HSNC University Mumbai
(2020-2021)

Ordinances and Regulations

With Respect to

Choice Based Credit System
(CBCS)
For the Programmes Under

The Faculty of Science and Technology

For the Course

Biotechnology

Curriculum – Third Year Undergraduate Programme

Semester-V and Semester -VI
2022-2023

Part –I

Outline of Choice Based Credit System as outlined by University Grants Commission:

R. ****: The Definitions of the Key Terms Used in The Choice Based Credit System and Grading System
Introduced from The Academic Year 2020-2021 Are as Under:

1. Core Course: A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.

2. Elective Course: Generally, a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the candidate's proficiency/skill is called an Elective Course.

2.1Discipline Specific Elective (DSE) Course: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).

2.2Dissertation/Project: An elective course designed to acquire special/advanced knowledge, such as supplement study/support study to a project work, and a candidate studies such a course on his own with an advisory support by a teacher/faculty member is called dissertation/project. A Project/Dissertation work would be of 6 credits. A Project/Dissertation work may be given in lieu of a discipline specific elective paper.

2.3 Generic Elective (GE) Course: An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective.
P.S.: A core course offered in a discipline/subject may be treated as an elective by other discipline/subject and vice versa and such electives may also be referred to as Generic Elective.

3. Choice Base Credit System: CBCS allows students to choose inter- disciplinary, intra-disciplinary courses, skill-oriented papers (even from other disciplines according to their learning needs, interests and aptitude) and more flexibility for students.

4. Honours Program: To enhance employability and entrepreneurship abilities among the learners, through aligning Inter Disciplinary / Intra Disciplinary courses with Degree Program. Honours Program will have 40 additional credits to be undertaken by the learner across three years essentially in Inter / Intra Disciplinary course.

A learner who joins Regular Undergraduate Program will have to opt for Honours Program in the first year of the Program. However, the credits for honours, though divided across three years can be completed within three years to become eligible for award of honours Degree.

5. Program: A Program is a set of course that are linked together in an academically meaningful

way and generally ends with the award of a Degree Certificate depending on the level of knowledge attained and the total duration of study, B.Sc. Programs.

6. Course: A 'course' is essentially a constituent of a 'program' and may be conceived of as a composite of several learning topics taken from a certain knowledge domain, at a certain level. All the learning topics included in a course must necessarily have academic coherence, i.e., there must be a common thread linking the various components of a course. A number of linked courses considered together are in practice, a 'program'.

7. Bridge Course: Bridge course is visualized as Pre semester preparation by the learner before commencement of regular lectures. For each semester the topics, whose knowledge is considered as essential for effective and seamless learning of topics of the Semester, will be specified. The Bridge Course can be conducted in online mode. The Online content can be created for the Bridge Course Topics.

8. Module and Unit: A course, which is generally, an independent entity having its own separate identity, is also often referred to as a 'Module' in today's parlance, especially when we refer to a 'modular curricular structure'. A module may be studied in conjunction with other learning modules or studied independently. A topic within a course is treated as a Unit. Each course should have exactly 3 Units.

9. Self-Learning: 20% of the topics will be marked for Self-Learning. Topics for Self-Learning are to be learned independently by the student, in a time- bound manner, using online and offline resources including online lectures, videos, library, discussion forums, fieldwork, internships etc.

Evaluative sessions (physical/online), equivalent to the credit allocation of the Self Learning topics, shall be conducted, preferably, every week for each course. Learners are to be evaluated real time during evaluative sessions. The purpose of evaluative sessions is to assess the level of the students' learning achieved in the topics ear marked for Self-Learning.
The teacher's role in these evaluative sessions will be that of a Moderator and Mentor, who will guide and navigate the discussions in the sessions, and offer concluding remarks, with proper reasoning on the aspects which may have been missed by the students, in the course of the Self-Learning process.
The modes to evaluate self-learning can be a combination of the various methods such as written reports, handouts with gaps and MCQs, objective tests, case studies and Peer learning. Groups can be formed to present self- learning topics to peer groups, followed by Question-and-Answer sessions and open discussion. The marking scheme for Self-Learning will be defined under Examination and Teaching.
The topics stipulated for self-learning can be increased or reduced as per the recommendations of the Board of Studies and Academic Council from time to time. All decisions regarding evaluation need to be taken and communicated to the stakeholders preferably before the commencement of a semester. Some exceptions may be made in exigencies, like the current situation arising from the lockdown, but such adhoc decisions are to be kept to the minimum possible

10.Credit Point: Credit Point refers to the 'Workload' of a learner and is an index of the number of learning hours deemed for a certain segment of learning. These learning hours may include a

variety of learning activities like reading, reflecting, discussing, attending lectures / counseling sessions, watching especially prepared videos, writing assignments, preparing for examinations, etc. Credits assigned for a single course always pay attention to how many hours it would take for a learner to complete a single course successfully. A single course should have, by and large a course may be assigned anywhere between 2 to 8 credit points wherein 1 credit is construed as corresponding to approximately 30 to 40 learning hours.

11. Credit Completion and Credit Accumulation: Credit completion or Credit acquisition shall be considered to take place after the learner has successfully cleared all the evaluation criteria with respect to a single course. Thus, a learner who successfully completes a four CP (Credit Point) course may be considered to have collected or acquired four credits. Learner level of performance above the minimum prescribed level (viz. grades / marks obtained) has no bearing on the number of credits collected or acquired. A learner keeps on adding more and more credits as he completes successfully more and more courses. Thus, the learner 'accumulates' course wise credits.

12.Credit Bank: A Credit Bank in simple terms refers to stored and dynamically updated information regarding the number of Credits obtained by any given learner along with details regarding the course/s for which Credit has been given, the course-level, nature, etc. In addition, all the information regarding the number of Credits transferred to different programs or credit exemptions given may also be stored with the individual's history.

13.Credit Transfer: (performance transfer) When a learner successfully completes a program, he/she is allowed to transfer his/her past performance to another academic program having some common courses and Performance transfer is said to have taken place.

14. Course Exemption: Occasionally, when two academic programs offered by a single university or by more than one university, may have some common or equivalent course-content, the learner who has already completed one of these academic programs is allowed to skip these 'equivalent' courses while registering for the new program. The Learner is 'exempted' from ‘relearning' the common or equivalent content area and from re-appearing for the concerned examinations. It is thus taken for granted that the learner has already collected in the past the credits corresponding to the exempted courses.

Part-II

O*** The fees for transfer of credits or performance will be based on number of credits that a learner has to complete for award of the degree.**

The Scheme of Teaching and Examination:

The performance of the learners shall be evaluated in two components: Internal Assessment with 40% marks by way of continuous evaluation and by Semester End Examination with 60% marks by conducting the theory examination.

INTERNAL ASSESSMENT:- It is defined as the assessment of the learners on the basis of continuous evaluation as envisaged in the credit based system by way of participation of learners in various academic and correlated activities in the given semester of the programme.

A). Internal Assessment–40%- 40marks

Practical's (internal Components of the Practical Course)

1. **For Theory Courses**

Sr. No.	Particulars	Marks
1	**ONE** class test / online examination to be conducted in the given semester	15 Marks
2	One assignment based on curriculum (to be assessed by the teacher Concerned	10 Marks
3	Self-Learning Evaluation	10 Marks
4	Active participation in routine class instructional deliveries	05 Marks

2. For Courses with Practicals

Each practical course can be conducted out of 100 marks .with 20 marks for internal and 30 marks for external.

Practical's (Internal component of the Practical Course)

Sr. No	Evaluation type	Marks
1	Two Best Practicals /Assignments/Presentation /Preparation of models/ Exhibits **Or** One Assignment/ project/presentation to be assessed by teacher concerned	10
2	Journal	05
3	Viva	05

Practical examination:
Practical exam would be conducted over a period of 3 days; 100M for each practical paper.

Each student to perform 2 major and 2 minor practical for Sem V and 2 major and project presentation for Sem VI,

Viva would be conducted during the practical during Sem V; Sem VI would have ONLY project presentation.

Distribution of marks for the experiments carried out during the examination:
Sem V (50M/ paper): Major: 20M; Minor: 10M; Viva: 10M; Journal 10M.
Sem VI (50M/paper): Major (x2): 40M; Journal: 10M; Project 50M
The report could be around 25-30 pages with appropriate referencing and formatting.

Marks distribution for the project would be as follows:
25M documentation, 15M presentation, 10 M viva and interactions;

Students would undertake a project for 1-2 months during the last semester for 50 M.
The project should include either of the following:
1. One/ more major instrumentation OR
2. One / more major technique/s required in the field of interest OR
3. Bioinformatics OR
4. Biostatistics
The semester end examination (external component) of 60 % for each course will be as follows:

Duration – 2 Hours

Theory Question Paper Pattern:-

There shall be five questions each of 15 marks. On each unit there will be one question and the first and second one will be based on entire syllabus.
All questions shall be compulsory with internal choice within the questions. (Each question will be of 20 to 23 marks with options.)
Question may be subdivided into sub-questions a, b, c… and the allocation of marks depend on the weightage of the topic.

The marks will be given for all examinations and they will be converted into grade (quality) points. The semester-end, final grade sheets and transcripts will have only credits, grades, grade points, SGPA and CGPA.

3. Project and Assignment:

Project or Assignment, which can in the following forms

- Case Studies
- Videos
- Blogs
- Research paper (Presented in Seminar/Conference)
- Field Visit Report
- Presentations related to the subject (Moot Court, Youth Parliament, etc.)
- Internships (Exposition of theory into practice)
- Open Book Test
- any other innovative methods adopted with the prior approval of Director Board of Examination and Evaluation.

4. Self-Learning Evaluation

- 20% OF THE TOPICS OF CURRICULUM ARE LEARNED BY THE STUDENT THROUGH SELF-LEARNING USING ONLINE / OFFLINE ACADEMIC RESOURSE SPECIFIED IN THE CURRICULUM.

- HENCE 20% OF THE LECTURES SHALL BE ALLOCATED FOR EVALUATION OF STUDENTS ON SELF LEARNING TOPICS

- The identified topics in the syllabus shall be learnt independently by the students in a time bound manner preferably from online resources. Evaluative sessions shall be conducted by the teachers and will carry 10 Marks.

