॥ सा विद्या या विमुक्तये ॥

स्वामी रामानंद तीर्थ मराठवाडा विद्यापीठ, नांदेड

'ज्ञानतीर्थ', विष्णुपुरी, नांदेड – ४३१ ६०६ (महाराष्ट्र राज्य) भारत

SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

'Dnyanteerth', Vishnupuri, Nanded - 431 606 (Maharashtra State) INDIA

स्वामी रामानंद तीर्थ मराठवाडा विद्यापीठ, नांदेड

Established on 17th September, 1994, Recognized By the UGC U/s 2(f) and 12(B), NAAC Re-accredited with 'B++' grade

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विज्ञान व तंत्रज्ञान विद्याशाखे अंतर्गत राष्ट्रीय शैक्षणिक धोरण २०२० नुसार पदव्यूत्तर द्वितीय वर्षाचे अभ्यासक्रम (Syllabus) शैक्षणिक वर्ष २०२४–२५ पासून लागू करण्याबाबत.

प रि प त्र क

या परिपत्रकान्वये सर्व संबंधितांना कळविण्यात येते की, या विद्यापीठा अंतर्गत येणा–या सर्व संलग्नित महाविद्यालयामध्ये शैक्षणिक वर्ष २०२४–२५ पासून राष्ट्रीय शैक्षणिक धोरणानुसार पदव्यूत्तर द्वितीय वर्षाचे अभ्यासक्रम लागू करण्याच्या दृष्टीकोनातून विज्ञान व तंत्रज्ञान विद्याशाखे अंतर्गत येणा–या अभ्यासमंडळांनी तयार केलेल्या पदव्यूत्तर द्वितीय वर्षाच्या अभ्यासक्रमांना मा. विद्यापरिषदेने दिनांक १५ मे २०२४ रोजी संपन्न झालेल्या बैठकीतील विषय क्रमांक १५/५९–२०२४ च्या ठरावाअन्वये मान्यता प्रदान केली आहे. त्यानुसार विज्ञान व तंत्रज्ञान विद्याशाखेतील खालील एम. एस्सी द्वितीय वर्षाचे अभ्यासक्रम (Syllabus) लागू करण्यात येत आहेत.

1) M. Sc. II year Biotechnology (Affiliated College)
2) M. Sc. II year Biotechnology (Campus)
3) M. Sc. II year Bioinformatics (Sub Campus Latur)
4) M. Sc. II year Bioinformatics (Affiliated College)
5) M. Sc. II year Clinical Research (Affiliated College)
6) M. Sc. II year Botany (Campus)
7) M. Sc. II year Herbal Medicine
8) M. Sc. II year Boany (Affiliated College)
9) M. Sc. II year Geology (Campus)
10) M. Sc. II year Dairy Science
11) M. Sc. II year Electronics
12) M. Sc. II year Environmental Science
13) M. Sc. II year Environmental Science (Campus)
14) M. Sc. II year Geography (Campus)
15) M. Sc. II year Applied Mathematics
16) M. Sc. II year Mathematics
17) M. Sc. II year Mathematics (Campus)
18) M. Sc. II year Microbiology
19) M. Sc. II year Microbiology (Campus)
20) M. Sc. II year Statistics
21) M. Sc. II year Statistics (Campus)

सदरील परिपत्रक व अभ्यासक्रम प्रस्तुत विद्यापीठाच्या **www.srtmun.ac.in** या संकेतस्थळावर उपलब्ध आहेत. तरी सदरील बाब ही सर्व संबंधितांच्या निदर्शनास आणून द्यावी, ही विनंती.

'ज्ञानतीर्थ' परिसर,
विष्णुपुरी, नांदेड – ४३१ ६०६.
जा.क्र.:शै–१/एनइपी/विवत्रंविपदवी/२०२४–२५/१०९
दिनांक १२.०६.२०२४

डॉ. सरिता लोसरवार
सहा.कुलसचिव
शैक्षणिक (१–अभ्यासमंडळ) विभाग

प्रत : १) मा. आधिष्ठाता, विज्ञान व तंत्रज्ञान विद्याशाखा, प्रस्तुत विद्यापीठ.
२) मा. संचालक, परीक्षा व मुंल्यमापन मंडळ, प्रस्तुत विद्यापीठ.
३) मा. प्राचार्य, सर्व संबधित संलग्नित महाविद्यालये, प्रस्तुत विद्यापीठ.
४) मा. संचालक, सर्व संकुले परिसर व उपपरिसर, प्रस्तुत विद्यापीठ
५) सिस्टीम एक्सपर्ट, शैक्षणिक विभाग, प्रस्तुत विद्यापीठ. याना देवून कळविण्यात येते की, सदर परिपत्रक संकेतस्थळावर प्रसिध्द करण्यात यावे.

SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

STRUCTURE AND SYLLABUS OF TWO-YEAR MASTERS

PROGRAM IN SCIENCE

UNDER

NATIONAL EDUCATION POLICY (NEP 2020)

In

SUBJECT: BIOTECHNOLOGY

FACULTY OF SCIENCE AND TECHNOLOGY

M. Sc. Second Year

(Affiliated Colleges)

With Effect From June 2024

From the Desk of the Dean, Faculty of Science and Technology:

Swami Ramanand Teerth Marathwada University, Nanded, enduring to its vision statement "***Enlightened Student: A Source of Immense Power***", is trying hard consistently to enrich the quality of science education in its jurisdiction by implementing several quality initiatives. Revision and updating curriculum to meet the standard of the courses at national and international level, implementing innovative methods of teaching-learning, improvisation in the examination and evaluation processes are some of the important measures that enabled the University to achieve ***the 3Es, the equity, the efficiency*** and ***the excellence*** in higher education of this region. To overcome the difficulty of comparing the performances of the graduating students and also to provide mobility to them to join other institutions the University has adopted the cumulative grade point average (CGPA) system in the year 2014-2015. Further, following the suggestions by the UGC and looking at the better employability, entrepreneurship possibilities and to enhance the latent skills of the stakeholders the University has adopted the Choice Based Credit System (CBCS) in the year 2018-2019 at graduate and post-graduate level. This provided flexibility to the students to choose courses of their own interests. To encourage the students to opt the world-class courses offered on the online platforms like, NPTEL, SWAYM, and other MOOCS platforms the University has implemented the credit transfer policy approved by its Academic Council and also has made a provision of reimbursing registration fees of the successful students completing such courses.

SRTM University has been producing a good number of high calibre graduates; however, it is necessary to ensure that our aspiring students are able to pursue the right education. Like the engineering students, the youngsters pursuing science education need to be equipped and trained as per the requirements of the R&D institutes and industries. This would become possible only when the students undergo studies with an updated and evolving curriculum to match global scenario.

