ➢ Cantor, C.R. & Schimmel, P.R. (1980). *Biophysical Chemistry Part I, II & III*. New York, USA: W. H. Freeman and Company. ➢ Ferdinand, W. (1976). *The Enzyme Molecule*. New Jersey, USA: John Wiley & Sons Ltd.	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Suggested e- Resources: ➢ **Metabolic pathways, Biomolecules** https://epgp.inflibnet.ac.in/ahl.php?csrno=2 ➢ **Mechanism of enzyme action** http://www.biologydiscussion.com/enzymes/enzymes-properties-and-mechanism-of-enzyme-action/6145 ➢ **E-book for Garrett and Grisham** https://bit.ly/2TbDWWR	
4.	**BIO 404L:** Bioscience Lab-I	After successful completion of the course, students should be able to: • Demonstrate use of various tools and techniques for detection and quantification of biomolecules. • Perform various biochemical assays for fats, carbohydrate, protein and enzymes • Demonstrate microbiological techniques • Access, retrieve, and analyze nucleotide and protein sequences using bioinformatics tools	1. Demonstration, principle and use of lab equipments: Centrifuges (~~Table top~~ and high speed), ~~Balances (electrical and digital).~~ ~~2. Demonstration, principle and use of lab equipments: Spectrophotometer, pH meter.~~ 3. Estimation of proteins by Lowry's ~~and TCA methods.~~ 5. Estimation of carbohydrates (reducing and non-reducing sugar). 6. Estimation of fats (cholesterol). 7. ~~Preparation and purification of casein from buffalo milk.~~ 8. Separation of amino acids by TLC and paper chromatography. 9. ~~Determination of Logic properties (pH value of Lysine by titration).~~ 10. ~~To find λmax for proteins.~~ 11. ~~Use of selective and diagnostic media for cultivation, isolation, enumeration and purification of microorganisms.~~ ~~12.~~ Measurement of bacterial ~~and fungal~~ growth. 13. Isolation and enumeration of microbes from air/soil by serial dilution/agar plating method. 14. Antibiotic sensitivity test. 15. ~~Microbiological examination of food~~.	**Analytical Techniques-I** 1. Demonstration: Working principle & applications of - Centrifuges (high speed refrigerated centrifuge & ultracentrifuge). - Fluorescence microscope. - Atomic absorption spectrophotometer, HPLC, FPLC, GC-MS. 2. Separation of amino acids by TLC and Paper Chromatography. **Cell and Molecular Biology** 3. Study of different stages of mitosis (onion root tip) and meiosis (onion buds/grasshopper testis) and determine the mitotic index. 4. Separation of chloroplast by sucrose density gradient centrifugation. **Biochemistry** 5. To prepare sodium acetate buffer and validate the Henderson-Hasselbach equation. 6. Extraction of crude enzyme from germinating mung bean seeds. 7. Estimation of total protein content by Lowry's method. 8. Separation of protein by SDS PAGE. 9. Estimation of acid phosphatase activity using	The experiments have been reframed and modified keeping in consideration, the suggested syllabus.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			16. Citric acid production by A. niger. ~~17.~~ Study of cell division in plants and animals,~~Giant chromosomes.~~ 18. Separation of different organelles/molecules by sucrose density gradient/differential gradient. 19. Separation and identification of serum proteins/plant proteins by gel electrophoresis. 20. ~~Histochemical localization of biomolecules (protein, carbohydrate or any other).~~ ~~21. Bioinformatics exercise 1~~ 22. ~~Bioinformatics exercise 2.~~	standard curve of p-nitrophenol. 10. Purification of the crude enzyme extract (from Expt. 6) using ammonium sulphate precipitation and ion exchange/ affinity chromatography (demonstration). 11. Determination of kinetic properties (K_m and V_{max} values) of acid phosphatase. 12. Estimation of total carbohydrates using Anthrone method. 13. Estimation of reducing sugar by Nelson-Somogyi method. 14. Estimation of fats (cholesterol). **Microbiology** 15. Isolation and enumeration of microbes from soil and water. 16. Staining of selected bacterial and fungal strains. 17. Estimation of bacterial growth by turbidometric method. 18. Antibiotic sensitivity test. 19. Estimation of infectivity titre of a virus sample using Plaque assay. **Bioinformatics** 20. Database Search: Use and analysis of BLAST tool for protein and DNA sequences. 21. Molecular Evolution: Multiple sequence alignment and phylogenetic analysis (Clustal X/ Mega/ Tree-View). 22. Structure Prediction: Protein secondary and tertiary structure prediction using online tools. 23. Molecular Visualization: Structural analysis of PDB entries for active and inactive states of protein(Pymol). **Suggested Books:**	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				➢ Aneja, K. R. (2001). *Experiments in Microbiology, Plant Pathology, Tissue Culture and Mushroom Production Technology*. New Delhi, India: New Age International Ltd. ➢ Cappuccino, J. G. & Welsh, C. (2019). *Microbiology: A Laboratory Manual*. New York, USA: Pearson. ➢ Sadasivam, S., & Manickam, A. (1996). *Biochemical Methods* (2nd ed.). New Delhi: New Age International Publishers. ➢ Saxena, J., Baunthiyal., & Ravi, I. (2015). *Laboratory Manual of Microbiology, Biochemistry and Molecular Biology*. Jodhpur: Scientific Publishers. ➢ Tille, P. M. & Forbes, B. A. (2017). *Bailey & Scott's Diagnostic Microbiology*. St. Louis, Missouri: Elsevier. **Suggested e- Resources:** ➢ **Harisha, S. Biotechnology procedures and experiments handbook** http://site.iugaza.edu.ps/mwhindi/files/BIOTECHNOLOGY-PROCEDURES-AND-EXPERIMENTS-HANDBOOK.pdf ➢ **Introduction to biotechnology** http://www.austincc.edu/awheeler/Files/BIOL%201414%20Fall%202011/BIOL1414_Lab%20Manual_Fall%202011.pdf	
5.	**BIO 407:** Cell and Molecular Biology	After successful completion of the course, students should be able to: • Understand membrane transport and cell signalling mechanisms. • Develop comprehensive understanding of endo-membrane system	**Section-A** • Molecular structure and function: ~~Structural models,Composition and dynamics;~~ Transport of ions and macromolecules; Pumps, carriers and channels; Membrane carbohydrates and their significance in cellular recognition; cellular junctions and adhesions; ~~structure and functional~~	**Section-A** • Molecular structure and function of plasma membrane: Transport of ions & macromolecules; Pumps, carriers and channels; Membrane carbohydrates & their significance in cellular recognition; Cellular junctions & adhesions.	Plasmodesmata already covered in 'cell junctions'

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		• Understand molecular mechanisms of prokaryotes and eukaryotes	~~significance of plasmodesmata~~. • Endocytosis and exocytosis, clathrin~~&coatomer~~ coated vesicles, SNARE proteins. • Cell to cell signaling :autocrine, paracrine and endocrine stimulation. • Signaling via G-protein linked cell-surface receptors, adenylatecyclase system, inositol phosphate pathway, role of Ca^{2+} -ions. • Signallingvia enzyme-linked surface receptors, tyrosine kinases. • Steroid receptors. **Section-B** • ~~Mitochondrial membrane organization~~,transport of proteins into mitochondria and chloroplasts. ~~Genome of mitochondria and cholorplasts.~~ • Concept of signal peptide, SRP, SRP Receptor, ~~transport of soluble and membrane bound proteins in Endoplasmic Reticulum,~~ ER Resident proteins, ER chaperone proteins and their functions, glycosylation of proteins in ER. • Golgi apparatus, role in protein glycosylation and transport. • Lysosomes, intracellular digestion, sorting of lysosomal enzymes in Golgi, lysosomal storage diseases. **Section-C** • Replication of genetic material in prokaryotes and eukaryotes: initiation, elongation and termination; Replication of single stranded circular DNA. • Prokaryotic transcription: Transcription units; RNA polymerase structure and assembly; Promotors; Rho-dependent and Rho-independent termination; Anti-termination.	• Endocytosis & exocytosis, clathrin coated vesicles, SNARE proteins. • Cell to cell signalling: autocrine, paracrine and endocrine stimulation. • Signaling via G-protein linked cell surface receptors, adenylate cyclase system, inositol phosphate pathway, role of Ca^{2+} ions. • Signaling via enzyme-linked surface receptors, tyrosine kinases. • Steroid receptors. **Section-B** • Protein sorting and targeting: Signal hypothesis, SRP, SRP Receptor, ER Resident proteins, ER chaperone proteins & their functions, glycosylation of proteins in ER. • Golgi apparatus, role in protein glycosylation and transport. • Lysosomes, intracellular digestion, sorting of lysosomal enzymes in Golgi, lysosomal storage diseases. • Transport of proteins into mitochondria & chloroplasts. • Cell Cycle & its regulation, apoptosis. **Section-C** • Replication of genetic material in prokaryotes & eukaryotes: initiation, elongation & termination; Replication of single stranded circular DNA. • Prokaryotic transcription: Transcription units; RNA polymerase structure & assembly; Promotors, Rho-dependent & Rho-independent	The deleted portion has been replaced with more relevant topic Cell Cycle and its regulation and division.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• Eukaryotic transcription: RNA polymerase structure and assembly; RNA polymerase I, II, III; eukaryotic promoters and enhancers; general transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF). • Post transcriptional modifications: processing of hnRNA, tRNA and rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; Splicing; RNA editing; Nuclear export of mRNA; ~~mRNA stability;~~ Catalytic RNA. • Translation: Translation machinery; ~~Ribosomes: composition and assembly;~~ Genetic code~~: degeneracy of codons, initiation and termination codons, wobble hypothesis,genetic code in mitochondria;~~IsoacceptingtRNA; ~~Mechanism of~~ initiation, elongation and termination; Co- and post-translational modifications. **Books recommended :** ➢ Cell and Molecular Biology : De Robertis& De Robertis, B.I. Waverly Pvt. Ltd., New Delhi. ➢ The world of the cell : W.M. Becker, Pearson Education. ➢ Cell and Molecular Biology : G. Karp, John Wiley & Sons. ➢ The Cell - A Molecular Approach : Cooper, Sinauer. ➢ Cell and Molecular Biology : P.K. Gupta, Rastogi Publications. ➢ Molecular Cell Biology :Lodish, Baltimore, W. H. Freeman & Co. ➢ Molecular Biology of the Cell : Bruce Albert, Garland Publication, NY. ➢ Essentials of Cytology : C.B. Powar, Himalaya Publications.	termination; Anti-termination. • Eukaryotic transcription: RNA polymerase structure and assembly; RNA polymerase I, II, III; eukaryotic promoters & enhancers; general transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF). • Post transcriptional modifications: processing of hnRNA, tRNA and rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; splicing; RNA editing; nuclear export of mRNA; catalytic RNA. • Genetic code, Isoaccepting tRNA; Translation: Translation machinery: initiation, elongation and termination; Co-and post-translational modifications. **Suggested Books:** ➢ De Robertis, E.D.R. & De Robertis, E.M.F. (2017). *Cell and Molecular Biology*. New York, USA: Lippincott Williams & Wilkins. ➢ Hardin, J., Bertoni, G. & Lewis, K.J. (2011). *Becker's World of the Cell*. Essex, UK: Pearson Education Limited. ➢ Karp, G., Lwasa, J. & Larshall, W. (2015). *Cell and Molecular Biology: Concepts and Experiments*. New Jersey, USA: John Wiley & Sons Ltd. ➢ Cooper, G., M. & Hausman, R. E. (2004). *The Cell: A Molecular Approach*. Washington, D.C.: ASM Press. ➢ Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretsher, A., Ploegh, H., Amon, A. & Martin, K. C. (2007). *Molecular Cell Biology*.	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Principles of Genetics : Gardner, Simmons, Snustad, John Wiley & Sons. ➢ Gene VIII :Lewin, Pearson Education. ➢ Molecular Biology of Gene : J.D. Watson, Pearson Education. ➢ Molecular Biology : David Freifelder, Narosa Publishing House, New Delhi. ➢ Molecular Biology : R. Weaver, WCB McGraw Hill.	New York, USA: W. H. Freeman and Company. ➢ Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. & Walter, P. (2007). *Molecular Biology of the Cell*. UK: Garland Science. ➢ Freifelder, D. M. (1986). Molecular Biology. USA: Jones & Bartlett Publishers. **Suggested e- Resources:** ➢ **Cell Biology resources** https://www.nature.com/scitable ➢ **Sorting and trafficking of proteins** http://www.vcell.science/project/proteintrafficking ➢ **RNA editing** study.com/academy/lesson/rna-editing-definition-processes.html	
6.	**BIO 416:** Microbiology	After successful completion of the course, students should be able to: • Describe different methodologies for classification of microbes. • Understand structural, functional and metabolic diversity of bacteria • Explain viral structure, properties, replication and cultivation	**Section-A** ~~Discovery of Micro-organisms.~~ • Criteria for classification; molecular approaches • Bacteria: General features, Structural organisation, Nutrition, ~~Growth~~, ~~Respiration~~ ~~and Reproduction~~. • ~~Methanogens~~ and ~~Methylotrophs~~, Chemolithotrophs, Phototrophs, Sulphur reducing bacteria. • Archaebacteria **Section-B** • Nature of viruses, Organisation of virion, Animal, Plant and Bacterial Viruses. • Virus replication, Cultivation of viruses &	**Section-A** • History and scope of microbiology. • Bacteria: Structural organization. • Archaea: Structural organization and brief overview of major physiological groups (Halophiles, Methanogens, Thermophiles). • Growth of bacteria- bacterial growth curve, factors affecting growth. • Nutrition in bacteria- nutritional classes, modes of nutritional uptake, media (types) and culture methods. • Modes of bacterial reproduction. • Regulation in bacteria-operon concept-lac, trp and ara. **Section-B** • Classification of bacteria and approaches used (conventional and modern).	The current syllabus is too bulky and inadequately distributed in the three sections. Contents of section C will be taken up by biotechnology students in bioprocess engineering and environmental biotechnology papers. Also, the last two points of section B are more suited to bioprocess. In the proposed syllabus, the syllabus is more evenly distributed and pertinent content has been added for a more cohesive syllabus.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Virulence factor. • Isolation and screening of industrially important microbes. • Improvement of strains. **Section-C** Biofertilizer and Compost. - 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 transmission of diseases, indicator organisms.~~ **Books Recommended :** ➢ Introductory Microbiology : F.C. Ross, Columbus Charles E. Mehrill. ➢ Microbiology - Fundamentals and Applications : S.S. Purohit, Agro Botanical Publishers, Bikaner. ➢ Modern Concepts of Microbiology : H.D. Kumar and S. Kumar, Vikas Publishing House,	Metabolic diversity in bacteria- aerobic and anaerobic respiration (suphate, nitrate), fermentation (lactic, mixed, acetone-butanol, stickland fermentations and acetogenesis), chemolithotrophy(hydrogen, sulphur, nitrate and iron oxidizers), phototrophy (oxygenic and anoxygenic). • Unculturable microbes. • Bacterial quorum sensing. **Section-C** General properties, structure, taxonomy (ICTV & Baltimore classification)of virus. General features of viral replication, sub-viral particles – satellite virus, viroids& prions. Bacteriophages: one step growth curve, structure & life cycle of T_4 and lambda phages, molecular control of lytic & lysogenic cycle. Animal virus: structure and life cycle of- herpes simplex virus, papovavirus, reovirus & retroviruses. Plant virus: structure & life cycle of - geminivirus, caulimovirus & tobacco mosaic virus; virus-vector relationship. Virus assay: Plaque, pock, hemagglutination & transformation assays and concept of ID50. Cultivation of viruses. **Suggested Books:** ➢ Willey, J. M., Sherwood, L.M. & Woolverton, C.J. (2014). *Prescott's Microbiology* (9th ed.). New York, USA: McGraw-Hill Education. ➢ Madigan, M., Martinko, J., Stahl, D. & Clark, D. (2010). *Brock Biology of Microorganisms* (13thed.). UK: Pearson Education.	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			New Delhi. ➢ Microbiology : M.J. Pelczar,C.E.C. Sun and N.R. Krieg, Tata McGraw Hill, New Delhi. ➢ A Text book of Microbiology : R.C. Dubey and D.K. Maheshwari, S. Chand and Company. ➢ Microbiology : K.L. Burdon and R.P. Williams, Mcmillan Worth Publishers. ➢ Microbiology : B.D. Davis et al. : Harper and Row Publishers. ➢ Microbiology : E.W. Nester et al., Saunders international edition. ➢ Principle of Fermentation Technology : P.F. Stanbury and A. Whittaker, Pegamon Press. ➢ Fundamental principles of Bacteriology : A.J. Salle, Tata McGraw Hill. ➢ T.D. Boock's World of Microbiology : Madigan ➢ Microbiology :Presscott.	➢ Pelczar Jr., M.J., Chan, E.C.S. & Krieg, N.R. (2011). *Microbiology*. New York, USA: Tata McGraw-Hill. ➢ Kungo, R. (Ed.). (2017). Nanthnarayanand Paniker's *Textbook of Microbiology* (10th ed.). New Delhi, India: Universities Press. ➢ Moat, A. G., Foster, J.W. & Spector, M.P. (2003). *Microbial Physiology* (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 ➢ **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/	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				➢ **Structure and classification of Viruses** https://www.ncbi.nlm.nih.gov/books/NBK8174/ https://www.pnas.org/content/101/44/15556 ➢ **Virus replication** https://bit.ly/2BQLTa5	
M. Sc. Biotechnology II Semester					
7.	**BIO 405L:** Bioscience Lab-II	After successful completion of the course, students should be able to: • Demonstrate techniques used in immunology and genetic engineering • Perform key experiments for water quality analysis and other contaminants • Solve problems based on gene mapping and population genetics	1. To obtain standard curve of p-nitrophenol solution. 2. To prepare a sample of enzyme extract. 3. To determine activity of acid phosphatase from peas/moong seedlings. 4. Purification of an enzymatic protein by salt precipitation. 1. Determination of kinetic properties (Km and Vmax values) of an enzyme. 2. To check time and protein linearity of an enzymatic reaction. ~~3.~~ Immobilization of an enzyme. ~~4. Blood film preparation and identification of leucocytes.~~ 5. Lymphoid organs and their microscopic organization. 6. ~~Immunization, collection of serum~~. 7. Double diffusion and immuno-electrophoresis. 8. ELISA : Determination of antibody titre. 9. Immunodiagnostics (Demonstration using commercial kits). 10. Extraction and estimation of RNA. 11. Extraction and estimation of DNA. ~~12. To find □ max for nucleic acids.~~ ~~13. Preparation of metaphase chromosomes.~~ ~~14. Detection of ADH activity in tissue/cells by cytochemical staining using Drosophila.~~	**Environmental Biology and Biotechnology** 1. Determination of total hardness of water. 2. Determination of fluoride content in water. 3. Determination of BOD values. 4. Determination of LD_{50} for common pesticides/weedicides. 5. Bacteriological analysis of waste water. **Immunology** 6. To perform differential leucocytes count. 7. Lymphoid organs and their microscopic organization. 8. To perform immune diffusion by ouchterlony double diffusion method. 9. To perform immunoelectrophoresis. 10. ELISA: Determination of antibody titre. 11. Immunodiagnostics (Demonstration using commercial kits). **Genetic Engineering** 12. Extraction of genomic DNA by CTAB method and determination of its purity. 13. Estimation of DNA content by diphenyl amine (DPA) method. 14. PCR amplification of 'n' number of genotypes of a species using random primers (Demonstration). 15. Extraction of RNA by Phenol-Chloroform method and estimation by orcinol method.	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			~~15. Statistical problem.~~ 16. Genetic problem - (chromosome mapping).	**Genetics** 16. Study of sex chromatin from buccal epithelial/ hair bud cells. 17. Genetic exercise - Chromosome mapping, two and three point cross. - Quantitative genetics/ population genetics. **Biostatistics and Research Methodology** 18. Biostatistics problems based on following: - Measures of dispersion (variance). - Correlation analysis. - Probability and probability distribution. - Testing hypothesis by student t- test, Fisher's test, chi-square test and one way analysis of variance. **Suggested Books:** ➢ Aneja, K.R. (1996). *Experiments in Microbiology, Plant Pathology, Tissue Culture and Mushroom Cultivation* (2nd ed.). New Delhi: Wishwa Prakashan. ➢ Green, M. R., & Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual.* Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. ➢ Gupta S.P. (2000). *Statistical Methods.* S. Chand Publications. **Suggested e- Resources:** ➢ **Harisha, S. Biotechnology procedures and experiments handbook** https://bit.ly/2U0e39D ➢ **Introduction to biotechnology** https://bit.ly/2IICkzE	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
8.	**BIO 406:** Biostatistics and Research Methodology	After successful completion of the course, students should be able to: • Apply statistical analysis to biological data • Identify ethics in scientific research and associated methodologies • Develop skills in scientific writing.	**Section-A** • Scope of Biostatistics, variables in biology, collection, classification, tabulation of data. • Frequency distribution, diagrammatic and graphical presentation of statistical data, sampling techniques. • Measures of central location and dispersion, simple measure of skewness and kurtosis. • Probability, conditional probability. **Section-B** • Binomial, Poisson and Normal Distribution. • Correlation and Regression: Least Square method of fitting, Standard error of estimate, Correlation and regression coefficient. • Basic idea of significance testing, level of significance, students 't' test, $\chi 2$ (chi-square) test and F-test, Analysis of variance. **Section-C** • Introduction of Research Methodology: meaning and importance, nature and areas of research in Biological Sciences. • Formulation of a research problem (Hypothesis). • Elements in Research Methodology; Research Designs (CRD, RBD, LSD). • Ethical, legal and social issues in Biological Research. • Writing of Research Report/Research Paper: various components and their organization. **Recommended Books:** ➢ Singh S. (1988). Statistical methods for Research. Central publishing, Ludhiana. ➢ Gupta S.P. (2000). Statistical Methods. S. Chand Publications. ➢ Khan and Khanum (2012). Fundamentals of	No change in the syllabus **Suggested Books:** ➢ Singh S. (1988). *Statistical methods for Research.* Central publishing, Ludhiana. ➢ Gupta S.P. (2000). *Statistical Methods.* S. Chand Publications. ➢ Khan and Khanum (2012). *Fundamentals of*	