CLUB The self-learning topics into 3-4 GROUPS OF TOPICS ONLY FOR EVALUATION.

PRESCRIBE TIME DURATION (IN DAYS) FOR COMPLETION OF EACH GROUP OF TOPIC AND EARMARK SELF-LEARNING EVALUATION LECTURES IN THE TIMETABLE. HENCE, EACH GROUP OF TOPIC CAN BE ASSIGNED 3 REGULAR LECTURES FOR THIS EVALUATION FOR ENTIRE CLASS

3. Sub Topics
Each evaluative session shall carry 3 Marks (3 x 3 Units = 9 Marks).
Students who participate in all evaluative sessions shall be awarded 1 additional Mark.
4. Sub Topics
Each evaluative session shall carry 2.5 Marks (2.5 x 4 Units = 10 Marks)

EVALUATION OF SELF LEARNING TOPICS CAN COMMENCE IN REGULAR LECTURES ASSIGNED FOR SELF LEARNING EVALUATION IN THE TIMETABLE

3 .Evaluative sessions
Each evaluative session shall carry 3 Marks (3 x 3 = 9 Marks). Students who participate in all evaluative sessions shall be awarded 1 additional Mark.
4 Evaluative sessions
Each evaluative session shall carry 2.5 Marks (2.5 x 4 = 10 Marks). Methods for Evaluation of Self-learning topics:

- Seminars/presentation (PPT or poster), followed by Q&A − Objective questions /Quiz / Framing of MCQ questions.
- Debates
- Group discussion
- You-Tube videos (Marks shall be based on the quality and
- viewership)
- Improvisation of videos
- Role Play followed by question-answers

TEACHERS CAN FRAME OTHER METHODS OF EVALUATION ALSO PROVIDED THAT THE METHOD, DULY APPROVED BY THE COLLEGE EXAMINATION COMMITTEE, IS NOTIFIED TO THE STUDENTS AT LEAST 7 DAYS BEFORE THE COMMENCEMENT OF THE EVALUATION SESSION AND IS FORWARDED FOR INFORMATION AND

NECESSARY ACTION AT LEAT 3 DAYS BEFORE THE COMMENCEMENT OF THE EVALUATION SESSION

- Viva Voce
- Any other innovative method

SEMESTER END EXAMINATION: - It is defined as the examination of the learners on the basis of performance in the semester end theory / written examinations.

B. Semester End Examination- 60 % *60 Marks*

1) Duration – These examinations shall be of 2 Hours duration.
2) Question Paper Pattern: -

i. There shall be four questions each of 15 marks. ii. All questions shall be compulsory with internal choice within the questions.

ii. Question may be sub-divided into sub-questions a, b, c, d & e only and the allocation of marks depends on the weightage of the topic.

THE MARKS OF THE INTERNAL ASSESSMENT SHOULD NOT BE DISCLOSED TO THE STUDENTS TILL THE RESULTS OF THE CORRESPONDING SEMESTER IS DECLARED.

1. Course Objectives:

Semester V

US-TBT-501
Cell Biology and Developmental Biology (TBT 501)
The objective of this course is to provide insights into the mechanism of cell cycle and its regulation. The coursework deals with the cell signalling, Principles and Approaches to developmental biology in prokaryotic and eukaryotic organisms. It also provides an overview of cancer biology.

US-TBT-502
Medical Microbiology, Bioanalytical techniques and Biostatistics (TBT502)
The coursework allows students to learn various aspects of Virology .It also aids in learning about the chemotherapeutic drugs and their mode of actions. Additionally, the paper can help in the knowledge acquisition of enzymology. It also provides a detailed knowledge of advanced spectroscopic techniques, several bioanalytical techniques and their validation.

US-TBT-503
Genomics and Molecular Biology (TBT503)
The course introduces the students to the Genetic engineering of plants and animals. Additionally the coursework allows the students to learn about tools in molecular biology; recombinant protein and genome sequencing techniques.

US-TBT-504
Marine Biotechnology (TBT 504)
Coursework allows the students to learn basics of Marine Biotechnology with respect to different habitats and related organisms. The course work enables students to gain in depth knowledge of Marine Drugs ,Marine Enzymes, Marine Functional foods, Toxins .The paper also provides the students with knowledge of advanced tools and techniques for obtaining marine samples and their processing to acquire data .

US-TBT-505
Applied Component Biosafety and Food Biotechnology (TBT505)
The coursework allows students to develop an understanding of the different aspects of biosafety and Good Laboratory Practices. The Food Biotechnology coursework provides knowledge of principle food processing and preservation techniques. It also talks about the Food Safety and Quality Assurance in associated industries.

Semester VI

US-TBT-601
Biochemistry (TBT601)
The objective of this course is to gain an insight into the Metabolic Processes associated with carbohydrates and proteins. It also provides in depth knowledge of the endocrinology and hormones. The course work gives insights towards nutrition in humans and its clinical significance.

US-TBT-602
Industrial Microbiology (TBT602)
The objective of this course is to provide an understanding of the basic processes and the techniques of fermentation process and particulars of dairy industry. The course also provides the comprehension of industrial enzymology, quality assurance and quality control.

US-TBT-603
Basic pharmacology and Neurochemistry (TBT603)
The coursework helps students to learn about mechanism of drug action and its absorption, drug distribution and pharmacokinetics. Additionally, it provides knowledge of basic toxicology and regulatory toxicology. The coursework helps in the comprehension of basic neurochemistry.

US-TBT-604
Environmental Biotechnology (TBT604)
The objective of the coursework is to provide information about the renewable energy sources and its uses. The coursework also provides the students with various examples of different waste management systems and applications developed for better environmental control.

US-TBT-605
Applied component: Agri-Biotechnology (TBT605)
The course allows students to learn and understand the basic concepts and molecular markers in Plant breeding and crosses. It also aids in the understanding of phytopathology and plant stress. The coursework also provides the in-depth knowledge of biofertilizers and biopesticides.

1. **Process adopted for curriculum designing:**

The curriculum was designed in a stepwise manner, firstly based on feedback obtained from department teachers and students. Later several meetings were conducted with representatives from academia, industries and research institutions to assure that the syllabus is enriched in all the aspects.

2. **Salient features, how it has been made more relevant:**

While designing of the syllabus, care has been taken to balance biotechnological techniques with entrepreneurship skills .The course would help the students to develop creativity in designing products, build research skills, and provide better employment opportunities in areas like health care, agriculture, industry and environment.

3. **Learning Outcomes:**

The third year program is so designed as to educate the students about different disciplines of biotechnology. The syllabus is made with an approach on promoting interdisciplinary skills of sciences. The syllabus nourishes critical thinking, creates creativity and shares the importance about`` current requirement of biology in the world through topics like marine biotechnology, industrial biotechnology, enzymology, medical microbiology, pharmacology, agricultural biotechnology, etc. The student acquires the skills to analyse, correlate, and create solutions to different problems in the day-to-day life. The program focuses on making an individual sustain in the industries.

1. The program focuses on exploring the novels of theoretical biology through topics like developmental biology, cell signalling, and cancer.
2. The syllabus appreciates in prospecting discipline through marine biotechnology, biochemistry, pharmacology.
3. The program would enhance the student's orator skills and boost the confidence while explaining scientific terminologies.
4. The course focuses on teaching the problems of the world towards environmental, agricultural biotechnologies.
5. The student realizes a problem and works towards it by conducting experiments, analysing and interpreting the data through research work.
6. During the course of program, the student grasps industrial importance exploiting enzymes, microorganisms, and plants to produce energy, industrial chemicals and consumer goods, quality control and quality assurance.
7. The course accustoms the process of using recombinant DNA (rDNA) technology to alter the genetic makeup of an organism. Understand the importance of current advances in the field of human genome mapping, sequencing techniques.
8. Students would be equipped with knowledge and understanding of basic microbiological, bioanalytical, molecular biology skills in laboratory techniques viz. gradient technique, bioassays, enzymology, etc.

4. Input from stakeholders

Many new topics have been introduced to the students such as Developmental Biology, Marine Biotechnology, food processing and Neurochemistry. These topics have been included to give an exposure to broader spectrum of biotechnology and to get an insight about various disciplines of biology. On the other hand, the existing components are modified and shuffled in both the semesters based on period required to complete the particular paper. As suggested by the industrial, research and academic experts, practical applications of the fundamental techniques were incorporated and missing links between different subtopics were introduced. Subtopics more streamlined and were made specific (depth of the content).Newly introduced concepts like food processing; industry expert suggested food safety and precision agriculture. As suggested by academic experts, new topics such as Enzymology, Gene therapy, Marine ecology and phytopathology were introduced to the students at this basic level so that they are aware of these niche branches of biology. Also Mass spectrometry and amino acid sequencing was added to the existing protein biochemistry topic as an extension to identify proteins after their purification. Application of enzymes in industries was introduced to provide more depth to industrial microbiology component of the syllabus. Conventional methods of plant breeding was added to the Agribiotechnology applied component to establish correlation with the existing component of molecular markers used in plant breeding. These changes were suggested by research and industrial experts as these topics will act as connecting links between academia and research. As these techniques are currently been used in research and R&D departments of industries. The bioanalytical component and genetic engineering component assures that students are well versed with the principle and application of instruments and genetic engineering techniques required to produce transgenic organisms. The Biosafety and food processing in semester 5 was added at basic level so that the students get an idea about the field of food technology and the risk management of biohazards. Similarly, the component of Agribiotechnology was added as applied component of semester 6 to get insights about plant breeding and application of biotechnology in the field of agriculture.

Part 1- Preamble

The world today is living and benefiting from the present 'Era of Biotechnology'. Biotechnology is one of the recent branches of Life Sciences, which has extended and built up as a progressed multidisciplinary applied science in most recent couple of years. Biotechnology at its heart conceives a far-reaching investigation of the building blocks of life and this has prompted a novel status for Biotechnology in research and industry.

The financial capability of Biotechnology is settled which has nearly gotten synonymous with current improvement. Biotechnology has its applications in every field contacting every human action. Applied Biotechnology is presently a work in press finding applications in Industry, Agriculture, Health and Environment.