Higher education is a dynamic process and in the present era the stakeholders need to be educated and trained in view of the self-employment and self-sustaining skills like start-ups. Revision of the curriculum alone is not the measure for bringing reforms in the higher education, but invite several other initiatives. Establishing industry-institute linkages and initiating internship, on job training for the graduates in reputed industries are some of the important steps that the University would like to take in the coming time. As a result, revision of the curriculum was the need of the hour and such an opportunity was provided by the New Education Policy 2020. National Education Policy 2020 (NEP 2020) aims at equipping students with knowledge, skills, values, leadership

qualities and initiates them for lifelong learning. As a result the students will acquire expertise in specialized areas of interest, kindle their intellectual curiosity and scientific temper, and create imaginative individuals.

The curriculum given in this document has been developed following the guidelines of NEP-2020 and is crucial as well as challenging due to the reason that it is a transition from general science based to the discipline-specific-based curriculum. All the recommendations of the ***Sukanu Samiti*** given in the **NEP Curriculum Framework-2023** have been followed, keeping the disciplinary approach with rigor and depth, appropriate to the comprehension level of learners. All the Board of Studies (BoS) under the Faculty of Science and Technology of this university have put in their tremendous efforts in making this curriculum of international standard. They have taken care of maintaining logical sequencing of the subject matter with proper placement of concepts with their linkages for better understanding of the students. We take this opportunity to congratulate the Chairman(s) and all the members of various Boards of Studies for their immense contributions in preparing the revised curriculum for the benefits of the stakeholders in line with the guidelines of the **Government of Maharashtra regarding NEP-2020**. We also acknowledge the suggestions and contributions of the academic and industry experts of various disciplines.

We are sure that the adoption of the revised curriculum will be advantageous for the students to enhance their skills and employability. Introduction of the mandatory ***On Job Training, Internship program*** for science background students is praise worthy and certainly help the students to imbibe first hand work experience, team work management. These initiatives will also help the students to inculcate the workmanship spirit and explore the possibilities of setting up of their own enterprises.

Dr. M. K. Patil
Dean
Faculty of Science and Technology

Preamble:

The National Education Policy 2020 (NEP 2020) is formulated to revamp education system and lay down road map for new India. This policy is framed based on the fundamental pillars of access, equity, quality, affordability, and accountability and seeks to transform India into a thriving knowledge society and a global knowledge superpower.

Some of the important features of National Education Policy are increasing gross enrolment ratio in higher education, holistic and multidisciplinary education with multiple entry/exit options, establishment of academic bank of credit, setting up of multidisciplinary education and research Universities and National Research Foundation, expansion of open and distance learning to increase gross enrolment ratio, internationalization of education, motivated with energized and capable faculty, online and digital education and effective governance and leadership.

As per the National Education Policy, the Government of Maharashtra has proposed a model curriculum framework and an implementation plan for the State of Maharashtra. It is to suggest and facilitate the implementation of schemes and programs, which improve not only the level of academic excellence but also improve the academic and research environment in the state. The proposed curriculum framework endeavors to empower the students and help them in their pursuit for achieving overall excellence.

In view of NEP priority and in-keeping with its vision and mission, process of updating the curriculum is initiated and implemented in SRTM University at UG and PG level from the academic year 2023-2024.

Biotechnology is often considered as the technology of hope for meeting future challenges like feeding our increasing population, cleaning dangerously polluted environments and potentiating healthcare sector etc. Establishment of new IISERs, Central Universities and IITs indicate that we are already on the track of developing infrastructure and human resource. Our dream of becoming future 'superpower' will not be possible without Biotechnology and inclusive efforts. Therefore, it is necessary to attract young and bright students and train them in the field of Biotechnology.

Keeping in mind, BOS in Biotechnology and Bioinformatics prepared the curriculum to ensure up-to-date level of understanding of Biotechnology. Studying Biotechnology prepares the students for their career working either in educational institutions or industries in which they can be directly involved in the teaching, research and development. Also, to ensure uniform curriculum and its quality at UG/PG level, curriculum of different Indian Universities, syllabus of NET, SET, MPSC and UPSC and the UGC model curriculum are referred to serve as a base in updating the same.

The comments or suggestions from all teachers, students and other stakeholders are welcome for upbringing this curriculum.

Salient Features:

The syllabus of M Sc Biotechnology has been framed to meet the requirement of Choice Based Credit System under NEP 2020. The courses offered here in will train and orient the students in the specific fields of Biotechnology.

The Core Courses deal with Biochemistry, Cell and Developmental Biology, Microbiology and Virology, Biochemistry, Immunotechnology, Molecular Genetics, Genetic Engineering,

Industrial Biotechnology, Plant Biotechnology, Process Biotechnology, Pharmaceutical Biotechnology and Computational Biology.

Apart from the core courses, the Department Specific Elective Courses deal with Techniques in Biotechnology, Plant Metabolism and Development, Enzymology, Nano biotechnology, IPR, Environmental Biotechnology and Animal Biotechnology. These courses offered during this program are designed with the aim of imparting specific skills to the students which will lead to the employability of the students. There are also two Research Projects in third and fourth semester respectively.

This would help students to lay a strong foundation in the field of Biotechnology.

Overall after completion of this course, students will also acquire fundamental knowledge and applications of Biotechnology.

Program Educational Objectives:

The Objectives of this program are:

PEO1: To offer postgraduate program in Biotechnology based on the needs of industries, academic and research institutions worldwide.

PEO2: To promote and popularize Biotechnology at grass root level and attract young and budding talent.

PEO3: To expose the students to the different emerging fields of Biotechnology.

PEO4: To update curriculum by introducing recent advances in the subject and enable the students to face NET, SET, UPSC and other competitive examinations successfully.

PEO5: To train and orient the students so as to develop human resource for the educational institutes and other organizations.

PEO6: To inculcate analytical and application-oriented abilities to create active and frontline researchers and human resource for the industries.

PEO7: To develop specific skills amongst students for self-employability through the development of their own enterprises.

Program Outcomes:

The Outcomes of this program are:

PO1: This Biotechnology program shall promote and popularize Biotechnology at grass root level and shall also attract young and budding talent.

PO2: This program will expose the students to the different emerging fields of Biotechnology.

PO3: This will provide updated curriculum with recent advances in the subject and enable the students to face NET, SET, UPSC and other competitive examinations successfully.

PO4: This program shall train and orient the students so as to develop human resource for the educational institutes and other organizations.

PO5: This program shall train and orient the students so as to develop active and frontline researchers and human resources for the industries.

PO6: This will also develop specific skills amongst students for self-employability through the development of their own enterprises.

Prerequisite:

The students seeking admission to this program should have cleared B Sc or B Pharm or B Sc Agri from any statutory University. The optional courses are offered to the students registered for post-graduate programs. Such students should have the basic knowledge of Biotechnology and willing to gain additional knowledge in the field of Biotechnology.

Admissions to this program are given as per the University rules.