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			Biostatistics.Ukaz Publications. ➢ Zerold J. (2009). BiostatisticalAnalysis. UK: Pearson Education. ➢ Marcello P. and Kimberlee G. (2000). Principles of Biostatistics. Duxbury. ➢ Prasad S. (2012). Elements of Biostatistics.Rastogi Publications. ➢ Rastogi V. B. (2015). Biostatistics. Medtec publications. ➢ Basotia, G.R. and Sharma K.K. (1999). Research Methodology.Mangal Deep Publications. ➢ Chaudhary C.M. (1991). Research Methodology. RBSA Publications. ➢ Dorendro A. (2016). Research Methodology in Zoology.Pearlbooks . ➢ Kadam R.M. and Allapure R. B. (2016). Research Methodology in Botany.Gaurav Books	*Biostatistics*. Ukaz Publications. ➢ Zerold J. (2009). *Biostatistical Analysis*.UK: Pearson Education. ➢ Marcello P. and Kimberlee G. (2000). *Principles of Biostatistics*. Duxbury. ➢ Prasad S. (2012). *Elements of Biostatistics*.Rastogi Publications. ➢ Rastogi V. B. (2015). *Biostatistics*. Medtec publications. ➢ Basotia, G.R. & Sharma K.K. (1999). *Research Methodology*. Mangal Deep Publications. ➢ Chaudhary C.M. (1991). *Research Methodology*. RBSA Publications. ➢ Dorendro A. (2016). *Research Methodology in Zoology*. Pearlbooks. ➢ Kadam R.M. & Allapure R. B. (2016). *Research Methodology in Botany*. Gaurav Books. **Suggested e- Resources:** ➢ **ANOVA** https://www.analyticsvidhya.com/blog/2018/01/anova-analysis-of-variance/ ➢ **Regression Analysis** https://bit.ly/2s9vHdM ➢ **Student's t Test- Interactive tutorial** https://www.ruf.rice.edu/~bioslabs/Stats_tutorial/index.html	
9.	**BIO 410:** Genetics	After successful completion of the course, students should be able to: • Understand the theoretical and experimental foundations of classical and molecular genetics. • Describe the basics of genetic	**Section-A** • Definition of gene: genetic & biochemical view; Gene: unit of structure & function, complementation test. • Mendelian Genetics: Mendel's experimental design; Mendelian Genetics in humans: Pedigree analysis.	**Section A** • Definition of gene: genetic & biochemical view; Gene: unit of structure & function, complementation test. • Mendelian Genetics: Mendel's experimental design; Mendelian Genetics in humans: Pedigree analysis.	Genetic recombination models is important to be discussed to understand result of crossing over, gene conversion is important consequence of recombination.

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

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			chromosomal abnormalities-deletion; duplication; translocation; Sex determination; Lyon hypothesis; Role of Y chromosome; Genetic recombination; Disorders of sex chromosomes and autosomes; • Molecular cytogenetics-Fluorescence In Situ Hybridization (FISH); Comparative Genomic Hybridization (CGH). • Genetics of bacteria and bacteriophages: Genetic analysis of Bacteria; Genetic mapping in bacteria by conjugation, transformation and transduction; Mapping of bacteriophage gene. • Population genetics: the Hardy-Weinberg law; Genetic variation in natural populations; Forces that change gene frequency in populations; Genetic basis of speciation. **Books Recommended :** ➢ Principles of Genetics 4th Ed :Snustad& Simmons, John Wiley & Sons. ➢ i-Genetics : P.J. Russel, Pearson Education. ➢ Principles of Genetics 8th Ed : Gardner, Simmons, Snustad, John Wiley & Sons. ➢ Genetics : P.K. Gupta, Rastogi Publications. ➢ Genetics - A molecular approach : T.A. Brown, Chapman and Hall. ➢ Concepts of Genetics 7th Ed. : William S. Klug, Pearson Education. ➢ Principles of Genetics : R.H. Tamarin, Tata McGraw Hill. ➢ Genetics-From Genes to Genomes : Hartwell, McGraw Hill.	karyotype analysis, chromosome banding techniques. • Cell division & errors in cell division; Non disjunction. • Structural and numerical chromosomal abnormalities- deletion, duplication, translocation; Sex determination; Lyon hypothesis; Role of Y chromosome; Disorders of sex chromosomes & autosomes. • Molecular cytogenetics-Fluorescence in Situ Hybridization (FISH); Comparative Genomic Hybridization (CGH). • Genetics of bacteria and bacteriophages; Genetic mapping in bacteria by conjugation, transformation and transduction. • Mapping of bacteriophage gene. • Population genetics: Hardy-Weinberg law; Genetic variation in natural populations; Forces that change gene frequency in populations; Genetic basis of speciation. **Suggested Books:** ➢ Klug, W. S., Cummings, M.R., Spencer, C.A. & Palladine, M.A. (2015). *Concepts of Genetics* (11th ed.). UK: Pearson Education. ➢ Gardner, E.J., Simmons, M.J., & Snustad, D.P. (2005).*Principles of Genetics* (8th ed.). New Jersey, USA: John Wiley & Sons Ltd. ➢ Benjamin, A.P. (2003). *Genetics: A conceptual approach*. New York, USA: W. H. Freeman and Company. ➢ Russel, P.J. (2010). *iGenetics* (3rd ed.). UK: Pearson Education. ➢ Brown, T.A. (1992). *Genetics- A Molecular Approach*. London, UK: Chapman & Hall.	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Genetics 5th Eds. : D.L. Hartl and E.W. Jones, Jones and Barlett Publishers, Canada. ➢ An Introduction to Genetic Ananlysis : Suzuki, Griffith, Miller &Lewonith. ➢ Molecular Biology : Weaver, WCB McGraw Hill.	➢ Gupta, P.K. (2010).*Genetics*. Meerut, India: Rastogi Publications. **Suggested e- Resources:** ➢ **Cytogenetic methods and Disease** www.nature.com/scitable/topicpage/cytogenetic-methods-and-disease-flow-cytometry-cgh-772 ➢ **CGH Analysis** www.cs.cmu.edu/~epxing/Class/10810-05/Lecture11.pdf ➢ **Population Genetics** https://biomed.brown.edu/Courses/BIO48/6.PopGen1.HW.drift.HTML	
10.	**BIO 411:** Immunology	After successful completion of the course, students should be able to: • Evaluate and compare the role of various components and mechanisms of the immune system. • Describe various immune response mechanisms • Develop concept of antibody generation and various immunological techniques	**Section-A** • Basic concepts of immunology: specific and nonspecific defense mechanisms (innate and acquired immunity), organs and cells of immune system. • Antigen and Antigenicity: concept of immunogens, antigens, heptans, mitogens and superantigens. Properties of antigens, ~~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,	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	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			I.M (2011). *Roitt's Essential Immunology* (12th ed.). New Jersey, USA: John Wiley & Sons Ltd. ➢ Goldsby, R. A., Kindt, T.J., & Osborne, B. A. (2006). *Kuby Immunology* (6th ed.). New York, USA: W.H. Freeman & Co. Ltd. ➢ Paul, W.E. (1999). *Fundamental Immunology* (14th ed.). USA: Lippincott-Raven. ➢ Peakman, M.,&Vergani, D. (2009). *Basic and Clinical Immunology* (2nd ed.). US: Elsevier Health Sciences. ➢ Tizard, I.R. (2017). *Veterinary Immunology* (10th ed.). US: Elsevier Health Sciences.	Ltd. ➢ Goldsby, R. A., Kindt, T.J. & Osborne, B. A. (2006). *Kuby Immunology* (6th ed.). New York, USA: W.H. Freeman & Co. Ltd. ➢ Paul, W.E. (1999). *Fundamental Immunology* (14th ed.). USA: Lippincott-Raven. ➢ Peakman, M. &Vergani, D. (2009). *Basic and Clinical Immunology* (2nd ed.). US: Elsevier Health Sciences. ➢ Tizard, I.R. (2017).*Veterinary Immunology* (10th ed.). US: Elsevier Health Sciences. **Suggested e- Resources:** ➢ **Basic Immunology** https://bit. y/2E6Zz16l ➢ **Monoclonal Antibodies** https://www.genscript.com/how-to-make-monoclonal-antibodies.html ➢ **Complement system** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3956958/	
11.	**BT 406:** Enzymology and Enzyme Technology	At the end of this course, the students will have fundamental knowledge of enzymes and varioustechniques involved in their production and purification. They would also learn about theirapplication in different fields such as medical, textile, chemical processes, etc. They can applythis knowledge for better understanding of other basic and advanced courses in biologicalsciences as well as to solve research based problems.	**Section-A** • History and introduction to enzymes: ~~Classification of enzymes. IUPAC system, nomenclature, E.C. numbers.~~ • ~~Enzyme kineties (Michaelis – Menten laws), importance and determination of Vmax and Km values, Hofstee's plot, L & B plots.~~ • Bisubstrate reactions-ordered & random sequential mechanism. Theorell chance mechanism, ping pong mechanism, products of inhibition in bisubstrate reactions. • ~~Enzyme inhibition: competitive, non competitive and other types.~~ **Section-B**	This course is proposed to be discontinued from II Semester.	Some part of the syllabus is integrated with I Semester course "Biochemistry". Remaining part of the syllabus is revised as per the present need and proposed as an elective course named as "Enzyme Technology" in the III Semester.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• Extraction of soluble and membrane bound enzymes from microbial, plant and animal tissues. • Purification of enzymes: salt precipitation, gel filtration, ion exchange and affinity chromatography. Regulation of enzyme activity, various controls (metabolic compartmentation, covalent modifications and others), feedback regulation, allosteric enzymes ~~Coenzymes, Isozymes and~~ Multienzyme complexes • Methods of storing enzymes. **Section-C** • Large scale production of enzymes including genetic engineering approaches for their over production. • Enzyme engineering; identification of active sites, approaches for modification of catalytic properties. • Techniques of enzyme immobilization ~~and their applications in:~~ ~~i.~~ Food industry- ~~High fructose syrup, cheese making and beer industry.~~ ii. Antibiotics and other Pharamaceuticals iii. Medical applications ~~iv.~~ Analysis of substances, ~~enzyme electrodes, enzyme thermistors.~~ ~~• Basic idea of proteomics~~ **Suggested Books:** ➢ Understanding Enzymes : T. Palmer. ➢ Fundamentals of Enzymology : Price and Stevenson. ➢ The Enzyme : Dixon and Webb, Academic Press, London. ➢ Methods in Enzymology : Academic Press.		