Biotechnology necessitates well-trained and duly skilled individuals to constitute Industry and Research divisions. The field is novel and thus requests contributions to Infrastructure and Technology from all fields. The worldwide focus is now growing around inventions that can ease life and purpose. Biotechnology is destined to introduce a paradigm shift in the world's technologies and human perspective.

The interest for prepared workforce in Biotechnology is regularly developing in Fundamental Research and Industry Sector. Scholastic and Research Sectors likewise require interdisciplinary prepared labour to facilitate the Biotechnology Revolution.

The need of great importance is to configure a prospectus, which keeps pace with changing occasions and innovation with stresses on applications while clarifying innovation top to bottom. The present syllabus is drafted foreseeing the future needs of Biotechnology Sector with more accentuation on granting hands-on aptitudes. The central purpose is laid on making schedule perfect with improvements in academics, research and commercial divisions. The theory and practical course introduced will prompt range of abilities to advance Biotechnology Sector.

The rebuilt prospectus consolidates fundamental knowledge of Physics, Chemistry and Biology considering headways in innovation. The educational program plans to grant essential information with accentuation on its applications to prepare the understudies business

To comply with the education policy of Government of India, we have included Online Courses (OLC), which is available on NPTEL or SWAYAM portals under MOOCS programme being developed by MHRD. The online SLE (Self Learning and Evaluation) courses would inculcate the habit of self-study at their own pace by the students and acclimatize them to future technologies of learning processes.

Part 2- The Scheme of Teaching and Examination is as under:

Semester –V

Summary

Sr. No.	Choice Based Credit System			Subject Code	Remarks
1	Core Course (**Biotechnology**)			US-TBT-501, US-TBT-502, US-TBT-5P1, US-TBT-503, US-TBT-504, US-TBT-5P2	
2	Elective Course	Discipline Specific Elective (DSE) Course			
		2.1	Interdisciplinary Specific Elective (IDSE) Course	US-TBT-505, US-TBT-5P3	
		2.2	Dissertation/Project		
		2.3	Generic Elective (GE) Course		
3	Ability Enhancement Courses (AEC)				
4	Skill Enhancement Courses (SEC)				

Third Year Semester V Internal and External Detailed Evaluation Scheme

Sr. No.	Subject Code	Subject Title	Periods Per Week						Internals				Total Marks
			Units	S.L.	L	T	P	Credit	S.L.E.	CT+AT= 15+5	PA	SEE	
1	US-TBT-501	Cell Biology and Developmental Biology	4	20%*	3	0	0	2.5	10	20	10	60	100
2	US-TBT-502	Medical Microbiology , Bioanalytical techniques and Biostatistics	4	20%*	3	0	0	2.5	10	20	10	60	100
3	US-TBT-503	Genomics and Molecular Biology	4	20%*	3	0	0	2.5	10	20	10	60	100
4	US-TBT-504	Marine Biotechnology	4	20%*	3	0	0	2.5	10	20	10	60	100
5	US-TBT-505	Biosafety and Food Biotechnology	4	20%*	3	0	0	2	10	20	10	60	100
8	US-TBT-5P1	Practicals Based US-TBT-501 + Practicals Based US- TBT-502			0		6	3				100	100
9	US-TBT-5P2	Practicals Based US- TBT-503 + Practicals Based US- TBT-504			0		6	3				100	100
10	US-TBT-5P3	Practicals Based US- SBT-505			0		6	2				100	100
	Total Hours / Credit							20	Total Marks				1000

Third Year Semester V - Units – Topics – Teaching Hours

S.N	Subject Code	Subject Unit Title		Hours /Lectures	Total No. of hours/lectures	Credit	Total Marks
1	US-TBT-501	1	Cell Cycle	15	60 L	2.5	100 (60+40)
		2	Cell Signaling	15			
		3	Developmental Biology	15			
		4	Cancer Biology	15			
2	US-TBT-502	1	Virology	15	60L	2.5	100 (60+40)
		2	Chemotherapeutic drugs	15			
		3	Enzymology	15			
		4	Bioanalytical techniques and Biostatistics	15			
3	US-TBT-503	1	Genetic engineering of plants	15	60L	2.5	100 (60+40)
		2	Transgenic Animals	15			
		3	Tools in molecular biology and cloning vectors in animals	15			
		4	Recombinant protein , Genome sequencing and mobile DNA elements	15			
4	US-TBT-504	1	Marine Biotechnology- Introduction & Marine organisms	15	60L	2.5	100 (60+40)
		2	Marine Drugs and Enzymes	15			
		3	Marine functional foods, Cosmetics and Biotoxins	15			
		4	Tools, Methodology and Pollution in Marine Ecosystem	15			
5	US-TBT-505	1	Introduction to biosafety	15	60L	2	100 (60+40)
		2	Good Laboratory Practices (GLP)	15			
		3	Food processing and preservation	15			
		4	Food Safety and Quality Assurance	15			
6		1	Practicals based on US-TBT-501	3		3	100

	US-TBT-3P1	2	Practicals based on US-TBT-502	3	72 lectures per batch		(80+10 +10)
7	US-TBT-3P2	1	Practicals based on US-TBT-503	3	72 lectures per batch	3	100 (80+10 +10)
		2	Practicals based on US-TBT-504	3			
8	5P3	3	Practicals based on US-TBT-505	3	48 lectures per batch	2	100 (80+10 +10)
			TOTAL			20	1000

- **Lecture Duration – 50 Minutes = 0 .83 Hours. (45 Lectures equivalent to 33.75 hours)**
- **One Credit =19.92 hours equivalent to 20 Hours**

L: Lecture: Tutorials P: Practical Ct-Core Theory, Cp-Core Practical, SLE- Self learning evaluation CT-Commutative Test, SEE- Semester End Examination , PA-Project Assessment, AT-Attendance

Course code: US-TBT-501 Cell Biology and Developmental Biology

Unit	Content	No. of Lectures
1	**Cell Cycle** 1.1. **Cell cycle Introduction(3L)** 1.1.1. Prokaryotic Cell Cycle 1.1.2. Eukaryotic Cell Cycle 1.2. **The Early Embryonic Cell Cycle and the Role of MPF(4L)** 1.3. **Yeasts and the Molecular Genetics of Cell-Cycle Control(4L)** 1.4. **Apoptosis, Cell-Division Controls in Multicellular Animals(4L)**	15
2	**Cell Signaling** **2.1. Introduction to cell signaling and signal transduction (3L)** 2.1.1. General Principles of Cell Signaling 2.2. **Signaling via G-Protein-linked Cell-Surface Receptors (3L)** 2.3. **Signaling via Enzyme-linked Cell-Surface Receptors (3L)** 2.4. **Target-Cell Adaptation, The Logic of Intracellular Signaling(3L)** 2.5. **Lessons from Computer-based "Neural Networks"(3L)**	15
3	**Developmental Biology** **3.1. Principles and Approaches to developmental biology(3L)** 3.1.1. The anatomical approach 3.1.2. The cellular basis of Morphogenesis 3.1.3. Evolutionary and medical embryology 3.1.4. Teratology and mathematical modelling 3.2. **Fertilization(3L)** 3.2.1. External fertilization in sea urchins 3.2.2. Internal fertilization in mammals 3.3. **Early development(3L)** 3.3.1. Early development in mammals, 3.3.2. Early development in sea urchins and Morphogenic determinants 3.2. **Pattern formation and segmentation in Drosophila(1L)** 3.3. **Late development in mammals- (3L)** 3.3.1. Anterior and posterior axis formation 3.4. **Desirable characteristics of Model organisms (2L)**	15

	3.3.1. Arabidopsis thalliana 3.3.2. Zebra fish 3.3.3. Frog	
4	**Cancer Biology** 4.1. **Cancer (4L)** 4.1.1. Introduction, 4.1.2. Development and causes of cancer 4.1.3. Properties of cancer cells, transformation, 4.2. **Tumour viruses (4L)** 4.2.1. Adenovirus, 4.2.2. Herpes virus, 4.2.3. Hepatitis C and B, 4.2.4. SV40 and polyomavirus, 4.2.5. Papillomavirus and retrovirus 4.3. **Oncogenes (4L)** 4.3.1. Proto-oncogenes, 4.3.2. Oncogenes- retroviral 4.3.3. Oncogenes in human cancer, 4.3.4. Functions of oncogene products, 4.4. **Tumour suppressor genes(2L)** 4.4.1. Identification, functions and role of Oncogenes and tumour suppressor genes 4.5. **Chemotherapy(1L)**	

Self-Learning topics (Unit wise):

Unit	Topic
1.1	Cell cycle checkpoints, Cyclin dependent kinases
2.5	Neural networks, G-protein Receptors
3.2	External fertilization, Patterning in drosophila
4.3	SV 40, p53

Online Resources

https://nptel.ac.in/courses/117105084
https://dth.ac.in/medical/course-inner.php?id=299
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3628882/
https://nptel.ac.in/courses/102106084
https://nptel.ac.in/courses/102106084
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2694755/
https://dth.ac.in/medical/courses/pathology/2/5/index.php

Course code: US-TBT-502 Medical Microbiology and Bioanalytical techniques

Unit	Content	No. of Lectures
1	**Virology** 1.1. **Introduction to viruses(2L)** 1.1.1. Position of viruses in biological spectrum 1.1.2. General structure and Properties of Viruses 1.2. **Baltimore Classification and Taxonomy(ICTV) (2L)** 1.3. **Cultivation of viruses (2L)** 1.4. **Reproduction of viruses (2L)** 1.4.1. Key steps of Viral Replication Cycle 1.4.2. Types of viral genome and their replication: 1.4.2.1. dsDNA, 1.4.2.2. ssDNA, 1.4.2.3. ss/dsDNA (using RNA intermediate), 1.4.2.4. dsRNA, 1.4.2.5. +ssRNA, 1.4.2.6. -ssRNA, 1.4.2.7. Viruses with ssRNA genome using dsDNA intermediate 1.5. **Virus purification and assays (1L)** 1.6. **Cytocidal infections and cell damage(2L)** 1.7. **Viroids and Prions(1L)** 1.8. **Bacteriophages (1L)** 1.9. **Vaccines (1L)** 1.10. **Viruses used in Genetic engineering- Adenovirus and Lentivirus (1L)**	15
2	**Chemotherapeutic drugs** 2.1. **Discovery and Design of antimicrobial agents(1L)** 2.2. **Classification of Antibacterial agents (2L)** 2.1.1. Selective toxicity, MIC and MLC 2.2. **Inhibition of cell wall synthesis (Mode of action for)(2L)** 2.2.1. Beta lactam antibiotics: Penicillin Cephalosporins 2.2.2. Glycopeptides: Vancomycin 2.2.3. Polypeptides: Bacitracin 2.3. **Injury to Plasma membrane (1L)** 2.3.1. Polymyxin 2.4. **Inhibition of protein synthesis(2L)** 2.4.1. Aminoglycosides,	15

