Department of Bioscience & Biotechnology
Banasthali Vidyapith, Banasthali

Minutes of the Board of Studies held on March 15, 2012 at 10:00 am in Conference Hall, Vidya Mandir, Banasthali Vidyapith

Present

1.	Prof. S.L. Kothari	External Member
2.	Prof. S.S. Sharma	External Member
3.	Dr. Veena Garg	Internal Member
4.	Dr. Veena Sharma	Internal Member
5.	Dr. G. S. Shekhawat	Internal Member
6.	Dr. Anubhuti Sharma	Internal Member
7.	Dr. Suphiya Khan	Internal Member
8.	Dr. Suman Gupta	Internal Member
9.	Dr. Nidhi Srivastava	Internal Member
10.	Mr. C.K. Sharma	Internal Member
11.	Dr. Renu Bist	Internal Member
12.	Dr. Dipjyoti Chakraborty	Internal Member
13.	Dr. Jyoti Srivastava	Internal Member
14.	Dr. Shrilekha Misra	Internal Member
15.	Ms. Tripti Sharma	Internal Member
16.	Dr. Rachana Jain	Internal Member
17.	Dr Kambaska Kumar Behera	Internal Member
18.	Dr. Afroz Alam	Internal Member
19.	Dr. Sharad Vats	Internal Member
20.	Dr. Rashmi Tripathi	Internal Member
21.	Dr Monika Saxena	Internal Member
22.	Mr Arun Sharma	Internal Member
23.	Dr Kakoli Dutt	Internal Member
24.	Mr Ravi Dhabhai	Internal Member
25.	Mr Anand Prakash	Internal Member
26.	Prof. Vinay Sharma	Convener (in the Chair)

Note: Prof. S.D. Purohit, Prof. H.N. Verma and Prof. Ashok Kumar, External Members and Dr Nilima Kumari, Internal Member could not attend the meeting.

Convener welcomed all the members and introduced them to the external experts of BOS, Prof. S.L. Kothari and Prof. S.S. Sharma

1. The Board took up for confirmation of the minutes of its last meeting held on October 09, 2010.
   The Board resolved that the minutes of its last meeting be confirmed.

2. The Board considered the syllabi for Ph.D. Entrance Examination for Banasthali Research Entrance Test (BRET) in Bioscience and Biotechnology. The Convener placed for discussion a model representative syllabus as per the mandate of UGC covering all aspects relevant for any entrance exam with greater emphasis on general and basic aspects Biotechnology, Botany and Zoology having twelve sections. Prof SS Sharma & Prof SL Kothari noted that the syllabus is comprehensive. The Board resolved that entrance exam would be based on the topics mentioned in the syllabus, however there questions would not be equally distributed among the different sections and this should be indicated in the syllabus. The proposed syllabus is included as Appendix – I (pages 6-10). The questions will be submitted within 2 weeks.

3. The Broad verified the names of various degrees offered by Dept of Bioscience and Biotechnology keeping in view the list of degrees specified by the University Grants Commission. The Board noted that the Department offers only B.Sc., B.Tech., M.Sc. and Ph.D. degrees in accordance with the list provided by the UGC.

4. In view of the decision of Academic Council and Executive Council from 2009 onwards and in view of the Roadmap prepared by the Academic Council in its meeting held on 19th February, 2012, the Board framed the course structure and recurring, non-recurring requirements of M. Tech. (Biotechnology) Program. The Board resolved to recommend that the program may begin from 2013-14 as many more additional resources in terms of infrastructure, equipments etc., are required for a course of such specialized nature. The Convener detailed the proposed course and enlightened the Board of the various aspects of the course and the possibility of offering the electives. The Board resolved that Biosafety, Bioethics and IPR,

Biodiversity and Conservation, Renewable energy courses be taken as reading elective. The details are included in Appendix II (pages 11-15).

5. The Board verified the course codes of all ongoing programmes in Bioscience and Biotechnology and keeping in view the structure presented in Academic Council. The Convernor mentioned the utility of a uniform course code and the objective behind the same at Banasthali. Dr Veena Garg detailed the intricacies of the course code and the principles on which it has been based on. The Board resolved that some of the course codes need to be changed. A list of the modified and corrected course codes is included as Appendix – III (pages 16-46)

6. The Convener proposed a sample model handout and invited suggestions regarding various points to be included in the 'Handout' for further improvement and its effectiveness in view of the decision of the Academic Council to make course 'Handout' mandatory for every course offered by the Vidyapith with effect from July, 2012. Dr Kothari emphasized that teacher should have some flexibility to suitably modify the proposed model handout keeping the overall spirit intact. A copy of the Handout approved by the Board is included in Appendix – IV (pages 47).

7. The Convener apprised the Board that Item no 8 of the Agenda pertaining to ways and means to make Certificate/Diploma courses more effective by not infringing on the academic calendar of the Vidyapith by way of excessive examinations and also by making them more learning-centric rather than examination-centric is not applicable to the Department of Bioscience and Biotechnology as no such course is being offered at present.

8. The Board suggested ways and means to strengthening continuous assessment policy. Convener put forward the present system followed in the Department whereby continuous assessment is based on a periodical test (mid-term examination) and a combination of two more assessments, viz. class test/ seminar/ assignment. The external experts felt that the scheme is good enough to assess the overall progress of the students. There were a few suggestions towards improvement of continuous assessment, viz. introduction of quiz, group discussion, surprise test, dictating a technical paragraph base on the course and checking the same for spelling mistakes

etc. However overall the Board felt that the existing policy is adequate to assess the students and resolved to recommend the continuation of the existing policy.

9. The Board recommended additional text book(s) for the under-graduate programmes, wherever required. A list is included as Appendix – V (pages 48-57).

10. The board updated the panel of examiners for various examinations at Bachelor's and Master's degree in accordance with the Bye-laws 15.3.02 of the Vidyapith. The already existing panel will continue to be retained.

11. The Board considered Courses of Study, Curricula and Scheme of Examination in the Department. The Convener apprised the Board that the Post graduate Bioscience/ Biotechnology/ AMBT syllabus had been modified in the previous meeting of the BOS on 09.10.2010 according to the DBT guidelines and are to be implemented in the session 2012-13. As such, at present there is no suggestion of change for the forthcoming semester.

    A minor change in BTech practical course 1.6/ 2.6 to be implemented from the session 2012-13 was approved and enclosed as Appendix VI A (page 58).

    A modification in the B.Sc. Zoology and M.Sc. Bioscience (Animal Science) was considered and approved in consideration of UGC guidelines for gradually phasing out dissections oriented practicals. The Board resolved that the dissections be completely done away with in all of the practical courses. The modified course structure to be implemented w.e.f. session 2012-13 is enclosed as Appendix VI B (page 59-64) for B.Sc. Bioscience – Zoology course and Appendix VI C (page65-66) for M.Sc. Bioscience (Animal Science) courses.

12. The board considered the reports of examiners in various examinations of 2010-2011.

    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. There was also a discussion over the issuance of supplementary copies and their misuse by the students, for instance leaving many pages blank, writing only half page, as well as inconvenience to the office and invigilators to keep an account of these copies and so on.

In view of this, the Board unanimously recommended that the supplementary copies in final/ term examinations be discontinued and if the need be, the number of pages in the main copy may be increased accordingly.

13. 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 2010-11. These were thoroughly studied by the various subject teachers and the following observations were made:

The analysis of the question papers summarized in Appendix VIIA (page 67-68) and details given in various tables and figures Appendix VIIB (UG, page 69-93), (B.Tech. Biotechnology, page 94-103) and (PG, page 104-118).

It was found that quality of question papers has not deteriorated in the session 2010-11 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 meeting ended with vote of thanks to chairperson.

Verified

Offg. Secretary
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Appendix II

Proposal for M.Tech in Biotechnology

In the year 2008 Banasthali University started B.Tech. Biotechnology with intake of 82 students at its main campus. Department of Bioscience and Biotechnology has very good infrastructure required to run the course including modern equipments. Besides a Green House and an Animal House, the department has several equipments costing over Rs. 10 lacs. Departmental library is also enriched with text books and reference books. The overall response to the course is good in terms of admission and applications received for the course.

The Department of Biotechnology has dedicated faculty and staff to build intellectual and successful biotechnology engineers. The course has been tailored by in house faculty members and leading academicians of esteemed institutions. The courses are mainly based on presentations and interactions with industry, enabling students to take decisions based on their strong academic, practical and industrial background in biotechnology sector. The courses are reviewed regularly in consultation with our board of studies, comprising people from industry, research, and top academics from all over India. Thus the course is designed to fulfill requirement of biotechnology engineers in the growing worldwide industry.

Keeping the above trends requirement in mind the Department of Bioscience and Biotechnology has framed a curriculum of Post Graduate programme M.Tech. in Biotechnology consisting of various subjects that give solid foundation in the first year and then carryout research work on industry related project during dissertation work in the second year. The curriculum incorporates the component of problem solving and project work in area of specialization. We can initiate this course from session 2013-14, because we shall be having sufficient facilities and space for running this course in 2013-14.

The objectives of proposing M. Tech Biotechnology:

To provide excellent education in an inspiring environment where delivery of outstanding knowledge of biotechnology is integrated with nationally and internationally recognized research to carry out and publish progressive multidisciplinary research in the discovery, utilization and evaluation of biotechnology process:

- To provide higher education in Biotechnology Engineering.
- Educate students for technical competence, hands-on training and knowledge management in different areas of Biotechnology.
- Promote scientific capacity building among students in different specializations of Biotechnology.
- Motivate students towards entrepreneurship for better competence in the market.

Biotechnology in India

The Biotechnology industry in India is a multi bullion-dollar industry business. In the rapidly changing scenario of globalization and introduction of SEZ's many new industries are in pipeline for Biotechnology based industries**.** Biotechnology industry plays an important role in progress of a country and human mankind thus we have great opportunities for the field of Biotechnology Engineering.

Biotechnology combines genetics, biochemistry, microbiology, immunology, bioprocess engineering, tissue culture technology, molecular biology and recombinant DNA technology.

Biotechnology has applications in the production of medical and veterinary products, bio chemicals, food, drugs and pharmaceuticals, diagnostics, food products, neutraceuticals, etc. and

in the fields of chemical engineering, energy, pollution control, environment protection and waste management. Industrial units in these fields need personnel skilled and trained in biotechnology.

In order to have uniformity in course contents, requisite standards of education, technical faculty, facilities and infrastructure at international level colleges are going for accreditation and certifications from internationally approved regulating agencies.

The students passing out of this course will have opportunities in the various fields of Biotechnology Engineering like as research & development which is the heart of any industry, as it is the key of growth and sustenance. Mainly M.Tech. Biotechnology & Ph.D.'s are in great demand in the various areas of Biotechnology R&D. Excellent opportunities exist for the professionals in teaching profession. As per A.I.C.T.E. norms the minimum entry –level as Assistant Professor is M.Tech. This profession is associated with job satisfaction and social status as teaching is considered to be a noble profession. A Biotechnology professional can work as a production engineer, officer, executive, manager etc., involve in the production of bulk Biotechnology products & intermediates. One of the import areas in Biotechnology industry is developing viable processes for the manufacturing of Biotechnology products and intermediates for their commercial production. Quality control (Q.C.) and quality assurance (Q.A.) are the most important and integral areas of Biotechnology industry. Highly specialized and trained staff is required to handle sensitive analytical procedures and sophisticated equipments. B.Tech. and M.Tech. are preferred for Analysis / Q.A. jobs. An aspirant can enter into various openings viz. professional sales executive to the level of international marketing and exports.

Proposed intake of students: 30 students per year

Duration:

The duration of M.Tech. Biotechnology shall be two years, divided into four semesters. Last two semesters are for dissertation work.

Eligibility:

The candidate seeking admission M.Tech Biotechnology must have:

The candidate who have passed B.E./B.Tech Bio-Technology, Biochemical Engineering, Chemical Engineering, B. Pharmacy and related disciplines or, M.Sc. Life Sciences and related disciplines

Admission:

The admission to M.Tech. Biotechnology will be on the basis of the performance in the qualifying examination and the performance in the aptitude test. The weightage for qualifying examination and aptitude test will be equal.

Facilities which 'we need' to run M. Tech. Course:

- 1 class room
- 2 laboratories
- Staff : Teaching staff -04

  Non-Teaching staff -02
- Adequate furniture
- Chemicals, glass wares and equipments.

Summary of the expenditure and generation of funds
(During year 2013-15)

Year	Expenditure				Generation of Funds From Fees (Rs in lacs)	Net Outcome (Rs in lacs)
	Recurring (Rs in lacs)		Non Recurring (List of Instruments enclosed on page no. 5)	Total (Rs in lacs)		
	On staff	On Others				
I year (2013-14)	19.6	6.3	39.52	65.42	22.5	**-42.92**
II year (2014-15)	19.6	6.3	-	25.9	43.5	**17.6**
Total	**39.2**	**12.6**	**39.52**	**91.32**	**66.0**	**-25.32**

Table 1: Recurring Expenditure on Staff*

Year	Teaching		Non- Teaching				Total (Rs. in lacs)
	No. of Faculty	Approx. Salary (Rs. in lacs) per year	No. of Lab. Asst.	Approx. Salary (Rs. in lacs) per year	No. of Lab. Boy	Approx. salary (Rs. in lacs) per year	
I Year (2013-14)	04	15.0	02	3.6	02	1.0	**19.6**
II Year (2014-15)	04	15.0	02	3.6	02	1.0	**19.6**
Grand Total							**39.2**

Table 2: Other Recurring Expenditure

S.No.	Budget Required per year	Expenditure (Approx.) Rs. in lacs
1	Library Books	1.0
2	Chemical, Glassware	5.0
3	Miscellaneous	0.3
Total		**6.3**

Table 3: (Table 1+ Table 2) Summary of Recurring Expenditure for two Years

Year	Expenditure on Staff (Rs. in lacs) (Obtained from table 1)	Other Expenditure (Rs. in lacs) (Obtained from table 2)	Total (Rs. in lacs)
I Year (2013-14)	19.6	6.3	**25.9**
II Year (2014-15)	19.6	6.3	**25.9**
Total			**51.8**

Table 4: Financial Resources (Generation of Funds)

Year	No. of Students	Proposed Fee (Rs. in lacs) per Student	Total (Rs. in lacs)	Prospectus Fee (Rs. in lacs)	Total (Rs. in lacs)
I Year (2013-14)	30	0.7	21.0	1.5	**22.5**
II Year (2014-15)	30+30	0.7	42.0	1.5	**43.5**
Grand Total					**66.0**

Table 5: Number of Lab & Class Room Required:

Year	Total Intake of students per Year	No. of Lab Required	No. of Class Rooms Required
I Year (2013-14)	30	02	01
II Year (2014-15)	30	-	-

Table 6: List of Equipments required for M. Tech. Biotechnology

S.No.	Equipments	Number required	Approx. Price/Unit (Rs. in lacs)	Total Cost (Rs. in lacs)
1.	Bioreactor with chiller	1	11.50	11.50
2.	Elisa Reader	1	3.00	3.00
3.	Gel Electrophoresis (Horizontal)	2	0.60	1.20
4.	Gel Electrophoresis (Vertical)	2	0.60	1.20
5.	Incubator Shaker	2	1.50	3.00
6.	Gradient PCR	1	6.00	6.00
7.	UV-Transilluminator	1	1.00	1.00
8.	Gel Rocker (Horizontal)	1	0.32	0.32
9.	Cooling Centrifuge	1	2.00	2.00
10.	-20^{o}C Deep Freezer	1	0.80	0.80
11.	Manual sequencer	1	2.50	2.50
12.	UV-Vis Spectrophotometer	1	4.00	4.00
13.	Binocular microscope	5	2.50	2.50
14.	Autoclave (Vertical)	1	0.50	0.50
	Total			**39.52**

M. Tech. Biotechnology
Proposed Scheme of Examination and Courses of Study

Yr	Course No.	First Semester	L	T	P	Total Marks	Course No.	Second Semester	L	T	P	Total Marks
I	MBT 1.1	Engineering Mathematics	3	1	-	60	MBT 2.1	Immunotechnology	3	1	-	60
	MBT 1.2	Advanced Cell Biology	3	1	-	60	MBT 2.2	Plant Tissue Culture	3	1	-	60
	MBT 1.3	Bioprocess Engineering-I	3	1	-	60	MBT 2.3	Bioprocess Engineering-II	3	1	-	60
	MBT 1.4	Enzyme Technology	3	1	-	60	MBT 2.4	Recombinant DNA Technology	3	1	-	60
	MBT 1.5	Animal Tissue Culture	3	1	-	60	MBT 2.5	Elective	3	1	-	60
	MBT 1.6	Seminar	2	-	-	30	MBT 2.6	Lab-II	-	-	12	90
	MBT 1.7	Lab-I	-	-	12	90						
Total			17	**5**	**12**	**420**	**Total**		**15**	**5**	**12**	**390**