Dr Sunita D Lohare
Chairman, BOS in Biotechnology and Bioinformatics
Swami Ramanand Teerth Marathwada University,
Nanded 431606.

Details of the Board of Studies Members in the subject of Biotechnology and Bioinformatics under the Faculty of Science & Technology, S.R.T.M. University, Nanded.

Sr No	Name of the Member	Designation	Sr No	Name of the Member	Designation
1	Dr Sunita Dhundiraj Lohare, Shri Havgiswami Mahavidyalaya, Udgir, Dist -Latur Mob 9284161504	Chairman	2	Dr Babasaheb S Surwase School of Life Sciences SRTM University, Nanded 431606. Mob 9075829767	Member
3	Dr Pratap V. Deshmukh Nagnath Arts, Commerce and Science College, Aundha Nagnath, Dist. Hingoli Mob 9637202024	Member	4	Dr Komal S. Gomare Dept of Biotechnology, Dayanand Science College, Latur Mob 9284238413	Member
5	Dr. Vaibhav D. Deshpande, General Manager, Quality Corporate Office, Wockhardt, Mumbai Mob 9100988260	Member	--	--	--
	Invitee Members				
6	Dr Laxmikant Kamble School of Life Sciences, SRTM University, Nanded 431606. Mob: 8669695555	Member	7	Dr M M V Baig Dept of Biotechnology, Yeshwant Mahavidyalaya, Nanded. Mob 9422170641	Member
8	Dr A B Gulwe Dept of Technology SRTM University Sub Campus, Latur. Mob 7387120874	Member	9	Dr Prashant Thakare Department of Biotechnology, SGB Amravati University, Amravati. Mob: 9822222822	Member
10	Dr Sanjog T. Thul Environmental Biotechnology and Genomics Division, National Environmental and Engineering Research Institute (CSIR-NEERI). Nagpur. Mob 9881877072	Member	11	Dr Arun Ingale School of Life Sciences, North Maharashtra University, Umavinagar, Jalgaon. Mob: 9822708707	Member
12	Dr Shivraj Hariram Nile Department of Food Science and Agriculture, National Agri-Food Biotechnology Institute (NABI), Mohali, Punjab. Mob 9561740707	Member	13	Dr Sunil Hajare Department of Biotechnology, New Model Degree College, Hingoli . Mob 8378878817	Member

Swami Ramanand Teerth Marathwada University, Nanded

Faculty of Science & Technology

Credit Framework and Structure of Two Year PG Program (NEP 2020)

Subject: M Sc Biotechnology (Affiliated Colleges) (R-2023)

Year & Level	Sem	Major Subject		RM	OJT / FP/CS (3-Cr)	Research Project	Practicals (1-Cr)	Credits	Total Credits
		(DSC- 4 Cr)	(DSE- 3 Cr)						
1	1	SBTTC-401 Cell and Developmental Biology SBTTC-402 Microbiology and Virology SBTTC-403 Biochemistry	SBTTE-401 Techniques in Biotechnology **OR** SBTTE-403 Plant Metabolism and Development	SVECR 401 Research Methodology (3-Cr)	--		SBTTP-401 Lab Course in Cell and Developmental Biology SBTTP-402 Lab Course in Microbiology and Virology SBTTP-403 Lab Course in Biochemistry SBTTE-402 Lab Course in Techniques in Biotechnology **OR** SBTTE-404 Lab Course in Plant Metabolism and Development	22	44
	2	SBTTC-451 Molecular Genetics SBTTC-452 Immunotechnology SBTTC-453 Process Biotechnology	SBTTE-451 Enzymology **OR** SBTTE-453 Nanobiotechnology	---	SBTTX-451 (O/F/C)	--	SBTTP-451 Lab Course in Molecular Genetics SBTTP-452 Lab Course in Immunotechnology SBTTP-453 Lab Course in Process Biotechnology SBTTE-452 Lab Course in Enzymology **OR** SBTTE-454 Lab Course in Nanobiotechnology	22	
Exit option: Exit Option with PG Diploma in Basic Biotechnology (After 2024-25)									
2	3	SBTTC-501 Genetic Engineering SBTTC-502 Industrial Biotechnology SBTTC-503- Plant Biotechnology	SBTTE-501 English and Science Communication Skills **OR** SBTTE-502 Intellectual Property Rights /Online Certification Course NPTEL /SWAYM /MOOC of equivalent credits	--	--	Research Project SBTTR-501 (4-Cr)	SBTTP-501 Lab Course in Genetic Engineering SBTTP-502 Lab Course in Industrial Biotechnology SBTTP-503 Lab Course in Plant Biotechnology	22	44
	4	SBTTC-551 Computational Biology SBTTC-552 Pharmaceutical Biotechnology	SBTTE-551 Environmental Biotechnology **OR** SBTTE-553 Animal Biotechnology	SVECP-551 Publication Ethics (2-Cr)	--	Research Project SBTTR-551 (6-Cr)	SBTTP-551 Lab Course in Computational Biology SBTTP-552 Lab Course Pharmaceutical Biotechnology SBTTE-552 Lab Course in Environmental Biotechnology **OR** SBTTE-554 Lab Course in Animal Biotechnology	22	
Total Credits		44	12	05	03	10	14		**88**

DSE indicates Department Specific Elective Course. Biotechnology student, in particular semester, can opt either of these courses OR a course offered by other Departments. DSC- Department Specific Core, OJT- On Job Training, FP- Field Project, CS- Case Study, RM- Research Methodology, Cr- Credit, VEC- Value Education Course, R- Revision, Credits of four semesters = 88, Total Marks of All Four Semesters = 2200

M. Sc. Second Year Semester III (Level 7.0)

Teaching Scheme

Subject	Course Code	Course Name	Credits Assigned			Teaching Scheme	
			Theory	Practical	Total	Theory (Hrs/ Week)	Practical (Hrs/Week/Batch)
Major	SBTTC-501	Genetic Engineering	04	--	04	04	--
	SBTTC-502	Industrial Biotechnology	04	--	04	04	--
	SBTTC-503	Plant Biotechnology	04	--	04	04	--
Elective (DSE)	SBTTE-501 SBTTE-502	English and Science Communication Skills **OR** Intellectual Property Rights/Online certification course NPTEL /SWAYM /MOOC of equivalent credit	03	--	03	03	--
Research Project	SBTTR-501	Research Project	--	04	04	--	08
DSC Practical	SBTTP-501	Lab Course in Genetic Engineering	--	01	01	--	02
	SBTTP-502	Lab Course in Industrial Biotechnology	--	01	01	--	02
	SBTTP-503	Lab Course in Plant Biotechnology	--	01	01	--	02
Total Credits			**15**	**07**	**22**	**15**	**14**

M. Sc. Second Year Semester III (Level 7.0)

Examination Scheme

[20% Continuous Assessment (CA) and 80% End Semester Assessment (ESA)]