	2.4.2. Tetracyclines 2.4.3. Chloramphenicol 2.4.4. Macrolides 2.4.5. Erythromycin **2.5. Inhibition of Nucleic acid synthesis (2L)** 2.5.1. Quinolones, 2.5.2. Rifampicin, 2.5.3. Metronidazole 2.6. **Antimetabolites:(1L)** 2.6.1. Sulphonamides, 2.6.2. Trimethoprim 2.7. **Drug Resistance (1L)** 2.7.1. Mechanism, Origin 2.7.2. and transmission of drug resistance **2.8. Use and misuse of antimicrobial agents(1L)** **2.9. Antifungal and Antiviral drugs(2L)**	
3	**Enzymology** 3.1. **Definition, Classification and nomenclature of enzymes (2L)** 3.2. **Chemical Nature and properties of Enzymes (1L)** 3.3. **Mechanism of Enzyme Action(2L)** 1.3.1. Active Sites, Enzyme Specificity, Co-factors 3.4. **Factors affecting enzyme activity(3L)** 4.1.1. pH 4.1.2. Temperature 4.1.3. Substrate Concentration **4.2. Enzyme Kinetics, Michaelis–Menten Equation(3L)** **4.3. Enzyme inhibitors and its types (4L)** 4.1.1. Competitive 4.1.2. Uncompetitive 4.1.3. Non-Competitive	
4	**Bioanalytical techniques and Biostatistics** 4.1**Principle, instrumentation, working and applications : (5L)** 4.1.1. Fluorescence Spectroscopy 4.1.2. Infrared Spectroscopy/Vibrational Spectroscopy 4.1.3. Fourier Transform Infrared Spectroscopy 4.1.4. Atomic absorption Spectroscopy 4.1.5. Inductively Coupled Plasma Mass Spectrometry 4.2. **Advanced instrumentation in Bioanalysis of clinical samples(1L)**	15

	4.2.1. Flowcytometer, blood gas analyzer, automatic haematology analyzer, blood glucose analyzer, alcohol breath analyzer 4.3. **Thermal methods of analysis(2L)** 4.3.1. Thermogravimetry 4.3.2. Differential thermal analysis 4.3.3. Differential scanning calorimetry 4.4. **Particle size analysis (2L)** 4.4.1. Dynamic image analysis (DIA), 4.4.2. Static laser light scattering (SLS) 4.4.3. Dynamic light scattering (DLS) 4.4.4. Sieve analysis. 4.5. **Validation of analytical methods (With Example of HPLC and HPTLC) (1L)** 4.6. **Biostatistical Analysis of generated data (4L)** 4.6.1. Steps in Testing Statistical Hypothesis 4.6.2. Parametric Tests: Z Test – Single Mean and Two Means 4.6.3. tTest – Single Mean, Paired and Unpaired 4.6.4. Chi Square Test	

Self-Learning topics (Unit wise):

Unit	Topic
1.7	Prions, Viroids
2.9	Superficial mycosis, cancer chemotherapy
3.3	Isozymes, Active site of enzymes
4.1 ,4.2	FTIR, Flow cytometry

Online Resources

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC346867/ https://dth.ac.in/medical/course-inner.php?id=137 https://dth.ac.in/medical/courses/pharmacology/2/8/index.php https://nptel.ac.in/courses/103108139 https://nptel.ac.in/courses/102105083 https://dth.ac.in/medical/course-inner.php?id=81 https://dth.ac.in/medical/course-inner.php?id=75

Course Code: US-TBT-5P1

Practical I	**Title of Paper: Cell Biology and Bioanalytical techniques**	**Total Credits: 2**
Unit	**Content**	**No. of Lectures**
	1. HPLC, GC and HPTLC methodology and validation. 2. MIC and MLC of any one antibiotic 3. Antibiotic sensitivity test using agar cup method 4. Antibiotic sensitivity test using paper disc method 5. Chick embryo candling and inoculation methods Demonstration experiment 6. Study of Mesophiles and Mesophilic enzymes: a. Isolation of mesophiles from compost b. Screening of potent cellulolytic mesophilic for study of cellulase enzyme (Qualitative) c. Folin Lowry method (Protein estimation) d. Evaluation of Thermal stability of the enzyme 7. Demonstration of Flow cytometry 8. Problems based on Biostatistics	**90**

Course Code: US-TBT-503 Genomics and Molecular Biology

Unit	Content	No. of Lectures
1	**Genetic engineering of plants** 1.1. **Methods in plant genetic engineering (4L)** 1.1.1. Plant transformation with the Ti plasmid of *A. tumefaciens*, 1.1.2. Ti plasmid derived vector system 1.2. **Vectors for plants (4L)** 1.2.1. Ti plasmid and Ri plasmid 1.2.2. Plant viruses as cloning vector (caulimovirus, geminivirus) 1.3. **Generation of Transgenic plants (5L)** 1.3.1. Physical methods of transferring genes to plants electroporation, 1.3.2. Microprojectile 1.3.3. Bombardment, 1.3.4. Liposome mediated transfer 1.3.5. Protoplast fusion 1.4. **Cloning in plants by direct gene transfer (2L)** 1.4.1. Chloroplast 1.4.2. Nucleus	15
2	**Transgenic Animals** 2.1. **Methodology of Transgenic mice generation (4L)** 2.1.1. Retroviral method 2.1.2. DNA microinjection 2.1.3. Embryonic Stem cells method 2.2. **Genetic manipulation with cre-loxP(1L)** 2.3. **Vectors for animal cells(3L)** 2.4. **Transgenic animal recombination system(3L)** 2.5. **Cloning livestock by nuclear transfer(2L)** 2.6. **Green Fluorescent Protein(1L)** 2.7. **Transgenic fish generation(1L)**	15
3	**Tools in molecular biology and cloning vectors in animals** 3.1. **Cloning vectors for:(4L)** 3.1.1. Yeast 3.1.2. Insects 3.1.3. Mammals	15

	3.2. **Construction of DNA libraries (2L)** 3.2.1. Genomic DNA libraries, 3.2.2. cDNA libraries 3.3. **Screening (3L)** 3.3.1. Hybridization screening, 3.3.2. Immunological screening, 3.3.3. Protein activity screening 3.4. **Detection (3L)** 3.4.1. HART, 3.4.2. HRT, 3.4.3. Chromosome walking and jumping 3.5. **Recombinant molecules(3L)** 3.5.1. Human insulin 3.5.2. Somatostatin 3.5.3. Interferons	
4	**Recombinant protein , Genome sequencing and mobile DNA elements** 4.1. **Analysis of recombinant proteins from Post Translational modification (3L)** 4.2. **DNA sequencing methods(5L)** 4.2.1. Maxam Gilbert's method 4.2.2. Sanger's dideoxy method 4.2.3. Automated DNA sequencing 4.2.4. Pyrosequencing 4.2.5. Next Generation Sequencing 4.3. **Human genome Project-Key conclusions(3L)** 4.3.1. Duchenne Muscular Dystropy 4.3.2. Cystic fibrosis 4.4. **Gene therapy -** somatic and germ line gene therapy**(4L)**	15

Self-Learning topics (Unit wise):

Unit	Topic
1.1, 1.2	Geminivirus, Micropropagation
2.2,2.5	Livestock improvement, cre-lox P system
3.1 ,3.2	DNA cloning and hybridization, plasmid vectors
4.2,4.4	Shotgun sequencing, Gene therapy

Online Resources

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6638828/
https://nptel.ac.in/courses/102103016
https://nptel.ac.in/courses/102103013
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6333611/
https://nptel.ac.in/courses/102104052
https://nptel.ac.in/courses/102103013
https://nptel.ac.in/courses/102104056
https://nptel.ac.in/courses/102103041

Course Code: US-TBT-504 Marine Biotechnology

Unit	Content	No. of Lectures
1	**Marine Biotechnology- Introduction & Marine organisms** 1.1. **Introduction to marine biotechnology (7 L)** 1.1.1. The marine ecosystem and its functioning 1.1.2. Ecosystems and habitats in marine environment 1.1.3. Intertidal zone 1.1.4. Estuarine zone 1.1.5. Salt marsh 1.1.6. Mangrove 1.1.7. Coral reef 1.1.8. Arctic, Antarctic 1.1.9. Coastal 1.1.10. Deep sea ecosystems 1.1.11. Hydrothermal vents 1.2. **Marine biotechnologically relevant microorganisms (8L)** 1.2.1. Fungus: Habitat and diversity, Collection, isolation and identification of fungus 1.2.2. Prototroph: Discovery of picoeukaryotic phytoplankton 1.2.3. Viruses: General features, Marine phages, Impact of marine viruses on mollusks 1.2.4. Marine algae: Microalgae, Macroalgae 1.2.5. Corals: Soft corals, Hard corals 1.2.6. Sponges and associated Microorganisms	15
2	**Marine Drugs and Enzymes** 2.1. **Cultivation techniques of marine bacteria (2L)** 2.2. **Marine drugs (3L)** 2.2.1. Omega –conotoxin MVIIA 2.2.2. Ecteinascidins 2.2.3. Cytarabine 2.3. **Marine natural products in advanced clinical trials: (6L)** 2.3.1. Aplidine 2.3.2. Halichondrin B 2.3.3. Bryostatin 1 2.3.4. Kahalalide F 2.3.5. Squalamine 2.4. **Marine enzymes (4L)** 2.4.1. Polysaccharide-degrading enzymes	15