Yr	Course No.	Third Semester	L	T	P	Total Marks	Course No.	Fourth Semester	L	T	P	Total Marks
II	MBT 3.1	Reading elective (Self study)	2	-	-	30		Dissertation I.) Report II.) Presentation III.) Viva-Voce				 100 100 100
	MBT 3.2	Dissertation										
Total			**2**	**-**	**-**	**30**	**Total**					**300**

S. No.	Electives	Reading electives
1.	Cancer Biology	1. Biosafety, Bioethics and IPR
2.	Bioinformatics	2. Renewable Energy Sources
3.	Drug Designing	3. Biodiversity and Conservation
4.	Nanobiotechnology	
5.	Medical Biotechnology	
6.	Bio-Entrepreneurship	
7.	Food Biotechnology	
8.	Environmental Biotechnology	

Verified

Offg. Secretary
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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. Tech Biotechnology

Existing Courses					
M. Tech. Biotechnology Sem. I		**L**	**T**	**P**	**C**
BT 501	Advanced Cell Biology	4	0	0	4
BT 502	Bioprocess Engineering-I	4	0	0	4
BIN 501	Biological Databases and Computational Biology	4	0	0	4
BT 511	Enzyme Technology	4	0	0	4
BT 505L	Biotechnology Lab-I	0	0	12	6
MATH 506	Engineering Mathematics	4	0	0	4
	Total	**20**	**0**	**12**	**26**

Proposed Courses					
M. Tech. Biotechnology Sem. I		**L**	**T**	**P**	**C**
BT	Advanced Cell Biology	4	0	0	4
BIN	Biological Databases and Computational Biology	4	0	0	4
MATH 506	Engineering Mathematics	4	0	0	4
BT	Term Paper-I/Minor Project	0	0	8	4
BT	Elective I	4	0	0	4
BT L	Biotechnology Lab-I	0	0	12	6
	Total	**16**	**0**	**20**	**26**

Existing Courses					
M. Tech. Biotechnology Sem. II		**L**	**T**	**P**	**C**
BT 503	Bioprocess Engineering-II	4	0	0	4
BT 514	Genetic Manipulation Technology (C.W. M.Sc. Sem IV Bioinfo BT 514)	4	0	0	4
BT 516	Immunotechnology	4	0	0	4
BT 520	Plant and Animal Cell Culture Technology	4	0	0	4
BT 512	Elective*	4	0	0	4
BT 506L	Biotechnology Lab-II	0	0	12	6
	Total	**20**	**0**	**12**	**26**
	Electives*				
BIN 502	Computer Aided Drug Designing	4	0	0	4
BIN 503	Elements of Bioinformatics	4	0	0	4
BIO 417	Structural Biology	4	0	0	4
BIO 501	Bioentrepreneurship	4	0	0	4
BIO 502	Cancer Biology	4	0	0	4
BT 510	Environmental Biotechnology	4	0	0	4
BT 512	Food Biotechnology	4	0	0	4
BT 517	Medical Biotechnology	4	0	0	4
BT 519	Nanobiotechnology	4	0	0	4

Proposed Courses					
M. Tech. Biotechnology Sem. II		**L**	**T**	**P**	**C**
BT 503	Bioprocess Engineering	4	0	0	4
BT 514	Genetic Manipulation Technology	4	0	0	4
BT	Term paper-II/Minor project	0	0	8	4
BT	Elective-II	4	0	0	4
	Open Elective	4	0	0	4
BT 506L	Biotechnology Lab-II	0	0	12	6
	Total	**16**	**0**	**20**	**26**

Existing Courses					
M. Tech. Biotechnology Sem. III		**L**	**T**	**P**	**C**
	Reading Electives - I*	0	0	4	2
BT 602P	Project Part - I	0	0	48	24
	Total	**0**	**0**	**52**	**26**

Proposed Courses					
M. Tech. Biotechnology Sem. III		**L**	**T**	**P**	**C**
	Reading Elective - I	0	0	0	2
BT 602P	Project Part - I	0	0	48	24
	Total	**0**	**0**	48	**26**

Existing Courses					
M. Tech. Biotechnology Sem. IV		**L**	**T**	**P**	**C**
	Reading Electives - II	0	0	4	2
BT 603P	Project Part - II	0	0	48	24
	Total	**0**	**0**	**52**	**26**
Reading Electives I/ II					
BIO 601R	Biodiversity and Conservation	0	0	4	2
BIO 602R	Bioethics, Biosafety and IPR	0	0	4	2
BT 604R	Renewable Energy Sources	0	0	4	2

Proposed Courses					
M. Tech. Biotechnology Sem. IV		**L**	**T**	**P**	**C**
	Reading Elective - II	0	0	0	2
BT 603P	Project Part - II	0	0	48	24
	Total	**0**	**0**	48	**26**

	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

	Proposed List of Electives proposed to be offered in I & II Semester
BIN 502	Computer Aided Drug Designing
BIN 503	Elements of Bioinformatics
BIO 417	Structural Biology
BIO 501	Bioentrepreneurship
BIO 502	Cancer Biology
BT 510	Environmental Biotechnology
BT	Food Biotechnology
BT 517	Medical Biotechnology
BT 519	Nanobiotechnology
BT	Enzyme Technology
BT	Immunotechnology
	Proposed List of Reading Elective-I & II proposed to be offered in III & IV Semester
BT	Molecular Plant Breeding
	Intellectual Property Rights
BT	Human Genetics and Diseases
BT	Medical Microbiology
BT	Protein Engineering
BT	Drug Discovery
BT	Downstream Processing http://nptel.ac.in/syllabus/102106022
BT	Bioreactor https://swayam.gov.in/course/1339-bioreactors
BT	Mass Spectrometry based Proteomics https://onlinecourses.nptel.ac.in/noc15_bt05/preview https://swayam.gov.in/search?keyword=Mass%20spectrometry%20based%20proteomics

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

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
M. Tech. Biotechnology I Semester					
1)	**BT 501** Advanced Cell Biology	After successful completion of the course, students should be able to: • Describe processes in cell biology • Compare the role of various characteristic bio-molecules of living organisms. • Apply concepts of cell biology to relevant and specific problems	**Section A** ~~Basic overview of cell organelles, cell cycle, cell membrane, cytoskeleton, cell motility and shape. Mitochondria: membrane organization, transport of proteins into mitochondria and chloroplasts. Semiautonomous organelles concept, cell-cell signaling. DNA~~ replication, Transcription and Translation. **Section B** Lysosomes: intracellular digestion, sorting of lysosomal enzymes in Golgi, lysosomal storage diseases. ~~Signal hypothesis:~~ Concept of signal peptide, SRP, SRP Receptor, transport of soluble and membrane bound proteins in Endoplasmic Reticulum, ER Resident proteins, ER chaperone proteins and their functions, protein glycosylation. **Section C** ~~DNA -protein interaction: Mobility shift DNA binding assay, Methylation and Uracil interference assay, DNase I foot printing, UV cross linking of protein to nucleic acid. Yeast one and two hybrid system for DNA -protein/ protein-protein interaction .Expression of~~	**Section-A** • Replication of genetic material in prokaryotes and eukaryotes, Replication of single stranded circular DNA. • Prokaryotic transcription and Anti-termination; Eukaryotic transcription • Post transcriptional modifications: processing of hnRNA, tRNA and rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; Splicing; RNA editing; Nuclear export of mRNA; Catalytic RNA. • Translation: Genetic code; Translation machinery; Isoaccepting tRNA; Mechanism of initiation, elongation and termination; post-translational modifications. **Section B** • Molecular structure and function: Structural models, Composition and dynamics; Transport of ions and macromolecules; Pumps, carriers and channels; Membrane carbohydrates and their significance in cellular recognition; cellular junctions and adhesions; structure and functional significance of plasmodesmata. • Endocytosis and exocytosis, clathrin & coatomer coated vesicles, SNARE proteins. • Cell to cell signalling : autocrine, paracrine and endocrine stimulation. Signaling via G-protein linked cell-surface receptors, adenylate cyclase system, inositol phosphate pathway, role of Ca^{2+} -ions; signalling via enzyme-linked surface receptors, tyrosine kinases. Steroid receptors. **Section C** • Cell cycle and its regulation, apoptosis. • Transport of proteins into mitochondria and chloroplasts. • Concept of signal peptide, SRP, SRP Receptor, transport of soluble and membrane bound proteins in Endoplasmic Reticulum, ER Resident proteins, ER chaperone proteins and	The contents have been rearranged with incorporation of new and relevant topics in all the sections.

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			~~proteins in E.coli, insect cell and Mammalian cell, GST- fusion protein purification, Far western analysis, FISH & GISH techniques.~~ **Books Recommended:** ➢ Cell and Molecular Biology : De Robertis & De Robertis, B.I. Waverly Pvt. Ltd., New Delhi. ➢ The world of the cell : W.M. Becker, Pearson Education. ➢ Cell and Molecular Biology : G. Karp, John Wiley & Sons. ➢ The Cell - A Molecular Approach : Cooper, Sinauer. ➢ Cell and Molecular Biology : P.K. Gupta, Rastogi Publications. ➢ Molecular Cell Biology : Lodish, Baltimore, W. H. Freeman & Co. ➢ Molecular Biology of the Cell : Bruce Albert, Garland Publication, NY. ➢ Essentials of Cytology : C.B. Powar, Himalaya Publications. ➢ Principles of Genetics : Gardner, Simmons, Snustad, John Wiley & Sons. ➢ Gene VIII : Lewin, Pearson Education.	their functions, glycosylation of proteins in ER. Golgi apparatus, role in protein glycosylation and transport. • Lysosomes, intracellular digestion, sorting of lysosomal enzymes in Golgi, lysosomal storage diseases. **Suggested Books:** ➢ Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008). *Molecular Biology of the Cell* (5th Ed.). New York: Garland Science. ➢ Cooper, G. M., & Hausman, R. E. (2013). *The Cell: a Molecular Approach* (6th Ed.). Washington: ASM ; Sunderland. ➢ Gardner, E. J., Simmons, M. J., & Snustad, D. P. (1991). *Principles of genetics*. New York: J. Wiley. ➢ Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2012). *Becker's World of the Cell*. Boston (8th Ed.). Benjamin Cummings. ➢ Karp, G. (2008). *Cell and molecular biology: Concepts and experiments*. *John New Jersey: Wiley and Sons* ➢ Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014). *Lewin's Genes XI*. Burlington, MA: Jones & Bartlett Learning. ➢ Lodish, H. F. (2016). *Molecular Cell Biology* (8th Ed.). New York: W.H. Freeman. ➢ Watson, J. D. (2008). *Molecular Biology of the Gene* (5th ed.). Menlo Park, CA: Benjamin/Cummings. **Suggested e-Resources:** ➢ **mRNA export** https://www.researchgate.net/profile/Evelina_Tutucci/publication/51156486_Keeping_mRNPs_in_check_during_assembly_and_nuclear_export/links/02e7e5213704c24e86000000/Keeping-mRNPs-in-check-during-assembly-and-nuclear-export.pdf ➢ **ER chaperons and folding enzymes** https://iubmb.onlinelibrary.wiley.com/doi/full/10.1002/iub.1272	

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				➢ **Lysosomal storage disorders** https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1365-2141.2004.05293.x	
2)	**BT 502:** ~~Bioprocess Engineering-I~~				The contents of the first semester core course BT 502: "Bioprocess Engineering-I" and second semester core course BT 503: "Bioprocess engineering-II" are proposed to be merged, modified and offered as new common course named as "Bioprocess engineering" in the second semester of the programme.
3)	**BIN 5** Biological Databases and Computational Biology	After successful completion of the course, students should be able to: • Mine the biological databases to identify relevant sequence/structure for studies • Carry out sequence based evolutionary	**Section A** Biological Databases: Primary Secondary, Composite Databases ~~& their file formats~~. Nucleic Acids (GenBank, DDBJ, EMBL), Proteins (SWISS-PROT, PIR), Structures (PDB, ~~HSSP,~~ SCOP, ~~FSSP~~, CATH), Specialized (KEGG, Transfac, ReBase), Submission & Retrieval of data from public databases. **Section B** Sequence alignment: Local and Global alignment concepts, Scoring matrices - PAM and BLOSUM, Gap penalties, Dot Plot, Dynamic programming ~~methodology-~~ Needleman- Wunsch algorithm, Smith-	**Section A** • Introduction to biological Databases: primary, secondary, composite databases. • Sequence databases: Nucleic Acids (GenBank, DDBJ, EMBL), Proteins (SWISS-PROT, PIR) • Structures Databases: PDB, SCOP, CATH. • Specialized databases: KEGG, Transfac, ReBase • Submission and retrieval of data to/from public databases. **Section B** • Introduction to Sequence alignment: dot plot, scoring matrices (PAM and BLOSUM), gap penalties, ends free alignment.	HSSP and FSSP are part of PDB annotation system Local is SW algorithm and Global is NW algorithm therefore

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		studies • Perform molecular modeling studies with biological macromolecules and explain the results	Waterman algorithm, Databases similarity searching: Algorithms of FASTA, BLAST ~~and their variants~~, Multiple sequence alignment, Progressive alignment. **Section C** ~~Detecting~~ ORF's, Gene ~~finding methods~~: ~~content and signal methods,~~ ~~Genome comparison~~, ~~Markov chain, Random Walk, Hidden Markov models,~~ Docking and modeling substrate receptor interactions. Methods for Phylogenetic analysis: Distance and Character based methods. **Books Recommended:** ➢ Bioinformatics –Sequence and Genome analysis- David W. mount. ➢ Bioinformatics-from Genomes to drugs- Thomas lengauer. ➢ Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids, Richard Durbin, S. Eddy, A. Krogh, G. Mitchison. ➢ David Mount (2001) Bioinformatics – Sequence and Genome analysis, CSHL Press. ➢ Introduction to Bioinformatics-Terasa K. Attwood. ➢ Bioinformatics –A practical guide to the analysis of genes and proteins-Baxevanis and Ouellette.	• Concept of dynamic programming: Needleman- Wunsch (global alignment) algorithm, Smith-Waterman (local alignment) algorithm. • Databases similarity search: algorithms of FASTA, BLAST. Statistical significance of alignment scores. • Concept of multiple sequence alignment: Progressive alignment. **Section C** • Computational approaches of ORF and Gene identification. • Models of evolution, methods of Phylogenetic analysis Distance based (UPGMA and NJ method) and Character based (Maximum parsimony). • Homology based modeling three dimensional structure of proteins. • Concept of molecular docking: modeling substrate - receptor interaction and its applications. **Suggested Books:** ➢ Baxevanis, A.D. & Ouellette, B.F.F. (2004). *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins* (3rd ed.). Wiley. ➢ Bosu, O. & Thukral, S.K. (2007). *Bioinformatics: database, tools and algorithms* (1st ed.). Oxford University Press. ➢ Sharma, V., Munjal, A., & Shanker, A. (2017). *A Text Book of Bioinformatics* (2nd ed.). Meerut: Rastogi Publications. ➢ Sinha, P.K & Sinha, P. (2016). *Computer Fundamentals* (6th ed.). New Delhi: BPB publication. **Suggested e-Resources:** ➢ **Chou-Fasman Method for protein secondary structure prediction** https://pdfs.semanticscholar.org/fd8c/c95aec2d7af19ed28eea3688b3c231d0e745.pdf ➢ **Homology modeling** https://proteinstructures.com/Modeling/homology-modeling.html ➢ **Bioinformatic tools**	repetitions are deleted. Markov chain, random walk and HMM are not relevant to this paper as these statistical techniques are of

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				https://nptel.ac.in/courses/102103044/pdf/mod6.pdf ➢ **Essential bioinformatics** http://www.aun.edu.eg/molecular_biology/Procedure%20Bioinformatics22.23-4-2015/Xiong%20-%20Essential%20Bioinformatics%20send%20by%20Amira.pdf	
4)	**BT 511** ~~Enzyme Technology~~				The core course BT 511: 'Enzyme Technology' of the first semester is proposed to be offered as an elective course.
5)	**BT:** Term Paper-I/Minor Project				**Newly Introduced**
6)	**BT 505L** Biotechnology Lab - I	After successful completion of the course, students should be able to: • Demonstrate an understanding of microbial production of biomolecules • Gain hands on training on extraction and bio-separation techniques for various metabolites • Learn basic tools of bioinformatics • Analyze and	1. Reductase test for milk~~; dye reduction test~~. 2. Extraction and determination of protein content by Lowry's method. 3. ~~To~~ determine the peroxide value in oil/fat sample. 4. Separation of secondary metabolites/ sugars/ phenolic acids/ fatty acids by Thin Layer chromatography. 5. Engineering Mathematics/Statistical problems-I. 6. Engineering Mathematics/Statistical problems-II. 7. Estimation of amylase activity in germinating seeds. 8. Determination of the optimum temperature and effect of pH on amylase enzyme activity. 9. Buccal smear – Identification of Barr Body. 10. Isolation of cell organelles, viz. chloroplast/ mitochondria/ amyloplast. 11. Production of penicillin. 12. Lipase production and estimation. 13. Filtration/Mass balance based problems. 14. Energy balance based problems. 15. To determine inhibition constant (K_i) for various	**Biological Databases and Computational Biology** 1. Molecular Evolution: Multiple sequence alignment alignment and phylogenetic analysis (Clustal X/ Mega/ Tree-View). 2. Database Search: Use and analysis of BLAST tool for protein and DNA sequences. 3. Structure Prediction: Protein secondary and tertiary structure prediction using online ExPASy tools. 4. Molecular Visualization: Structural analysis of PDB entries for active and inactive states of protein (Pymol/Chimera/DeepView). **Advanced Cell Biology** 5. Buccal smear – Identification of Barr Body. 6. Isolation of cell organelles, viz. chloroplast/ mitochondria/ amyloplast. 7. Determination of hydrogen peroxide scavenging activity of plant. 8. Separation of secondary metabolites/ sugars/ phenolic acids/ fatty acids by Thin Layer chromatography. **Enzymology and Bioprocess Engineering** 9. Reductase test for milk.	Repetition has been removed More relevant experiments have been added.