Subject	Course Code	Course Name	Theory				Practical		Total Marks
			Continuous Assessment (CA)			ESA			
			Test I	Test II	Avg of (T1+T2)/2	Total	CA	ESA	
Major (DSC)	SBTTC-501	Genetic Engineering	20	20	20	80	--	--	100
	SBTTC-502	Industrial Biotechnology	20	20	20	80	--	--	100
	SBTTC-503	Plant Biotechnology	20	20	20	80	--	--	100
Elective (DSE)	SBTTE-501 **OR** SBTTE-502	English and Science Communication Skills Intellectual Property Rights/Online certification course NPTEL /SWAYM /MOOC of equivalent credit	15	15	15	60	--	--	75
Research Project	SBTTR-501	Research Project	--	--	--	--	20	80	100
DSC Practical	SBTTP-501	Lab Course in Genetic Engineering	--	--	--	--	05	20	25
	SBTTP-502	Lab Course in Industrial Biotechnology	--	--	--	--	05	20	25
	SBTTP-503	Lab Course in Plant Biotechnology	--	--	--	--	05	20	25

M. Sc. Second Year Semester 4 (Level 7.0)

Teaching Scheme

Subject	Course Code	Course Name	Credits Assigned			Teaching Scheme	
			Theory	Practical	Total	Theory (Hrs/ Week)	Practical (Hrs/ Week/Batch)
Major	SBTTC-551	Computational Biology	04	--	04	04	--
	SBTTC-552	Pharmaceutical Biotechnology	04	--	04	04	--
Elective (DSE)	SBTTE-551 SBTTE-553	Environmental Biotechnology **OR** Animal Biotechnology	03	--	03	03	--
Value Education Course	SVECP-551	Publication Ethics	02	--	02	02	--
Research Project	SBTTR-551	Research Project	--	06	06	--	12
DSC Practical	SBTTP-551	Lab Course in Computational Biology	--	01	01	--	02
	SBTTP-552	Lab Course Pharmaceutical Biotechnology	--	01	01	--	02
DSE Practical	SBTTE-552 SBTTE-554	Lab Course in Environmental Biotechnology **OR** Lab Course in Animal Biotechnology	--	01	01	--	02
Total Credits			**13**	**09**	**22**	**13**	**18**

M. Sc. Second Year Semester IV (Level 7.0)

Examination Scheme

[20% Continuous Assessment (CA) and 80% End Semester Assessment (ESA)]

Subject	Course Code	Course Name	Theory				Practical		Total Marks
			Continuous Assessment (CA)			ESA			
			Test I	Test II	Avg of (T1+T2)/2	Total	CA	ESA	
Major (DSC)	SBTTC-551	Computational Biology	20	20	20	80	--	--	100
	SBTTC-552	Pharmaceutical Biotechnology	20	20	20	80	--	--	100
Elective (DSE)	SBTTE-551 SBTTE-553	Environmental Biotechnology **OR** Animal Biotechnology	15	15	15	60	--	--	75
Value Education Course	SVECP-551	Publication Ethics	--	10	10	40	--	--	50
Research Project	SBTTR-551	Research Project	--	--	--	--	30	120	150
DSC Practical	SBTTP-551	Lab Course in Computational Biology	--	--	--	--	05	20	25
	SBTTP-552	Lab Course Pharmaceutical Biotechnology	--	--	--	--	05	20	25
DSE Practical	SBTTE-552 SBTTE-554	Lab Course in Environmental Biotechnology **OR** Lab Course in Animal Biotechnology	--	--	--	--	05	20	25

SBTTC-501 GENETIC ENGINEERING

Teaching Scheme

CourseCode	Course Name	Teaching Scheme (Hrs.)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
SBTTC-501	Genetic Engineering	04	--	04	--	04

Assessment Scheme

Course Code	Course Name	Theory				Practical		Total
		CA			ESA			
		Test I	Test II	Avg of (T1+T2)/2		CA	ESA	
SBTTC-501	Genetic Engineering	20	20	20	80	--	--	100

Course pre-requisite:

A prerequisite for a Generic Engineering course will be knowledge of basic Genetics, Molecular Biology, Biochemistry with a foundational course in Cell Biology, Microbiology with essential knowledge of basic Molecular Biology concepts, such as DNA and RNA structure and function, genetics, and molecular biology.

Course Objectives:

- To understand the basics of cell biology and concept of rDNA technology.
- To know clone and gene cloning, cloning strategies in biological systems.
- To become aware of tools and techniques, applications and advantages etc.

Course Outcomes:

- Students will become aware about rDNA technology, its advantages and disadvantages in addition to tools and techniques.
- It will help in avoiding spread of misconception about GMO in society.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1		**Molecular Tools in Genetic Engineering**	**15**
	1.1	Restriction Endonucleases, Modification methylases and other enzymes needed in genetic engineering.	
	1.2	Cloning vectors: Plasmids and plasmid vectors, Phages and Phage derived Vectors, Phagemids, Cosmids,	
	1.3	Artificial chromosome vectors (YAC, BAG) Animal virus derived vectors – SV40 and retroviral vectors. Ti, Ri plasmid vectors.	
	1.4	Physical methods of Gene transfer: Gene gun, Microinjection, Electroporation, Liposomes.	
2		**Molecular cloning**	**15**
	2.1	Construction of Genomic DNA and cDNA libraries, screening of recombinants. DNA analysis: labeling of DNA and RNA probes.	
	2.2	Southern and fluorescence in situ hybridization, DNA fingerprinting, chromosome walking.	
	2.3	Techniques for gene expression: Northern and Western blotting, gel retardation technique,	
	2.4	DNA foot printing. SI mapping, Reporter assays.	
3		**Techniques in Molecular cloning**	**15**
	3.1	Chemical synthesis and Sequencing of DNA. Polymerase chain reaction and its applications	
	3.2	Protein Engineering and Applications: Site-directed mutagenesis,	

	3.3	PCR based methods of mutagenesis, DNA Shuffling.	
	3.4	Strategies for production and purification of recombinant proteins, production of recombinant proteins, recombinant vaccines and pharmaceuticals, concept of Bio-pharming.	
4		**Strategies of Gene Expression and applications**	**15**
	4.1	Expression strategies for heterogonous genes: in prokaryotes, plant, animal cells. Genetic and Physical Mapping of genome.	
	4.2	Use of transposons in genetic analysis: Transposon tagging and its use in identification and isolation of genes. Transgenic Animals, Plants,	
	4.3	Gene Therapy: Gene replacement, gene augment.	
	4.4	Bio safety regulation: Physical and Biological containments.	
			60

Text and Reference Books:

1. Nicoll, D.S.T., An Introduction to Genetic Engineering, Cambridge University Press, UK: 1994.
2. Watson, J.D., Recombinant DNA, Scientific American Books, USA: 1992.
3. Brown, T.A., Gene Cloning: An Introduction, Stanley Thornes, UK: 2010.
4. Glick, B.R. & Pasternak, J.J., Molecular Biotechnology, ASM Press, USA: 2010.
5. Sambrook, J. & Russell, D.W., Molecular Cloning: A Laboratory Manual, CSHL Press, USA: 2001.
6. Innis, M.A. & Gelfand, D.H. (Eds.), PCR Applications: Protocols for Functional Genomics, Academic Press, USA: 1999.
7. Glover, D.M., Genetic Engineering: Cloning DNA, Chapman and Hall, New York, USA: 1980.
8. Alcamo, I.E., DNA Technology: The Awesome Skill, Academic Press, USA:1995.
9. Winnacker, E. (Ed.), From Genes to Clones, Panima Publishing Corporation, Nee Delhi: 1987.
10. Brown, T.A., Genomes, John Wiley & Sons, USA: 2006.