	2.4.2. Proteases 2.4.3. Halogenating enzymes	
3	**Marine functional foods, Cosmetics and Biotoxins** 3.1. **Food marine-derived ingredients with biological properties (8L)** 3.1.1. Polysaccharide, 3.1.2. Proteins 3.1.3. Peptides and amino acids 3.1.4. Fatty acids 3.1.5. Pigments 3.1.6. Phenolic compounds 3.1.7. Minerals 3.2. **Cosmetics (1L)** 3.3. **Cosmeceuticals (3L)** 3.3.1. Components of cosmetics 3.3.2. Skin treatments on basis of marine derived products 3.4. **Marine toxins (3L)** 3.4.1. Lipophilic toxins 3.4.2. Hydrophilic toxins	15
4	**Tools, Methodology and Pollution in Marine Ecosystem** 4.1. **Bioinformatics techniques on marine genomics (5L)** 4.1.1. Bioinformatics resources 4.1.2. Application of Remote sensing in Oceanography 4.2. **Microbial bioprospecting in marine environments(5L)** 4.2.1. Culture dependent method 4.2.2. Culture independent methods 4.3. **Control of pollution using marine resources(5L)** 4.3.1. Aquaculture 4.3.2. Biofouling- quorum sensing 4.3.3. Biosorption of heavy metals	15

Self-Learning topics (Unit wise):

Unit	Topic
1.1, 1.2	Corals, Freshwater ecosystem
2.3	Anti- cancer drugs from marine organisms, cytarabine
3.1 ,3.3	Glycans, Marine based nutraceuticals
4.2,4.3	Quorum sensing, Proteomics

Online Resources

https://nptel.ac.in/courses/120108002
https://nptel.ac.in/courses/120108002
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6780632/
https://www.ncbi.nlm.nih.gov/books/NBK557680/
https://archive.nptel.ac.in/content/storage2/courses/102105089/pdf/Mod%2010_Lecture%2046_Protein%20Carbohydrate%20Interactions%20I.pdf
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4626693/
https://nptel.ac.in/courses/102106035
https://nptel.ac.in/courses/102103017

Course Code: US-TBT-5P2

Practical II	**Title of Paper: Molecular Biology and marine biotechnology**	**Total Credits: 2**
Unit	**Content**	**No. of Lectures**
	1. Phage titration 2. Gradient plate technique 3. Study of any 5 marine bacteria and algae (Macro and micro 4. DPPH assay for antioxidant extracted from marine algae 5. Extraction of carotenoids from marine algae/Bacteria/Fungi 6. Extraction and estimation of Gelatin / Collagen. 7. Extraction of alkaloids from marine organisms and their separation by TLC 8. Preparation of competent cells and transformation 9. Study of lac Gene Expression using Blue-White Selection 10. Detection of auxotroph by Replica Plate method	**90**

Course Code: US-TBT-505Applied Component: Biosafety and Food Biotechnology

Unit	Content	No. of Lectures
1	**Introduction to biosafety** 1.1. **Introduction to Biosafety (1L)** 1.1.1. Concepts on biosafety in Biotechnology 1.2. **Biological Risk Assessment:(2L)** 1.2.1. Hazardous Characteristics of 1.2.1.1. Agents 1.2.1.2. Laboratory Procedures 1.3. **Genetically modified agent hazards-Cell cultures(1L)** 1.4. **Potential Hazards Associated with Work Practices (1L)** 1.5. **Safety Equipment and Facility Safeguards(2L)** 1.6. **Pathogenic risk and management(1L)** 1.7. **Regulating rDNA technology(2L)** 1.8. **Genetically engineered crops, livestock Bioethics(3L)** 1.9. **Contemporary issues in Bioethics(2L)**	15
2	**Good Laboratory Practices (GLP)** 2.1. **Concept of GLP(1L)** 2.2. **Practicing GLP(1L)** 2.3. **Guidelines to GLP (3L)** 2.4. **Documentation of Laboratory work(2L)** 2.5. **Preparation of SOPs (2L)** 2.6. **Calibration records (1L)** 2.7. **Validation of methods (2L)** 2.8. **Documentation of results (1L)** 2.9. **Audits& Audit reports(2L)** 2.10. **Regulatory bodies**- IBSC, GEAC and RCGM	15
3	**Food processing and preservation** 3.1. **Food Additives – Intentional / Unintentional: (3L)** 3.1.1. Antioxidants, chelating agents, colouring agents, emulsions, flavoring agents, humectants and anticaking agents, leavening agents, nutrient supplements, non-nutritive sweeteners, pH controlling agents 3.2. **Processing of cereal grains: (2L)**	15

	3.2.1.Milling, parboiling, flakes, puffs, malting, starch extraction, gluten extraction. Semolina, pasta production 3.3. **Processing of Fruits and vegetables (1L)** 3.3.1. Jams, Ketchup, pickles 3.4. **Processing of Oilseeds (extraction of oil) (1L)** 3.5. **Probiotic, Prebiotics, synbiotic foods (1L)** 3.6. **Food Rheology (1L)** 3.7. **Processing of Meat (1L)** 3.7.1. Aging, Tenderizing, Curing 3.8. **Effect of processing on Nutritive Value of Foods:(1L)** 3.9. **Newer methods of food processing:** Microwave, high pressure, 3.9.1. Ohmic heating, radiation sterilization, minimally processed Foods. 3.10. **Principles and Methods of Food Preservation** 3.9.1. **Physical Methods (2L)** 3.10.1.1. Blanching, pasteurization, canning, chilling, freezing. Irradiation, dehydration**.** 3.9.2. **Chemical Methods(2L)** 3.10.1.2. Salt, sugar, Benzoate salts, metabisulfite salts, citrate, acetate. 3.11. **Emerging Preservation Technologies-Natural antimicrobials, hydrostatic pressure, electric pulse(1L)**	
4	**Food Safety and Quality Assurance** 4.1. **Principles of food spoilage (3L)** 4.1.1. Physical, 4.1.2. Chemical 4.1.3. Microbial 4.2. **Food Hazards(3L)** 4.2.1. **Microbial:** bacterial, fungal, protozoal, viral, emerging food pathogens 4.2.2. **Nonmicrobial: adulteration**, natural/artificial colouring agents, metals, etc. 4.3. **Food analysis(3L)** 4.3.1. Sensory, 4.3.2. Chemical, 4.3.3. Microbiological, 4.3.4. Rapid detection methods- ELISA, LFIA & Natural dye test 4.3.5. CDC programs – PulseNet, FoodNet	15

	4.4. **Safe Process Design and Operation (4L)** 4.4.1. GMP, 4.4.2. HACCP, 4.4.3. Food Hygiene and sanitation, 4.4.4. Risk assessment, 4.4.5. Flow sheets 4.5. **Food Standards and Laws**(2L) 4.5.1. National, 4.5.2. International legislation 4.5.3. Agencies governing food and its quality- FSSAI, FDA	

Unit	Topic
1.2, 1.4	GEAC, RCGM-RDAC
2.1	Concept of GLP
3.9	Probiotics, Principles of food preservation
4.4	HACCP, food biosensors

Self-Learning topics (Unit wise):

Online Resources

https://geacindia.gov.in/functions.aspx
https://ibkp.dbtindia.gov.in/Content/Commitee?AspxAutoDetectCookieSupport=1
https://onlinecourses.nptel.ac.in/noc20_bt31/preview
https://nptel.ac.in/courses/126103017
https://nptel.ac.in/courses/126105015
https://www.fda.gov/food/hazard-analysis-critical-control-point-haccp/haccp-principles-application-guidelines
https://nptel.ac.in/courses/126103017

Course Code: US-TBT-5P3

Practical III	**Title of Paper: Applied component**	**Total Credits: 2**
Unit	**Content**	**No. of Lectures**
	1. Calibration of measuring cylinders, colorimeters, fridge 2. Calibration of pH meter and weighing balance 3. Vitamin B12 bioassay 4. Testing for toxic adulterants in food 5. Estimation of starch content in the food 6. Estimation of reducing sugars and non-reducing sugars in the food 7. Determination of crude fiber (CF) in food sample 8.Sterility testing of injectable 9. Study of microbes involved in spoilage of any one food material-and writing a report	**90**

SEM VI

Part 2- The Scheme of Teaching and Examination is as under:
Semester – VI
Summary

Sr. No.	Choice Based Credit System			Subject Code	Remarks
1	Core Course (**Biotechnology**)			US-TBT-601, US-TBT-602, US-TBT-6P1, US-TBT-603, US-TBT-604, US-TBT-6P2	
2	Elective Course	Discipline Specific Elective (DSE) Course			
		2.1	Interdisciplinary Specific Elective (IDSE) Course	US-TBT-605, US-TBT-6P3	
		2.2	Dissertation/Project	Part of US-TBT-6P2	
		2.3	Generic Elective (GE) Course		
3	Ability Enhancement Courses (AEC)				
4	Skill Enhancement Courses (SEC)				

Third Year Semester VI Internal and External Detailed Evaluation Scheme

Sr. No.	Subject Code	Subject Title	Periods Per Week						Internals				Total Marks
			Units	S.L.	L	T	P	Credit	S.L.E.	CT+AT= 15+5	PA	SEE	
1	US-TBT-601	Biochemistry	4	20%*	3	0	0	2.5	10	20	10	60	100
2	US-TBT-602	Industrial Microbiology	4	20%*	3	0	0	2.5	10	20	10	60	100
3	US-TBT-603	Basic pharmacology and Neurochemistry	4	20%*	3	0	0	2.5	10	20	10	60	100
4	US-TBT-604	Environmental Biotechnology	4	20%*	3	0	0	2.5	10	20	10	60	100
5	US-TBT-605	Applied component: Agri-Biotechnology	4	20%*	3	0	0	2	10	20	10	60	100
8	US-TBT-6P1	Practicals Based US-TBT-501 + Practicals Based US- TBT-502			0		6	3				100 (80+20)	100
9	US-TBT-6P2	Practicals Based US- TBT-503 + Practicals Based US- TBT-504			0		6	3			50	50	100
10	US-TBT-6P3	Practicals Based US- SBT-505			0		6	2				100 (80+20)	100
	Total Hours / Credit							20	Total Marks				1000

L: Lecture: Tutorials P: Practical Ct-Core Theory, Cp-Core Practical, SLE- Self learning evaluation CT-Commutative Test, SEE- Semester End Examination , PA-Project Assessment, AT- Attendance