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		solve problems for statistics, mass balance and energy balance.	inhibitors of enzyme reactions. 16. Separation of isoenzymes by native gel electrophoresis. 17. Determination of hydrogen peroxide scavenging activity of plant. 18. ~~Database similarity search using online BLAST P, BLAST N and BLAST X.~~	10. Extraction and determination of protein content by Lowry's method. 11. Estimation of amylase activity in germinating seeds. 12. Determination of the optimum temperature and effect of pH on amylase activity. 13. To determine inhibition constant (K_i) for various inhibitors of enzyme reactions. 14. Separation of isoenzymes by native gel electrophoresis. 15. Lipase production and estimation 16. Production of penicillin. 17. Filtration/Mass balance based problems. 18. Energy balance based problems. 19. To determine the peroxide value in oil/fat sample. **Engineering Mathematics** 20. Engineering Mathematics/Statistical problems-I. 21. Engineering Mathematics/Statistical problems-II. **Suggested Books:** ➢ Datta, A.K. (2014). *Basic Biostatistics and Application*. Kolkata: New Central Book Agency. ➢ Kumar, V. (2011). *Laboratory Manual of Microbiology*. New Delhi: Scientific Publishers. ➢ Mahajan, R., Sharma, J., & Mahajan, R.K. (2010). *Practical Manual of Biotechnology* (1st ed.). New Delhi: Vayu Education of India. ➢ Rao, P.H., & Janardhan, K. (2014). *Fundamentals of Biostatistics*. New Delhi: I. K. International Publishing House. ➢ Saxena, J., Baunthiyal., & Ravi, I. (2015). *Laboratory Manual of Microbiology, Biochemistry and Molecular Biology*. Jodhpur: Scientific Publishers. ➢ Shuler, M.L., & Kargi, F. (2002). *Bioprocess Engineering Basic Concepts* (2nd ed,). Prentice Hall PTR Upper Saddle River, NJ, USA. ➢ Swamy, P.M. *Laboratory Manual on Biotechnology* (1st ed.). Meerut: Rastogi Publication.	

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				➢ Yadav, V.K., & Yadav, N. (2018). *Biochemistry & Biotechnology: A Laboratory Manual*. Jaipur: Pointer Publisher. **Suggested e-Resources:** ➢ **Harisha, S. Biotechnology procedures and experiments handbook** http://site.iugaza.edu.ps/mwhindi/files/BIOTECHNOLOGY-PROCEDURES-AND-EXPERIMENTS-HANDBOOK.pdf ➢ **Introduction to biotechnology** http://www.austincc.edu/awheeler/Files/BIOL%201414%20Fall%202011/BIOL1414_Lab%20Manual_Fall%202011.pdf ➢ **Sequence Alignment** https://blast.ncbi.nlm.nih.gov/Blast.cgi	
M. Tech. Biotechnology II Semester					
7)	**BT 503:** ~~Bioprocess Engineering-II~~				The contents of the second semester core course "Bioprocess Engineering-II" and first semester core course "Bioprocess engineering-I" are proposed to be merged, modified and offered as new common course named as "Bioprocess engineering" in the second semester of the programme.
8)	**BT** Bioprocess	• After successful completion of	**Section A** Introduction to bioprocess, Steps in bioprocess	**Section A** Growth stoichiometry, Kinetics of Batch, Fed-batch and	"A typical new product from

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
	Engineering	the course, students should be able to: • Understand design of bioreactor and bioprocess parameters influencing production • Describe basic concepts of large scale production of industrially important bio-molecules • Plan a career in the biotechnology industry	development: ~~A typical new product from recombinant DNA.~~ An overview, growth factors and precursors for microorganisms. Isolation, selection and improvement of cultures – screening methods, culture preservation, strain improvement. Kinetics of microbial growth, thermal death ~~kinetics of micro-organisms~~, growth stoichiometry and elemental balances, kinetics of Batch, Fed-batch and Continuous operation of bioreactors, design of sterilization systems for liquids and gases. ~~Yields in cell culture.~~ **Section B** Heat transfer: General equipment for heat transfer, mechanisms of heat transfer, calculation of heat-transfer coefficients. Transport phenomena in bioprocess systems: Gas –liquid mass transfer in cellular systems, role of diffusion in bioprocessing, liquid- solid mass transfer, liquid –liquid mass transfer, gas-liquid mass transfer, measurement of kLa. Classification of fluids, fluids in motion, momentum transfer in fluids, viscosity measurement, effect of rheological properties on mixing. **Section C** Mechanical design and analysis of ~~biological reactors~~: Ideal bioreactors, bioreactor configurations of: plug-flow, packed bed, fluidized bed, trickle bed, photobioreactor, solid-state fermentation, on-line sensors for cell properties, off-line analytical methods, Immobilized biocatalysts: Formulation and characterization of immobilized cell biocatalysis, applications of immobilized cell biocatalysts. Animal and plant cell reactor technology: Environmental requirements for animal cell cultivation, reactors for large-scale production using animal cells, plant cell cultivation using bioreactors. **Books Recommended:**	Continuous operation of bioreactors, Gas –liquid mass transfer in cellular systems, role of diffusion in bioprocessing, measurement of volumetric mass transfer coefficient (K_La), Sterilization Kinetic, Fluid Rheology, Configuration of biological reactors: Plug-flow, packed bed, fluidized bed, photobioreactor, Stirred tank, Advanced cell bioreactor for cultivation of animal cells and plant cell culture. **Section B** Recovery and purification of products: strategies to recover and purify products, cell disruption, filtration, centrifugation, sedimentation, coagulation and flocculation, solid-liquid/liquid-liquid extraction, precipitation, adsorption, membrane separation- reverse osmosis, ultrafiltration, chromatography-FPLC,HPLC and HPTLC, affinity chromatography, electrophoresis, electrodialysis, crystallization, drying. **Section C** Importance of process flow sheeting in bioprocess engineering, development and utility of process flow diagrams, symbols for equipments, piping, instrumentation and controls, Scale up, Scale down, fermentation process economic, bioproduct regulation, medical applications of bioprocess engineering. Biological waste treatment: An example of the industrial utilization of mixed cultures. **Books Recommended:** ➢ Bailey, J.E., & Ollis, D.F. (1986). *Biochemical Engineering fundamentals* (2nd ed). McGraw-Hill College. ➢ Blanch, H.W., & Clark, D. S. (1997). *Biochemical Engineering*. CRC Press. ➢ Crueger, W., & Crueger, A. (2005). *Biotechnology- A Text Book of Industrial Microbiology*. Panima Publishing Corporation, New Delhi. ➢ Harrison, R. G., Todd, P. W., Rudge S. R., & Petrides, D. P. (2015). *Bioseparations Science and Engineering*. USA: Oxford University Press. ➢ Ogunnaike, B. A., & Ray, W. H. (1994). *Process Dynamics,*	recombinant DNA" has been already covered in section C of Bioprocess Engineering-II (BT 503). "thermal kinetic of microorganisms" has been rearranged as thermal cell death. Yield in cell culture has been rearranged. The word "bioreactor" has been already used for biological reactors.

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Shuler, M.L. and Kargi, F. Bioprocess Engineering : Basic concepts, 2 nd ed., Prentice- Hall, 2002. ➢ Doran Pauline M, Bioprocess Engineering Principles, Academic Press, 1995 ➢ Nielsen, J. and Villadsen, J. "Bioreaction Engineering Principles". Springer, 2007. ➢ Blanch, H.W and Clark D.S., "Biochemical Engineering", Marcel Dekker,1997 ➢ Bailey,J.E. and Ollis, D.F. Biochemical Engineering Fundamentals", 2nd ed.,McGraw Hill 1986. ➢ Stanbury, P.F., Stephen J. Hall & A. Whitaker, Principles of Fermentation Technology, Science & Technology Books. ➢ Thakore, S.B. and Bhatt, B.I. Introduction to process engineering and design, McGraw Hill 2009. ➢ Colin Ratledge, Bjorn Kristiansen, Basic Biotechnology, 2nd Edition, Cambridge University Press, 2001. ➢ Roger Harrison et al., Bioseparations Science and Engineering, Oxford University Press, 2003. ➢ W. Crueger and A.Crueger, Biotechnology- A Text Book of Industrial Microbiology.	*Modeling and Control*. Oxford University Press. ➢ Pandey, A., Larroche, C., Soccol, C. R., & Dussap, C. (2008). *Advances in Fermentation Technology*. Asiatech Publishers, Inc. ➢ Seader, J. D., & Henley, E. J. (2013). *Separation Process Principles*. Wiley India (P.) Ltd. ➢ Shuler, M.L., & Kargi, F. (2002). *Bioprocess Engineering Basic Concepts* (2nd ed). Prentice Hall PTR Upper Saddle River, NJ, USA. ➢ Stanbury, P.F., Whitaker, A., & Hall S.J. (1995).*Principles of Fermentation Technology* (2nd ed.). Elsevier Science Ltd. ➢ Stanbury, P.F., Whitaker, A., & Hall S.J. (2016).*Principles of Fermentation Technology* (3rd ed.). Elsevier Science Ltd. ➢ Thakore, S.B., & Bhatt, B.I. (2007). *Introduction to Process Engineering and Design*. Tata McGraw-Hill Publishing Company Limited ➢ Van Imp, J. F. M., Vanrollegham P. A., & Iserentant, D. I. (1998). *Advanced Instrumentation, Data Instrumentation, and Control of Biotechnological Processes*. Kluwer Academic Publishers ➢ Vogel, H.C., & Todaro, C. L. (1996). *Fermentation and Biochemical Engineering Handbook*. Elsevier. **Suggested e-Resources:** ➢ **Microbial culture fermentation** https://pdfs.semanticscholar.org/b4d3/7ed66ef2e37ce22ff7a3be09e3df7568fe49.pdf ➢ **Animal Cell Cutivation** https://nptel.ac.in/courses/102103012/pdf/mod6.pdf ➢ **Bioprocess Design** https://www.cri.or.th/en/mitthai/Announcement%20and%20Discussion%20Pages/BioprocessDesign.pdf ➢ **Bioprocess Control** http://cdn.intechopen.com/pdfs/44372/InTech-Bioprocess_modeling_and_control.pdf ➢ **Biotechnology- Downstream processing**	

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				https://nptel.ac.in/courses/102106022/	
9)	**BT 514** Genetic Manipulation Technology	After successful completion of the course, students should be able to: • Comprehend tools and techniques used for genetic manipulation of living organisms. • Familiarize with current genome editing techniques. • Develop research aptitude and technical skills to secure a job in genetic engineering labs.	**Section A** ~~Genetic engineering tools: Introduction, Historical perspective of Genetic Manipulation, Enzymes used in genetic engineering, Vectors used in genetic engineering pBR322 and pUC series,~~ Lambda and M13 based vectors~~,~~ Expression vectors, ~~T-vectors, Animal and plant virus based cloning vectors, Gene cloning and expression in *E.coli* and yeast (*Saccharomyces cerevisia*). Construction of gene libraries~~, cDNA~~, PCR based cDNA, subtractive cDNA, normalized cDNA, Genomic DNA, BAC and YAC library.~~ **Section B** ~~Screening and identification of libraries.~~ Automated DNA sequencing~~,~~ ~~Illumina and~~ Pyrosequencing~~ based~~ Next Generation Sequencing. Primer design, PCR: Nested PCR~~, 5' and 3' RACE PCR, inverse PCR, hybrid PCR, TAIL PCR, Real Time PCR, Cloning of PCR product. Promoters, Analysis of Gene Expression at transcription and translation level~~, Hybridization techniques~~, Transformation and transfection assays, In vitro mutagenesis, Antisense technology.~~ **Section C** ~~Genetically Modified Organisms: Introduction, Genetic transformation methods (*Agrobacterium* and virus mediated methods, Direct gene transfer by gene gun, electroporation, microinjection, Embryonic stem cells method). Choloroplast genetic engineering: Methodologies, foreign gene expression, advantages over nuclear transgenics, limitations, production of biopharmaceuticals. Applications of GMO (Agriculture,~~	• **Section A** • Concept of the structure of DNA, enzymes as tools of genetic engineering: restriction endonucleases, methylases, DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing; labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes • Hybridization techniques: northern, southern, south-western and far-western and colony hybridization, FISH and GISH. • Study of protein-DNA interactions: electrophoretic mobility shift assay, DNase footprinting, methyl interference assay, chromatin immunoprecipitation. • Protein-protein interactions using yeast two-hybrid system; phage display. **Section B** • Plasmid vectors; M13 mp vectors; PUC19 and Bluescript vectors, phagemids; Lambda vectors; Cosmids; YACs, BACs; Expression vectors (pMal; GST; pET-based vectors), Yeast vectors, Baculovirus and *Pichia* vectors, SV40 vectors, Ti and Ri vectors. • cDNA and genomic libraries, si RNA Technology, construction of siRNA vectors, chloroplast engineering, introduction to genome editing by CRISPR-CAS with its applications. **Section C** • Principles of PCR: primer design, fidelity of thermostable enzymes, types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR; T-vectors, PCR based site specific mutagenesis, PCR in molecular diagnostics (viral and bacterial detection). • Sequencing methods (enzymatic and chemical); automated DNA sequencing; Pyrosequencing and Next Generation	The contents have been rearranged in all the sections with incorporation of new and relevant topics.