SBTTP-501 LAB COURSE IN GENETIC ENGINEERING

1. Bacterial culture and antibiotic selection media. Preparation of competent cells
2. Isolation of plasmid DNA, Lambda phage DNA.
3. Quantitation of nucleic acids.
4. Agarose gel electrophoresis and restriction mapping of DNA.
5. Construction of restriction map of plasmid DNA
6. Cloning in plasmid/phagemid vectors.
7. Preparation of helper phage and its titration
8. Preparation of single stranded DNA template.
9. Oligonucleotide synthesis and DNA sequencing.
10. Gene expression in E coli and analysis of gene products
11. Study of PCR and PCR based markers AFLP/RAPD/SNP

SBTTC-502 INDUSTRIAL BIOTECHNOLOGY

Teaching Scheme

Course Code	Course Name	Teaching Scheme (Hrs.)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
SBTTC-502	Industrial Biotechnology	04	--	04	--	04

Assessment Scheme

Course Code	Course Name	Theory				Practical		Total
		CA			ESA			
		Test I	Test II	Avg of (T1+T2)/2		CA	ESA	
SBTTC-502	Industrial Biotechnology	20	20	20	80	--	--	100

Course pre-requisite:

A prerequisite for a Industrial Biotechnology course will be knowledge of basic microbiology, Genetics, Molecular Biology, Biochemistry with a foundational course in basic microbial culture techniques, fermentation process.

Course Objectives:

- To learn the analytical techniques for the identification of microbial products.
- To understand the Microbial production of Organic Acids and Solvents.
- To learn the Concept of quality control and quality assessment.

Course Outcomes:

On completion of this course, the students shall:

- Demonstrate knowledge about the techniques of microbial productions and acquire comprehensive knowledge on quality control and quality assessment.
- Acquire knowledge in Production and purification of microbial enzymes and other industrial products.
- Able to work in the section of quality control of Food industry.
- Shall develop scientific skills to work in Pharmaceutical and Research laboratories.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1		**Down Stream Processing:**	**15**
	1.1	Removal and Recovery of cell mass: Precipitation, Filtration and Centrifugation, Cell disruption - Physical and Chemical methods.	
	1.2	Purification of Product Liquid-liquid extraction: Solvent Recovery.	
	1.3	Chromatography: Adsorption, Ion-exchange, HPLC, GC-MS	
	1.4	Membrane processes: Ultrafiltration and Reverse Osmosis. Drying and Crystallization	
2		**Unit-II: Microbial fermentation**	**15**
	2.1	Production, recovery and applications: Alcohol, Glycerol, Acetone, Citric acid	
	2.2	Production, recovery and applications: L-Glutamic acid, L-Tryptophan Penicillin	
	2.3	Production, recovery and applications: Xanthan, Dextran and Alginate	
	2.4	Production and applications of: Proteases, Pectinases, Cellulase.	
3		**Microbial transformations**	**15**
	3.1	: Basic concept of Microbial transformations,	

	3.2	Types of bioconversion reactions: Oxidation, Reduction, Hydrolytic reactions, Condensations. Transformation of steroids and sterols.	
	3.3	Transformation of non-steroid compounds: L-Ascorbic acid, Prostaglandins, Antibiotics	
	3.4	Polyhydroxyalkanoates: Chemistry and properties, Polyhydroxybutyrate (PHB), biodegradable plastic. Microbial recovery of petroleum.	
4		**Concept of QC and QA**	**15**
	4.1	Introduction and overview of QC and QA QC	
	4.2	testing of products: Purity, Sterility, Toxicity, Carcinogenicity, Pyrogen testing.	
	4.3	Fermentation Economics, Cost Estimates, Process Design,	
	4.4	Capital Cost Estimates, Operating Cost Estimates.	
			60

Text and Reference Books:

1. Peppler, H. J., & Perlman, D. (Eds.). Microbial Technology, Vols. I & II. Elsevier Science Publishers. 2014.
2. Stanbury, P. F., Whitaker, A., & Hall, S. J. Principles of Fermentation Technology. Elsevier Science Publishers. 2013.
3. Casida, L. E. Industrial Microbiology. New Age International Publishers. 2005.
4. Crueger, W., & Crueger, A. Biotechnology: A Textbook of Industrial Microbiology. Panima Publishing Corporation. 1990.
5. Patel, A. H. Industrial Microbiology. Macmillan India Ltd. 2012.
6. Prescott, S., & Dunn, C. (Eds.) Industrial Microbiology. CBS Publishers & Distributors. 1982.
7. Subramaniam, G. (Ed.) Bioseparation & Bioprocessing. Wiley-VCH Verlag GmbH. 1998
8. Belter, P. A., & Cussler, E. L. Bioseparation: Downstream Processing for Biotechnology. Academic Press. 1994.
9. Schuger, L. Solvent Extraction in Biotechnology. Springer-Verlag. 2013.
10. Harrison, R. G. Bioseparation Science & Engineering. Oxford University Press. 2015.
11. BIOTOL Series. (Eds.) Product Recovery in Bioprocess Technology. Butterworth-Heinemann.1992.

SBTTP-502 LAB COURSE IN INDUSTRIAL BIOTECHNOLOGY

1. Production and isolation of bacterial exo-polysaccharides
2. Production and estimation of alkaline protease from bacterial source
3. Production and estimation of Bacterial enzymes lipase, Pectinase/ Cellulase/ Amylase
4. Production of sauerkraut by microorganisms
5. Production and estimation of lactic acid by *Lactobacillus* Sp.
6. Production and characterization of citric acid using *A. niger.*
7. Microbial transformations of steroids/antibiotics
8. Comparison of ethanol production using various Organic wastes /raw Material
9. Production and purification of fungal enzymes Amylase /Pectinase
10. Production of kojic acid.
11. Visit to fermentation industry

SBTTC-503 PLANT BIOTECHNOLOGY

Teaching Scheme

Course Code	Course Name	Teaching Scheme (Hrs.)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
SBTTC-503	Plant Biotechnology	04	--	04	--	04

Assessment Scheme

Course Code	Course Name	Theory				Practical		Total
		CA			ESA			
		Test I	Test II	Avg of (T1+T2)/2		CA	ESA	
SBTTC-503	Plant Biotechnology	20	20	20	80	--	--	100

Course pre-requisite:

A prerequisite for a Industrial Biotechnology course will be knowledge of basic plant biology, plant genetics, plant molecular biology, plant biochemistry with a foundational course in plant cell biology, with essential knowledge of basic plant science concepts, such as morphology, anatomy, physiology, structure and function plant cells.