Third Year Semester VI - Units – Topics – Teaching Hours

S.N	Subject Code	Subject Unit Title		Hours /Lectures	Total No. of hours/lectures	Credit	Total Marks
1	US-TBT-601	1	Protein Biochemistry	15	60L	2.5	100 (60+40)
		2	Metabolism	15			
		3	Endocrinology	15			
		4	Nutrition	15			
2	US-TBT-602	1	Dairy technology	15	60L	2.5	100 (60+40)
		2	Fermentation process	15			
		3	Applications of Enzymes in industries	15			
		4	Quality Assurance and Quality control (QA-QC)	15			
3	US-TBT-603	1	Mechanism of drug action and its absorption	15	60L	2.5	100 (60+40)
		2	Drug distribution and Pharmacokinetics	15			
		3	Basic Toxicology and Regulatory Toxicology	15			
		4	Neurochemistry				
4	US-TBT-604	1	Renewable sources of energy	15	60L	2.5	100 (60+40)
		2	Industrial effluent treatment	15			
		3	Wastewater treatment	15			
		4	Hazardous waste management	15			
5	US-TBT-605	1	Plant breeding techniques	15	60L	2.5	100 (60+40)
		2	Phytopathology and stress in plants	15			
		3	Molecular Markers in Plant Breeding	15			
		4	Food Safety and Quality Assurance	15			
8		1	Practicals based on US-TBT-601	3		3	100

	US-TBT-6P1	2	Practicals based on US-TBT-602	3	72 lectures per batch		
9	US-TBT-6P2	1	Practicals based on US-TBT-603	3	72 lectures per batch	3	100 (50+50)
		2	Practicals based on US-TBT-604	3			
		3	Research Project		1-2 Months		
10	US-TBT-6P3	1	Practicals based on US-TBT-605	3	48 lectures per batch	2	100
			TOTAL			20	1000

- **Lecture Duration – 50 Minutes = 0 .83 Hours. (45 Lectures equivalent to 33.75 hours)**
- **One Credit =19.92 hours equivalent to 20 Hours**

Course Code: US-TBT-601 Biochemistry

Unit	Content	No. of Lectures
1	**Protein Biochemistry** 1.1. **Protein structure(2L)** 1.1.1. Protein Tertiary 1.1.2. Quaternary Structures 1.2. **Protein Denaturation and Folding(3L)** 1.3. **Protein Function(2L)** 1.3.1. Reversible Binding of a Protein to a Ligand: Oxygen-Binding Proteins 1.4. **Protein Interactions Modulated by Chemical Energy: Actin, Myosin, and Molecular Motors(3L)** 1.5. **Protein purification(3L)** 1.6. **Amino acid sequencing by Edman degradation and Mass spectrometry (2L)**	**15L**
2	**Metabolism** 2.1. **Carbohydrate biosynthesis and its regulation (2L)** 2.1.1. Peptidoglycan in Bacteria 2.2. **Starch and sucrose in Plants(3L)** 2.3. **Glycogen in Animals(3L)** 2.4. **Pancreas – insulin and glucagon(2L)** 2.5. **Biosynthesis and regulation of Cholesterol(4L)** 2.6. **Atherosclerosis(1L)**	**15L**

3	**Endocrinology** 3.1. **Mechanism of action of group I and II hormones(1L)** 3.2. **Hypothalamus hormones: Structure, storage release, transport, biochemical functions and disorders (2L)** 3.3. **Anterior Pituitary gland(2L)** 3.3.1. Growth Hormone 3.3.2. Stimulating hormones 3.4. **Posterior Pituitary gland(1L)** 3.4.1. Oxytocin 3.4.2. Vasopressin 3.5. **Thyroid gland(2L)** 3.5.1. Thyroxine 3.5.2. Calcitonin 3.6. **Parathyroid gland** : PTH **(1L)** 3.7. **Adrenal medulla(1L)** 3.7.1. Epinephrine 3.7.2. Norepinephrine 3.8. **Adrenal cortex** :Glucocorticoids**(1L)** 3.9. **Female Gonads(2L)** 3.9.1. Estrogen 3.9.2. Progesterone 3.10. **Male gonads** : testosterone **(1L)** 3.11. **Placenta** :hCG**(1L)**	**15L**
4	**Nutrition** 4.1. **Vitamins : Dietary sources, Bioactive form, Functions Associated Disorders(7L)** 4.1.1. Fat soluble (A,D, E and K) 4.1.2. Water soluble vitamins(Vitamin B complex ,Vitamin C) 4.2. **Minerals** :**Physiological and biochemical functions of principal elements(Ca, P, Na, K, Cl, Fe, and I) and trace elements(Zn, F, Cu, Se) (7L)** 4.3. **Nutritional Disorders (1L)** 4.3.1. Malnutrition 4.3.2. Over nutrition (obesity) 4.3.3. PEM (Kwashiorkor and Marasmus)	**15L**

Self-Learning topics (Unit wise):

Unit	Topic

1.2, 1.4	Protein tertiary and quaternary structure, Mass spectrometry
2.1	Cholesterol- important aspects of its structure, Atherosclerosis
3.9	Hormonal regulation, Steroid hormones
4.4	Coenzyme and Vitamins, Malnutrition

Online Resources

https://nptel.ac.in/courses/102105089 https://nptel.ac.in/courses/102101050 https://dth.ac.in/medical/course-inner.php?id=116 https://dth.ac.in/medical/course-inner.php?id=114 https://archive.nptel.ac.in/courses/102/106/102106087/ https://nptel.ac.in/courses/104108056 https://nptel.ac.in/courses/104103071 https://nptel.ac.in/courses/102101091

Course Code: US-TBT-602 Industrial Microbiology

Unit	Content	No. of Lectures
1	**Dairy technology** 1.1. **Introduction of milk (3L)** 1.1.1. Normal flora and its enumeration, starter cultures 1.2. **Fermented products (3L)** 1.2.1. Butter, yogurt, buttermilk 1.3. **Factors affecting bacteriological quality and pasteurization (3L)** 1.4. **Detection tests of milk quality (3L)** 1.4.1. Physical 1.4.2. Chemical 1.4.3. Biological 1.5. **Computational methods of milk quality evaluation (3L)** 1.5.1. Digital imaging 1.5.2. Image processing and its purpose 1.5.3. Digital image acquisition	**15L**
2	**Fermentation process** 2.1. **Introduction to inoculum development (2L)** 2.2. **Generation of Industrial products using fermentation (10L)** 2.2.1. Alcohol: Wine, Sherry and champagne 2.2.2. Miso and Soy sauce production 2.2.3. Antibiotics :Streptomycin/ cephalosporins 2.2.4. Amino acids: Lysine, Glutamic acid 2.2.5. Single cell protein 2.3. **Immobilization of microbial cells and enzymes (3L)**	**15L**

3	**Applications of Enzymes in industries** 3.1. **Commonly used industrial enzymes (3L)** 3.1.1. Amylase, Cellulases, Pectinases, Oxidoreductases, Lipase, Protease 3.2. **Enzymes used in Fruit Juice Production and Processing (3L)** 3.3. **Cell wall degrading enzymes (3L)** 3.4. **Enzymes in Brewing (3L)** 3.4.1. Alpha- amylase in fermentation 3.4.2. Enzymes in Malting and Mashing 3.5. **Enzymes in Dairy Applications (3L)** 3.5.1. Cheese making process 3.5.2. Milk Protein Hydrolysate beta-Galactosidase 3.5.3. Enzymes in Detergent and Textile Industry	**15L**
4	**Quality Assurance and Quality control (QA-QC)** 4.1. **Principles of Good Manufacturing Practice (3L)** 4.2. **Quality Assurance and the control of microbial risk in medicine (3L)** 4.3. **Quality Assurance in formulations of design and development (3L)** 4.4. **GPMP (Good Pharmaceutical Manufacturing Practices) (3L)** 4.5. **Quality Control Procedures (3L)** 4.5.1. Manufacture and quality control of immunological products 4.5.2. Sterility testing of pharmaceutical products 4.5.3. Requirements for implementing 4.6. **Quality Management System for Pharmaceutical products**	**15L**

Self-Learning topics (Unit wise):

Unit	Topic
1.1, 1.5	Physicochemical Properties Of Milk, Milk Spoilage
2.2	Wine, Glutamic Acid Production
3.9	Cheddar Cheese, Whey Protein
4.4	Good Manufacturing Practices

Online Resources

https://nptel.ac.in/courses/126105013 https://nptel.ac.in/courses/126105013 https://nptel.ac.in/courses/102105058 https://nptel.ac.in/courses/102105058

https://nptel.ac.in/courses/126105013
https://nptel.ac.in/courses/126105013
https://www.fda.gov/drugs/pharmaceutical-quality-resources/current-good-manufacturing-practice-cgmp-regulations

Course Code: US-TBT-6P1

Practical I	**Title of Paper: Biochemistry and Industrial Microbiology**	**Total Credits: 2**
Unit	**Content**	**No. of Lectures**
	1. Estimation of Milk protein-Pynes method 2. Microbial analysis of Milk by MBRT and RRT 3. Phosphatase test in Milk 4. DMC of milk sample 5. Isolation of Normal flora from Milk and curd 6. Determination of blood glucose levels for detection of diabetes mellitus 7. Estimation vitamin C by DCPIP method from food samples 8. Estimation of Fe and Ca titrimetrically 9. Sterility checking of injectable	**90**

Course Code: US-TBT-603 Basic pharmacology and Neurochemistry

Unit	Content	No. of Lectures
1	**Mechanism of drug action and its absorption** 1.1. **Mechanism of drug action(1L)** 1.2. **Drug receptors and biological responses (2L)** 1.2.1. Second-messenger systems, the chemistry of drug–receptor binding 1.3. **Dose–response relationship (2L)** 1.3.1. Quantal relationships 1.3.2. Graded responses 1.3.3. Therapeutic index 1.4. **Effective Dose (ED50) And Lethal Dose(LD50) (1L)** 1.5. **Potency and Intrinsic Activity (1L)** 1.6. **Drug antagonism - (2L)** 1.6.1. Chemical antagonism 1.6.2. Functional antagonism 1.6.3. Competitive antagonism 1.6.4. Equilibrium competitive 1.6.5. Nonequilibrium competitive 1.6.6. Noncompetitive antagonism 1.7. **Properties of biological Membranes that influence drug Passage(1L)** 1.8. **Mechanisms of solute transport Across membranes (1L)** 1.9. **Absorption of drugs from the alimentary tract(2L)** 1.9.1. factors affecting rate of gastrointestinal absorption 1.10. **Absorption of drugs from lungs and skin (1L)** 1.11. **Absorption of drugs after parenteral administration (1L)**	**15L**