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

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• Radiations as environmental pollutants. • Effects of radiations at cellular, molecular & genetic level. **Section-C** • ~~Mutagenecity, carcinogenecity~~. • ~~Green house effect, acid rains~~. • ~~Ozone layer depletion, photochemical smog~~. • Types of solid wastes, transport, reuse & recycling. **M.Sc. III Semester Biotechnology core course** **BT 509: Environmental Biotechnology** **Section-A** • ~~Current status of biotechnology in environmental protection.~~ • ~~Sewage &~~ waste water treatment: ~~Physical, Chemical and biological treaments; Aerobic processes & anaerobic processes,~~ Primary, secondary and tertiary treatments; ~~Sludge dewatering & its disposal;~~ Water reclamation. Solid waste management: Methods & disposal ~~of non hazardous and hazardous solid wastes, recycling,~~ methods of disposal of radioactive waste. • ~~Conservation of Biodiversity: *Ex-situ & in-situ* methods.~~ **Section-B** • ~~Environmental Biotechnology in Agriculture~~: Biofertilizers ~~and microbial inoculants~~, Biopesticides. • Biodegradation of xenobiotic compounds: Simple aromatics, chlorinated polyaromatic petroleum products, Pesticides ~~and surfactants.~~ • Bioremediation ~~& Biorestoration: Reforestation~~	➢ Waste water treatment- sources of waste water, strategies used in primary, secondary & tertiary treatments, water reclamation. **Section C** ➢ Biofertilizers, biopesticides, compost & vermicompost. ➢ Biofuels: Biogas, bioethanol, biodiesel, biohydrogen. Biodegradable plastics. ➢ Biodegradation of xenobiotic compounds: Simple aromatics, chlorinated polyaromatic petroleum products & pesticides; role of degradative plasmids. ➢ Solid waste management: types, treatment & disposal strategies. ➢ Bioleaching of metals, microbially enhanced oil recovery. Bioindicators. **Suggested Books** ➢ Allen, K. (2016). *Environmental Biotechnology*. New Delhi, India: CBS Publishers. ➢ Miller, G.T. (2004). *Environmental Science: Working With The Earth* (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.	

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

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

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• Plasmids, Bacteriophages, pBR322 and pUC series of vectors, M13 and P2 phage based vectors, High capacity vectors: Cosmids, phagemid, ~~phasemid, YAC~~, BAC, Animal and Plant virus based cloning vectors, Shuttle vectors, Expression vectors, pMal, GST, pET-based vectors, ~~Insertion of foreign DNA into Host Cells, Transformation~~, Constructions of libraries, cDNA and genomic libraries, cDNA and genomic cloning, Expression cloning, Jumping and hopping libraries, South-western and Far-western cloning, Protein-protein interactive cloning and Yeast two hybrid system, Phage display. **Section-C** • Primer designing, Fidelity of thermostable enzymes, ~~DNA polymerase~~, Types of PCR- multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, in situ PCR, cloning of PCR products, T-vectors, ~~Proof reading enzymes~~, Principles in maximizing gene expression, Gene expression analyses, differential gene expression methods, Introduction of DNA into mammalian cells, ~~transfection techniques.~~ **Books Recommended :** ➢ Molecular Cloning Vol. 1, 2 and 3 :Sambrook, Russell and Maniatis, Cold Spring Harber laboratory, 2001. ➢ Molecular Biology of Gene : J.D. Watson, Pearson Education. ➢ An Introduction to Gene Technology-From genes to clones :Winnacker, VCH. ➢ Principles of Gene Manipulation : Old and Primrose. ➢ MoleculerBiotechnology : B.R. Glick and J.J. Pasternak, ASM Press Washington, USA.	• Plasmids, Bacteriophages, pBR322 & pUCseries of vectors, M13 based vectors. • High capacity vectors: cosmids, phagemids, BAC, animal & plant virus based cloning vectors, shuttle vectors; expression vectors: pMal, GST, pET-based vectors; *Baculovirus* and *Pichia* vectors.Introduction of DNA into mammalian cells. • cDNA& genomic libraries, expression, cloning, jumping & hopping libraries. **Section-C** • Primer designing, fidelity of thermostable enzymes. • Types of PCR- multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, *in situ* PCR, T-vectors. • Principles in maximizing gene expression, gene expression analyses, differential gene expression methods. **Suggested Books:** ➢ Brown, T. A. (2006). *Genomes* (3rd ed.). New York: Garland Science. ➢ Glick, B.R. & Pasternak, J.J. (1998). *Molecular Biotech: Principles and Application of Recombinant DNA*. US: ASM Press. ➢ Green, M. R. & Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. ➢ Old, R. W., Primrose, S. B. & Twyman, R. M. (2001). *Principles of Gene Manipulation: an*	Repeating topics have been removed Repeating topics have been removed

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Genetic Engineering : Science and ethics on new frontier : Michael Boylan, Pearson Education. ➢ An Introduction to Genetic Engineering : S.T. Nicholl, Cambridge University Press. ➢ Recombinant DNA Methodology : Grossman and Noldave, Academic Press.	*Introduction to Genetic Engineering*. Oxford: Blackwell Scientific Publications. ➢ Richard J. R. (2004). *Analysis of Genes and Genome*. New Jersey, USA: John Wiley & Sons Ltd. **Suggested e- Resources:** ➢ **Genetic engineering – Basics, New Applications and Responsibilities** http://library.umac.mo/ebooks/b28055287.pdf ➢ **Construction of genomic libraries** https://nptel.ac.in/courses/102103013/20 ➢ **Enzymes in genetic engineering** https://nptel.ac.in/courses/102103013/7	
M. Sc. Biotechnology III Semester					
14.	**BT 522**: Recombinant DNA Technology				The course BT 522: Recombinant DNA Technology which is offered as a core course in the existing syllabus but now contents of this course have been modified and proposed to be offered as an elective course.
15.	**BT504:** Bioprocess Engineering and Technology	After successful completion of the course, students should be able to: • Identify bioreactor design and differentiate between types • Explain kinetics of scale up and sterilization along with processes of downstreaming. • Demonstrate large scale production of biomolecules	**Section-A** • Microbial growth and ~~death kinetics.~~ • Mass balance, ~~maintenance coefficient~~ and yield concepts in bioprocesses engineering. • Substrate utilization and product formation kinetics. • Basic concept of volumetric mass transfer coefficient (kLa) and Medium Rheology. • Sterilization.	**Section – A** General concept of Fermentation, Types of bioreactors (CSTR, Bubble driven bioreactor, Packed bed bioreactor, Fluidized Bed bioreactor). • Basic concept of mass balance & yield coefficient. • Unstructured & structured growth model. Batch, continuous & fed batch processes with substrate utilization & product formation	The syllabus has been remodeled to include more relevant topics which are of current significance. Certain topics have been accommodated in different sections of the paper and other courses as per to their suitability. In Section C, the numbers of

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Section-B • Batch, continuous and fed batch processes. • ~~Brief overview of~~ different bioreactor configurations (Stirred tank, ~~Air lift~~ and Bubble columns). • Downstream processing: Bioseparation-~~filtration,centrifugation,sedimentation, flocculation~~; Cell disruption; Liquid-liquid extraction; ~~Purification by~~chromatographic techniques; Reverse osmosis and ultra filtration; Drying; Crystallization. **Section-C** • Analysis of a few industrially important bioprocesses/products such as (taking into consideration, the raw material, media, organism metabolic pathway, bioreactor, product separation and uses). ~~a.~~ Organic acids (acetic acid, citric acid, ~~lactic acid and propionic acid).~~ b. Solvents (Butanol, Acetone, Ethanol). c. Industrial enzymes (a-amylase, proteases~~,~~ ~~rennin~~, lipase) and d. Antibiotics (Penicillin, Streptomycin, ~~Cephalosporin~~, Tetracycline, ~~Bacitracin~~). **Books Recommended :** ➢ Biochemical Engineering : J.M. Lee. Prentice Hall. ➢ Bioprocess Engineering : M. Shuler and F. Kargi, Prentice Hall. ➢ Comprehensive Biotechnology : M. Moo Young, Editor. ➢ Biotechnology : H.J. Rehm and G. Reed, VCH.	kinetics. • Sterilization kinetics. **Section-B** Volumetric mass transfer coefficient (kLa). • Medium Rheology in bioprocesses engineering. • Downstream processing: Bioseparation-ultrafiltration, precipitation, Cell disruption, Liquid-liquid extraction, chromatography, drying, crystallization. • Upscaling of bioprocess. • Enzyme immobilization & immobilized cell systems. **Section-C** • Screening, maintenance & strain improvement of industrially important microbes. • Analysis of a few industrially important bioprocesses/products (taking into consideration- the raw material, media, organism metabolic pathway, bioreactor, product separation and uses): a. Organic acids (acetic acid, citric acid). b. Solvents (butanol, acetone, ethanol). c. Enzymes (α amylases, proteases, lipases) d. Antibiotics (penicillin, streptomycin). e. Recombinant product (humulin, erythropoietin) **Suggested Books:** ➢ Stanbury, P.F., Whitaker, A. & Hall, S.J. (1995). *Principles of Fermentation Technology* (2nd& 3rded.). US: Elsevier Science Ltd. ➢ Crueger, W. & Crueger, A. (1990). *Biotechnology, A Text Book of Industrial Microbiology* (2nd ed.). US.: Sinauer Associates	examples have been limited in order to generate a balance between sections.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Inc. ➢ Bailey, J.E. & Ollis, D.F. (1986). *Biochemical Engineering Fundamentals* (2nd ed.). New York, USA: McGraw-Hill Education. ➢ Clark, D.S. & Blanch, H.W. (1997). *Biochemical Engineering*. USA: CRC Press. ➢ Shuler, M.L., & Kargi, F. (2002). *Bioprocess Engineering Basic Concepts* (2nd ed.). New Jersey, USA: Prentice Hall PTR Upper Saddle River. **Suggested e- Resources:** ➢ **Microbial Enzymes** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5387804/pdf/BMRI2017-2195808.pdf ➢ **Acetone-Butanol Fermentation** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4894279/pdf/fnw134.pdf ➢ **Microbial culture fermentation** https://pdfs.semanticscholar.org/b4d3/7ed66ef2e37ce22ff7a3be09e3df7568fe49.pdf ➢ **Reverse Osmosis** https://www.oas.org/dsd/publications/unit/oea59e/ch20.htm	
16.	**BT 505L:** Biotechnology Lab-I	After successful completion of the course, students should be able to: • Perform production and scale up of some industrially relevant bioactive molecules from microbes • Demonstrate gene transfer techniques • Perform cell and tissue culture techniques	~~1. Determination of total hardness of water.~~ ~~2. Degradation of pesticide in soil and estimation of its residue.~~ ~~3. Determination of fluoride in water/soil/biosamples.~~ ~~4. Determination of BOD values.~~ ~~5. Determination of LD50 for common pesticides/weedicides.~~ ~~6. Bacteriological analysis of waste water.~~ ~~7. Detection of mutagens by Ames test.~~ 8. Isolation and determination of plasmid DNA from	**Bioprocess Engineering and Technology** 1. Production of citric acid from *Aspergillus* sp.and its estimation by titration. 2. Estimation of K_{La} by sodium sulphite method. 3. Production of alpha amylase from *Bacillus* sp. and its estimation. 4. Scale up of alpha amylase production from100 ml to 1 L. 5. Immobilization of enzyme by sodium alginate method.	The experiments have been reframed and modified keeping in consideration, the suggested syllabus.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			E. coli. 9. Electrophoretic separation of plasmid DNA. 10. Restriction digestion of plasmid DNA. 11. ~~To obtain transposon Tn5 insertion into the genome of AK 631 strain of *Rhizobium meliloti* using suicide plasmid veetor PGS 9.~~ 12. To transfer plasmid PJB3JI from J53 strain of *E. coli* to HB101 strain of *E.coli.* 13. ~~Estimation of Biomass.~~ 14. Estimation of growth and product yield in a Bioconversion process. 15. Comparison between aerobic and anaerobic process. 16. Enzyme biosynthesis and measurement of its activity. ~~17. Culture of stem explants.~~ ~~18.~~ . Embryo culture.	6. Estimation of growth and product yield in a Bioconversion process. 7. Comparison between aerobic and anaerobic process **Genetic Engineering** 8. Preparation of competent cells (*E. coli* DH5α strain). 9. Transformation of *E. coli* with plasmid and calculation of transformation efficiency. 10. Isolation of plasmid DNA from *E. coli* by alkaline lysis method. 11. Restriction digestion of plasmid DNA and its electrophoretic separation. 12. To transfer plasmid PJB3JI from J53 strain of *E. coli* to HB101 strain of *E.coli.* **Cell and Tissue Culture Technology** 13. To perform embryo culture from germinated mung bean seeds. 14. Shoot tip culture. 15. Protoplast culture and somatic hybridization. 16. Blood cell culture and determination of cell viability using Trypan blue method. 17. Preparation of metaphase chromosome from whole blood culture. **Suggested Books:** ➢ Kulandaivel, S. & Janarthanan, S. (2012). *Practical Manual of Fermentation Technology*. New Delhi, India: I.K. International Publishing House Pvt. Ltd. ➢ Cappuccino, J. G., & Welsh, C. (2016). *Microbiology: A laboratory Manual*. USA: Benjamin-Cummings Publishing Company. ➢ Collins, C. H., Lyne, P. M., Grange, J. M., & Falkinham, J.O. (2004). *Collins and Lyne's*	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Microbiological Methods (8th ed.). London, UK: Arnold. ➢ Green, M. R., & Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual.* Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. **Suggested e- Resources:** ➢ **Harisha, S. Biotechnology procedures and experiments handbook** https://bit.ly/2U0e39D ➢ **Introduction to biotechnology** https://bit.ly/2IICkzE	
17.	**BT 507:** Cell and Tissue Culture Technology	After successful completion of the course, students should be able to: • Develop comprehensive concepts of cell and tissue culture techniques and methodology • Demonstrate use of various plant and animal tissue culture techniques • Explain applications of cell and tissue culture in agriculture, horticulture, medicine and pharmaceutical industry	**Section-A** • Historical background and terminologies used in cell & tissue culture. • Basic techniques of cell and tissue culture, sterilization, aseptic tissue transfer, concept of totipotency. • Nutritional requirement of cell in vitro, various types of nutrient media. • Contamination and cytotoxicity • Cryopreservation and cell storage. • Isolation of plant cells, single cell cultures and cloning. **Section-B** • Organogenesis and somatic embryogenesis, applications in agriculture, horticulture & forestry. • Haploid production: androgenesis, gynogenesis various techniques, applications. • Production of disease free plants by tissue culture methods. • Protoplast isolation and culture, fusion of protoplasts.	No change in syllabus, suggested books and E resources added ➢ Bhojwani, S.S. & Razdan, M.K. (1996). *Plant Tissue Culture*. USA: Elsevier Science. ➢ Chawla, H. S. (2000). *Introduction to Plant Biotechnology*. US: Science Publishers. ➢ Razdan, M. K. (2006). *Introduction to Plant Tissue Culture*. New Delhi, India: Oxford and IBH Pub. ➢ Smith, R. H (Ed.). (2013). *Plant tissue culture: Techniques and experiments*. Amsterdam: Academic Press. ➢ Buler, M. (2003). *Animal Cell Culture and Technology* (2nd ed.). UK: Taylor & Francis. ➢ Mathur, S. (2006). *Animal Cell and Tissue Culture*. India: Agrobios. ➢ Clynes, M. (Ed.) (1998). *Animal Cell Culture Techniques*. Germany: Springer-Verlag Berlin Heidelberg. ➢ Pollard, J.W., & Walker, J.M. (Eds.). (1990). *Animal Cell Culture*. USA: Humana Press ➢ John, R. W. (2000). *Animal Cell Culture: A*	No Modification. c.w. M.Sc. Bioscience