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			~~Pharmaceutical, Food, Beverages, Dairy, Poultry), Ethical, legal and social issues, IPR in transgenic technology, Biosafety guidelines.~~ **Books Recommended:** ➢ Primrose S.B., Twyman R.H. and Old R.W. Principles of Gene Manipulation, 6th ed., Blackwell Science, 2001. ➢ Winnacker E.L. From Genes to clones: Introduction to Gene Technology, Panima, 2003. ➢ Glick B.R. and Pasternak J.J. Molecular Biotechnology: Principles and applications of recombinant DNA, 3rd ed., ASM Press, 2003. ➢ Lemonie, N.R. and Cooper, D.N. Gene therapy, BIOS Scientific, 1996. ➢ Allison LA . Fundamental Molecular Biology. Blackwell publishing. 2007 ➢ Watson et al. Recombinant DNA, 5th Ed, Freeman; 2006 ➢ Brown TA. Gene Cloning and DNA Analysis ; 5th Ed ; 2006 ➢ Reece RJ. Analysis of Genes and Genomes, Wiley; 2004. ➢ Kreuzer H and Massey A. Recombinant DNA and Biotechnology ; 2nd Ed; ASM; 2006. ➢ Korf BR. Human Genetics and Genomics; 3rd Ed; Blackwell; 2007. ➢ Sambrook & Russel. Molecular Cloning; 3rd Ed; Cold Spring Harbour Laboratory press, NY; 2001.	Sequencing; mutation detection: SSCP, DGGE, RFLP. **Suggested Books:** ➢ Brown, T.A. (2010). *Gene Cloning and DNA analysis: An Introduction.* Oxford: Wiley-Blackwell. ➢ Glick, B.R., Pasternak, J.J., & *Patten C.L.* (2010). *Molecular Biotechnology: Principles and applications of recombinant DNA* (4th ed). American Society for Microbiology. ➢ Lemonic, N.R., & Cooper, D.N. (1996). *Gene therapy*. BIOS Scientific publisher. ➢ Nicholl, D.S.T. (2008). *An introduction to Genetic Engineering* (3rd ed). Cambridge: Cambridge University Press. ➢ Primrose, S.B., Twyman R.H., & Old R.W. (2001). *Principles of Gene Manipulation* (6th ed). Wiley-Blackwell. ➢ Watson, J.D., Gilman, M., Witkowski J., & Zoller, M. (1992). *Recombinant DNA* (2nd ed.). W. H. Freeman publisher. **Suggested e-Resources:** ➢ **Next Generation Sequencing** file:///C:/Users/all/Downloads/49602.pdf ➢ **DNA sequencing- approaches** https://www.ncbi.nlm.nih.gov/books/NBK21117/CRISPR/ ➢ **CRISPR-CAS technology** https://www.ucll.be/sites/default/files/documents/gezondheid/crispr_cas_technology_-_manetsberger.pdf https://www.ncbi.nlm.nih.gov/pubmed/24584096 ➢ **Construction of siRNA expression vectors** https://www.thermofisher.com/us/en/home/references/ambion-tech-support/rnai-sirna/tech-notes/sirna-expression-vectors--with-selectable-markers.html ➢ **Gene knockout and transgenic mice** https://www.ncbi.nlm.nih.gov/books/NBK21632/	
10)	**BT 516: ~~Immunotechno~~**				The course BT 516: 'Immunotechnology'

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
	~~logy~~				which is offered as a core course in the second semester but now this course is proposed to be offered as an elective course.
11)	**BT:** Term Paper-II/Minor Project				**Newly Introduced**
12)	~~**BT 520** Plant and Animal Cell Culture Technology~~	~~After successful completion of the course, students should be able to:~~ ~~• Comprehend the tools and techniques used for animal and plant cell/tissue culture technology.~~ ~~• Develop skills for the production of commercially viable animal and plant products~~ ~~• Demonstrate the techniques learned for the future research~~	~~**Section A**~~ ~~Concept of cell culture, development of tissue culture, cellular totipotency, various terminologies associated with Plant tissue culture. Nutritional requirements and media preparation for plant and animal tissue culture. PGR's and their *in vitro* roles. Callus culture technique and applications. Suspension culture: Technique, growth measurement and applications. Organ culture techniques. Haploids and its application. Protoplast isolation, culture, Somatic hybridization: protoplast fusion, requirement and application. Micro propagation: Concept, stages, explants, Axillary bud proliferation.~~ ~~**Section B**~~ ~~Secondary metabolites production and biotransformations: Introduction, principal, optimization of yield. Somatic embryogenesis, somaclonal variation, Germplasm preservation. Basic concepts and essential steps for producing transgenic plants. Development of plants resistant to environmental stress and herbicides and pathogen resistant (Virus and insect). Introduction to animal cell cultures; animal cell growth characteristics, Disaggregation techniques, Primary cell cultures, Establishment and maintenance of primary cell cultures of adherent and non-adherent cell lines, . Secondary cell cultures, Establishment and maintenance of secondary~~		This course is discontinued

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			~~mammalian and insect cell lines, Organ and histotypic culture in animals. Preservation of cell lines: cryopreservation, cell banks, transporting cells.~~ ~~**Section C**~~ ~~Cell fusion: aim & requirement, fusogens, Somatic cell fusion, Selection of hybrids, Transfection: gene transfer methods for adherent & non- adherent animal cell cultures, Characterization of cell lines: Karyotyping, biochemical and genetic characterization of cell lines, cytotoxicity assays, cell viability assays. Production of vaccine in animal cells: use of Hybridoma for production of monoclonal antibodies, Bioreactors in animal cells: Bioreactors for large scale culture of animal cells, Transplantation: tissue culturing, Transplantation techniques, General overview of animal cell culture products.~~ ~~**Books Recommended:**~~ ~~➢ Plant Tissue Culture: Applications and Limitations. S.S. Bhojwani (1990), Elsevier, Amsterdam.~~ ~~➢ Plant biotechnology In Agriculture: K. Lindsey and M.G.K. Jones (1990), Prentice hall, New Jersey.~~ ~~➢ Dashek W.V. Methods in Plant Biochemistry and Molecular Biology, CRC Press, 1997.~~ ~~➢ Kirsi-Marja Oksman-Caldentey and Barz W.H. Plant Biotechnology and Transgenic Plants, Marcel Dekker Inc., 2002.~~ ~~➢ R.E. Spier and J.B Griffiths (1998). Animal cell Biotechnology, Academic Press.~~ ~~➢ Living resources for Biotechnology, Animal cells ; a.Doyle, R.Hay and B.E. Kirsop (1990), Cambridge University Press, Cambridge.~~ ~~➢ Freshney, R. Ian, "Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications,"~~		

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			~~6th ed., Wiley Blackwell.~~ ➢ ~~John R.W. (2006) Masters, Animal Cell Culture: Practical Approach, 3rd Edition, Oxford.~~ ➢ ~~M. Clynes (2006) Animal Cell Culture Techniques, 2ndt Edition, Springer.~~ ➢ ~~Basic Cell Culture Vol. 290 Protocols by Cheryl D Helgason, Cindy L~~ ➢ ~~Miller. Humanan Press~~ ➢ ~~Morgan, S.J. and Darling, D. C., "Animal Cell Culture," Bios Scientific Publishers in Association with the Biochemical society.~~ ➢ ~~In vitro Cultivation of Animal Cells: Biotechnology by Open Learning, Elsevier.~~ ➢ ~~Basic Cell Culture 2nd Edition by JM Davis Oxford Press~~ ➢ ~~Tissue Culture in Biological Research by G. Penso and D. Balduki.~~ ➢ ~~Biotechnology by B. D. Singh.~~ ➢ ~~Principle of Fermentation Technology by Whittaker.~~ ➢ ~~Gangal, Sudha, "Principles and Practice of Animal Tissue Culture, 2nd ed., Universities Press (India) Private Limited.~~ ➢ ~~In vitro Cultivation of Animal Cells: Biotechnology by Open Learning, Elsevier.~~ ➢ ~~Mathew, Jennie P., Roberts, Penelope E.,"Introduction to Cell and Tissue Culture: Theory & Techniques", Plenum Press, New York, 1998~~		
13)	**BT 506L** Biotechnology Lab - II	After successful completion of the course, students should be able to: • Gain hands on training on techniques related to	1. To study DNA amplification by PCR and resolution of PCR products on agarose gel. 2. Purification of amplified PCR Product by column purification. 3. Preparation of bacterial competent cells for transformation. 4. Transfer of recombinant vector into competent bacterial cells.	**Bioprocess Engineering** 1. Bioethanol production by immobilized *Saccharomyces cerevisiae* cells. 2. Separation of pigments from leaves or flowers by adsorption column chromatography. 3. To perform gel exclusion chromatography. 4. Lactic acid production. 5. Estimation of K_{La} by sodium sulphite method.	The practicals have been properly categorized Relevant practical has been introduced.

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		genetic engineering, plant tissue culture and immunology • Demonstrate an understanding of different methods for chromatography • Demonstrate a basic understanding of production and estimation of industrially important biofuel and acids. • Demonstrate a basic concept of in silico Primer designing	5. Preparation of stock media (RPMI 1640) from powder, preparation of complete media from stock and sterilization by filtration. 6. Preparation of metaphase chromosome from lymphocyte culture. 7. Isolation of single cells from intact plant organs by enzymatic method, single cell culture. 8. To isolate and inoculate anthers for haploid production. 9. To induce callus from the explants of Phaseolus mungo (Green Gram). 10. Rocket Immunoelectrophoresis. 11. Sandwich ELISA for the detection of an antigen. 12. Preparation of an immunoglobulin fraction from whole serum by ammonium sulphate precipitation. ~~13. To perform catalase test by using microorganism/plant.~~ 14. Bio ethanol production by immobilized Saccharomyces cerevisiae cells. 15. Separation of pigments from leaves or flowers by adsorption column chromatography. 16. To perform gel exclusion chromatography. 17. Lactic acid production. 18. in silico Primer designing.	**Cell Culture and Genetic Manipulation Technology** 6. Preparation of stock media (RPMI 1640) from powder, preparation of complete media from stock and sterilization by filtration. 7. Preparation of metaphase chromosome from lymphocyte culture. 8. Isolation of single cells from intact plant organs by enzymatic method, single cell culture. 9. To inoculate anthers for haploid production. 10. To induce callus from the explants of *Phaseolus mungo* (Green Gram). 11. To study DNA amplification by PCR and resolution of PCR products on agarose gel. 12. Purification of amplified PCR Product by column purification. 13. Preparation of bacterial competent cells for transformation. 14. Transfer of recombinant vector into competent bacterial cells. 15. *In silico* Primer designing. **Immunology** 16. Rocket Immunoelectrophoresis. 17. Sandwich ELISA for the detection of an antigen. 18. Preparation of an immunoglobulin fraction from whole serum by ammonium sulphate precipitation. **Suggested Books:** ➢ Saxena, J., Baunthiyal., & Ravi, I. (2015). *Laboratory Manual of Microbiology, Biochemistry and Molecular Biology*. Jodhpur: Scientific Publishers. ➢ Swamy, P.M. *Laboratory Manual on Biotechnology* (1st d.). Meerut: Rastogi Publication. ➢ Mahajan, R., Sharma, J., & Mahajan, R.K. (2010). *Practical Manual of Biotechnology* (1st ed.). New Delhi: Vayu Education of India. ➢ Sharma, R.K., Sangha, S.P.S. (2009). *Basic Techniques in Biochemistry & Molecular Biology*. New Delhi: I.K.	

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				International Publisher. ➢ Green, M. R., & Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual.*Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. **Suggested e-Resources** ➢ **Introduction to biotechnology** http://www.austincc.edu/awheeler/Files/BIOL%201414%20Fall%202011/BIOL1414_Lab%20Manual_Fall%202011.pdf ➢ **Harisha, S. Biotechnology procedures and experiments handbook** http://site.iugaza.edu.ps/mwhindi/files/BIOTECHNOLOGY-PROCEDURES-AND-EXPERIMENTS-HANDBOOK.pdf In silico primer design https://www.ncbi.nlm.nih.gov/tools/primer-blast/index.cgi	
Elective Courses proposed to be offered in I & II Semester					
1)	**BIN 502** Computer Aided Drug Designing	After successful completion of the course, students should be able to: • Understand the scope of pharmacogenomics and computer aided drug designing. • Identify and search potential drug leads using various tools of computational biology. • Develop data-mining skills	**Section A** Introduction to computer aided drug designing. Molecular descriptors, QSAR methodologies, Structure based drug designing, Ligand based drug designing, Different docking methodologies. **Section B** Pharmacophore identification, Pharmacophore generation (Hiphop and HypoGen theories), Combinatorial libraries, High throughput screening, Virtual screening, Lipinski's rule of five and its application in ADMET screening. Chemoinformatics: Introduction, Chemical Databases (ACD, MDDR and WDI), Application of Chemoinformatics in CADD. **Section C** Introduction to Pharmacogenomics and Pharmacogenetics, Clinical trials in Pharmacogenomics, Polymorphism of CYP450 enzymes affecting drug response, Role of SNP in Pharmacogenomics, The Multi	**Section A** • Introduction to computer aided drug designing. • Molecular descriptors, QSAR methodologies, structure based drug designing, ligand based drug designing, different docking methodologies. **Section B** • Pharmacophore identification, pharmacophore generation (Hiphop and HypoGen theories), combinatorial libraries, high throughput screening, virtual screening, Lipinski's rule of five and its application in ADMET screening. • Chemoinformatics: Introduction, Chemical Databases (ACD, MDDR and WDI), Application of Chemoinformatics in CADD. **Section C** • Introduction to pharmacogenomics and pharmacogenetics, clinical trials in Pharmacogenomics. • Polymorphism of CYP450 enzymes affecting drug response, role of SNP in pharmacogenomics.	Typographical corrections only

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		pertaining to drug discovery	Drug Resistance proteins: drug carriers affecting drug response. **Books Recommended:** ➢ Bioinformatics-from Genomes to drugs- Thomas lengauer. ➢ Molecular Modeling-Principles and applications- Andrew R. Leach. ➢ Fundamentals of Medicinal Chemistry by Gareth Thomas. ➢ Principles of Pharmacology: The Pathophysiologic Basis of Drug Therapy-David E. Golan. ➢ Pharmacogenomics: An Approach to New Drug Development: Chiranjib Chakraborty, Atanu Bhattacharyya.	• Multi Drug Resistance proteins: drug carriers affecting drug response. **Suggested Books:** ➢ Alvarez, J. & Shoichet, B. (2004). *Virtual Screening in Drug Discovery*. Taylor and Francis. ➢ Cramer, C. (2004). *Essentials of Computational Chemistry* (2 nd Ed). John Wiley. ➢ Thomas, G. (2003). *Fundamentals of Medicinal Chemistry*. John Wiley. ➢ Young, D.C. (2009). *Computational Drug Design*. John Wiley. **Suggested e-Resources:** ➢ **Personalized medicine** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2957753/ ➢ **Pharmacodynamics and pharmacokinetics** https://www.mheducation.co.uk/openup/chapters/9780335245659.pdf ➢ **Drug Discovery** http://www.kubinyi.de/lectures.html ➢ **Essential bioinformatics** http://www.aun.edu.eg/molecular_biology/Procedure%20Bioinformatics22.23-4-2015/Xiong%20-%20Essential%20Bioinformatics%20send%20by%20Amira.pdf	
2)	**BIN 503** Elements of Bioinformatics	After successful completion of the course, students should be able to: • Understand principles behind the genome wide coding region prediction and RNA folding.	**Section A** Genome comparison & analysis, Gene prediction, RNA structure prediction algorithms (Minimum free energy method, MFold, Coevolution method). Protein secondary structure prediction methods: Chou and Fasman, Garnier-Osguthorpe-Robson. Prediction of structural classes, motifs and domains. **Section B** Steps in Homology modeling, Threading; Contact potential, structural profile and segment matching method, Abinitio method, Protein structure comparison,	**Section A** • Genome comparison & analysis, Gene prediction, RNA structure prediction algorithms (Minimum free energy method, MFold, Coevolution method). • Protein secondary structure prediction methods: Chou and Fasman, Garnier-Osguthorpe-Robson, prediction of structural classes, motifs and domains. **Section B** • Steps in homology modeling, Threading, Contact potential, structural profile and segment matching method, *ab initio* method	Typographical corrections only