Course Objectives:

- To acquaint the students with basic principles and various methods of Tissue Culture.
- To impart knowledge about varied methods of gene transfer and transgenic plant development.
- To underhand basics of secondary metabolites and their engineering.
- To acquire knowledge about molecular markers and their use in plant breeding.

Course Outcomes:

On completion of this course, the students shall:

- Demonstrate the knowledge about the techniques of Plant Tissue Culture and acquire comprehensive knowledge on GM technology for quality characteristics and their role in crop improvement.
- Acquire knowledge in metabolic engineering and industrial products.
- Develop skills in molecular markers studies and their use in plant breeding.
- Shall develop scientific skills to work in Plant tissue culture, Pharmaceutical and Research laboratories.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1		**Plant Tissue Culture**	**15**
	1.1	Structure and organization of Plant tissue culture laboratory. Tissue culture media: Types, Composition and preparation. Initiation and maintenance of callus and suspension culture.	
	1.2	Somatic embryogenesis, Shoot tip culture, Protoplast culture. Embryo culture and embryo rescue. Anther, Pollen and Ovary culture for production of haploid plants.	
	1.3	Cryopreservation, slow growth and DNA banking for germ plasm conservation	
	1.4	Commercial application of tissue culture technology, examples: banana and Sugarcane.	
2		**Transgenic Crops**	**15**
	2.1	Molecular marker aided breeding: RFLP, RAPD, Microsatellites, AFLP etc.	
	2.2	Crops with resistance to biotic stresses, viruses, fungal and bacterial diseases: strategy and examples	

	2.3	Crops with resistance to abiotic stresses (Herbicides and drought conditions): strategy and examples.	
	2.4	Terminator technology. Ecological risk assessment of genetically modified crops	
3		**Microbes and Sustainable Agriculture**	**15**
	3.1	N2 fixing bacteria as microbial bio fertilizers: Symbiotic and non-symbiotic bacteria. Microbial inoculants for sustainable agriculture:	
	3.2	Microorganisms, Physiology and Production technology of (i) Cyanobacteria (ii) Plant growth promoting rhizobacteria (iii) Phosphate solubilizing microorganisms (iv) Mycorrhizae.	
	3.3	Classification of Plant Diseases based on Symptoms.	
	3.4	Plant Diseases: Causative agent, Symptoms, Mechanism of Action and Control Measures against plant diseases (Chemical and Biological)	
4		**Bio pesticides and Integrated Pest Management**	**15**
	4.1	Biological control, Plant bio pesticides and botanicals and microorganisms pest control.	
	4.2	Bio pesticides v/s chemical pesticides: advantages and disadvantages.	
	4.3	Examples of bio pesticides: Bt-based bio pesticides, Baculoviruses, Trichoderma.	
	4.4	Concept of Integrated Pest Management (IPM), Present status and future needs for making bio-pesticides	
			60

Text and Reference Books:

1. Razdan, M. K. Introduction to Plant Tissue Culture. Oxford & IBH Publishing Co. Pvt. Ltd.
2. BIOTOL Series. (Eds.) Biotechnological Innovations in Crop Improvement. Elsevier Science Publishers.
3. Schöpfer, K., & Kumar, A. Plant Cell and Tissue Culture: A Tool in Biotechnology. Springer-Verlag.
4. Bhojwani, S. S., & Razdan, M. K. Plant Tissue Culture. Elsevier Science Publishers.
5. Kumar, U. Methods in Plant Tissue Culture. Agrobios (India) Ltd.
6. Purohit, S. S. Agricultural Biotechnology. Agro Botanica, India. 1999.
7. Endress, R. Plant Cell Biotechnology. Springer-Verlag Berlin Heidelberg. 1994.
8. Subbarao, N. S. Soil Microbiology. Oxford University Press. 1999.
9. Melhotra, R., & Agarwal, G. C. Plant Pathology. Tata McGraw-Hill Publishing Company Ltd. 1983.
10. Gupta, P. K. Genetics and Biotechnology in Crop Improvement. Rastogi Publications.2008.

SBTTP-503 LAB COURSE IN PLANT BIOTECHNOLOGY

1. Preparation of Tissue culture Media.
2. Callus Culture, Organ Culture, organogenesis.
3. In vitro rooting and acclimatization.
4. Protoplast isolation and culture.
5. Anther Culture/ Production of haploids.
6. Agrobacterium culture, selection of tranformants, GUS assay.
7. Somatic embryogenesis
8. Isolation of nitrogen fixing rhizobia, Azotobacter
9. Isolation of phosphate solubilizing bacteria and determination of efficiency
10. Estimation of leg hemoglobin from root nodule of leguminous plant
11. Study of Bio pesticides: Trichoderma
12. Visit to commercial plant tissue culture laboratory

SBTTE-501 ENGLISH AND SCIENCE COMMUNICATION SKILLS

Teaching Scheme

Course Code	Course Name	Teaching Scheme (Hrs.)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
SBTTE-501	English and Science Communication Skills	03	--	03	--	03

Assessment Scheme

Course Code	Course Name	Theory				Practical		Total
		CA			ESA			
		Test I	Test II	Avg of (T1+T2)/2		CA	ESA	
SBTTE-501	English and Science Communication Skills	15	15	15	60	--	--	75

Course pre-requisite:

A prerequisite for English and Science Communication Skills course will be knowledge of basic English, English grammar, Basic understanding of English language and scientific concepts may be beneficial.

Course Objectives:

- To provide the students with the essential skills required for effective communication
- To provide a comprehensive view of business communication and its role in the corporate environment.

Course Outcomes:

Students will be able to:

- Understand and demonstrate the use proper writing techniques relevant to the present day technological demands, including anticipating audience reaction.
- Write effective and concise letters and memos, prepare informal and formal reports, proofread and edit copies of business correspondence.
- Develop interpersonal skills that contribute to effective personal social and professional relationships.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1		**Essentials of Communication:**	**15**
	1.1	Meaning, Definition, process, feedback, emergence of communication as a key concept in the corporate and global world,	
	1.2	impact of technological advancements on communication.	
	1.3	Channels of Communication: Formal and Informal:	
	1.4	Vertical, horizontal, diagonal, and grapevine.	
2		**Methods and Modes of Communication:**	**10**
	2.1	Verbal and nonverbal, Verbal Communication:	
	2.2	Characteristics of verbal communication,	
	2.3	Non-verbal Communication:	
	2.4	Characteristics of non-verbal communication, kinesics, proxemics and chronemics.	
3		**Soft Skills**	**10**
	3.1	a) Importance of listening skills, cultivating good listening skills, Interpersonal skills.	
	3.2	b) Negotiation skills.	
	3.3	c) Time management skills.	