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			• Somatic hybrids, selection methods, gene expression in somatic hybrids. **Section-C** • Disaggregation of animal tissue, isolation of cells, single cell culture, routine maintenance of animal cell lines. • Cloning & selection of specific animal cell types. • Transfection: gene transfer methods for adherent and non-adherent cell culture. • Cell fusion: fusogen, animal somatic cell fusion and selection of cybrids. • Animal organ culture. • Elementary idea about animal cell culture products. **Recommended Books:** ➢ Bhojwani, S.S. &Razdan, M.K. (1996). *Plant Tissue Culture*.USA: Elsevier Science. ➢ Chawla, H. S. (2000). *Introduction to Plant Biotechnology*. US: Science Publishers. ➢ Razdan, M. K. (2006). *Introduction to Plant Tissue Culture*. New Delhi, India: Oxford and IBH Pub. ➢ Smith, R. H (Ed.). (2013). *Plant tissue culture: Techniques and experiments*. Amsterdam: Academic Press. ➢ Butler, M. (2003).*Animal Cell Culture and Technology* (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	*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/haploid-plants/production-of-haploid-plants-with-diagram/10700 ➢ **Preservation of cell lines** https://www.ukessays.com/essays/biology/techniques-for-cell-preservation-biology-essay.php ➢ **Somatic hybridization** http://www.biologydiscussion.com/somatic-	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			➢ John, R. W. (2000). *Animal Cell Culture: A Practical Approach* (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.	hybridization/somatic-hybridization-aspects-applications-and-limitations/10686 ➢ **Animal cell culture products** http://www.biologydiscussion.com/biotechnology/animal-biotechnology/applications-of-animal-cell-cultures/10457 ➢ **Cell Culture Technology** https://onlinecourses.nptel.ac.in/noc17_bt21/preview	
18.	**BT 509 ~~Environmental Biotechnology~~**	After successful completion of the course, students should be able to: • Understand different waste management processes and generation of energy from waste • Explain impact of GMOs on environment. • Describe various roles played by microbes in biodegradation, bioremediation and plant growth promotion.	**BT 509: Environmental Biotechnology** **Section-A** - ~~Current status of biotechnology in environmental protection.~~ - ~~Sewage &~~ waste water treatment: ~~Physical, Chemical and biological treaments; Aerobic processes & anaerobic processes,~~ Primary, secondary and tertiary treatments; ~~Sludge dewatering & its disposal;~~ Water reclamation. - Solid waste management: Methods & disposal ~~of non hazardous and hazardous solid wastes, recycling,~~ methods of disposal of radioactive waste. - ~~Conservation of Biodiversity: *Ex situ & in situ* methods.~~ **Section-B** - ~~Environmental Biotechnology in Agriculture~~: Biofertilizers ~~and microbial inoculants~~, Biopesticides. - Biodegradation of xenobiotic compounds: Simple aromatics, chlorinated polyaromatic petroleum products, Pesticides ~~and surfactants.~~ - Bioremediation ~~& Biorestoration:~~	This course is proposed to be discontinued in the present form from the III Semester. **Suggested Books:** ➢ Jogdand, S. N. (2010). *Environmental Biotechnology (Industrial pollution management)* (3rd ed.). Mumbai, India: Himalaya Publishing House. ➢ Srinivasan, D. (2009). *Environmental Engineering*. New Delhi, India: PHI Learning Pvt. Ltd. ➢ Thakur, I. S. (2012). *Environmental Biotechnology: Basic concepts and Application* (2nd ed.). New Delhi: I K International Publishing House. ➢ Modi, P. N. (2015). *Sewage treatment & disposal and waste water engineering*. New Delhi, India: Rajsons Publications Pvt. Ltd. ➢ Milton, W. (Ed.). (1999). *An Introduction to Environmental Biotechnology*. USA: Springer. ➢ Tripathi, B. N., Shekhawat, G. S., & Sharma, V. (Ed.). (2009). *Applications of Biotechnology*. Jaipur, India: Aavishkar	The course contents are proposed to be revised and merged with the M.Sc. Bioscience III Semester core course BIO 408 "Environmental Biology and Toxicology" to propose a new core course i.e. "Environmental Biology and Biotechnology in the II Semester.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			~~Reforestation through micro-propagation, development of stress tolerant plants, and use of mycorrhiza in reforestation of soil contaminated with heavy metals.~~ **Section-C** - Biofuels: ~~Energy crops, Conventional sources of biofuel, Second and third generation of biofuel,~~ Biogas, Bioethanol, Biohydrogen. Biodegradable plastics. - Bioindicators ~~and Biosensers for detection of environmental pollution.~~ - Environmental genetics: Degradative plasmids, ~~release of GE microbes in environment.~~ **Books Recommended :** ➢ Environmental Impact Assessment : Clark, Bissel&Watham. ➢ Introduction to Toxicology : J.A. Timberell. ➢ Fundamentals of Ecology :Eugen P. Odum. ➢ Field Biology : R.L. Smith. ➢ Encyclopedia of Pollution & its Control :Vol.I-VI. ➢ Environmental Chemistry : B.K. Sharma and H. Kaue, Goel Publishing House, Meerut. ➢ Environmental Biotechnology : S.K. Aggarwal, APH Publishing Corporation. ➢ Environmental Chemistry : A.K. Bhagi and G.R. Chatwal, Himalaya Publishing House, New Delhi.	Publishers. ➢ Tchobanoglous, G., Burton, F. L., Stensel, H. D., & Metcalf & Eddy. (2014). *Wastewater engineering: Treatment and reuse*. New Delhi, India: Tata McGraw Hill Edition. **Suggested e- Resources:** ➢ **Biological treatment of wastewater** http://www.neoakruthi.com/blog/biological-treatment-of-wastewater.html ➢ **Biogas** http://www.biologydiscussion.com/biomass/production-of-biogas-from-biomass/10436 ➢ **Biofuel** http://uru.ac.in/uruonlinelibrary/BioFuels/Biomass%20and%20biofuels.pdf ➢ **Biosensor** https://www.edgefx.in/biosensors-types-its-working-and-applications/ ➢ **Xenobiotic compound biodegradation** https://bit.ly/2GHRoMj	
19.	Critical Analysis of classical papers/ Landmark Discoveries	After successful completion of the course, students should be able to: • Analyze and give a critical description of the papers studied.		**Suggested Reading:** • Studies on the chemical nature of the substance inducing transformation of Pneumococcal types: Induction of transformation by a desoxyribonucleic acid	Seminar mode Proposed to be introduced

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		• Discuss the significance of the research work.		fraction isolated from *Pneumococcus type* III. Avery OT, Macleod CM, McCarty M.; J Exp Med. 1944 Feb 1;79(2):137-58. • Independent functions of viral protein and nucleic acid in growth of bacteriophage Hershey AD and Chase M.; J Gen Physiol. 1952 May;36(1):39-56. • Molecular structure of nucleic acids; a structure for deoxyribose nucleic acid Watson JD and Crick FH; Nature. 1953 Apr 25;171(4356):737-8. Transposable mating type genes in *Saccharomyces cerevisiae* James Hicks, Jeffrey N. Strathern& Amar J.S. Klar; Nature 282, 478-483,1979. • Messelson& Stahl experiment demonstrating semi-conservative replication of DNA. Meselson M and Stahl FW.; Proc Natl Acad Sci U S A. 1958 Jul 15;44(7):671-82 • In vivo alteration of telomere sequences and senescence caused by mutated Tetrahymena telomerase RNAs Guo-Liang Yu, John D. Bradley, Laura D. Attardi& Elizabeth H. Blackburn; Nature 344, 126-132, 1990 • A protein-conducting channel in the endoplasmic reticulum Simon SM AND BlobelG.; Cell. 1991 May 3;65(3):371-80 • Identification of 23 complementation groups required for post-translational events in the yeast secretory pathway Novick P, Field C, Schekman R.; Cell. 1980 Aug;21(1):205-15 • A yeast mutant defective at an early stage in import of secretory protein precursors	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				into the endoplasmic reticulum Deshaies RJ and Schekman R.; J Cell Biol. 1987 Aug;105(2):633-45 • Reconstitution of the Transport of Protein between Successive Compartments of the Golgi Balch WE, Dunphy WG, Braell WA, Rothman JE.; Cell. 1984 Dec;39(2 Pt 1):405-16 • A complete immunoglobulin gene is created by somatic recombination Brack C, Hirama M, Lenhard-Schuller R, Tonegawa S.; Cell. 1978 Sep;15(1):1- • A novel multigene family may encode odorant receptors: a molecular basis for odor recognition Buck L and Axel R; Cell. 1991 Apr 5;65(1):175-87 • Kinesin walks hand-over-hand Yildiz A, Tomishige M, Vale RD, Selvin PR.; Science. 2004 Jan 30;303(5658):676-8 • Mutations affecting segment number and polarity in Drosophila Christiane Nusslein-Volhard and Eric Weischaus; Nature 287, 795-801, • Information for the dorsal--ventral pattern of the *Drosophila* embryo is stored as maternal mRNA Anderson KV and Nüsslein-Volhard C; Nature. 1984 Sep 20-26;311(5983):223-7 • Hedgehog signalling in the mouse requires intraflagellar transport proteins Huangfu D, Liu A, Rakeman AS, Murcia NS, Niswander L, Anderson KV.; Nature. 2003 Nov 6;426(6962):83-7	
Elective Courses to be offered in III Semester					**(Common with M.Sc.**