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		• Predict 3D structure of proteins and their regular structural elements for the integrity of the structure. • Analyze, interpret and understand the protein structure informatics. • Write perl program to solve the biological problems.	Structure comparison algorithms (dynamic programming, distance matrix). Perl language and syntax, scalars, arithmetic and logical operators, arrays, array functions, hashes, hash functions, conditional statements (if/else, elsif), control structures (for, foreach, while). **Section C** Pattern matching, substitutions, translations, splits and joins, file handling; opening, reading and closing a file, directory handling; opening, reading and closing a directory, subroutines, references, packages, modules, classes, objects, introduction to Bioperl. **Books Recommended:** ➢ Philip E. Bourne and Helge Weissig, Structural Bioinformatics-. ➢ David W. Mount, Bioinformatics - Sequence and Genome analysis. ➢ Tom Christian Sen, Nathan Torkington, Perl Cook book, 2nd Edition, O'REILLY ➢ James D. Tisdall, Beginning Perl for Bioinformatics, 2001, O'REILLY ➢ James D. Tisdall, Mastering Perl for Bioinformatics, 2003, O'REILLY ➢ Larry Wall, John Orwant, Tom Christian Sen, Programming Perl, O'REILLY	• Protein structure comparison, structure comparison algorithms (dynamic programming, distance matrix). • Perl language and syntax, scalars, arithmetic and logical operators, arrays, array functions, hashes, hash functions, conditional statements (if/else, elsif), control structures (for, foreach, while). **Section C** • Pattern matching, substitutions, translations, splits and joins, file handling, opening, reading and closing a file. • Directory handling, opening, reading and closing a directory, subroutines, references, packages, modules, classes, objects, introduction to Bioperl. **Suggested Books:** ➢ Christiansen, T., & Torkington, N. (2003). *Perl Cookbook: Solutions & Examples for Perl Programmers*. " O'Reilly Media, Inc.". ➢ Essen, L. O. (2003). *Structural Bioinformatics*. Edited by Philip E. Bourne and Helge Weissig. *Angewandte Chemie International Edition*. ➢ Mount, D. W. (2001). *Bioinformatics: Sequence and Genome analysis*. Cold Spring Harbor, N.Y: Cold Spring Harbor Laboratory Press. ➢ Tisdall, J. (2003). *Mastering Perl for Bioinformatics: Perl Programming for Bioinformatics*. " O'Reilly Media, Inc.". **Suggested e-Resources:** ➢ **Chou-Fasman Method for protein secondary structure prediction** https://pdfs.semanticscholar.org/fd8c/c95aec2d7af19ed28eea3688b3c231d0e745.pdf ➢ **Homology modeling** https://proteinstructures.com/Modeling/homology-modeling.html ➢ **Essential bioinformatics** http://www.aun.edu.eg/molecular_biology/Procedure%20Bioinformatics22.23-4-2015/Xiong%20-	

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				%20Essential%20Bioinformatics%20send%20by%20Amira.pdf ➢ **Bioinformatic tools** https://nptel.ac.in/courses/102103044/pdf/mod6.pdf	
3)	**BIO 417** Structural Biology	After the successful completion of the course, students should be able to: • Explain the biophysical processes working at molecular level. • Answer the biological questions of macromolecular folding and interactions • Understand the molecular processes behind locomotion, neuronal signaling and vision.	**Section A** Introduction to protein structure: Physical and chemical properties of amino acids and polypeptides, secondary, super secondary, tertiary and quaternary structure of proteins, Helix-coil transition, and Ramachandran plot. Protein structure determination: Isolation and purification of proteins, Methods for determination of size of proteins, Basic principles of X-ray diffraction studies, Phase determination, Calculation and interpretation of electron density map, Electron crystallography of proteins. **Section B** Protein secondary structure prediction methods: Chou and Fasman, Garnier-Osguthorpe-Robson.Classification of three-dimensional structure of protein: Prediction of structural classes, motifs, folds and domains, classification of three-dimensional structures in Protein Data Bank (HSSP, SCOP, FSSP, CATH). **Section C** Nucleic acid structure: Nucleic acid conformation, A-DNA, B-DNA, Z-DNA and C-DNA, their geometrical and structural features, RNA secondary and tertiary structures, idea about local doublet parameters.Molecular interactions: Protein-Protein interactions, Protein-DNA interactions. Techniques for the studies of these interactions. Forces that stabilize bimolecular structure. **Books Recommended:** ➢ Principles of Biochemistry-Lehninger. ➢ Biochemistry-Stryer. ➢ Biophysical Chemistry-Cantor and Schimmel.	**Section A** • Introduction to protein structure: Physical and chemical properties of amino acids and polypeptides, secondary, super secondary, tertiary and quaternary structure of proteins, Helix-coil transition, and Ramachandran plot. • Protein structure determination: Isolation and purification of proteins, Methods for determination of size of proteins, Basic principles of X-ray diffraction studies, Phase determination, Calculation and interpretation of electron density map, Electron crystallography of proteins. **Section B** • Protein secondary structure prediction methods: Chou and Fasman, Garnier-Osguthorpe-Robson. • Classification of three-dimensional structure of protein: Prediction of structural classes, motifs, folds and domains, classification of three-dimensional structures in Protein Data Bank (HSSP, SCOP, FSSP, CATH). **Section C** • Nucleic acid structure: Nucleic acid conformation, A-DNA, B-DNA, Z-DNA and C-DNA, their geometrical and structural features. • RNA secondary and tertiary structures, idea about local doublet parameters. • Molecular interactions: Protein-protein interactions, protein-DNA interactions, techniques for the studies of these interactions. Forces that stabilize bimolecular structure. **Suggested Books:** ➢ Berg, J. M., Tymoczko, J. L., Stryer, L., & Stryer, L. (2002). *Biochemistry*. New York: W.H. Freeman. ➢ Cantor, C. R., & Schimmel, P. R. (1980). *Biophysical*	Typographical corrections only

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Practical Biochemistry-Wilson and Walker. ➢ Bioinformatics –Sequence and Genome analysis-David W. mount. ➢ Structural Bioinformatics-Philip E.Bourne and Helge Weissig	*Chemistry Part I: The Conformation of Biological Macromolecules*. New York: W. H. Freeman & Company. ➢ Gu, J., & Bourne, P. E. (2011). *Structural Bioinformatics*. Chicester: Wiley. ➢ Hoffmann, A., Clokie, S., Wilson, K., & Walker, J. M. (2018). *Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology: Principles and Techniques of Biochemistry and Molecular Biology*. Cambridge: Cambridge University Press. ➢ Lehninger, A. L., Nelson, D. L., & Cox, M. M. (2000). *Lehninger Principles of Biochemistry*. New York: Worth Publishers. ➢ Mount, D. W., & Cold Spring Harbor Laboratory Press. (2006). *Bioinformatics: Sequence and Genome analysis*. Cold Spring Harbor, N.Y: Cold Spring Harbor Laboratory Press. **Suggested e-Resources:** ➢ **Chou-Fasman Method for protein secondary structure prediction** https://pdfs.semanticscholar.org/fd8c/c95aec2d7af19ed28eea3688b3c231d0e745.pdf ➢ **Homology modeling** ➢ https://proteinstructures.com/Modeling/homology-modeling.html ➢ **Essential bioinformatics** http://www.aun.edu.eg/molecular_biology/Procedure%20Bioinformatics22.23-4-2015/Xiong%20-%20Essential%20Bioinformatics%20send%20by%20Amira.pdf ➢ **Protein protein interaction** https://nptel.ac.in/courses/102103017/pdf/lecture%2020.pdf	
4)	**BIO 501** Bioentrepreneurship	After successful completion of the course, students should be able to:	**Section A** Entrepreneurship: meaning and definition; fundamentals of entrepreneurship; development of entrepreneurship through training, achievement motivation training- theory	**Section A** • Entrepreneurship: meaning and definition; fundamentals of entrepreneurship; development of entrepreneurship through training, achievement motivation training- theory and	Typographical corrections only

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		• Comprehend fundamental concepts of entrepreneurship • Identify and utilize various schemes promoting entrepreneurship • Develop skills to convert a viable idea into start ups	and concept, Kakinada experiment: developing achievement motivation, experiential exercises, scoring and coding; Entrepreneurship in area of Biotechnology; MSMEs: definition, role in India's Economic development, regulations covering MSMEs, sources of information and non financial support, Incentives and benefits available to MSMEs entrepreneurs; schemes for women entrepreneurs, psychological stress encountered by women in the light of her dual role and managing it. **Section B** Business Opportunity sensing and idea generation, Idea Feasibility testing through market research, Developing Vision and Mission statements, Deciding the offering and identifying target market, Positioning the offering, Designing Sales Process, Marketing mix and promotional strategies, Maintaining and hiring team, Knowing Competitors; preparing revenue model up to break-even point, Projecting future moves of business, Product Road Map, writing a detailed Business Plan, Basics of finance & accounting, Raising Funds- banks, financial institutions, venture capitalists, angel investors, bootstrapping; Role of incubation cntres **Section C** Role of Knowledge centres like universities and institutions and R & D; Role of Technology and Upgradation; Managing technology transfer; Regulation for transfer of foreign Technology; Technology Transfer agencies; Business Crisis and its management; Ethical Entrepreneurship; Social Entrepreneurship; Use of IT in business administration, Available Software for better financial management; Setting an E-Business; Key Leadership and Management skills. **Books Recommended:**	concept, Kakinada experiment: developing achievement motivation, experiential exercises, scoring and coding. • Entrepreneurship in area of Biotechnology; MSMEs: definition, role in India's economic development, regulations covering MSMEs, sources of information and non financial support, Incentives and benefits available to MSMEs entrepreneurs. • Schemes for women entrepreneurs, psychological stress encountered by women in the light of her dual role and managing it. **Section B** • Business opportunity sensing and idea generation, idea feasibility testing through market research, Developing Vision and mission statements, deciding the offering and identifying target market, positioning the offering. • Designing sales process, marketing mix and promotional strategies, maintaining and hiring team. • Knowing competitors, preparing revenue model up to break-even point, projecting future moves of business, product road map, writing a detailed business plan, basics of finance & accounting. • Raising funds: banks, financial institutions, venture capitalists, angel investors, bootstrapping; role of incubation centres **Section C** • Role of knowledge centres like universities and institutions and R & D, role of technology and upgradation, managing technology transfer, regulation for transfer of foreign technology, technology transfer agencies. • Business crisis and its management, ethical entrepreneurship, social entrepreneurship, use of IT in business administration, available software for better financial management; setting an E-business; key leadership and management skills. **Suggested Books:** ➢ Barringer, B. R., & Ireland, R. D. (2019). *Entrepreneurship:*	

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Jain P.C.: Hand book for new entrepreneurs: Oxford University Press. ➢ Lalitha D. Rani : Women Entrepreneurs, A.P.H. Publishing Corporation. ➢ Drucker Peter F : Innovation and Entrepreneurship, New Delhi Heineman, UBSPD ➢ David Holt : Entrepreneurship and New Venture Creation, Prentice Hall of India. ➢ Other Suggested readings apart from text books include motivational titles in air for instance, The Goal, Rich Dad Poor Dad, Count you Chicken Before they Hatch, The Winning, A Monk who sold his Ferrari, Stay Hungry Stay Foolish, 60 Keys to Success etc.	*Successfully launching new ventures*. New York, NY Pearson Education ➢ Drucker, P. F. (2015). *Innovation and entrepreneurship: Practice and principles*. London: Routledge. ➢ Holt, D. H. (1992). *Entrepreneurship: New venture creation*. Englewood Cliffs, N.J: Prentice Hall. ➢ Jain, P. C. (1998). *Handbook for new entrepreneurs*. New Delhi, India: Oxford University Press. ➢ Schaper, M., & Schaper, M. (2014). *Entrepreneurship and small business*. Milton, Qld: John Wiley and Sons Australia. **Suggested e-Resources:** ➢ **Start up and Technology news** https://techcrunch.com/ ➢ **Demo events** http://www.demo.com/ehome/DEMO/home/ ➢ **Entrepreunership in biotechnology** http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.463.4354&rep=rep1&type=pdf	
5)	**BIO 502** Cancer Biology	After successful completion of the course, students should be able to: • Explain mechanisms leading to cancer • Identify sources of cancer causing agents • Understand various therapies involved in cancer treatment	**Section-A** Basics of cancer biology, Cancer incidence and mortality, Cancer as a cellular disease, Tumor growth kinetics. Different forms of cancers, Diet and cancer. Regulation of cell cycle, Modulation of cell cycle in cancer. Oncogenes and tumor suppressor genes. Aberrant cell signaling in cancer, anti-apoptotic mechanisms for survival of cancer cells **Section-B** Environmental carcinogens, carcinogen metabolism. Chemical carcinogenesis, Targets of chemical carcinogenesis, initiation, promotion, and progression. Radiation induced carcinogenesis. Animal models of cancer research, athymic nude mice, syngeneic mouse model, transgenic mouse model **Section-C** Molecular mechanisms of tumor angiogenesis. Cancer	**Section-A** • Basics of cancer biology, cancer incidence and mortality, cancer as a cellular disease, tumor growth kinetics. • Different forms of cancers, diet and cancer. Regulation of cell cycle, modulation of cell cycle in cancer. • Oncogenes and tumor suppressor genes. Aberrant cell signaling in cancer, anti-apoptotic mechanisms for survival of cancer cells **Section-B** • Environmental carcinogens, carcinogen metabolism. Chemical carcinogenesis, targets of chemical carcinogenesis, initiation, promotion, and progression. • Radiation induced carcinogenesis. animal models of cancer research, athymic nude mice, syngeneic mouse model, transgenic mouse model. **Section-C** • Molecular mechanisms of tumor angiogenesis, cancer	Typographical corrections only

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			invasion and metastasis. Concept of stem cells in cancer. Advances in cancer detection. Different forms of therapy: chemotherapy, radiotherapy, and surgery. Chemoprevention of cancer. **Books Recommended:** ➢ Biology of Cancer by Robert Weinberg ➢ Cancer Biology, R.J.B. King ➢ Cancer Biology, R.W. Ruddon ➢ Molecular Biology of Human Cancers, W. A. Schulz ➢ Molecular Biology of Cancer, F. Macdonald, C.H.J. Ford, and A.G. Casson ➢ Chemoprevention of cancer and DNA damage by dietary factors, S. Knasmuller, D. M. DeMarini, I. Johnson, and C. Gerhauser.	invasion and metastasis. • Concept of stem cells in cancer, advances in cancer detection. Different forms of therapy: chemotherapy, radiotherapy, and surgery. **Suggested Books:** ➢ King, R., & Robins, M. (2006). *Cancer biology*. Harlow, England: Pearson/Prentice Hall. ➢ Macdonald, F., Ford, C. H. J., & Casson, A. G. (2004). *Molecular biology of cancer*. London: BIOS Scientific Publishers. ➢ Ruddon, R. W. (1995). *Cancer biology*. New York: Oxford University Press. ➢ Weinberg, R. A. (2007). *The biology of cancer*. New York: Garland Science. **Suggested e-Resources:** ➢ **Types of cancer** https://nptel.ac.in/courses/104103068/pdf/M4.pdf ➢ **Carcinogenes** http://www.prc.cnrs.fr/IMG/pdf/cmr-criteria-clp.pdf https://www.ilo.org/legacy/english/protection/safework/ghs/ghsfinal/ghsc10.pdf ➢ **Cancer Therapy** https://www.aafp.org/afp/2008/0201/p311.pdf	
6)	**BT 510** Environmental Biotechnology	After successful completion of the course, students should be able to: • Understand sources and role of environmental contaminants • Demonstrate various techniques involved in	**Section A** Definition and Scope of Environmental Biotechnology; Environmental Pollution; Types, Causes and Effects of Soil, air, water, oil and heavy metal. Pollution, control measures. Social Issues- Green House Gases, Global Warming, Acid Rain, Ozone depletion, nuclear accidents and holocaust. Purification of waste water; Aerobic and anaerobic treatments; Laboratory methods for the detection of coli form organisms in water; Water recycling methods; Management of radioactive pollutants in water, VOC, COD BOD and BOD sensors.	**Section A** • Definition and scope of environmental biotechnology, environmental pollution: Types, causes and effects on soil, air, water. • Control measures of pollution, social issues: Green house gases, global warming, acid rain, ozone depletion, nuclear accidents and holocaust. • Purification of waste water: Aerobic and anaerobic treatments, laboratory methods for the detection of coliform organisms in water. • Water recycling methods, management of radioactive pollutants in water, VOC, COD BOD and BOD sensors.	Typographical corrections only

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		bioremediation • Develop understanding of generation of energy from waste	**Section B** Molecular biology tools for Environmental management, rDNA technology in waste treatment, Genetically modified organisms in Waste management, Genetic Sensors, Metagenomics, Bioprospecting, Nanoscience in Environmental management, Phytoremediation for heavy metal pollution, Biosensors development to monitor pollution. Biomass waste as renewable source of energy, Cellulose and Hemi cellulose as source of energy Biocomposting, Vermiculture, Biofertilizers, Organic farming, Biofuels, Biomineralization, Bioethanol and Biohydrogen, **Section C** Bioelectricity through microbial fuel cell, Conversion of Solid Waste to Methane; Biogas production, Management of Sludge and Solid waste treatment- Land filling, lagooning, Ecofriendly agriculture. Definition, Types- Ex situ and In situ Bioremediation; genetically Engineered Microbes for Bioremediation; Bioremediation of Ground Water; Biodegradation of Hydrocarbons, Pesticides, Herbicides, Insecticides and Xenobiotics. **Books Recommended:** ➢ Indu shekhar Thakur, 2006. Environmental Biotechnology- Basic concepts and Applications. ➢ Foster C.F; Johnware D.A, 1987. Environmental Biotechnlogy.Ellis Harwood Ltd. ➢ Chakraborty K.D. Omen G.S. Biotechnology and Bio degradation, Advances in Applied Biotechnology series, Vol. 1, Gulf Publications Co. London 1989. ➢ Organic farming BY Dr. Sharma	**Section B** • Molecular biology tools for environmental management, rDNA technology in waste treatment, genetically modified organisms in Waste management, genetic sensors, metagenomics, bioprospecting, nanoscience in environmental management. • Phytoremediation for heavy metal pollution, biosensors development to monitor pollution. • Biomass waste as renewable source of energy, cellulose and hemi cellulose as source of energy, biocomposting, vermiculture, biofertilizers, organic farming, biofuels, biomineralization. **Section C** • Bioelectricity through microbial fuel cell, Conversion of Solid Waste to Methane. • Biogas production, management of sludge and solid waste treatment: Land filling, lagooning, ecofriendly agriculture. • *Ex situ* and i*n situ* bioremediation; genetically engineered microbes for bioremediation, bioremediation of ground water, biodegradation of hydrocarbons, pesticides, herbicides, insecticides and xenobiotics. **Suggested Books:** ➢ Jogdand, S. N. (2010). *Environmental Biotechnology (Industrial pollution management)* (3rd ed.). Mumbai, India: Himalaya Publishing House. ➢ Metcalf & Eddy. (Ed.). (1991). *Wastewater Engineering Treatment Disposal and Reuse* (3rd Edition). New Delhi, India: Tata McGraw Hill Edition. ➢ Milton, W. (Ed.). (1999). *An Introduction to Environmental Biotechnology*. USA: Springerlink, ➢ Modi, P. N. (2015). *Sewage treatment & disposal and waste water engineering*. New Delhi, India : Rajsons publications Pvt. Ltd. ➢ Srinivasan, D. (2009). *Environmental Engineering*. New Delhi, India: PHI Learning Pvt. Ltd.	