	3.4	d) Stress management skills.	
4		**Written Communication:**	**10**
	4.1	Business letters, memos, minutes of meeting,	
	4.2	Notices, emails, agendas and circulars.	
	4.3	Technical Report Writing: Types of Reports,	
	4.4	contents of reports. Formatting, writing styles and documentation.	
			45

Text and Reference Books:

1. Strunk, Jr., W., & White, E. B. The Elements of Style. Longman. 2020.
2. Brunell, C. Talking Science With Kids. National Geographic Society. 2017.
3. King, S. On Writing. Scribner. 2002.
4. Ziman, H. How to Write a Science Research Paper. W. H. Freeman and Company. 1997.
5. Lehman, C. M., DuFrene, D. D., & Walker, B. BCOM: An Innovative Approach to Learning and Teaching Business Communication. Cengage Learning. 2019.
6. American Psychological Association. Publication Manual of the American Psychological Association (APA Style). 2019.
7. McMurrey, A. M., & Buckley, J. Handbook for Technical Writing. Cengage Learning. 2008.
8. Good, D. C. Science Fiction as Science Education. Springer International Publishing. 2004.
9. Thaiss, C. Writing Science in the Twenty-First Century. Oxford University Press. 2019.
10. Carroll, R. T. The Skeptical Inquirer's Guide to Science and Critical Thinking. Wiley-Blackwell. 1990.
11. Lesikar, R. V., & Flately, M. E. Basic Business Communication: Skills for Empowering the Internet Generation. Tata McGraw-Hill Publishing Company Limited2021.

SBTTE-502 INTELLECTUAL PROPERTY RIGHTS

Teaching Scheme

Course Code	Course Name	Teaching Scheme (Hrs.)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
SBTTE-502	Intellectual Property Right	03	--	03	--	03

Assessment Scheme

Course Code	Course Name	Theory				Practical		Total
		CA						
		Test I	Test II	Avg of (T1+T2)/2	ESA	CA	ESA	
SBTTE-502	Intellectual Property Right	15	15	15	60	--	--	75

Course pre-requisite:

A prerequisite for Intellectual Property Right course will be knowledge of Basic understanding of property law and business concepts is recommended. Courses in biochemistry, cell biology, or genetics may be helpful for understanding biological inventions.

Course Objectives:

- To provide the students with the essential knowledge of Intellectual Property Right and patenting of Biological materials.

Course Outcomes:

Students will be able to:

- Understand the procedure of patenting of biological inventions.
- Write thesis and Manuscript writing
- Understand Plant breeder's right and Farmer's right.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1		**Research:**	**15**
	1.1	Definition, Importance and Meaning of Research, Objectives of research, Characteristics of Research, Types of Research.	
	1.2	Steps in Research; Identification, Selection and Formulation of Research Problem, Research Design, Formulation of Hypothesis, Review of Literature.	
	1.3	Sampling Techniques: Sampling theory, Types of Sampling, Steps in Sampling,	
	1.4	Sample Size, Advantages and limitations.	
2		**Thesis and Manuscript writing:**	**10**
	2.1	Abstract, Introduction, Materials and Methods,	
	2.2	Results and Discussion, Summary and Conclusion, References (IMRAD). Preparation of	
	2.3	Manuscript; Author instructions, modes of paper communication, criteria for publication.	
	2.4	Presentation of a scientific Paper.	
3		**Introduction to IPR and Patents:**	**10**
	3.1	Intellectual property, Protection of Intellectual property,	
	3.2	World organizations, forms of protection- patent, copyright, trademark, geographical indications, trade secrets.	
	3.3	Criteria and procedure of patenting, Patent procedure in India. Types of patenting,	

	3.4	Patent infringement- meaning, scope, litigation and examples.	
4		**Patenting biological material.**	**10**
	4.1	Patenting of biological materials with examples.	
	4.2	Plant breeder's right: concept of UPOV, Breeders exemption, Plant variety protection in India.	
	4.3	Farmer's right, advantages and disadvantages of PBR.	
	4.4	Technology transfer-Introduction, types of technology transfer and Indian scenario.	
			45

Text and Reference Books:

1. Kothari CR. Research methodology: Methods and techniques. New Age International; 2004.
2. Creswell, J.W. "Research Design: Qualitative, Quantitative, and Mixed Methods Approaches." Sage Publications. 2014
3. Saldaña, J. "The Coding Manual for Qualitative Researchers." Sage Publications. 2015
4. Patel, V. "Research Methodology and IPR." Oxford University Press. 2016
5. Kumar, R. "Research Methodology: A Step-by-Step Guide for Beginners." Sage Publications. 2019.
6. Srivastava, P., & Misra, S. "Intellectual Property Rights: Basic Concepts and Methodologies." Springer. 2017
7. Debi S. Mishra. Intellectual Property Rights. Butterworths India; Fourth Edition, 2018.
8. Gupta PK. Elements of biotechnology. Rastogi Publications; 1994.
9. BD Singh Biotechnology. Kalyani Publication. New Delhi.2005.
10. Goel D, Parashar S. IPR, biosafety and bioethics. Pearson Education India; 2013.

SBTTR-501 RESEARCH PROJECT

Teaching Scheme

Course Code	Course Name	Teaching Scheme (Hrs.)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
SBTTR-501	Research Project	--	08	--	04	04

Assessment Scheme

Course Code	Course Name	Theory				Practical		Total
		CA			ESA			
		Test I	Test II	Avg of (T1+T2)/2		CA	ESA	
SBTTR-501	Research Project	--	--	--	--	20	80	100

Course pre-requisite:

A prerequisite for Intellectual Property Right course will be knowledge of Basic understanding and Strong foundation in critical thinking and writing, Completion of introductory course in your chosen topic or study.

Course Objectives:

- To develop a nuanced understanding of the research process in your chosen field.
- To critically evaluate different research methodologies and approaches.
- To formulate clear research questions and hypotheses.
- To conduct a comprehensive literature review.
- To understand ethical considerations in research.

Course Outcomes:

Students will be able to:

- Ability to articulate the significance and objectives of your research project.
- Proficient in identifying and justifying appropriate research methods.
- Familiarity with ethical research practices and protocols.
- Skillful in conducting a thorough literature review in your chosen field.
- Capacity to formulate clear and compelling research questions and hypotheses.