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
					AMBT III Sem.)
1)	**BT:** Enzyme Technology	After successful completion of the course, students should be able to: • Develop understanding of enzymes and their mechanism of action and regulation. • Explain the production of enzymes. • Learn wide applications of enzymes and their future potential.	**BT 406: Enzymology and Enzyme Technology** **Section-A** • History and introduction to enzymes: ~~Classification of enzymes. IUPAC system, nomenclature, E.C. numbers.~~ • ~~Enzyme kinetics (Michaelis – Menten laws), importance and determination of Vmax and Km values, Hofstee's plot, L & B plots.~~ • Bisubstrate reactions-ordered & random sequential mechanism. Theorell chance mechanism, ping pong mechanism, products of inhibition in bisubstrate reactions. • ~~Enzyme inhibition: competitive, non-competitive and other types.~~ **Section-B** • Extraction of soluble and membrane bound enzymes from microbial, plant and animal tissues. • Purification of enzymes: salt precipitation, gel filtration, ion exchange and affinity chromatography. Regulation of enzyme activity, various controls (metabolic compartmentation, covalent modifications and others), feedback regulation, allosteric enzymes ~~Coenzymes, Isozymes and~~ Multienzyme complexes • Methods of storing enzymes. **Section-C** • Large scale production of enzymes including genetic engineering approaches for their over production. • Enzyme engineering; identification of active sites,	**Enzyme Technology** **Section-A** • Enzymes: Scope, historical developments, distinguishing features. • Mechanisms of enzyme action: Concept of active site, specificity of enzyme action. • Methods of characterization of enzymes – Development of enzymatic assays • Bisubstrate reactions-ordered & random sequential mechanism. Theorell chance mechanism, ping pong mechanism, products of inhibition in bisubstrate reactions. Regulation of enzyme activity, various controls (metabolic compartmentation, covalent modifications and others), feedback regulation, allosteric enzymes. **Section-B** • Extraction of soluble and membrane bound enzymes from microbial, plant and animal tissues. • Purification of enzymes: salt precipitation, gel filtration, ion exchange, affinity chromatography, enzyme crystallization, drying and freeze drying. • Large scale production of enzymes including genetic engineering approaches for their over production. • Methods of storing enzymes. • Multienzyme complexes. • Designer enzymes, Thermophilic enzymes, Metal degrading enzymes.	The course "Enzyme Technology" is proposed as a new elective course by updating and shifting the existing core course BT 406 "Enzymology and Enzyme Technology" from the II Semester to III Semester.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			approaches for modification of catalytic properties. • Techniques of enzyme immobilization ~~and their applications in:~~ ~~v.~~ Food industry- ~~High fructose syrup, cheese making and beer industry.~~ vi. Antibiotics and other Pharamaceuticals vii. Medical applications ~~viii.~~ Analysis of substances, ~~enzyme electrodes, enzyme thermistors.~~ ~~• Basic idea of proteomics~~	**Section-C** • Enzyme engineering; identification of active sites, approaches for modification of catalytic properties. Synzymes. • Techniques of enzyme immobilization: Adsorbtion, Covalent bonding, Gel Entrapment and Microencapsulation. • Applications of enzymes in: i. Food industry- Baking industry, Dairy industry, Beverage industry ii. Antibiotics and other pharamaceuticals iii. Medical applications iv. Analysis of substances v. Leather industry vi. Textile industry • Enzyme biosensors. **Suggested Books:** ➢ Palmer, T. & Bonner, P. (2014). *Enzymes: Biochemistry, Biotechnology and Clinical Chemistry*. UK: Woodhead Publishing Limited. ➢ Buchholz, K., Kasche, V. and Bornscheuer, U. (2005). *Biocatalysts and Enzyme Technology*, WILEY–VCH. ➢ Pandey A., Webb C., Soccol, C. R. and Larroche, C. (2006). *Enzyme Technology*. Springer. ➢ Price N. & Stevenson L. (1999). *Fundamentals of Enzymology: Cell and Molecular Biology of catalytic Proteins*, Oxford University Press. ➢ Daniel L. Purich (2009). *Contemporary*	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Enzyme Kinetics and Mechanism. Atlantic Publishers and Distributers. ➢ Blanch, H.W., & Clark, D.S. (1997). *Biochemical Engineering*, Marcel Dekker. ➢ Drauz K., Gröger, H. and May, O. (2012). *Enzyme Catalysis in Organic Synthesis: A Comprehensive Handbook*, Volume 1, Wiley-VCH Verlag & Co. **Suggested e-resources:** ➢ **Enzymes: properties and mechanisms** http://www.biologydiscussion.com/enzymes/enzymes-properties-and-mechanism-of-enzyme-action/6145 ➢ **Enzyme technology: metagenomics, evolution and biocatalysis** https://searchworks.stanford.edu/view/8775255	
2)	**BIO 503:** Fundamentals of Bioentrepreneurship	After successful completion of the course, students should be able to: • Understand role of entrepreneurship in promoting innovation and wealth generation. • Develop skills for writing business models for new ideas and market segments. • Explain various financial, marketing, sales and legal issues associated with entrepreneurship.	**Section-A** • ~~Accounting and Finance: Taking decision on starting a venture; Assessment of feasibility of a given venture/new venture; Approach a bank for a loan; Sources of financial assistance~~; Making a business proposal/~~Plan for seeking loans from financial institution and banks; Funds from bank for capital expenditure and for working; Statutory and legal requirements for starting a company/venture; Budget planning and cash flow management.~~ • ~~Basics in accounting practices: concepts of balance sheet, P &~~ L ~~account and double entry book keeping; Estimation of income, expenditure, income tax etc.~~ **Section-B** • Marketing: Assessment of market demand for	**Section-A** • Concept of entrepreneurship; Classification and types of entrepreneurship, Myths about entrepreneurship; Role of entrepreneurship in wealth building and creating an impact; Society, Technology and Entrepreneurship. • Creativity and Innovation; Types and forms of Innovation; Sources of innovative opportunity; Entrepreneurship as a career option. **Section-B** • Introduction to the Design Thinking Process;	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			potential product (s) of interest; Market conditions, segments; prediction of market changes; Identifying needs of customers including gaps in the market, packaging the product; Market linkages, branding issues; Developing distribution channels; Pricing/Policies/Competition; Promotion/Advertising; Services Marketing. • ~~Negotiations/Strategy: with financiers, bankers etc; with government/law enforcement authorities: with companies/Institutions for technology transfer; Dispute resolution skills; External environment/changes; Crisis/Avoiding/Managing; Broader version Global thinking.~~ **Section-C** • ~~Information Technology: How to use IT for business administration; Use of IT in improving business performance; Available software for better financial management; E business setup, management.~~ • ~~Human Resource Development (HRD): Leadership skills; Managerial skills; Organization structure, pros & cons of different structures; Team building, teamwork; Appraisal; Rewards in small scale set up.~~ • Fundamentals of Entrepreneurship, Support mechanism for ~~entrepreneurship in India, Role of knowledge centre and R & D, knowledge centres like universities and research institutions; Role of technology and upgradation; Managing Technology Transfer; Regulations for transfer of foreign technologies; Technology transfer agencies.~~ **Recommended Books:** ➢ Patzelt, H., &Bernner, T. (Eds.). (2008).	Problem identification; Idea Generation; Value Proposition; Lean Canvas. • Identifying Customer Segments; Idea Validation; Developing Business Model; Sizing the opportunity; Building MVP; Concept of Start-up, Importance of Incubation. **Section-C** • Financial and Non financial support**:** Revenue streams; Pricing and Costs; Sources of funds; Importance of project management. • Marketing and Sales: Positioning; Channels and Strategy; Sales Planning. • Team: Importance of teambuilding; Complementary skill sets. • Legal issues: Brief overview of- intellectual property rights, patents, trademarks, copy rights, trade secrets, licensing and GI. • Business Plan writing. • Policies and Initiatives to promote Entrepreneurship in India. **Suggested Books:** ➢ Jain, P.C. (2001). *Hand Book for New*	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Handbook of Bioentrepreneurship. Berlin, Germany: Springer. ➢ Robert, D. H., & Peters, M. P. (2002). *Entrepreneurship*. New York, USA: McGraw-Hill Education ➢ Shane, S. (2004). *Academic Entrepreneurship: University Spinoffs and Wealth Creation*. Northampton, M.A.: Edward Elgar	*Entrepreneurs*. UK: Oxford University Press. ➢ Hisrich R. D., Manimala M. J., Peters Michael P. & Shepherd D. A. *Entrepreneurship* (9th ed.). McGraw Hill Publication. ➢ Roy, R. (2011). Entrepreneurship (2nd ed.). UK: Oxford University Press. ➢ Drucker, P. (2015). *Innovation and Entrepreneurship* (1st ed.). Routledge Classics. ➢ Kotler, P & Keller, K.L. (2017).*Marketing Management* (15th ed.). Pearson Publications ➢ Desai, V. (2011) *Dynamics of Entrepreneurial Development & Management* (6t ed.). Mumbai: Himalaya Publishing House. ➢ Khanka, S.S. (2007) *Entrepreneurial Development.* New Delhi: S. Chand & Company Ltd. ➢ Mohanty, S K. (2005). *Fundamentals of Entrepreneurship*. EEE Prentice Hall India Learning Private Limited. ➢ Gupta C.B. & Srinivasan N.P. (2013). *Entrepreneurship Development in India.* Sultan Chand & Sons. ➢ Gupta A.K. (2016).*Grassroots Innovations (Minds On the Margin Are Not Marginal Minds)*. Random House. ➢ Patzelt, H., &Bernner, T. (Eds.). (2008). *Handbook of Bioentrepreneurship*. Berlin, Germany: Springer. ➢ Robert, D. H., & Peters, M. P. (2002). *Entrepreneurship*. New York, USA: McGraw-Hill Education ➢ Shane, S. (2004). *Academic Entrepreneurship: University Spinoffs and Wealth Creation*. Northampton, M.A.: Edward	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Elgar **Suggested e-Resources:** ➢ **Entrepreneurship** https://www.startupcommons.org/what-is-startup-ecosystem.html https://getproductmarketfit.com/how-to-select-test-to-get-market-validation-for-new-product-or-business-idea/ https://www.coursera.org/learn/wharton-launching-startup https://www.coursera.org/learn/wharton-entrepreneurship-opportunity http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.463.4354&rep=rep1&type=pdf ➢ **Accounts and Bioentrepreneur** https://www.nature.com/bioent/2003/031101/full/bioent779.html ➢ **Bioentrepreneurship** www.birac.nic.in/webcontent/jk.pdf ➢ **Biotechnology and entrepreneurship** http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.463.4354&rep=rep1&type=pdf	
3)	**BIO 505:** Microbial Technology	After successful completion of the course, students should be able to: • Utilize various strategies for strain improvement, overexpression, maintenance and containment of microbes • Describe strategies used for large scale production of various industrially relevant bioactive molecules from microorganisms .	**Section-A** • Biotechnological innovation in pharmaceutical, health, agricultural and industrial sectors. • Strategies for selection and improvement of industrial strains. • Measurement and control of bioprocess parameters. • Genetic and environmental control of metabolic pathways. **Section-B** • Industrial production of Biofuel,	**Section-A** • Biotechnological innovation in pharmaceutical, health, agricultural & industrial sectors. • Strategies for selection & improvement of industrial strains. • Measurement & control of bioprocess parameters. • Genetic & environmental control of metabolic pathways. **Section-B** • Industrial production of Biofuel,	Typological corrections have been made.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Biotransformation of Steroids, Single Cell Protein. • Biofertilizers (Rhizobium and BGA); Biopesticides (Bt toxin) • Biosensors (NH4, Sulphide); Biofilms. • Biopolymers (-PHB, Xanthum gum) **Section-C** • Microbial overproduction of recombinant molecules: Selection of suitable promoter sequences, ribosome binding sites, fusion protein tags, purification tags, protease cleavage sites and enzymes, inducible expression systems, limitations of metabolic engineering. • Large scale production using recombinant microorganisms: peptic hormones (secretin), metabolic engineering of antibiotics, basic ides of biohydrometallury. • Maintenance and containment of recombinant microorganisms. **Books Recommended :** ➢ Biotechnological Innovations in Chemical Synthesis, BIOTOL, Butterworth - Heinemann. ➢ Industrial Microbiology, G. Reed (editor), CBS Publishers (A VI Publishing Company) ➢ Genetics and Biotechnology of Industrial Microorganisms. C.L. I-le' -shnergev, S.W. Queener and Q Hegen. American Society of Microbiology. ➢ Protein Expression A Practical Approach: Edited by S.J. Higgins and B.D. Hames (OUP).	Biotransformation of Steroids, Single Cell Protein. • Biofertilizers (*Rhizobium* and BGA); Biopesticides (Bt toxin). • Biosensors (NH_4, Sulphide); Biofilms. • Biopolymers (PHB, Xanthum gum). **Section-C** • Microbial overproduction of recombinant molecules: Selection of suitable promoter sequences, ribosome binding sites, fusion protein tags, purification tags, protease cleavage sites and enzymes, inducible expression systems, limitations of metabolic engineering. • Large scale production using recombinant microorganisms: peptic hormones (secretin), metabolic engineering of antibiotics, basic idea of biohydrometallurgy. • Maintenance and containment of recombinant microorganisms. **Suggested Books:** ➢ BIOTOL, Currell, B.C., & Dam-Miera, R.C.E. (1997). *Biotechnological Innovations in Chemical Synthesis (BiotolSer)*. Oxford, UK: Butterworth-Heinemann, Elsevier. ➢ Reed, G. (2004). Prescott and Dunn's Industrial Microbiology. New Delhi, India: CBS Publishers. ➢ Glazer, A.N., & Nikaido, H. (2008). *Microbial Biotechnology*. UK: Cambridge University Press. ➢ Kun, L.Y. (Ed.) (2003). *Microbial Biotechnology: Principles and Applications*.	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Singapore: World Scientific Publication Co.Ptv. Ltd. ➢ Braun,V. & Gotz, F. (Eds.). (2002). *Microbial Fundamentals of Biotechnology*. Germany: Wiley-Vch. ➢ Gupta, V.K. (Ed.), Sharma, G.D. (Ed.),Tuohy, M.G. (Ed.), Gaur, R. (Ed.). (2016). *The Handbook of Microbial Bioresources* (1st ed.). New Delhi, India: CABI Publishing. ➢ Crueger, W. & Crueger, A. (1990). *Biotechnology, A Text Book of Industrial Microbiology* (2nd ed.). U.S: Sinauer Associates Inc. **Suggested e- Resources:** ➢ **Microbial Biotechnology** https://bit.ly/2XmRZs2 ➢ **Biosensor** https://www.edgefx.in/biosensors-types-its-working-and-applications/ ➢ **Biofertilizer** www.krishisewa.com/articles/organic-agriculture/115-biofertilizers.html ➢ **Biopesticide** www.agriinfo.in/default.aspx?page=topic&superid=3&topicid=1950	
4)	**BT 513:** Food Process and Biotechnology	After successful completion of the course, students should be able to: • Explain strategies of food preservation, spoilage and quality assessment • Understand various policies related to GM food and its safety assessment • Demonstrate the principles for	**Section-A** • Introduction and development of food biotechnology; Current status of Transgenic crops for crop improvement and enhanced agronmic performance. • International and National guidelines for safety assessment of genetically modified (GM) foods. • Contemporary food related policy issue and their implications.	**Section-A** • Introduction and development of food biotechnology; Current status of transgenic crops for crop improvement & enhanced agronomic performance. • International and National guidelines for safety assessment of genetically modified (GM) foods. • Contemporary food related policy issue & their	Some typological errors have been corrected. Butter has been replaced by kefir as it is a more important fermentation product of milk. Also food yeasts have been deleted as it is more relevant in fermentation.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		production of various processed food	• General principals of Food spoilage, factors affecting spoilage; Methods of food preservation. Food products with enhanced shelf-life. **Section-B** • Mechanism of enzyme function and reactions in Food processing; Enzymic bioconversions e.g. starch and sugar conversion process; HFCS; Interesterified fat, hydrolysed protein etc. and their downstream processing. • Baking by amylases; Deoxygenation and desugaring by glucose oxidases; Beer mashing and chill proofing. • ~~Cheese making by proteases and~~ various other enzyme catalytic actions in food processing.- Fermented dairy products: cheese, yogurt, ~~butter~~; Bacteriocin from lactic acid bacteria and Alcoholic beverages. • Fermented vegetables, oriental foods, meat products, Fish& poultry products. **Section-C** • Process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products. • Biotechnology applications in the production of additives/ingredients: Enzymes. • Carotenoids, amino acids, organic acids, vitamins, colouringflavours and nutraceuticals. • Production of new protein foods-Single cell proteins (SCP), mushroom, ~~food yeasts~~, algal proteins. • Quality control of food-Detection system, Enzyme	implications. • General principles of food spoilage, factors affecting spoilage; Methods of food preservation. Food products with enhanced shelf-life. **Section-B** • Mechanism of enzyme function and reactions in food processing; Enzymic bioconversions e.g. starch and sugar conversion process; HFCS; Interesterified fat, hydrolysed protein etc. and their downstream processing. • Baking by amylases; Deoxygenation and desugaring by glucose oxidases; Beer mashing and chill proofing. • Various enzyme catalysed actions in food processing- fermented dairy products (cheese, yogurt, kefir), alcoholic beverages, fermented vegetables, oriental foods, meat products, fish & poultry products. Bacteriocin from lactic acid bacteria. **Section-C** • Bioconversion of process wastes to useful products -whey, molasses, starch substrates and other food wastes. • Biotechnology applications in the production of additives/ingredients: enzymes, carotenoids, amino acids, organic acids, vitamins, colouring flavours and nutraceuticals. • Production of new protein foods- Single cell proteins (SCP), mushroom, algal proteins. • Quality control of food- detection system, Enzyme Immunoassay and Radio-immunoassay.	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Immunoassay and Radio-immunoassay. **Books Recommended :** ➢ Food Microbiology: W.C. Fragier, D.C. 1995. Westhoft 3rd Ed. Tata McGraw Hill. ➢ Food Microbiology : M.R. Adams, M.O. Moss, 1998 New Age International (P) Ltd. ➢ Principles of Fermentation Technology: P.F. Stanbury, A. Whittaker, S.J. Hall 1995. 2nd Edn. Pergamon Press. ➢ Basic Food Microbiology: G.J. Banwart (1898) CBS Publishers and Distributors, Delhi. ➢ Dairy Microbiology: R.K. Robinson (1990) Elsevier Applied Sciences, London.	**Suggested Books:** ➢ Frazier, W.C. & Westhoff, D.C. (2003). *Food Microbiology*. New York, USA: Tata McGraw Hill. ➢ Adams, M. R. & Moss, M. O. (2007). *Food Microbiology*. UK: Royal Society of Chemistry. ➢ Stanbury, P.F., Hall, S. J. & Whitaker, A. (1999). *Principles of Fermentation Technology*. Oxford, UK: Butterworth-Heinemann, Elsevier. ➢ Banwart, G.J. (1989*). Basic Food Microbiology*. New Delhi, India: CBS Publishers. ➢ Robinson, R.K. (1990). *Dairy Microbiology*. London, UK: Elsevier Applied Sciences. ➢ Pandey, A., Larroche, C., Soccol, C. R. & Dussap, C. (2008). *Advances in Fermentation Technology*. New Delhi, India: Asiatech Publishers, Inc. ➢ Joshi, V. K. & Pandey, A. (1999). *Biotechnology: Food Fermentation*. New Delhi, India: Asia tech Publishers Inc. **Suggested e- Resources:** ➢ **Quality control of food detection system** https://www.engineersgarage.com/Contribution/Arduino-based-Smart-IoT-Food-Quality-Monitoring-System ➢ **Food Preservation** https://sciencesamhita.com/methods-of-food-preservation/ ➢ **History of microorganisms in food** https://faculty.weber.edu/coberg/class/3853/3853%20HistoryofFood.htm	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				➢ **Genetically modified food** http://anrcatalog.ucdavis.edu/pdf/8180.pdf	
5)	**BT 515:** Genomics and Proteomics	After successful completion of the course, students should be able to: • Describe principles of functional genomics • Develop an understanding of proteomics and associated techniques • Understand comprehensive concept of nucleotide and protein sequencing.	**Section-A** • ~~Whole genome analysis: preparation of ordered cosmid libraries, bacterial artificial chromosome libraries. Shotgun libraries and sequencing, YAC.~~ • ~~Sequence analysis: computational methods, homology algorithms (BLAST) for proteins and nucleic acids, open reading frames, annotation of genes, EST.~~ • ~~Conserved protein motifs related structure/function (PROSITE, PI' AM, Profilescan).~~ • ~~Physical and Genetic mapping.~~ **Section-B** • ~~DNA microarray: printing of oligonucleotides and PCR products on glass slides, nitrocellulose paper.~~ • ~~Analysis of SNP using DNA chips.~~ • ~~Whole genome analysis for global patterns of gene expression using fluorescent labeled cDNA or end labeled RNA probes.~~	**Section – A** • Genomics – Introduction to genome & genomics; genetics *vs.* genomics. DNA microarray; preparation, understanding of microarray data, normalizing microarray data, detecting differential gene expression, correlation of gene expression data to biological process & analysis tools. Gene Expression Omnibus (GEO). • Large scale genome sequencing strategies. Genome assembly & annotation. Genome databases of plants, animals & pathogens. • Metagenomics: Gene networks: basic concepts, computational model such as Lambda receptor & lac operon. • Prediction of genes, promoters, splices sites, regulatory regions: basic principles, application of methods to prokaryotic & eukaryotic genomes. **Section – B** • Introduction to proteome and proteomics; protein chemistry *vs.* proteomics. Analytical techniques of proteomics; working principles of 2D – gel electrophoresis, mass spectrometry with their merits and demerits. • Mass spectrometers for protein and peptide sequencing; MALDI – TOF, electospray ionization coupled tandem Mass spectrometry. Tandem mass analyzer, triple quadrupole mass analyzer, ion – trap mass analyzer and FT – ion cyclotron resonance MS. Peptide Mass Fingerprinting.	The syllabus has been remodeled keeping in mind the current advances in technology.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Section-C • ~~Proteomics Technology - Separation & isolation of protein, acquisition of protein structure database utilization.~~ • ~~Applications of Mass spectroscopy in proteomics : Isolation and sequence analysis of individual protein spots.~~ • ~~Types of Proteomics.~~ • ~~Proteomics Applications.~~ • ~~Protein and Peptide microarray.~~ • ~~Advantages & disadvantages of DNA & Protein microarrays~~. **Books Recommended :** ➢ Introduction to Bioinformatics - Parrysmith and Attwood. ➢ Introduction to Bioinformatics - Baxevenis and Oulette	• Sequencing the protein fragments: Scoring Algorithm for Spectral analysis. Application of SALSA in amino acid – Motif searching. **Section – C** • Next generation sequencing & assembly: elements of big data analysis, NGS Platforms based on pyrosequencing, sequencing by synthesis, emulsion PCR approach with small magnetic beads & single molecule real time (SMRT) sequencing. • Genome assembly algorithms, De-novo assembly algorithms. • Sequence Alignment formats: Sequence Alignment/Map (SAM) format, Binary Alignment/Map (BAM) format. Protein function prediction using Machine learning tools: supervised/unsupervised learning, neural network, SVM. • Protein-protein interactions: databases such as STRINGS, DIP, PPI server & tools for analysis of protein-protein interactions. **Suggested Books:** ➢ Brown, S.M. (2015). *Next-generation DNA sequencing Informatics* (2nd ed.). Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. ➢ Liebler, D. C. (2001). *Introduction to proteomics tools for the new biology*. US: Humana Press. ➢ Lesk, A.M. (2015). *Introduction to Genomics* (2nd ed.). Oxford, UK: Oxford University Press. ➢ Pevsner, J. (2017). *Bioinformatics and Functional Genomics* (3rd ed.). New Jersey,	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				USA: John Wiley & Sons Ltd. ➢ Twyman, R.M. (2004). *Principles of Proteomics*. New Delhi, India: CBS Publishers. ➢ Thangadurai, D. & Sangeetha, J. (2015). *Genomics and Proteomics: Principles, Technologies, and Applications*. USA: CRC Press. ➢ Pennington, S. R. & Dunn, M. J. (Eds.). (2000). *Proteomics: From protein sequence to function*. Oxford, UK: Bios Scientific Pub Ltd. **Suggested e- Resources:** ➢ **Proteomics** https://nptel.ac.in/courses/102101055/4 ➢ **Genomics** https://bit.ly/2Nq86jQ	
6)	**BT 516:** Immunotechnology	After successful completion of the course, students should be able to: • Describe various theories describing antibody formation • Explain the mechanism of immune response to various stimuli • Elucidate on vaccines and their development.	**Section-A** • Structure, genomic organisation, expression and functions of major histocompatibility complex. • Organisation and expression of immunoglobulin genes ~~and antibody diversity~~. • T cell receptors - genomic organisation, structure and isolation of TCR. • ~~Immune regulation, positive and negative selection in thymus, apoptosis.~~ **Section-B** • ~~Immunity to infectious diseases.~~ • Immunodeficiency and AIDS. • ~~Transplantation Immunology.~~ • ~~Tumor Biology.~~	**Section- A** • Structure, genomic organization, expression and functions of major histocompatibility complex (MHC). • Organization and expression of immunoglobulin genes. • T-cell receptors- genomic organization, structure and isolation of TCR. • Antibody diversity- mini gene theory, mutation theory, germ line theory, somatic recombination, V(D) J recombination. Combinatorial diversity, junctional diversity. **Section-B** • ABO Blood groups, blood transfusion, Bombay phenotype, Rh blood group, DAT test, MN blood group. • Immunity to infectious diseases: Viral, bacterial, fungal and parasitic infections.	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Section-C • ~~Various approaches to vaccines.~~ • ~~T cell cloning,engineered antibodies production~~. • ~~Radioimmunoassay, Enzyme linked immunosorbant assay, ELISPOT, Immunoblotting (western blotting).~~ • ~~Immunofluroescence, Immunoelectron microscopy, cell cytotoxicity assays and flow cytome~~try. **Books Recommended:** ➢ Abbas, A. K., Lichtman, A. H., &Pillai, S. (2017). *Cellular and Molecular Immunology* (9th ed.). Amsterdam, Netherlands: Elsevier. ➢ Delves, P. J., Martin, S. J., Burton, D. R., &Roitt, I. M. (2006*). Roitt's Essential Immunology* (11thed.). New Jersey, USA: Wiley-Blackwell. ➢ Punt, J., Stranford, S., Jones, P., & Owen, J. (2018). *Kuby Immunology (*8th ed.). New York, USA: W. H. Freeman and Company. ➢ Tizard, I. R. (1995). *Immunology: Introduction,* (4th ed.). Philadelphia, USA: Saunders College Publishing.	• Immunodeficiency disease: Primary and secondary immunodeficiency disease (AIDS). **Section –C** • History of vaccination, immunization types and vaccination properties. • Types of vaccines: Live, killed, subunit, recombinant viral, synthetic peptide, anti-idiotype, DNA, toxoid, conjugate, recombinant vector & plant based vaccines. • Stages of vaccine development and some common vaccines used in human MMR, poliovaccine & BCG vaccines. **Suggested Books:** ➢ Austyn, J.M. &Wood, K.J. (1993). *Principles Of Cellular and Molecular Immunology*. London, U.K: Oxford University Press. ➢ Benjaminin, E., Coico, R. & Sunshine, G. (2000).*im*: A short course (4th ed.). New York, USA: Wiley-Liss. ➢ Cunnigham, A.J. (1978).*Understanding Immunology*. London, U.K.: Academic Press Inc. ➢ Hildemann, W.H. (1984). *Essentials of Immunology*. USA: Elsevier Science Ltd. ➢ Johnstone, A. & Thorpe, R. (1996) *Immunochemistry In Practice* (3rded.). US: Wiley-Blackwell. ➢ Joshi, K.R. & Osama, N.O. (2004). *Immunology and Serology*. India: Agrobios. ➢ Khan, F.H. (2009). *The Elements Of Immunology*. India: Pearson Education. ➢ Punt, J., Stranford, S., Jones, P. & Owen,	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				J. (2018). *Kuby Immunology (*8th ed.). New York, USA: W. H. Freeman and Company. ➢ Reeves, G. & Todd, I. (2001). *Lecture Notes on Immunology* (4th ed.). US: Wiley-Blackwell. ➢ Rich, R.R., Fleisher, T. A, Shearer, W.T., Schroeder, H., Frew, A.J. & Weyand, C.M. (2018). *Clinical Immunology: Principles and Practice* (5th ed.). USA: Elsevier Science Ltd. ➢ Tizard, I. R. (1995). *Immunology: Introduction,* (4th ed.). Philadelphia, USA: Saunders College Publishing. **Suggested e- Resources:** ➢ **Antibodies and antigens** https://nptel.ac.in/courses/102103038/download/module2.pdf ➢ **Vaccines** https://nptel.ac.in/courses/104108055/37 ➢ **DNA vaccines** https://nptel.ac.in/courses/102103041/18 ➢ **Transplantation immunology** https://nptel.ac.in/courses/102103038/31	
7)	**BT 521:** Plant Biotechnology	After successful completion of the course, students should be able to: • Demonstrate principles for development of various stress resistant plants • Understand various techniques used in plant biotechnology	**Section-A** • Introduction, examples of current use of plant biotechnology. • Development of pathogen resistant plants (virus & insect resistance). • Development of plants of improved seed quality. • Artificial seeds. • Development of plants resistant to environmental stress. • Development of herbicide resistant plants. • Future outlook.	**Section A** • Introduction, examples of current use of plant biotechnology. • Development of pathogen resistant plants (virus & insect resistance). • Development of plants of improved seed quality; Artificial seeds. • Development of plants resistant to environmental stress and herbicides. • Future outlook.	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Section-B • Immobilization of cells. • Gene delivery methods in intact and cultured tissues and cells. 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. • Cryobiology of plant cell cultures~~and establishment of gene banks.~~ • Edible vaccines. • ~~Radiobiology of cultured plant cells.~~ **Books Recommended :** ➢ Biotechnology - A Laboratory Course : J. M. Becker, G.A. Coldwell and E.A. Zachgo, Academic Press, New York. ➢ Genetic Engineering Technology in Industrial	**Section-B** • Immobilization of cells. • Direct gene delivery methods. • Vector based gene delivery methods: *Agrobacterium*, Ti plasmid based vectors, viral vectors. • Chloroplast engineering: Advantages of transplastomics, applications in production of biopharmaceuticals, introduction of agronomic traits, viz. disease resistance, herbicide resistance, salt and drought resistance; phytoremediation etc. • Biotechnology of biological nitrogen fixation: *nif* genes. **Section-C** • Production of metabolites; metabolic engineering and industrial products: Overview of plant secondary metabolites; control mechanisms and manipulation of phenyl propanoids and shikimate pathways; general strategy to regulate the production of plant cell products. • Biotransformation using plant cells. • Cryobiology of plant cell cultures. • Edible vaccines. • Molecular markers - hybridization and PCR based markers RFLP, RAPD, STS, SSR, AFLP, SNP markers. **Suggested Books:** ➢ Singh, B.D. (2011). *Plant Biotechnology* (2nd ed.). New Delhi, India: Kalyani Publisher. ➢ Chawla, H.S. (2009). *Plant Biotechnology*	Modifications have been done in the light of current technologies.