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
				➢ Thakur, I. S. (2012). *Enviromental Biotechnology: Basic concepts and Application* (2nd ed.). New Delhi: I K International Publishing House. ➢ Tripathi, B. N., Shekhawat, G. S., & Sharma, V. (Ed.). (2009). *Applications of Biotechnology*. Jaipur, India: Aavishkar publishers. **Suggested e-Resources:** ➢ **Biological treatment of wastewater** http://www.neoakruthi.com/blog/biological-treatment-of-wastewater.html ➢ **Biogas** http://www.biologydiscussion.com/biomass/production-of-biogas-from-biomass/10436 ➢ **Biofuel** http://uru.ac.in/uruonlinelibrary/BioFuels/Biomass%20and%20biofuels.pdf ➢ **Biosensor** https://www.edgefx.in/biosensors-types-its-working-and-applications/ ➢ **Xenobiotic compound biodegradation** http://www.biologydiscussion.com/microbiology-2/bioremediation/xenobiotic-compounds-meaning-hazards-and-biodegradation/55625	
7)	**BT 512** Food Biotechnology	After successful completion of the course, students should be able to: • Learn processing and preparation of various food products. • Determine role of microbes in food spoilage and understand	**Section A** Constituent of food – contribution to texture, flavour and organoleptic properties of food, food additives – intentional and non-intentional and their functions. Enzymes in food processing. Physical Properties of Foods-Rheological, Thermal, Aerodynamic, hydrodynamic and Electrical properties of food. Raw material characteristics, cleaning, sorting and grading of foods; physical conversion operations – mixing, emulsification, extraction, filtration, centrifugation, membrane separation, crystallization, heat processing, evaporation, dehydration. Dehydration- Dehydration	**Section A** • Constituent of food – contribution to texture, flavour and organoleptic properties of food. • Food additives – intentional and non-intentional and their functions. • Enzymes in food processing. Physical Properties of Foods: Rheological, thermal, aerodynamic, hydrodynamic and electrical properties of food. • Raw material characteristics, cleaning, sorting and grading of foods; physical conversion operations – mixing, emulsification, extraction, filtration, centrifugation, membrane separation, crystallization, heat processing,	

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		the various methods used for food preservation • Understand the scope of food biotechnology for future endeavors	principles, Preparation of fruits and vegetables for dehydration. - Equipments used for drying with their principles, Packaging of Dried slices, Dices and powder. **Section B** Emerging technologies in food processing- High pressure processing of Foods, Pulsed electric field processing of Foods, Osmotic dehydration of Foods, ~~Ohmic and Ultrasound Processing of Foods,~~ Hurdle technology. Principles of food preservation; UHT, LTT, canning, frozen storage, irradiation, acidulants, salts and sugar. Factors leading to rancidity and reversion. Colloidal systems in food, stability of colloidal system. ~~Bread and baked goods, dairy products – milk processing, cheese, butter, vegetable fermentations, meat, poultry and fish products, sugar and distillation industries; Beverages – wine, beer;~~ food aroma compounds: microbial and enzymatic techniques. **Section C** Bread and baked goods, dairy products – milk ~~processing~~, cheese, butter, ice-cream, vegetable and fruit products; edible oils ~~and~~ fats; meat, poultry and fish products; confectionery, ~~beverages. Colloidal systems in food, stability of colloidal system~~. Types of Food Starches, Soluble Fibers: Pectin, Gums &Mucilages. Popular oils and fats in foods- pulses, dairy products and vegetable oils. ~~Factors leading to rancidity and reversion.~~ Properties of granular food and powders. **Books Recommended:** ➢ Coultate T.P. Food – The chemistry of its components, 2nd ed., Royal society, London, 1992. ➢ Sivasankar B. Food processing and preservation, Prentice Hall of India Pvt.Ltd., New Delhi, 2002. ➢ Fennema O.R. ed. Principles of food science: Part I, Food chemistry, Marcel Dekker, New York, 1976.	evaporation, dehydration. • Dehydration- Dehydration principles, Preparation of fruits and vegetables for dehydration. Equipments used for drying with their principles, packaging of dried slices, dices and powder. **Section B:** • Emerging technologies in food processing: High pressure processing, pulsed electric field processing, osmotic dehydration, hurdle technology. • Principles of food preservation: UHT, LTT, canning, frozen storage, irradiation, acidulants, salts and sugars. • Factors leading to rancidity and reversion. Colloidal systems in food, stability of colloidal system. • Food aroma compounds microbial and enzymatic techniques. Types of Food Starches, Soluble Fibers: Pectin, Gums &Mucilages. Properties of granular food and powders. **Section C:** • Food processing technology-Bread and baked goods, dairy products: milk, cheese, butter, ice-cream. Vegetable and food products. • Food processing technology: Edible oils, fats, meat, poultry and fish products, confectionary, beverages- wine, beer. • Popular oils and fats in foods-pulses, dairy products and vegetable oils. Sugar and distillation industries. **Suggested Books:** ➢ Adams, M. R., & Moss, M. O. (2007). *Food Microbiology*. Royal Society of Chemistry. ➢ Banwart, G.J. (1989*). Basic Food Microbiology*. CBS Publishers and Distributors, Delhi ➢ Frazier, W.C., &Westhoff, D.C. (2003). *Food Microbiology*. Tata McGraw Hill, Inc., New York. ➢ Joshi, V. K., &Pandey, A. (1999). *Biotechnology: Food Fermentation*. Asiatech Publishers Inc	The repetitive contents in the section B have been removed. The repetitive contents in the section C have been removed.

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Frazier W.C. and Westhoff D.C. Food Microbiology, 4th ed. McGram-Hill Book Co., New York, 1988. ➢ Brenner, J.G., Butters, J.R., Cowell, N.D. and Lilly, A.E.V. Food engineering operations, 2nd ed., Applied Sciences Pub.ltd., London,1979. ➢ Pyke, M. Food Science and Technology , 4th ed., John Murray, London, 1981 ➢ Food Biotechnology. Ed. Kalidas Shetty, Gopinadhan Paliyath, Anthony Pometto and Robert E. Levin. Taylor and Francis ➢ Banwart, George. J., "Basic Food Microbiology," CBS Publishers and Distributors, New Delhi. ➢ Nuri N. Mohsenin: Physical Properties of Plant and Animal Materials Gordon and Reach Science Publishers (1970) ➢ Nuri N. Mohsenin: Thermal Properties of Food & Agricultutral materials Gordon and Reach Science Publishers (1970) ➢ Da-wen Sun: Emerging Technologies for Food Processing, Elsevier Academic PressMarcel Dekker Inc. NY (1995)	➢ Robinson, R.K. (1990).*Dairy Microbiology*. Elsevier Applied Sciences, London. **Suggested e-Resources:** ➢ **Quality control of food detection system** https://www.engineersgarage.com/Contribution/Arduino-based-Smart-IoT-Food-Quality-Monitoring-System ➢ **Food Preservation** https://sciencesamhita.com/methods-of-food-preservation/ ➢ **Genetically modified food** http://anrcatalog.ucdavis.edu/pdf/8180.pdf	
8)	**BT 517** Medical Biotechnology	After successful completion of the course, students should be able to: • Understand various in utero diagnostic techniques • Identify gene therapy techniques used for the treatment of diseases • Comprehend the	**Section A** Prenatal diagnosis - Invasive techniques - Amniocentesis, Fetoscopy, Chorionic Villi Sampling (CVS), Noninvasive techniques - Ultrasonography, X-ray, TIFA, maternal serum and fetal cells in maternal blood. Diagnosis using protein and enzyme markers, monoclonal antibodies. DNA/RNA based diagnosis Hepatitis, HIV - CD 4 receptor. Microarray technology-genomic and cDNA arrays, application to diseases. **Section B** Clinical management and Metabolic manipulation – PKU, Familial Hypercholesterolemia, Rickets, ADA, Congenital hypothyroidism. Gene therapy - Ex-vivo,	**Section A** • Prenatal diagnosis, invasive techniques: Amniocentesis, fetoscopy, chorionic villi sampling (CVS). • Noninvasive techniques: Ultrasonography, X-ray, TIFA, maternal serum and fetal cells in maternal blood. • Diagnosis using protein and enzyme markers, monoclonal antibodies. DNA/RNA based diagnosis Hepatitis, HIV - CD 4 receptor. • Microarray technology: genomic and cDNA arrays, application to diseases. **Section B** • Clinical management and metabolic manipulation: PKU, Familial Hypercholesterolemia, Rickets, ADA, Congenital hypothyroidism.	Typographical corrections only

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		applications of embryonic stem cells	Invivo, Insitu gene therapy, Stratagies of gene therapy: gene augmentation **Section C** Vectors used in gene therapy Biological vectors – retrovirus, adenoviruses, Herpes Synthetic vectors– liposomes, receptor mediated gene transfer. Gene therapy trials – Familial Hypercholesterolemia, Cystic Fibrosis, Solid tumors. Properties and application of embryonic stem cells and its potential, Nanomedicine. **Books Recommended:** ➢ Diagnostic and Therapeutic Antibodies (Methods in Molecular Medicine by Andrew J.T. George (Editor), Catherine E. Urch (Editor) Publisher: Humana Press; edition (2000) ➢ Molecular Diagnosis of Infectious Diseases (Methods in Molecular Medicine) by Jochen Decker, U. Reischl Amazon ➢ Human Molecular Genetics by T. Strachan, Andrew Read Amazon Sales Rank: ➢ Principles of Biostatistics by Marcello Pagano , Kimberlee Gauvreau ➢ Essentials of Epidemiology in Public Health, Second Edition by Ann Aschengrau , George R., III Seage ➢ Stem Cells: From Bench to Bedside- Ariff Bongso, Eng Hin Lee. ➢ Stem Cells-C S Potten.	• Gene therapy: Ex-vivo, in vivo, in situ gene therapy, strategies of gene therapy, gene augmentation **Section C** • Vectors used in gene therapy: retrovirus, adenoviruses, herpes synthetic vectors, liposomes, receptor mediated gene transfer. • Gene therapy trials, familial hypercholesterolemia, cystic fibrosis, solid tumors. • Properties and application of embryonic stem cells and its potential, nanomedicine. **Suggested Books:** ➢ Aschengrau, A., & Seage, G. R. (2014). *Essentials of epidemiology in public health.* ➢ Bongso, Ariff. & Lee, Eng Hin. (2005). *Stem cells : from bench to bedside.* Singapore : World Scientific Publishing ➢ George, A. J., & Urch, C. E. (Eds.). (2000). *Diagnostic and therapeutic antibodies* (Vol. 40). Springer Science & Business Media. ➢ Pagano, M., & Gauvreau, K. (2000). *Principles of biostatistics*. Australia: Duxbury. ➢ Strachan, T., Read, A. P., & Strachan, T. (2011). *Human molecular genetics*. New York: Garland Science. **Suggested e-Resources:** ➢ **Prenatal Diagnosis** http://semmelweis.hu/noi1/files/2017/02/Prenatal-diagnostic-methods.pdf ➢ https://www.health.wa.gov.au/docreg/Education/Prevention/Genetics/HP3131_prenatal.pdf ➢ **Gene Therapy** https://nptel.ac.in/courses/102103013/pdf/mod8.pdf http://uniqure.com/patients/Gene-Therapy-Information.pdf ➢ **Nanomedicine** https://noharm-europe.org/sites/default/files/documents-files/2462/HCWH%20Europe%20Nanoreport.pdf	
9)	**BT 519**	After successful	**Section A**	**Section A**	Typographical changes

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
	Nanobiotechnology	completion of the course, students should be able to: • Understand the fundamental concepts of nanobiotechnology • Apply engineering concepts to the nano-scale domain and design processing conditions • Plan research career in institute working on nanobiotechnology	Nanoscale and nanobiotechnology: Introduction to Nanoscience and Nanotechnology; Milestones in Nanotechnology; Overview of Nanobiotechnology and Nanoscale processes; Physicochemical properties of materials in Nanoscales. Fabrication and characterization of nanomaterials: Types of Nanomaterials (Quantum dots, Nanoparticles, Nanocrystals, Dendrimers, Buckyballs, Nanotubes); Gas, liquid, and solid –phase synthesis of nanomaterials. **Section B** Lithography techniques (Photolithography, Dip-pen and Electron beam lithography); Thin film deposition; Electrospinning. Bio-synthesis of nanomaterials. Properties and measurement of nanomaterials: Optical Properties: Absorption, Fluorescence, and Resonance; Methods for the measurement of nanomaterials; Microscopy measurements: SEM, TEM, AFM and STM. Confocal and TIRF imaging. Nanobiology and bioconjugation of nanomaterials: Properties of DNA and motor proteins; Lessons from nature on making nanodevices; Reactive groups on biomolecules (DNA & Proteins). **Section C** Surface modification and conjugation to nanomaterials. Fabrication and application of DNA nanowires; Nanofluidics to solve biological problems. Nano drug delivery and nanomedicine: Properties of nanocarriers; drug delivery systems used in nanomedicine; Enhanced Permeability and Retention effect; Blood-brain barrier; Active and passive targeting of diseased cells; Health and environmental impacts of nanotechnology. **Books Recommended:** ➢ Nanobiotechnology: Concepts, Applications and	• Nanoscale and nanobiotechnology: Introduction to nanoscience and nanotechnology, milestones in nanotechnology, overview of nanobiotechnology and nanoscale processes. • Physicochemical properties of materials in nanoscales. Fabrication and characterization of nanomaterials: Types of nanomaterials (quantum dots, nanoparticles, nanocrystals, dendrimers, buckyballs, nanotubes). • .Gas, liquid, and solid –phase synthesis of nanomaterials. **Section B** • Lithography techniques (photolithography, dip-pen and electron beam lithography), Thin film deposition, Electrospinning. • Bio-synthesis of nanomaterials, properties and measurement of nanomaterials, optical properties: absorption, fluorescence, and resonance. • Methods for the measurement of nanomaterials, microscopy measurements: SEM, TEM, AFM and STM, confocal and TIRF imaging. • Nanobiology and bioconjugation of nanomaterials: Properties of DNA and motor proteins, Lessons from nature on making nanodevices, reactive groups on biomolecules (DNA & Proteins). **Section C** • Surface modification and conjugation to nanomaterials. Fabrication and application of DNA nanowires. • Nanofluidics to solve biological problems. • Nano drug delivery and nanomedicine: Properties of nanocarriers, drug delivery systems used in nanomedicine, enhanced permeability and retention effect, blood-brain barrier, active and passive targeting of diseased cells, health and environmental impacts of nanotechnology. **Suggested Books:** ➢ Bhattacharya, S. (2013). *Introduction to nanotechnology*. New Delhi: Wisdom Press.	only