2	**Drug distribution and Pharmacokinetics** 2.1. **Factors influencing drug distribution (2L)** 2.2. **binding of drugs to plasma proteins (1L)** 2.3. **Selective accumulation of drugs (1L)** 2.4. **Physiological barriers to drug distribution (3L)** 2.5. **Drug concentration–time profiles and basic pharmacokinetic parameters (3L)** 2.6. **Additional pharmacokinetic parameters (5L)** 2.6.1. Bioavailability 2.6.2. Clearance 2.6.3. Volume of Distribution 2.6.4. Protein Binding 2.6.5. Pharmacokinetics of single versus multiple dosing 2.6.6. Nonlinear pharmacokinetics	**15 L**
3	**Basic Toxicology and Regulatory Toxicology** 3.1. **Principles of toxicology (1L)** 3.2. **Manifestations of toxicity(2L)** 3.2.1. Organ Toxicity, 3.2.2. Immunotoxicity, 3.2.3. Reproductive Toxicity , 3.2.4. Toxic Effects on Genetic Material 3.2.5. Cell Replication 3.3. **Definitions used in Toxicology (1L)** 3.4. **Adverse reaction to drugs (4L)** 3.4.1. Allergy 3.4.2. Chronic organ toxicity 3.4.3. Impaired reproductive functions 3.5. **Exposure to non-therapeutic toxicants and treatment(7L)** 3.5.1. Specific poisonings: 3.5.2. Cyanide, 3.5.3. Methanol, 3.5.4. Ethylene glycol, 3.5.5. Hydrocarbons, 3.5.6. Volatile solvents, 3.5.7. Heavy metals 3.5.8. Herbicides and pesticides 3.5.9. Biological substances	15

4	**Neurochemistry** 4.1. **Anatomy and functioning of the neurons (1L)** 4.2. **Organization of brain (1L)** 4.3. **Neuronal pathways and systems (1L)** 4.4. **Propagation of nerve impulses (2L)** 4.5. **Neuronal excitation and inhibition using ion channels (3L)** 4.6. **Synapses and gap junctions (3L)** 4.7. **Action of Neurotoxins and neurotransmitters (4L)**	15

Self-Learning topics (Unit wise):

Unit	Topic
1.2,1.7	Drug-receptor interactions, Routes of administration
1.2, 1.6	Pharmacokinetics, Drug metabolism
3.2, 2.6	Toxicology of organic compounds, Allergy
4.7	Neurotransmitters, GABA

Online Resources

https://nptel.ac.in/courses/104106106 https://nptel.ac.in/courses/104106106 https://nptel.ac.in/courses/104106106 https://nptel.ac.in/courses/104106106 https://nptel.ac.in/courses/122106030 https://nptel.ac.in/courses/127106228 https://nptel.ac.in/courses/104105120 https://nptel.ac.in/courses/104105120

Course Code: US-TBT-604 Environmental Biotechnology

Unit	Content	No. of Lectures
1	**Renewable sources of energy** 1.1. **Energy sources renewable(4L)** 1.1.1. Solar energy 1.1.2. Wind power 1.1.3. Geothermal energy 1.1.4. Hydropower 1.1.5. Biomass energy 1.2. **Biogas technology(5L)** 1.2.1. Biogas plant & types 1.2.2. Biodigester 1.2.3. Biogas- composition, production and factors affecting production, 1.2.4. Uses of biogas 1.3. **Biofuels (4L)** 1.3.1. Microbial hydrogen production 1.3.2. Petrocrops 1.3.3. Algal Biofuels 1.4. **Carbon credits (1L)** 1.5. **Life cycle assessment in environmental management(1L)**	**15L**
2	**Industrial effluent treatment** 2.1. **Degradation of Xenobiotic compounds:(2L)** 1.1.1. Xenobiotic compounds in environment, Persistent compounds 2.2. **Chemical properties influencing biodegradability(2L)** 2.3. **Developing micro-organism and degradation mechanism-(2L)** 2.4. **Biodegradation of Xenobiotic compounds(3L)** 2.5. **Use of immobilized enzymes or microbial cells for treatment(1L)** 2.6. **Waste monitoring and management of Solid waste, treatment(3L)** 2.7. **Pollution indicator and biosensors(2L)**	15

3	**Wastewater treatment** 3.1. **Introduction to wastewater treatment(5L)** 3.1.1. Biological treatment, impact of pollutants on biotreatment 3.1.2. Use of packaged organisms and genetically engineered organisms in waste treatment 3.2. **Heavy metal pollution(5L)** 3.2.1. Sources, 3.2.2. Microbial systems for heavy metal accumulation, 3.2.3. Techniques used for heavy metal removal 3.3. **Biosorption(5L)** 3.3.1. By bacteria, fungi and algae, 3.3.2. Factors affecting biosorption limitations of biosorption	**15L**
4	**Hazardous waste management** 4.1. **Biodegradation of waste from industries(10L)** 4.1.1. Distillery 4.1.2. Dye industry 4.1.3. Antibiotic industry 4.1.4. Removal of oil spillage & grease deposits 4.2. **Medical solid waste management (2L)** 4.2.1. Processing and disposal 4.2.2. Evaluation of medical waste management 4.2.3. General remedial measures for medical waste management 4.3. **Radioactive waste (1L)** 4.4. **EPA and National Environmental Policy (2L)**	**15L**

Self-Learning topics (Unit wise):

Unit	Topic
1.1,1.3	Biodiesel production, Energy production from organic wastes through anaerobic digestion.
2.5,2.7	Enzyme immobilization, Biosensors
3.3	Metal leaching, Bioremediation
4.2	Waste handling, separation and storage at source, composting

Online Resources

Links
https://nptel.ac.in/courses/102105058 https://nptel.ac.in/courses/103107125 https://nptel.ac.in/courses/102105058 https://nptel.ac.in/courses/127105225 https://nptel.ac.in/courses/102105058 https://nptel.ac.in/courses/105107173

https://nptel.ac.in/courses/105103205 https://nptel.ac.in/courses/105103205

Course Code: US-TBT-6P2

Practical II	**Title of Paper: Basic pharmacology and Environmental biotechnology**	**Total Credits: 2**
Unit	**Content**	**No. of Lectures**
	1 LD 50, ED 50 evaluation using suitable models e.g. Daphnia 2. Study the effect of heavy metals on the growth of bacteria 3. Study of physico-chemical parameters of any one industrial effluent sample (pH, colour, turbidity, Total solids) 4. Estimation of chromium from Effluents (Demonstration) 5. Degradation of Azo Dyes using bacteria from effluent samples 6. Visit to ETP/ CETP 7. Book review (Emperor of all Maladies)	**90**

Course Code: US-TBT-605 Applied component: Agri-Biotechnology

Unit	Content	No. of Lectures
1	**Plant breeding techniques** 1.1. **Plant breeding techniques (5L)** 1.1.1. Aim and objectives of plant breeding, it's significance in crop development, 1.1.2. Various methods of plant breeding in self and cross pollinated crops, acclimatization , selection, 1.1.3. Pure line theory 1.2. **Genetic consequences and difference between self and cross pollinated crops (5L)** 1.2.1. Clonal selection, 1.2.2. Population improvement programme, 1.2.3. Heterosis: genetical and physiological basis 1.3. **Male sterility and it's exploitation, (1L)** 1.4. **Interspecific/ intergeneric hybridization, (1L)** 1.5. **Polyploidy: genotype and environment interactions, importance of polyploidy in plant breeding (2L)** 1.6. **Introduction to seed production(1L)**	**15L**
2	**Phytopathology and stress in plants** 2.1. **Introduction to the science of phytopathology (1L)** 2.2. **Classification of plant diseases, symptoms, signs, and related terminology (1L)** 2.3. **Stress in plants-Abiotic stress (4L)** 2.3.1. Physiological and molecular responses of plants to water 2.3.2. Stress, salinity stress, temperature stress – heat and cold, Photo oxidative 2.3.3. Stress, stress perception and stress signaling pathways, Ionic and 2.3.4. Osmotic homeostasis, reactive oxygen species scavenging 2.4. **Stress in plants-Biotic stress (3L)** 2.4.1. Parasitic causes of plant diseases (fungi, bacteria, viruses, protozoa, algae), 2.5. **Non- parasitic causes of plant diseases(3L)** 2.6. **Infection process- Survival and dispersal of plant pathogens (1L)**	**15L**

	2.7. **Plant disease epidemiology (1L)** 2.8. **Principles and methods of plant disease management (1L)**	
3	**Molecular Markers in Plant Breeding** 3.1. **Genetic markers in plant breeding (5L)** 3.1.1. Classical markers, 3.1.2. DNA markers(RFLP, RAPD, AFLP, SSR, SNP) 3.2. **Application of Molecular Markers to Plant Breeding [LOD Score, quantitative trait locus (QTL) mapping] (5L)** 3.3. **Plant DNA Barcoding (5L)** 3.3.1. Barcoding markers (matk, rbcl, ITS, tmhpsba), 3.3.2. Steps involved 3.3.3. Recent advances 3.3.4. Benefits, 3.3.5. Limitations	**15L**
4	**Biofertilizers and Biopesticides** 4.1. **Biofertilizers: (2L)** 4.1.1. Nitrogen-fixing Rhizobacteria - Symbiotic Nitrogen Fixers 4.1.2. Nonsymbiotic Nitrogen Fixers 4.2. **Plant Growth Promoting Microorganisms (2L)** 4.2.1. Phosphate Solubilizing Microbes (PSM), 4.2.2. Phytohormones 4.3. **Induced Systemic Resistance- (2L)** 4.4. **Plant Growth Promotion by Fungi–Mycorrhizae(3L)** 4.4.1. Arbuscular Mycorrhizae 4.4.2. Ectomycorrhizae 4.5. **Microbial Inoculants (3L)** 4.5.1. Inocula, carriers, and applications 4.5.2. Monoculture and co-culture 4.5.3. Inoculant formulations 4.5.4. Biocontrol, 4.5.5. Polymicrobial inoculant formulations 4.6. **Biopesticides (3L)** 4.6.1. Types of biopesticides 4.6.2. Use of *Bacillus thuringiensis* in Biopesticides, 4.6.3. Insect viruses 4.6.4. Entomopathogenic fungi(characteristics, physiology, mechanism of action and application	**15L**