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			Pharmacy : Ed. - J.M. Tabor. ➢ Tissue Culture, Methods and Applications : P.F. Kruse. ➢ Plant Tissue Culture : Sharma and Alam; IK International Publiser Pvt. Ltd.	(3rd ed.). New Delhi, India: Oxford & IBH Publishing Co. Pvt. Ltd. ➢ Slater, A. (2008). *Plant Biotechnology: The Genetic Manipulation of Plants* (2nd ed.). Oxford, UK: Oxford Publisher. ➢ Peter, K.V., & Keshavachandran, R. (2008). Plant Biotechnology: Methods in Tissue Culture and Gene Transfer. India: Universities Press. ➢ Murphy, D. (2007). *Plant Breeding and Biotechnology: Societal Context and the Future of Agriculture* (1st ed.). UK: Cambridge University Press. ➢ Singh, B.S. (2007). *Fundamentals of Plant Biotechnology*. New Delhi, India: Satish Serial Publishing House. **Suggested e- Resources:** ➢ **Chloroplast Biotechnology** https://onlinelibrary.wiley.com/page/journal/14677652/homepage/chloroplast_biotechnology_special_issue.htm ➢ **Plant transformation technologies** http://repository.ias.ac.in/57240/1/23-pub.pdf ➢ **Abiotic stress and transgenics** http://repository.ias.ac.in/89833/1/1-pub.pdf	
8)	**BT 522:** Recombinant DNA Technology	After successful completion of the course, students should be able to: • Explain techniques used for DNA synthesis, amplification and sequencing • Describe strategies of cloning in both prokaryotes and eukaryotes. • Identify novel diagnostic tools	**Section-A** • Chemical synthesis of DNA: Phosphodiester, triester approaches, ~~amidite method~~, solid phase automated synthesis of DNA. • Sequencing of DNA : ~~Chemical and dideoxy methods~~, ~~random and directed approaches~~, automated DNA sequencing, improved gel based sequencers, mass spectrometry based sequencing, pyrosequencing, 454 sequencing technologies.	**Section-A** • Chemical synthesis of DNA: phosphodiester, phosphotriester, phosphite triester approaches, phosphoramidite solid phase automated synthesis of DNA, post-synthetic processing. • Sequencing of DNA: Maxam-Gilbert method, Sanger sequencing technique, automated DNA sequencing, improved gel based sequencers, primer walking method, whole genome shotgun	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
		of rDNA and gene therapy	• PCR in gene recombination, Deletion, Addition, Overlap extension. PCR in molecular diagnostics. Viral and bacterial detection, PCR based mutagenesis, Mutation detection: SSCP, DGGE, RFLP, Oligo ligation assay (OLA), Mismatch chemical cleavage (MCC), High resolution melt analyses, Allele-specific amplification (ASA). • Applications of Transposons in genetic engineering : construction of R plasmids, gene tagging and isolation, mutagenesis genome characterization etc. **Section-B** • ~~Vectors expressing cloned DNA in *E. coli.*~~ • Molecular cloning in ~~*E. coli &*~~ *Bacillus subtilis*. • Cloning in yeast. • DNA cloning in mammalian cells with SV-40 vector. • Cloning in plants: Direct and vector based approaches. **Section-C** • Site directed mutagenesis. • New Diagnostics in rDNA technology: Detection of genetic disorders, ~~test for pathogens,~~ DNA finger printing. • Gene Silencing techniques, ~~Introduction of siRNA and~~ siRNA technology, Micro RNA, Construction of siRNA vectors, ~~Principle and~~ application of gene silencing, ~~Gene~~ knockouts, ~~Gene replacement, Gene targeting, Transgenics~~, gene	sequencing, mass spectrometry based sequencing, pyrosequencing, 454 sequencing technologies. • Overlap-extension PCR in gene recombination, deletion & addition. • Mutation detection: SSCP, DGGE, RFLP, Oligo ligation assay (OLA), Mismatch chemical cleavage (MCC), High resolution melt analyses, Allele-specific amplification (ASA). • Applications of Transposons in genetic engineering: construction of R plasmids, gene tagging and isolation, mutagenesis, genome characterization etc. **Section-B** • Molecular cloning in *Bacillus subtilis*. • Cloning in yeast. • DNA cloning in mammalian cells with SV-40 vector. • Cloning in plants: Direct and vector based approaches. • Site directed mutagenesis: Oligonucleotide directed mutagenesis, PCR based mutagenesis. • Introduction to genome editing by CRISPR-CAS and its applications. **Section-C** • New diagnostics in rDNA technology: detection of genetic disorders, PCR in molecular diagnostics: Viral and bacterial detection, DNA finger printing. • Gene silencing techniques: RNAi, siRNA technology, construction of siRNA vectors, micro RNA, ribozymes, applications of gene silencing. • Knockout mice.	"Gene cloning and expression in *E. coli*," is a repetition of the paper Genetic Engineering taught in M.Sc. II Semester. The same has been replaced with recent genome editing technique "CRISPR-CAS"