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			Perspectives, Christof M. Niemeyer (Editor), Chad A. Mirkin (Editor) , Wiley-VCH; 1 edition , 2004. ➢ NanoBioTechnology: BioInspired Devices and Materials of the Future by Oded Shoseyov and Ilan Levy, Humana Press; 1 edition 2007. ➢ NanoBiotechnology Protocols (Methods in Molecular Biology) by Sandra J Rosenthal and David W. Wright , Humana Press; 1 edition, 2005. ➢ Bio-Nanotechnology_ Concepts and applications. Madhuri Sharon, Maheshwar Sharon, Sunil Pandey and Goldie Oza, Ane Books Pvt Ltd, 1 edition 2012 ➢ Microscopy Techniques for Material Science. A. R. Clarke and C. N. Eberhardt (Editors) CRC Press. 1st Edition, 2002.	➢ Bhushan, B. (2017). *Springer Handbook of Nanotechnology*. Berlin, Heidelberg: Springer Berlin Heidelberg. ➢ Di, V. M. (2008). *Introduction to nanoscale science and technology*. New York, NY: Springer. ➢ Wilson, M. (2004). *Nanotechnology: Basic science and emerging technologies*. Boca Raton: Chapman & Hall/CRC. **Suggested e-Resources:** ➢ **Nanofluidic devices** https://aip.scitation.org/doi/pdf/10.1063/1.4794973?class=pdf ➢ **Quantam dot** file:///C:/Users/all/Downloads/9783642449093-c2.pdf ➢ **Preparation of Nanomaterial** https://nptel.ac.in/courses/103103033/module9/lecture2.pdf ➢ **Nanodrug delivery system** http://cdn.intechopen.com/pdfs/40262/InTech-Nanotechnology_in_drug_delivery.pdf http://iapc-obp.com/assets/files/883189NBDD.pdf	
10)	**BT 511** Enzyme Technology	After successful completion of the course, students should be able to: • Describe structure, functions and the mechanisms of action of enzymes • Get exposure of wide applications of enzymes and their future potential • Describe	**Section A** Introduction to enzymes, Classification, Sources, Mechanism of enzyme action. Strategies of purification of enzymes, criteria of purity, molecular weight determination and characterization of enzymes. Methods for investigating the kinetics of Enzyme catalysed reactions – Initial velocity Studies, Estimation of Michaelis Menten parameters, Effect of pH and temperature on enzyme activity, Modeling of rate equations for single and multiple substrate reactions. **Section B** Kinetics of inhibition- Reversible Inhibitors, Tight Binding Inhibitors, Time-Dependent Inhibition. Techniques of enzyme immobilization; kinetics of immobilized enzymes, effect of solute, Partition & diffusion on the kinetics of immobilized enzymes, design	**Section A** • Introduction to enzymes, classification, sources, mechanism of enzyme action. • Strategies of purification of enzymes, criteria of purity, molecular weight determination and characterization of enzymes. • Methods for investigating the kinetics of enzyme catalysed reactions – initial velocity studies, estimation of Michaelis Menten parameters, effect of pH and temperature on enzyme activity, modeling of rate equations for single and multiple substrate reactions. **Section B** • Kinetics of inhibition: Reversible Inhibitors, tight Binding Inhibitors, time-Dependent Inhibition. • Techniques of enzyme immobilization, kinetics of immobilized enzymes, effect of solute, partition & diffusion on the kinetics of immobilized enzymes, design and	Typographical corrections only

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		methods for enzyme mediated production of drugs, fine chemicals and other industrial intermediates	and configuration of immobilized enzyme reactors, applications of immobilized enzyme technology, Economic argument for immobilization. Functional group interconversion using enzymes (hydrolysis reaction, oxidation/reduction reactions, C-C bond formations). Cooperativity in Enzyme Catalysis. **Section C** Reaction engineering for enzyme-catalyzed biotransformations. Catalytic antibodies. Biocatalysts from extreme Thermophilic and Hyperthermophilic microorganisms (extremozymes). The design and construction of novel enzymes, artificial enzymes, Biotransformation of drugs (hydroxylation of Steroids), Host Guest Complexation chemistry, enzyme design using steroid templates, enzymes for production of drugs, fine chemicals and chiral intermediates. Enzymes of biological importance- Acetylcholinesterase, angiotensin converting enzyme (ACE), ACE Inhibitors, HMG Co A reductase inhibitors, pseudocholinesterase, 5-nucleotidase(5NT) and glucose-6-phosphate dehydrogenase(GPD). **Books Recommended:** ➢ Blanch, H.W., Clark, D.S. "Biochemical Engineering." Marcel Dekker, 1997. ➢ Lee, James M. "Biochemical Engineering." PHI, 1982. ➢ Bailey J.E. & Ollis, D.F. "Biochemical Engineering Fundamentals." 2nd Edition. McGraw Hill, 1986. ➢ Faber, Kurt "Biotransformations in Organic Chemistry : A Textbook." 5th Edition. Springer, 2008. ➢ Palmer, Trevor. "Enzymes : Biochemistry, Biotechnology, Clinical Chemistry." 2nd Edition, East West Press, 2008.	configuration of immobilized enzyme reactors, applications of immobilized enzyme technology, Economic argument for immobilization. • Functional group interconversion using enzymes (hydrolysis reaction, oxidation/reduction reactions, C-C bond formations). Cooperativity in enzyme catalysis **Section C** • Reaction engineering for enzyme-catalyzed biotransformations. Catalytic antibodies. • Biocatalysts from extreme thermophilic and hyperthermophilic microorganisms (extremozymes). • The design and construction of novel enzymes, artificial enzymes • Biotransformation of drugs (hydroxylation of Steroids), host guest complexation chemistry, enzyme design using steroid templates, enzymes for production of drugs, fine chemicals and chiral intermediates. • Enzymes of biological importance: Acetylcholinesterase, angiotensin converting enzyme (ACE), ACE Inhibitors, HMG Co A reductase inhibitors, pseudocholinesterase, 5-nucleotidase (5NT) and glucose-6-phosphate dehydrogenase (GPD). **Suggested Books:** ➢ Bhaskar, A., Vidhya, V. G. (2014). *Enzyme Technology*. India: Mjp Publishers. ➢ Copeland, R. A. (2000). *Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis*. USA: John Wiley & Sons. ➢ Devasena, T. (2010). *Enzymology* (3rd ed.). UK: Oxford University Press. ➢ Meena, M., & Chauhan, D. (2009). *Fundamentals of Enzymology*. Jaipur, India: Aavishkar publishers. ➢ Palmer, T., & Bonner, P. (2008). *Enzymes: Biochemistry, Biotechnology, Clinical Chemistry* (2nd ed.). India: East West Publications.	

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			➢ Robert A. Copeland. "A Practical Introduction to Structure, Mechanosm, and Data Analysis." Second Edition, John Wiley & Sons Inc. Publication, 2000.	➢ Scopes, R. K. (2013). *Protein Purification: Principles and Practice* (3rd ed.). USA: Springer. **Suggested e-Resources:** ➢ **Factors affecting rate of chemical reaction** https://www.adichemistry.com/physical/kinetics/factors/factors-affecting-rate-reaction.html ➢ **Extraction and purification of enzyme** http://chemsites.chem.rutgers.edu/~kyc/Teaching/Files/543-05/09%20544-10%20ppt.pdf ➢ **Catalytic antibodies** https://nptel.ac.in/courses/104103018/28	
11)	**BT 516** Immunotechnology	After successful completion of the course, students should be able to: • Compare and describe the different components of immune system and their functions. • Demonstrate and understand the principle techniques used for disease diagnostics. • Apply the knowledge of disease resistance and gene therapy in clinical research.	**Section A** Concept of immunity, cells and organs involved in the immune system, clonal selection theory, ubiquity of innate immunity, antigens, basic structure of antibodies, complementarity determining regions (CDRs) and antigenic determinants, multigene organization of Ig genes, assembly of TCR genes, antibody diversity and its generation **Section B** Antibody engineering, general organization and immune responsiveness of MHC, roles of APCs, components of immune effector mechanism (cytokines, chemokines, T cells and NKs), antigen antibody interactions and their diagnosis methods: cross reactivity, surface plasmon response (SPR), RIA, ELISA, western blotting, immunoprecipitation, immunofluorescence, flow cytometry, immunoelectron microscopy, **Section C** Mechanism of self tolerance and autoimmunity hypersensitivity, designing of vaccines, primary and secondary immunodeficiency, cancer immunotherapy, general and specific immunosuppressive therapy, hybridoma technology, SCID mice, SCID- human mice,	**Section A** • Concept of immunity, cells and organs involved in the immune system, clonal selection theory, ubiquity of innate immunity. • Antigens, basic structure of antibodies, complementarity determining regions (CDRs) and antigenic determinants. • Multigene organization of Ig genes, assembly of TCR genes, antibody diversity and its generation **Section B** • Antibody engineering, general organization and immune responsiveness of MHC, roles of APCs. • Components of immune effector mechanism (cytokines, chemokines, T cells and NKs). • Antigen antibody interactions and their diagnosis methods: cross reactivity, surface plasmon response (SPR), RIA, ELISA, western blotting, immunoprecipitation, immunofluorescence, flow cytometry, immunoelectron microscopy, **Section C** • Mechanism of self tolerance and autoimmunity, hypersensitivity. • Designing of vaccines, primary and secondary immunodeficiency, cancer immunotherapy. • General and specific immunosuppressive therapy, hybridoma	Typographical corrections only

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
			technology for separation or identification of antigen **Books Recommended:** ➢ Kuby Immunology (sixth edition) by Kindt, Goldsby, Osborne, Publisher Sara Tenney, 2007 ➢ Immunology and Immunotechnology by Ashim K Chakravarty, Oxford University Press, 2006. ➢ Janeway's Immunobiology (seventh edition) by Kenneth Murphy, Paul Travers , Mark Walport, Publisher Garland Science Taylor and Francis, 2008. ➢ The elements of Immunology by Fahim Halim Khan, Publisher Pearson education, 2009.	technology, SCID mice, SCID- human mice, technology for separation or identification of antigen. **Suggested Books:** ➢ Abbas, A. K., Lichtman, A. H. &Pillai, S. (2017). *Cellular and Molecular Immunology*(9th ed.). Elsevier. ➢ Delves, P. J., Martin, S. J., Burton, D. R., &Roitt, I. M. (2006*). Roitt's Essential Immunology,* (11th ed.). Wiley-Blackwell. ➢ Punt, J., Stranford, S., Jones, P., & Owen, J. (2018). *Kuby Immunology (*8th ed.). W. H. Freeman and company. ➢ Tizard, I. R. (1995). *Immunology: Introduction,* (4th ed.). Philadelphia: Saunders College Publishing. **Suggested e-Resources:** ➢ **Cellular and Molecular Immunology** https://ocw.mit.edu/courses/health-sciences-and-technology/hst-176-cellular-and-molecular-immunology-fall-2005/lecture-notes/ ➢ **Immunology** https://study.com/academy/topic/immunology.html ➢ **Antibodies** https://nptel.ac.in/courses/102103038/download/module2.pdf https://nptel.ac.in/courses/102103047/PDF/mod5.pdf	
Reading Electives-I &II to be offered in III & IV Semester					
1)	~~**BIO 601R Biodiversity and Conservation**~~	~~After successful completion of the course, students should be able to:~~ ~~• Understand the concepts of biodiversity~~ ~~• Comprehend ways to manama biodiversity and government bodies involved~~	~~**Section A**~~ ~~**General Account:**~~ ~~Concept and facts: ecological diversity; organism diversity (á, â, and ã); genetic diversity. Magnitude and distribution. Hot spots of biodiversity. India's biodiversity. Factors that control species diversity. Generation of biodiversity.~~ ~~**Section B**~~ ~~**Threats and management:**~~ ~~Species extinction (local, ecological, biological, background extinction, anthropogenic extinction); causes of extinction. Chain extinction. Key stone species.~~		This is removed and replaced with relevant reading elective paper

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		~~in making conservation strategies~~ ~~• Understand various biodiversity conservation strategies~~	~~Extinction vortex.~~ ~~IUCN and its major activities. IUCN status categories (extinct, extinct in wild, critically endangered, endangered, vulnerable, lower risk, data deficient, not evaluated). Red Data Book. Rare species. Indeterminate species.~~ ~~**Section C**~~ ~~**Conservation of biodiversity**~~ ~~Conservation strategies~~ ~~*In situ* biosphere reserve, national park, wildlife sanctuaries, sacred forests.~~ ~~*Ex situ* cryo-preservation,Gene banks, DNA banks. Endangered species in India.~~ ~~**Books Recommended:**~~ ~~➢ Textbook of Biodiversity, K V Krishnamurthy, Science Publishers~~ ~~➢ Biodiversity, E.O. Wilson, editor,frances M. Peter, Associate Editor, National Academy press, Washington, D.C., 1988~~		
2)	~~**BIO 602R Bioethics, Biosafety and IPR**~~	~~After successful completion of the course, students should be able to:~~ ~~• Explain role of biotechnology in sustainable research and various ethical implications~~ ~~• Understand biosafety objective, implementation, necessity and legislations~~	~~**Section A**~~ ~~History and principles of bioethics, ethical dimensions of medicine and biotechnology viz. organ transplant, human genome project, cloning, surrogacy, artificial insemination, egg donation abortion, euthanasia.~~ ~~Convention on biological diversity; Overview of Cartagena Protocol, Codex Alimentarius, FAO, OECD and their role in enforcing Biosafety; Role of NGOs in biotechnology.~~ ~~**Section B**~~ ~~Issues of Biosafety; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety guidelines – Government of India; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO~~		This is removed and replaced with relevant reading elective paper

S. No.	Course List	Learning Outcomes	Existing Syllabus	Suggested Syllabus	Remarks
		• Develop preliminary understanding of Intellectual Property with emphasis on patents	applications in food and agriculture; Environmental release of GMOs; Biosafety management **Section C** History of IPR, types of IPR; Role of WIPO and WTO in IPR. Classification of patents; granting of patents and patenting authorities; rights and duties of patent owner; Patent infringement- meaning, scope and litigation; Invention in context of "prior art"; Patent databases; Country-wise patent searches (USPTO, EPO, India etc.) US Patent act; Indian Patent act. Filing of a patent application; Precautions before patenting-disclosure/non-disclosure; WIPO Treaties; Budapest Treaty; PCT and Implications; Role of a Country Patent Office; Case studies in IPR.s **Books Recommended:** ➢ Bioethics and Biosafety by M.K. Sateesh. I.K. International ➢ Biosafety and bioethics. Ed. Raj Mohan Joshi. Isha Books ➢ Bioethics. An introduction to the history, methods and practice. By N. Jecker, A.R. Jonsen and R.A. Perlman. Jones and Bartlett publications and Bioethics by Deepa Goel and Shomini Parashar. Pearson ➢ http:// Bioethics by S. Ignacimuthu s.j. Narosa Publishing House Pvt. Ltd. ➢ IPR, Biosafety www.w3.org/IPR/ ➢ http://www.wipo.int/portal/index.html.en ➢ http://www.ipr.co.uk/IP_conventions/ patent_cooperation_treaty.html ➢ www.patentoffice.nic.in ➢ www.iprlawindia.org/ - 31k - Cached Similar page ➢ http://www.cbd.int/biosafety/ background.shtml ➢ http://www.cdc.gov/OD/ohs/ symp5/jyrtext.html		

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			➢ ~~http://web.princeton.edu/sites/ehs/biosafety/biosafetypage/section3.html~~		
3)	~~**BT 604R Renewable Energy Sources**~~	~~After successful completion of the course, students will be able to:~~ ~~• Understand the various forms of conventional and non conventional energy resources~~ ~~• Design working models of renewable energy~~ ~~• Understand the applications and limitations of renewable energy sources~~	~~**Section A**~~ ~~Availability, importance, utilization, economics and growth rates of renewable energy sources. Combustion calculations, Conventional thermal power plant design and its operation, Superheat, reheat and regeneration, Other auxiliaries of thermal plant. High pressure boilers, Steam generator control. Biomass and its types, Biomass fuel characterization; thermo chemical and biochemical processes; reaction kinetics; energy and mass balance equations; studies of processes and system design for gasification, pyrolysis and liquefaction of biomass. Biochemical and thermochemical conversion of biomass. Design of biogas plants and gasifiers; Fuel related properties of biomass; planning and management of biomass collection, utilization, handling and pre-conditioning processes such as size reduction and densification; combustion, pyrolysis and gasification of biomass, photosynthetic efficiency, plant productivity and bio-energy yield, biomass waste.~~ ~~**Section B**~~ ~~Chemistry, process and performance analysis of biofuels; alcohol production: pre-treatment of biomass, fermentation with process details and dehydration; operational performance of I.C. engines on producer gas, biogas, alcohol, and plant oils and their esters. Solar radiation intensity and solar geometry. Analysis and design of non-concentrating and concentrating solar collectors. Solar energy storage techniques, Steady and transient heat transfer analysis of solar cookers, solar ponds, solar stills and solar dryers. Design of solar thermal systems; hot water systems, space heating and cooling systems, solar drying system for agricultural produce etc. Economic analysis of solar energy systems.~~		This is removed and replaced with relevant reading elective paper