Self-Learning topics (Unit wise):

Unit	Topic
1.5, 1.6	Triploid production by Endosperm culture, Artificial seed production
2.5,2.6	Role of Jasmonic acid in plants, Host plant resistance
3.1	Marker assisted plant breeding, RAPD
4.1,4.6	Biofertilizer production, Biopesticide production

Online Resources

https://nptel.ac.in/courses/102103016 https://nptel.ac.in/courses/102103016 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7073113/ https://nptel.ac.in/courses/126104003 https://nptel.ac.in/courses/102103013 https://www.ncbi.nlm.nih.gov/probe/docs/techrapd/ https://nptel.ac.in/courses/102105058 https://nptel.ac.in/courses/102105058

Course Code: US-TBT-6P3

Practical III	**Title of Paper: Applied component**	**Total Credits: 2**
Unit	**Content**	**No. of Lectures**
	1.RAPD analysis demonstration experiment 2.Isolation of Rhizobium 3.Isolation of Azotobacter 4.Isolation of Phosphate solubilizing bacteria 5.Study of effect of abiotic stress on plants 6.Rapid screening tests for abiotic stress tolerance (drought, PEG, Mannitol & salinity NaCl) 7.Estimation of antioxidants and antioxidant enzymes 8.Evaluation of effect of stress on Ascorbate, Catalase, and Peroxidase activity 9.Visit to greenhouse facility and submission of field visit report	**90**

Reference Books-Semester V

US-TBT-501

1. Molecular Cell Biology. 7th Edition, (2012) Lodish H., Berk A, Kaiser C., K Reiger M., Bretscher A., Ploegh H., Angelika Amon A., Matthew P. Scott M.P., W.H. Freeman and Co., USA
2. Molecular Biology of the Cell, 5th Edition (2007) Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Garland Science, USA
3. Cell Biology, 6th edition, (2010) Gerald Karp. John Wiley & Sons., USA
4. The Cell: A Molecular Approach, 6th edition (2013), Geoffrey M. Cooper, Robert E. Hausman, Sinauer Associates, Inc. USA
5. Developmental Biology; Scott Gilbert; 9th Edition.

US-TBT-502

1. Principles and techniques in biochemistry and molecular biology (2010), Keith Wilson and John Walker, 7th edition, Cambridge University Press
2. Biophysics (2002) Vasantha Pattabhi and N. Gautham, Kluwer Academic Publishers
3. Physical Biochemistry: principles and applications, 2nd edition (2009), David Sheehan, John Wiley & Sons Ltd.
4. Mim's Medical Microbiology 5th edition
5. Microbiology by Prescott Harley and Klein 5th edition Mc Graw Hill
6. Medical Microbiology Jawetz,E., Brooks,G.E, Melnick,J.L., Butel,J.S Adelberg E. A 18th edition
7. Medical Microbiology by Patrick Murray 5th edition
8. Foundations In Microbiology by Talaro and Talaro Third edition W.C Brown
9. Understanding Viruses by Teri Shors
10. Biochemistry by Donald Voet and Judith Voet 4th edition.

US-TBT-503

1. iGenetics A Molecular Approach 3rd Edition Peter J. Russell.
2. Molecular Biotechnology-Principles and Applications of Recombinant DNA
3. Technology 3rd Edition Glick B.R., Pasternak J.J., Patten C.L.
4. Principles of Gene Manipulation 7th Edition Primrose S.B., Twyman R.M.
5. Biotechnology 3rd Edition S.S. Purohit.
6. Genomes 3rd Edition T.A. Brown.
7. Biotechnology B.D. Singh.
8. Gene Cloning and DNA Analysis 6th Edition T.A. Brown.
9. Genomics Cantor C.R., and Smith C.L. John Wiley & Sons. (1999)

10. Human y-interferon expression in the mammary gland of transgenic mice DOI: 10.1016/0014-5793(93)80063-z
11. What is next generation sequencing? doi: 10.1136/archdischild-2013-30434

US-TBT-504

1. Kim, S.K. Springer Handbook of Marine Biotechnology; Springer: Berlin, Germany; Heidelberg, Germany, 2015.
2. Blanca Hernández-Ledesma, Miguel Herrero-Bioactive Compounds from Marine Foods-Plant and Animal Sources-Wiley-Blackwell (2013)
3. Fabio Rindi, Anna Soler-Vila, Michael D. Guiry (auth.), Maria Hayes (eds.)-Marine Bioactive Compounds_ Sources, Characterization and Applications-Springer US (2012)
4. W. Evans-Trease and Evans Pharmacognosy 15th ed.-Saunders (2010)
5. Applications of Remote Sensing in Satellite Oceanography: A Review-https://doi.org/10.1016/j.aqpro.2015.02.075

US-TBT-505: APPLIED COMPONENT

1. Pharmaceutical Microbiology-Hugo, W.B, Russell, A.D 6theditionOxford Black Scientific Publishers.
2. Biosafety in Microbiological and Biomedical Laboratories-5thEdition, L. Casey Chosewood Deborah E. Wilson U.S. Department of Health and Human Services Centers for Disease Control and Prevention National Institutes of Health.
3. Molecular Biotechnology –Principles and Applications of Recombinant DNA Glick, B.R. Pasternak, J.J Patten, C.L 3rdeditionASM press
4. Food Microbiology by William C. Frazier and Dennis C. Westhoff – 4th Edition
5. FSSAI Manual Chapter 1

Reference Books-Semester VI

US-TBT-601

1. Lehninger, principles of biochemistry, 4th edition (2005), David Nelson and Michael Cox *W.H. Freeman* and Company, New York.
2. Biochemistry , 4th edition (2010), Voet and Voet, John Wiley and sons, USA
3. Harper's Illustrated Biochemistry, 27th edition, RK Murray, DK Granner, PA Mayes and VW Rodwell, McGraw Hills publication.
4. Biochemistry, 4nd edition (2017), Satyanarayana and Chakrapani, Books & Allied (P) Ltd
5. Nutrition Science, 6th edition (2017), Srilakshmi, new age international publishers.

US-TBT-602

1. Applied Dairy Microbiology Elmer H Marth and James L Steele Mercel Dekker Inc New York, 2nd edition
2. Microbial Technology Peppler,H.J and Perlman,D 2nd Academic Press Practicals
3. Industrial Microbiology Prescott and Dunn CBS publishers
4. Dairy technology by Yadav and Grower
5. Fermentation technology by Stanbury and Whitaker
6. Pharmaceutical Microbiology by Russel and Hugo
7. Enzymes in industry, W Aehle Processing technologies for milk and milk products by Ashok Kumar Agarwal and Megh R Goyal, CRC press.

US-TBT-603

1. Textbook of Medical Physiology Guyton, A.C and Hall 11th edition J.E Saunders
2. Modern Pharmacology with clinical Applications Craig,C.R, Stitzel,R.E 5th edition
3. Clinical Pharmacology Bennet, PN Brown,M.J, Sharma,P 11th edition Elsevier
4. Biochemistry Metzler, D.E Elsevier

US-TBT-604

1. Environmental Biotechnology Allan Scragg Oxford University press
2. Environmental Biotechnology (Basic concepts and applications) Indu Shekar Thakur IK

3. Internationals
4. Environmental Biotechnology (Industrial pollution management) S. D. Jogdand Himalaya Publishing House
5. Clean Development Mechanism and Carbon Credits A Primer, Professional Development Committee The Institute of Chartered Accountants of India (Set up by an Act of Parliament) New Delhi
6. A Guide for EPA Region 8 Small Communities 2010 Revised Edition
7. Environmental Management by Iyyanki V.Muralikrishna Valli Manickam

US-TBT-605: Applied component: Agri-Biotechnology

1. Principles of Plant Breeding by Allard R W 1960 .Kalyani Publishers, New Delhi
2. Principles of Plant Breeding by Singh B.D 1983 .Kalyani Publishers, New Delhi.
3. Principles of Genetics by Gardner E.J, M.J Simons and D.P Sanstad 1991.John Wiley and Sons Inc New York
4. Introduction to principles of plant pathology by R. S. Singh, Oxford and IBH Publ. Co., New Delhi (1996)
5. Essentials of plant pathology by V. N. Pathak, Prakash Publ., Jaipur (l972)
6. Plant pathology by G. N. Agrios 4th edition, Academ. Press, New york (2004)
7. Introductory Plant Pathology by M. N. Kamat, Prakash Publications, Jaipur (l967)
8. Plant diseases by R. S. Singh 1983 Oxford and IBH Publishing Co. New Delhi.
9. Introductory Plant Pathology by H.C. Dube
10. M. Ajmal Ali, G. Gyulai, F. Al-Hemaid -Plant DNA Barcoding and Phylogenetics, LAP Lambert Academic Publishing (2015)
11. P. Parvatha Reddy (auth.)-Sustainable Crop Protection under Protected Cultivation-Springer Singapore (2016)
12. S.B. Anderson (ed.), Plant Breeding from Laboratories to Fields, InTech,2013 Henry Leung, Subhas Chandra Mukhopadhyay (eds.) - Intelligent Environmental Sensing (2015, Springer International Publishing)
13. Travis R. Glare, Maria E. Moran-Diez - Microbial-Based Biopesticides_ Methods and Protocols (2016, Humana Press)
14. Altieri, Miguel A.Farrell, John G-Agroecology- The Science Of Sustainable Agriculture, Second Edition-CRC Press (2018)
15. Arie Altman, Paul Michael Hasegawa-Plant Biotechnology and Agriculture_ Prospects for the 21st Century-Academic Press (2011)