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
			therapy. ~~Basic idea of~~ drug designing. • Cloning and expression of human interferon gene **Books recommended :** ➢ Molecular Cloning Vol. 1, 2 and 3 :Sambrook and Russell, Cold Spring Harberlaboratory, 2001. ➢ Molecular Biology of Gene : J.D. Watson, Pearson Education. ➢ An Introduction to Gene Technology-From genes to clones :Winnacker, VCH. ➢ Principles of Gene Manipulation : Old and Primrose. ➢ Molecular Biotechnology : B.R. Glick and J.J. Pasternak, ASM Press, Washington, USA. ➢ Genetic Engineering : Science and ethics on new frontier : Michael Boylan, Pearson Education. ➢ An Introduction to Genetic Engineering : S.T. Nicholl, Cambridge University Press. ➢ Recombinant DNA : J.D. Watson, W.H. Freeman. ➢ Nucleic acid and biotechnology : H.D. Kumar. ➢ Understanding DNA and Gene Cloning :Darlica, John Wiley and Sons.	• Gene therapy: types, viral and non viral vectors. An overview of structure and ligand based drug designing. • Cloning and expression of human interferon gene. **Suggested Books:** ➢ Sambrook, J.F. & Russell, D.W. (2001). *Molecular Cloning: A Laboratory Manual* (3rd ed.) Vol. 1, 2 and 3. Cold Spring Harbor laboratory. NY: Cold Spring Harbor Laboratory Press. ➢ Watson, J. D., Baker, T.A. & Bell, S.P. (2014). *Molecular Biology of the Gene* (7th ed.). US: Pearson. ➢ Winnacker, E.L. (1987). *From Genes to Clones: Introduction to Gene Technology*. Germany: Wiley VCH. ➢ Primrose, S. B. & Old, R.W. (2001). *Principles of Gene Manipulation* (6th ed.). New Jersey, USA: Wiley-Blackwell. ➢ Glick, B.R., Pasternak, J.J. & Patten, C.L. (2010). *Molecular Biotechnology: Principles and Applications of Recombinant DNA* (4thed.). US: American Society for Microbiology. ➢ Boylan, M. & Brown, K.E. (2001). *Genetic Engineering: Science and Ethics on New Frontier*. UK: Pearson Education. ➢ Nicholl, D.S.T. (2008). *An Introduction to Genetic Engineering* (3rded.). UK: Cambridge University Press. ➢ Watson, J.D., Meyers, R.M., Caudy, A.A. & Witkowski, J.A. (2007). *Recombinant DNA: Genes and Enomes-A short Course* (3rded.).	

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. ➢ Kumar, H.D. (1990). *Nucleic Acid And Biotechnology*. New Delhi, India: Vikas Publication. ➢ Drlica, K. (2003). *Understanding DNA and Gene Cloning* (4th ed.). New Jersey, USA: John Wiley & Sons Ltd. **Suggested e-Resources :** ➢ **Solid phase oligonucleotide** synthesis:https://www.atdbio.com/content/17/Solid-phase-oligonucleotide-synthesis ➢ **DNA sequencing** approaches:https://www.ncbi.nlm.nih.gov/books/NBK21117/CRISPR/ ➢ **Cas technology** https://bit.ly/2Edvm06 ➢ **Construction of siRNA expression vectors** https://bit.ly/2EqNLI8 ➢ **Gene knockout and transgenic mice** https://www.ncbi.nlm.nih.gov/books/NBK21632/	
9)	Bio Physics-I	After completion of this course, the students will be able to- • Understand the concepts of physical principles in the biomolecular systems. • Know properties and conformations of biomolecules • Understand the interaction between physics and biology		**Section A** • Introduction: Brief introduction to all aspects of Biology, cellular automata, Conway's Game of life. • Cell structure and function: Cell theory, cell membrane and transport, membranous organelles, Non-membranous organelles, Nuclear components and major cell types, viruses. • Molecules in the cell: carbohydrates, lipids, proteins and nucleic acids, their structure and function.	(New Introduced Elective Course, cw M.Sc. Physics)

S. No.	Course List	Learning Outcome	Existing Syllabus	Suggested Syllabus	Remarks
				• Code of life: Central dogma, DNA replication, transcription and translation. • Energy in life forms: Cellular Respiration, Glycolysis, Krebs cycle, Electron transport chain, ATP calculation, Photosynthesis, C4 pathway. **Section B** • Intermolecular interactions: Covalent interactions, disulphide bonds, van der Waals interactions, bond angles and torsions. Role of hydrogen bonding and hydrophobicinteraction in biomolecular structures. Examples of α-helices and β-sheets in proteins, Watson-Crick pairs in DNA, stacking interactions in DNA and RNA. • Protein Conformation: Conformational properties of polypeptides, Ramachandran plot, Helical parameters and conformation, organization as secondary and supersecondary structures in proteins, domains and motifs. Protein folding in vivo and in vitro of globular proteins, basic idea. **Section C** • Molecular Mechanics: Force field equation, Lennard Jones Potential, Potential energy surface, Z-matrix, Molecular modeling, Energy minimization techniques, Exhaustive search method, steepest descent and conjugate gradient methods, Molecular dynamics simulation, Verlet algorithm and simulated annealing protocol. • Experimental techniques used to determine biomolecular structure: Principles and application of UV-visible,	

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				circular dichroism and fluorescence spectroscopy. • Case studies on Helix to coil transitions, melting curves in proteins and DNA structures. X-ray crystallography of biomolecules: Obtaining single crystals of biomolecules, Single crystal data collection, Determination of point group, space group from symmetry of diffraction patterns, deducing cell parameters, interpretation of intensity data, Calculation of electron density, Solving the phase problem, Structure validation. **Suggested Books:** ➢ Tuszynski, J.A. & Kurzynski, M. (2003). *Introduction to molecular biophysics*. CRC press. ➢ Schlick, T. (2010). *Molecular modeling and Simulation: An Interdisciplinary Guide: An Interdisciplinary Guide* (Vol. 21). Springer Science & Business Media. ➢ Voet, D., Voet, J. G. & Pratt, C. W. (2013). *Fundamentals of Biochemistry: Life At The Molecular Level* (No. 577.1 VOE). Hoboken: Wiley. ➢ Cantor, C. R., & Schimmel, P. R. (1980). *Biophysical CHEMISTRY: PART III: The Behavior Of Biological Macromolecules*. Macmillan. ➢ Van Holde, K. E. J. W. *Principles of Physical Biochemistry*/ Kensal E. Van Holde, W. Curtis Johnson, P. Shing Ho. ➢ Jensen, J. H. (2010). *Molecular Modeling Basics*. CRC Press. ➢ Nelson, P. (2004). *Biological Physics*. New	

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				York: WH Freeman. **Suggested e-Resources:** ➢ **Non-Conventional Energy Systems** https://nptel.ac.in/syllabus/1021 • **Quantum-mechanics of molecular structure** https://bit.ly/2SoEqof https://bit.ly/2SoEqof	
10)	Animal Biotechnology-I	At successful completion of this course students will be able to: • Comprehend tools of molecular biology and biotechnology for the improved production and protection of animals. • Evaluate and discuss public and ethical concerns over the use of animal biotechnology. • Demonstrate an understanding of the key topics in tissue engineering		**Section-A** • History and importance of animal biotechnology, cryopreservation of gametes & embryos in mammals, artificial insemination (AI) techniques & their development: estrus synchronization; semen collection, evaluation & storage. • *In Vitro* fertilization and embryo transfer; superovulation, Microinjection & macroinjection: introduction, procedure, applications advantages and limitations. Ethical, social & moral issues related to cloning, in situ & ex situ preservation of germplasm. **Section-B** • Introduction to stem cell-definition, classification, characteristics, differentiation and dedifferentiation, stem cell niche, stem cells vs somatic cells, mechanism of pleuripotency in stem cells, different kinds of stem cells: adult stem cells, embryonic stem cells, fetal tissue stem cell, umbilical cord blood stem cells. • Human embryonic stem cells and society: The religious, legal, ethical and scientific debate, stem cell banking and ethical approaches on	New proposed elective

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				stem cells. • Stem cell therapies: Clinical applications of stem cell therapy, parkinsons and alzheimers disease, diabetes, kidney failure, lymphoma and leukemic malignancies requiring stem cell therapy. **Section-C** • Principles of Tissue Engineering- History & scope, basics of tissue engineering, cell- ecm interaction, wound healing mechanism, tissue engineering bioreactors, models of tissue engineering, biomaterials in tissue engineering, bioartificial organs: source of cells, choosing the right scaffold material, mode of transplantation. • Tissue Engineering & future perspectives: commercial products. **Suggested Books:** ➢ Portner, R. (2007). *Animal Cell Biotechnology*. New York, USA: Humana Press. ➢ Butler, M. (Ed.). (1991). *Mammalian Cell Biotechnology; A Practical Approach*, London, UK: Oxford university press ➢ Lanza, R., Gearhart, J., & Hogan, B. (2009). *Essentials of Stem Cell Biology* (2nd ed.).London, UK: Academic Press. ➢ Lanza, R., Langer, R. & Vacanti, J.(2013). *Principles of Tissue Engineering* (4th ed.). London, UK: Academic Press. ➢ Kumaresan, V. (2008). *Applied Animal Biotechnology*. Tamil Nadu, India: Saras Publication. ➢ Singh, B., Gautam, S.K., & Chauhan, M.S. (2015). *Textbook of Animal Biotechnology*.	