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			~~Design of solar energy operated systems for heating, cooling, distillation, drying, dehydration, water pump and power generation for applications in agriculture.~~ ~~**Section C**~~ ~~Basic principles of wind energy conversion, site selection considerations, classification advantages and disadvantages of Wind Energy Conversion System (WECS), types of wind machines, performance of wind machines, Utilization of wind energy for generating electricity and mechanical power. Types of wind mill and their characteristics. Mechanics of wind mills. Introduction to geothermal energy and storage, hydrothermal resources, geo-pressured resources, petro-thermal resources, prime movers for geothermal energy conversion, applications of geothermal energy. Basic principle of tidal power, components of tidal power plant, site requirements, storage of tidal energy, advantages and limitations of tidal power generation. Photo Voltaic devices. Applications of renewable energy sources.~~ ~~**Books Recommended:**~~ ~~➢ Godfrey Boyle, Renewable Energy, Power for a Sustainable Future, Oxford University Press, U.K, 1996.~~ ~~➢ G.D. Rai, Non-Conventional Energy Sources, Khanna Publishers~~ ~~➢ H. P. Garg, J. Prakash, Solar Energy : Fundamentalsand Applications : Fundamentals and Applications 1 Edition, Tata Megraw Hill Education Private Limited (2000)~~ ~~➢ Ching T. Hou and Jei Fu Shaw, Biocatalysis and Bioenergy, John Wiley & Sons, 2008~~ ~~➢ L.L. Freris, Wind Energy Conversion systems, Prentice Hall, UK, 1990.~~ ~~➢ Johnson Gary, L., Wind Energy Systems, Prentice Hall, New York, 1985.~~		

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4)	**BT: Molecular Plant Breeding**	After completing this course, students will be able to: Understand strategies and applications of plant breeding technologies. • Comprehend the knowledge of different plat molecular markers • Plan a research career in the area of plant biotechnology		Plant breeding study involves breeding methods for self and cross pollinated crops. There are several limitations of conventional breeding. Thus, there is need to have a better breeding approaches to overcome this limitation. Development of molecular markers (RFLP, RAPD, SSRs, ISSRs, SNPs), construction of molecular maps and linkage analysis, mapping populations for QTLs using molecular markers play an important role in plant breeding. In order to develop potential plant having better qualities, Marker Assisted Selection (MAS) is also a viable approach which can be done by using selection of traits and markers, trait association, marker assisted backcrossing and recurrent selection, marker assisted hybrid breeding and marker assisted improved varieties/germplasm. **Suggested Books:** ➢ Chawla, H. S. (2000). *Introduction to Plant Biotechnology*. USA: Science Publishers. ➢ Glick, B.R., Pasternak, J.J., & *Patten C.L.* (2010). *Molecular Biotechnology: Principles and applications of recombinant DNA* (4th ed). American Society for Microbiology. ➢ Nicholl, D.S.T. (2008). *An introduction to Genetic Engineering* (3rd ed). Cambridge: Cambridge University Press. ➢ Primrose, S.B., Twyman R.H., & Old R.W. (2001). *Principles of Gene Manipulation* (6th ed). Wiley-Blackwell. ➢ Slater, A., Scott, N., & Fowler, M. (2008). *Plant Biotechnology: The Genetic Manipulation of Plants* (2nd edition). UK: Oxford University Press. ➢ Watson, J.D., Gilman, M., Witkowski J., & Zoller, M. (1992). *Recombinant DNA* (2nd ed.). W. H. Freeman publisher. **Suggested e-resources:** ➢ **Plant breeding** https://nptel.ac.in/courses/102103013/pdf/mod6.pdf ➢ **Molecular marker**	c.w. M.Sc. AMBT, BT, Bioscience

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				http://eacharya.inflibnet.ac.in/data-server/eacharya documents/55d44ff9e41301fd23d8facc_INFIEP_203/734/ET/203-734-ET-V1-S1__lec_32.pdf ➢ **Gene mapping in plant** http://eacharya.inflibnet.ac.in/data-server/eacharya-documents/55d44ff9e41301fd23d8facc_INFIEP_203/733/ET/203-733-ET-V1-S1__lec_31.pdf	
5)	**Intellectual Property Rights**	After completing this course, students will be able to: • Understand the concept of IPR and its types • Describe the steps for patenting • Discuss the role of WTO and WIPO on IPR		Intellectual property rights (IPR) have an old history and are very relevant for economic development. Various types of IPR (patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications) are recognized with specific uses. There is currently an emergence of specific IP pertaining to plants and animals (UPOV, Plant Breeder's rights and plant variety protection and farmers rights act, patent protection of plant and animal inventions (WTO) and Law on the protection of new plant varieties and animal breeds (WIPO)). It is important to know about types of patent applications and the process of patenting with special emphasis to India. The role of WTO (GATT and TRIPS) and WIPO in implementation of IPR is significant as understands the relevance of Patent Cooperation Treaty (PCT) in patenting. IPR also are associated with certain ethical dilemma and there are some interesting case studies which highlight its relevance. **Suggested Books:** ➢ Goel D. & Parashar S. (2013). *IPR, Biosafety and Bioethics* (1st ed.) Pearson Education India. ➢ Pandey, N. & Dharni, K. (2014). *Intellectual Property Rights.* PHI Learning ➢ Ramakrishna, B., & Kumar, A. (2017). *Fundamentals of Intellectual Property Rights: For Students, Industrialist and Patent Lawyers* (1st ed.). Notion Press ➢ Sateesh, M.K. (2008). *Bioethics and Biosafety*. I.K. International Publishing House. **Suggested e-resource** ➢ **World Trade Organisation**	c.w. M.Sc. AMBT, BT, Bioscience

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				http://www.wto.org ➢ **World Intellectual Property Organisation** http://www.wipo.int ➢ **International Union for the Protection of New Varieties of Plants** http://www.upov.int ➢ **National Portal of India** http://www.archive.india.gov.in	
6)	**BT: Human Genetics and Diseases**	After successful completion of the course students will be able to: • Understand hereditary and molecular genetics with a strong human disease perspective • Describe genetic abnormalities underlying human disease and disorders • Develop interest in biomedical research, genetic counseling, medicine, and clinical genetics		Since the rediscovery of Mendel's work in 1900, investigations on the genetic nature of human traits have gained significant importance. Understanding the genetic basis behind human disease is one of the most important reasons to study human chromosome structure, human karyotype, banding techniques, chromosome identification and nomenclature (ISCN)**.** Classical genetics has considerable importance in constructing genetic hypothesis from pedigree data analysis in monogenetic traits, autosomal dominant, autosomal recessive, sex linked dominant, sex linked recessive and sex influenced traits. The impact of consanguinity in causing sex linked anomalies (haemophilia, colour blindness and Duchenne Muscular Dystrophy) has been observed in human population. Current knowledge on genetic variations across populations is applied to study human health and diseases which include chromosomal disorders, structural and numerical chromosomal anomalies (Klinefelter syndrome, Down's syndrome, Turner syndrome, Achondroplasia), inborn errors of metabolism (Phenylketonuria (PKU), Alkaptonuria, Albinism, Galactosemia), haemoglobinopathies, Thalassemia syndromes, multifactorial disorders (diabetes, schizophrenia, huntington disease). Medical genetics involves ethical issues therefore serious discussion is required for prenatal/adult diagnosis of genetic disorders, medical ethics, risks and benefits, informed consent and right of choice. **Suggested Books:** ➢ Nussbaum, R., McInnes, R., & Willard, H. (2007). *Thompson & Thompson-Genetics in Medicine* (7th ed.).	c.w. M.Sc. AMBT, BT, Bioscience

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				Elsevier. ➢ Pasternak, J. J. (2005). *An Introduction to Human Molecular Genetics: Mechanisms of Inherited Diseases* (2nd ed.). Wiley-Blackwell. ➢ Strachan, T., & Read, A. P. (2018). *Human Molecular Genetics* (5th ed.). Garland Science. **Suggested e-resources** ➢ **Chromosome identification and nomenclature (ISCN)** http://www.cydas.org/Resources/ISCN_Discussion.html ➢ **Pedigree data analysis** https://learn.genetics.utah.edu/content/disorders/ ➢ **Genetic disorders** https://www.genome.gov/10001204/specific-genetic-disorders/ ➢ **Prenatal/ adult diagnosis of genetic disorders, medical ethics** https://www.michiganallianceforfamilies.org/all/#sectionD	
7)	**BT: Medical Microbiology**	After successful completion of the course, students should be able to: • Identify various bacterial, fungal, viral and protozoan diseases and their epidemiology • Understand the relevance of emerging and reemerging diseases		Medical Microbiology describes the cause, transmission, epidemiology, pathogenesis, symptoms, diagnosis and treatment of various bacterial (tuberculosis, typhoid, leprosy), fungal (superficial, subcutaneous, systemic mycosis), protozoan (Malaria, amoebiasis) and viral (AIDS, Influenza, measles) diseases. Currently, it is necessary to understand the impact of emerging and remerging diseases (cholera, dengue, multidrug resistant tuberculosis, H5N1 avian influenza, drug resistant malaria, chikungunya) on human health. Global assessment for various diseases also shows an increasing trend of nosocomial infections and opportunistic infections which cause significant mortality and health concerns. **Suggested books:** ➢ Brooks, G.F., Carroll, K.C., Butel, J.S., Morse, S.A., & Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's Medical Mcirobiology (26th ed.). US: Lange Medical Books, Mc Graw-Hill. ➢ Madigan, M., Martinko, J., Stahl, D., & Clark, D. (2010).	c.w. M.Sc. AMBT, BT, Bioscience

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				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://www.bmj.com/about-bmj/resources-readers/publications/epidemiology-uninitiated/1-what-epidemiology ➢ **Nosocomial Infections** https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3470069/	
8)	**BT: Protein Engineering**	On completion of this course, students should be able to: • Analyse structure and construction of proteins by computer-based methods • Describe structure and classification of proteins • Analyse and compare the amino acid sequence and structure of proteins, and relate this information to		An introduction to protein engineering for developing proteins with desired functions. Various methods (rational design and directed evolution) of protein engineering are employed to manipulate the different features or characteristics (affinity, specificity and stability etc) of proteins. Engineering various physicochemical and biological properties (stability to changes in parameters as pH, temperature, amino acid sequence and aggregation propensities etc) of the proteins could be important in their use as protein drugs and/or catalysts in bioreactors. The insight into the fundamental understanding of the mechanisms and forces (Van der waals, electrostatic, hydrogen bonding, weakly polar interactions, and hydrophobic effects), by which protein stabilizes, will help in the formulation of protein based pharmaceuticals. Protein engineering with site-specifically incorporation of unnatural or non-canonical amino acids has been used to improve protein function for medical and industrial applications. Different computational approaches (sequence and 3D structure analysis, data mining, Ramachandran map etc) to protein engineering would help to address the requirements in order to find amino acid sequences that will optimize a desired property (physicochemical property and/or biological function) of a protein. Determination of the	c.w. M.Sc. AMBT, BT, Bioscience

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		the function of proteins • Explain how proteins can be used for different industrial and academic purposes such as structure determination, organic synthesis and drug design. • Plan and carry out activity measurements of isolated proteins and characterize their purity and stability.		physicochemical properties of proteins using various spectroscopic methods (Far-UV and Near-UV CD, Fluorescence, UV absorbance and Optical rotatory dispersion) would further support the drug development process. Yeast surface display (YSD) has become a valuable protein engineering tool for modifying the affinity, specificity, and stability of antibodies, as well as other proteins. YSD could be successfully used for protein epitope mapping, identification of protein-protein interactions, and uses of displayed proteins in industry and medicine. Developing vaccines and peptidomimetics will further allow the investigators to identify novel therapeutic leads for numerous unmet clinical needs. **Suggested Books:** ➢ Cleland, J. L., and Craik, C. S. (2006). *Protein Engineering, Principles and Practice*, Vol 7. Springer Netherlands. ➢ Creighton, T. E. (1997). *Protein Structure: a Practical Approach*, 2nd Edition. Oxford University press. ➢ Kyte, J. (2006). *Structure in Protein Chemistry*, 2nd Edition. Garland publishers. ➢ Mueller, K., and Arndt, K. (2006). *Protein Engineering Protocols*, 1st Edition. Humana Press. ➢ Robertson, D., and Noel, J. P. (2004). *Protein Engineering Methods in Enzymology*, Vol 388. Elsevier Academic Press. ➢ Walsh, G. (2014). *Proteins: biochemistry and biotechnology*, Second edition. Chichester, West Sussex: Wiley Blackwell. ➢ Williamson, M. P. (2012). *How proteins work*. New York: Garland Science. **Suggested e-resources:** ➢ **Protein Engineering**: https://nptel.ac.in/courses/102103017/pdf/lecture%2022.pdf ➢ **Conformational stability of proteins**: https://www.khanacademy.org/test-prep/mcat/biomolecules/amino-acids-and-proteins1/v/conformational-stability-protein-folding-and-	

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				denaturation ➢ **Protein Engineering with Non-Natural Amino Acids:** https://library.umac.mo/ebooks/b2805488x.pdf	
9)	**BT: Drug discovery**	On completion of this course, students should be able to: • Understand basics of R&D in drug discovery and should be able to apply knowledge gained in respective fields of pharmaceutical industry. • Understand the role of synthetic chemistry in the development of pharmaceutical agents; and the modification of chemical structures to develop new drug molecules. • Have an advanced understanding of the chemical structure of a pharmaceutical		Modern drug discovery involves the identification of a target or drug lead using different techniques including molecular modeling, combinatorial libraries and high-throughput screening (HTS). Rational drug design is based on the understanding of the three-dimensional structures and physicochemical properties of drugs and receptors. Knowledge of molecular mechanisms, molecular dynamics simulations and homology modeling is necessary for studying drug/receptor interactions. The different conformational sampling techniques, fitness functions used in molecular docking and computational receptor-based and ligand-based drug design approaches are mostly used to design compounds with improved biological activity in rational drug design. Quantitative drug design using QSAR models are used to correlate structural molecular properties (descriptors) with functions (i.e. physicochemical properties, biological activities, toxicity, etc.) of the compounds. Understanding the structure activity relationship between the 3D structure of a molecule and its biological activity may act as the basis for the prediction of compounds with improved biological activities. Different bio-analytical assays (LC/MS/MS, GC/MS and ELISA) could be developed further in support of *in vitro* and *in vivo* studies. Understanding the principles as well as an early characterization of drug toxicity, adsorption, distribution, metabolism and excretion (ADME) along with drug-drug interactions, plasma protein binding assays and metabolite profile studies helps in eliminating compounds with unacceptable pharmacokinetic characteristics, which is critical to successful drug discovery programs. **Suggested Books:** ➢ Dastmalchi, S. *et. al.* (2016). *Methods and Algorithms for Molecular Docking-Based Drug Design and Discovery*. IGI	c.w. M.Sc. AMBT, BT, Bioscience

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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.		Global. ➢ Krogsgaard-Larsen *et. al.* (2016). *Textbook of Drug Design and Discovery*. 5th Edition. CRC Press. ➢ Rahman, A. U., Caldwell, G. W., and Choudhary, M. I. (2007). *Frontiers in Drug Design and Discovery*. Bentham Science publishers Limited. ➢ Satyanarayanajois, S. D. (2011). *Drug Design and Discovery: Methods and Protocols*. Humana Press. **Suggested e-resources:** ➢ **Drug Discovery** https://www.studocu.com/en/document/university-of-leeds/drug-development-pre-clinical-to-practice/lecture-notes/lecture-i-drug-discovery-lecture-notes-lectures-1-8/615380/view ➢ **Peptide therapeutics** https://www.sciencedirect.com/science/article/pii/S1359644614003997**Bio-analytical techniques** https://www.pharmatutor.org/articles/bioanalytical-techniques-overview	

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

Verified

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