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				New Delhi, India:Teri Publication. **Suggested e-Resources** ➢ **Cryopreservation of gametes and embryos in mammals** https://www.glowm.com/section_view/heading/Gamete and Embryo Cryopreservation ➢ **Human embryonic stem cell** https://bit.ly/2GX5SXW ➢ **Stem cell therapies** https://www.closerlookatstemcells.org/stem-cells-medicine ➢ **History and scope of Tissue Engineering** https://www.stoodnt.com/blog/tissue-engineering-applications-scopes/	
Proposed Reading Elective –I & II to be offered in III & IV Semester					common with Applied Microbiology and Biotechnology for Sem III and IV, Bioscience Sem IV
1)	**Drug Discovery**	On completion of this course, students should be able to: • Understand basics of R&D in drug discovery and should be able to apply knowledge gained in respective fields of pharmaceutical industry. • Understand the role of synthetic chemistry in the development of pharmaceutical agents; and the modification of chemical structures to develop new drug molecules. • Have an advanced understanding of the chemical structure of a pharmaceutical		Modern drug discovery involves the identification of a target or drug lead using different techniques including molecular modeling, combinatorial libraries and high-throughput screening (HTS). Rational drug design is based on the understanding of the three-dimensional structures and physicochemical properties of drugs and receptors. Knowledge of molecular mechanisms, molecular dynamics simulations and homology modeling is necessary for studying drug/receptor interactions. The different conformational sampling techniques, fitness functions used in molecular docking and computational receptor-based and ligand-based drug design approaches are mostly used to design compounds with improved biological activity in rational drug	

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		agent and determine the chemical group/s responsible for a given biological effect. • Demonstrate a basic understanding of pharmacogenomics and bioinformatics as it relates to drug design and discovery. • Develop an understanding of drug targets as a recognition site for pharmaceutical agents; how the chemical structure of a substance influences interaction with a drug target; and the identification of new drug targets for future drug discovery.		design. Quantitative drug design using QSAR models are used to correlate structural molecular properties (descriptors) with functions (i.e. physicochemical properties, biological activities, toxicity, etc.) of the compounds. Understanding the structure activity relationship between the 3D structure of a molecule and its biological activity may act as the basis for the prediction of compounds with improved biological activities. Different bio-analytical assays (LC/MS/MS, GC/MS and ELISA) could be developed further in support of *in vitro* and *in vivo* studies. Understanding the principles as well as an early characterization of drug toxicity, adsorption, distribution, metabolism and excretion (ADME) along with drug-drug interactions, plasma protein binding assays and metabolite profile studies helps in eliminating compounds with unacceptable pharmacokinetic characteristics, which is critical to successful drug discovery programs. **Suggested Books:** ➢ Krogsgaard-Larsen *et. al.* (2016). *Textbook of Drug Design and Discovery*. 5th Edition. CRC Press. ➢ Satyanarayanajois, S. D. (2011). *Drug Design and Discovery: Methods and Protocols*. Humana Press. ➢ Rahman, A. U., Caldwell, G. W. & Choudhary, M. I. (2007). *Frontiers in Drug Design and Discovery*. Bentham Science publishers Limited. ➢ Dastmalchi, S. *et. al.* (2016). *Methods and Algorithms for Molecular Docking-Based*	

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

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				Galactosemia), haemoglobinopathies, Thalassemia syndromes, multifactorial disorders (diabetes, schizophrenia, huntington disease). Medical genetics involves ethical issues therefore serious discussion is required for prenatal/adult diagnosis of genetic disorders, medical ethics, risks and benefits, informed consent and right of choice. **Suggested Books:** ➢ Strachan T. & Read. A. (2011). *Human Molecular Genetics* (4th ed.). Garland Science ➢ Pasternak J. Fitzgerald. (1999). *An introduction to Human Molecular Genetics-Mechanism of Inherited Diseases*. Science Press. ➢ Thompson and Thompson.(2007).*Genetics in Medicine (7th Ed.*).Saunders **Suggested e- Resources** ➢ **Chromosome identification and nomenclature (ISCN)** http://www.cydas.org/Resources/ISCN_Discussion.html ➢ **Pedigree data analysis** https://learn.genetics.utah.edu/content/disorders/ ➢ **Genetic disorders** https://www.genome.gov/10001204/specific-genetic-disorders/ ➢ **Prenatal/ adult diagnosis of genetic disorders, medical ethics** https://www.michiganallianceforfamilies.org/all/#sectionD	
3)	**Intellectual Property Rights**	After completing this course, students will be able to:		Intellectual property rights (IPR) have an old history and are very relevant for economic	

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		• Understand the concept of IPR and its types • Describe the steps for patenting • Discuss the role of WTO and WIPO on IPR		development. Various types of IPR (patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications) are recognized with specific uses. There is currently an emergence of specific IP pertaining to plants and animals (UPOV, Plant Breeder's rights and plant variety protection and farmers rights act, patent protection of plant and animal inventions (WTO) and Law on the protection of New plant varieties and animal breeds (WIPO)). It is important to know about types of patent applications and the process of patenting with special emphasis to India. The role of WTO (GATT and TRIPS) and WIPO in implementation of IPR is significant as is understanding the relevance of Patent Cooperation Treaty (PCT) in patenting. IPR also are associated with certain ethical dilemma and there are some interesting case studies which highlight its relevance. **Suggested Books:** ➢ Sateesh, M.K. (2008). *Bioethics and 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	

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				➢ **World Intellectual Property Organisation**. http://www.wipo.int ➢ **International Union for the Protection of New Varieties of Plants.** http://www.upov.int ➢ **National Portal of India**. http://www.archive.india.gov.in	
4)	**Medical Microbiology**	After successful completion of the course, students should be able to: • Identify various bacterial, fungal, viral and protozoan diseases and their epidemiology • Understand the relevance of emerging and reemerging diseases	**Medical Microbiology and Immunology** **Section-A** • Innate and Acquired Immunity • Antigens : types of Antigens, Antigen specificity, haptens, Antibody structure and functions • MHC, Complement System • Cell mediated cytotoxicity : Origin, maturation and characterization of T-lymphocytes, Monocytes & Macrophages, Mechanism of T cell and NK cell mediated lysis, ADCC, Macrophage mediated cytotoxicity, lymphokines - the product of T cell activation. • Humoral immune response : Origin, maturation and characterization of B-lymphocytes, Activation and proliferation of B-cells, Formation of plasmablast, Plasma cells and memory cells, Interaction of B and T cells. **Section-B** • Hypersensitivity, Monoclonal antibodies and its applications. • Radioimmunoassay, Enzyme linked immunosorbant assay, immunoblotting, immunofluorescence and flowcytometry • Characteristics of infectious diseases, Herd immunity. • Disease cycle (Source of disease, reservoir,	**Medical Microbiology** Medical Microbiology describes the cause, transmission, epidemiology, pathogenesis, symptoms, diagnosis and treatment of various bacterial (tuberculosis, typhoid, leprosy), fungal (superficial, subcutaneous, systemic mycosis), protozoan (Malaria, amoebiasis) and viral (AIDS, Influenza, measles) diseases. Currently, it is necessary to understand the impact of emerging and remerging diseases (cholera, dengue, multidrug resistant tuberculosis, H5N1 avian influenza, drug resistant malaria, chikungunya) on human health. Global assessment for various diseases also shows an increasing trend of nosocomial infections and opportunistic infections which cause significant mortality and health concerns.	This course was earlier run as a core course in AMBT IIIrd sem.

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			carriers) • Transmission of pathogens (Air borne, contact transmission and vector transmission). **Section-C** • Bacterial Diseases : Epidemiology, Pathogenicity, Laboratory diagnosis, Prevention & control of the following diseases : Anthrax, Tuberculosis, Typhoid, Whooping cough, Tetanus, Diphtheria, Leprosy. • General Account of fungal diseases : Mycosis, Subcutaneous and deep. • General Account of viral & protozoan diseases : Pneumonia, Influenza, Mumps, Measles, Polio, Hepatitis B, Chickenpox, AIDS and Malaria, Leishmaniasis. • Brief account of sexually transmitted diseases. **Books Recommended :** ➢ Text Book of Microbiology : R. Ananthanarayanan and C.K. JayaramPanicker, Orient Longman, 1997. ➢ Medical Microbiology, Vol, 1 : Microbial infection : Mackie and MaCartney, Churchil Livingstone, 1996. ➢ Bailey and Scott's Diagnostic Microbiology : Baron EJ, Peterson LR and Finegold, SM Mosby, 1990. ➢ Essential immunology (1995) :Roitt, I.M. Black well Scientific Publications, Oxford. ➢ Fundamental immunology : W.E. Paul 1984, Raven Press, New York. ➢ Fundamentals of Immunology : R.M. Coleman, M.F. Lombord and R.E. Sicard (1992) - 2nd ed. C. Brown publishers. ➢ Immunology : D.M. Weir and J Steward 7th Ed. (1993).	**Suggested Books:** ➢ Brooks, G.F., Carroll, K.C., Butel, J.S., Morse, S.A. & Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's Medical Microbiology (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 McGraw-Hill. **Suggested e- resources:** ➢ **Emerging Diseases** ➢ https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3701702/ ➢ **Epidemiology** https://bit.ly/2SUmzum	

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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.	➢ **Nosocomial Infections** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3470069/	
5)	**Molecular Plant Breeding**	After completing this course, students will be able to: • Understand strategies and applications of plant breeding technologies. • Comprehend the knowledge of different plat molecular markers • Plan a research career in the area of plant biotechnology		Plant breeding study involves breeding methods for self and cross pollinated crops. There are several limitations of conventional breeding. Thus, there is need to have a better breeding approaches to overcome this limitation. Development of molecular markers (RFLP, RAPD, SSRs, ISSRs, SNPs), construction of molecular maps and linkage analysis, mapping populations for QTLs using molecular markers play an important role in plant breeding. In order to develop potential plant having better qualities, Marker Assisted Selection (MAS) is also a viable approach which can be done by using selection of traits and markers, trait association, marker assisted backcrossing and recurrent selection, marker assisted hybrid breeding and marker assisted improved varieties/germplasm. **Suggested Books:** ➢ Chawla, H. S. (2000). *Introduction to Plant Biotechnology*. USA: Science Publishers. ➢ Slater, A., Scott, N. & Fowler, M. (2008). *Plant Biotechnology: The Genetic Manipulation of Plants* (2nd ed.). UK: Oxford University Press. ➢ Primrose, S.B., Twyman R.H. & Old R.W. (2001). *Principles of Gene Manipulation* (6th ed.). Wiley-Blackwell. ➢ Nicholl, D.S.T. (2008). *An introduction to Genetic Engineering* (3rd ed). Cambridge:	

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				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)	**Protein Engineering**	On completion of this course, students should be able to: • Analyse structure and construction of proteins by computer-based methods • Describe structure and classification of proteins • Analyse and compare the amino acid sequence and structure of proteins, and relate this information to the function of proteins • Explain how proteins can be used for different industrial and academic purposes such as structure determination, organic synthesis and drug design.		An introduction to protein engineering for developing proteins with desired functions. Various methods (rational design and directed evolution) of protein engineering are employed to manipulate the different features or characteristics (affinity, specificity and stability etc) of proteins. Engineering various physicochemical and biological properties (stability to changes in parameters as pH, temperature, amino acid sequence and aggregation propensities etc) of the proteins could be important in their use as protein drugs and/or catalysts in bioreactors. The insight into the fundamental understanding of the mechanisms and forces (Van der waals, electrostatic, hydrogen bonding, weakly polar interactions, and hydrophobic effects), by which protein stabilizes, will help in the formulation of protein based pharmaceuticals. Protein	

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		• Plan and carry out activity measurements of isolated proteins and characterize their purity and stability.		engineering with site-specifically incorporation of unnatural or non-canonical amino acids has been used to improve protein function for medical and industrial applications. Different computational approaches (sequence and 3D structure analysis, data mining, Ramachandran map etc) to protein engineering would help to address the requirements in order to find amino acid sequences that will optimize a desired property (physicochemical property and/or biological function) of a protein. Determination of the physicochemical properties of proteins using various spectroscopic methods (Far-UV and Near-UV CD, Fluorescence, UV absorbance and Optical rotatory dispersion) would further support the drug development process. Yeast surface display (YSD)has become a valuable protein engineering tool for modifying the affinity, specificity, and stability of antibodies, as well as other proteins. YSD could be successfully used for protein epitope mapping, identification of protein-protein interactions, and uses of displayed proteins in industry and medicine. Developing vaccines and peptidomimetics will further allow the investigators to identify novel therapeutic leads for numerous unmet clinical needs. **Suggested Books:** ➢ Walsh, G. (2014). *Proteins: biochemistry and biotechnology*, Second edition. Chichester, West Sussex: Wiley Blackwell. ➢ Creighton, T. E. (1997). *Protein Structure: a Practical Approach*, 2nd Edition. Oxford University press. ➢ Cleland, J. L. & Craik, C. S. (2006). *Protein*	

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				Engineering, Principles and Practice, Vol 7. Springer Netherlands. ➢ Mueller, K., & Arndt, K. (2006). *Protein Engineering Protocols*, 1st Edition. Humana Press. ➢ Robertson, D., & Noel, J. P. (2004). *Protein Engineering Methods in Enzymology*, Vol 388. Elsevier Academic Press. ➢ Kyte, J. (2006). *Structure in Protein Chemistry*, 2nd Edition. Garland publishers. ➢ Williamson, M. P. (2012). *How proteins Work*. New York: Garland Science. **Suggested e- Resources:** ➢ **Protein Engineering**: https://nptel.ac.in/courses/102103017/pdf/lecture%2022.pdf ➢ **Conformational stability of proteins**: https://bit.ly/2y85mid ➢ **Protein Engineering with Non-Natural Amino Acids:** https://library.umac.mo/ebooks/b2805488x.pdf	

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

Verified

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