Curriculum Details:

1. Overview of the research process: Defining research, types of research, scientific method.
2. Research methodologies: Quantitative, qualitative, mixed methods, their strengths and limitations.
3. Choosing a research topic: Importance, feasibility, criteria for selection.
4. Formulating research questions and hypotheses: Specificity, clarity, operationalization.
5. Literature review: Conducting an effective search, evaluating sources, synthesizing findings.
6. Ethical considerations in research: Informed consent, data privacy, plagiarism, misconduct.

SEMESTER IV

SBTTC-551 COMPUTATIONAL BIOLOGY

Teaching Scheme

CourseCode	Course Name	Teaching Scheme (Hrs.)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
SBTTC-551	Computational Biology	04	--	04	--	04

Assessment Scheme

Course Code	Course Name	Theory				Practical		Total
		CA						
		Test I	Test II	Avg of (T1+T2)/2	ESA	CA	ESA	
SBTTC-551	Computational Biology	20	20	20	80	--	--	100

Course pre-requisite:

A prerequisite for a Computational Biology course will be knowledge of Strong foundation in mathematics and statistics is essential. Basic bioinformatics knowledge, Courses in biochemistry, molecular biology, or genetics are crucial for applying computational skills.

Course Objectives:

- To understand the concept of genomics, proteomics, biostatics and their applications.
- To learn about methods of studying genetic materials obtained from various environmental samples.
- To understand basic concepts of sequences, structural alignment, database searching, protein structure prediction.

Course Outcomes: Students will be able to

- Construct the phylogenetics of different sequences.
- Analyze sequence and structure of bio-macromolecule data
- Edit the three dimensional structure of protein using structural bioinformatics tools
- Explain the properties of genetic materials and storage and processing of genetic information.
- Analyze genomic data.
- Explain biological phenomena based on comparative genomics

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1		**Biological Data Bases**	**15**
	1.1	The need for computation in Biology: An introduction to Bioinformatics,	
	1.2	Historical overview, the principles involved, development of tools, internet based access.	
	1.3	Introduction to Biological Databases, Database Browsing and Data Retrieval – Sequence databases, Structural databases, Literature and other databases	
	1.4	Application of Bioinformatics Approaches for analysis and interpretation of Sequence Data and using: Homology Searches, Sequence Alignments, Pattern Searching.	
2		**Proteomics**	**15**
	2.1	Introduction to computational structural biology: Protein structure prediction using computational methods, Structure analysis, Classification of Proteins etc.	
	2.2	Strategies in Proteomics: 2 D PAGE, Mass spectrometry. Databases and search engines in proteomics.	

	2.3	Proteomics applications: Understanding the mechanism of pathogenesis, Drug discovery, Disease diagnosis, identification and characterization of novel proteins.	
	2.4	Protein-Ligand Docking: Introduction; Docking problems, methods for protein- ligand docking, validation studies and applications	
3		**Genomics**	**15**
	3.1	Introduction sequencing strategies for whole genome analysis, sequence data analysis.	
	3.2	Comparative Genomics: Protein evolution from exon shuffling, Protein structural genomics, Gene function by sequence comparison Global expression profiling: whole genome analysis of mRNA and protein expression, microarray analysis, types of microarrays and their applications	
	3.3	Functional genomics, Toxic genomics, Pharmacogenomics, Metagenomics. Metabolic engineering	
	3.4	Application of Bioinformatics Approaches for analysis and interpretation of Genome data such as – Gene prediction, Full Genome comparison etc.	
4		**Biostatistics**	**15**
	4.1	Brief description and tabulation of data and its graphical representation	
	4.2	Measurement of central tendency and dispersion- mean, mode, median, range	
	4.3	Mean deviation, standard deviation, variance.	
			60

Text and Reference Books:

1. Baldi, P., & Brunak, S. Bioinformatics: The machine learning approach. MIT Press. 2001
2. Baxevanis, A. D., & Ouellette, B. F. F. Bioinformatics: A practical guide. John Wiley & Sons. 2001
3. Attwood, T., & Parry-Smith, D. Introduction to bioinformatics. Prentice Hall. 1999
4. Clote, P., & Backofen, R. Computational molecular biology: An introduction. Wiley. 2000
5. Lesk, A. M. Introduction to bioinformatics. Oxford University Press. 2002
6. Mount, D. W. Bioinformatics: Sequence and genome analysis. Cold Spring Harbor Lab. Press. 2001
7. Pevzner, P. A. Computational molecular biology. MIT Press. 2000
8. Rosner, B. Fundamentals of Biostatistics." Cengage Learning. 2015
9. Glantz, S.A. Primer of Biostatistics." McGraw-Hill Education. 2019
10. Pagano, M., & Gauvreau, K. Principles of Biostatistics." Cengage Learning. 2018

SBTTP-551 LAB COURSE IN COMPUTATIONAL BIOLOGY

1. NCBI/EBI: Data access – standard search engines: data retrievals tools – Entrez, DBGET
2. and SRS, PubMed etc.
3. Software for data building. Submission of sequence to databases.
4. Sequence homology as product of molecular evolution, sequence similarity searches,
5. Sequence alignment-global, local, end free-space; measurement of sequence similarity
6. Homology Modeling
7. Phylogeny reconstruction by using biological data
8. Getting an amino acid sequence, nucleotide sequence by BLAST
9. Protein identification & characterization with peptide mass fingerprinting data.
10. Primary/ secondary structure analysis of proteins.

SBTTC-552 PHARMACEUTICAL BIOTECHNOLOGY

Teaching Scheme

CourseCode	Course Name	Teaching Scheme (Hrs.)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
SBTTC-552	Pharmaceutical Biotechnology	04	--	04	--	04

Assessment Scheme

Course Code	Course Name	Theory				Practical		Total
		CA			ESA			
		Test I	Test II	Avg of (T1+T2)/2		CA	ESA	
SBTTC-552	Pharmaceutical Biotechnology	20	20	20	80	--	--	100

Course pre-requisite:

A prerequisite for a Pharmaceutical Biotechnology course will be knowledge and thorough understanding of biochemistry, cell biology, and genetics is necessary. Courses in organic chemistry and microbiology are often recommended.

Course Objectives:

The objective of this course is to apply the basic concepts in the specific field of pharmaceutical biotechnology. The student will gain insights into identification and design of drugs that could be potentially useful in the identification of candidate drug which have efficacy in cell culture or animal models and thus the most effective compound could be employed based on the above results to put into clinical trials.

Course Outcomes: Students will be able to

- Construct the phylogenetics of different sequences.
- Analyze sequence and structure of bio-macromolecule data
- Edit the three dimensional structure of protein using structural bioinformatics tools
- Explain the properties of genetic materials and storage and processing of genetic information.
- Analyze genomic data.
- Explain biological phenomena based on comparative genomics

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1		**Chemotherapy**	**15**
	1.1	Antimicrobial Drug. Mechanism of action of antimicrobial agents.	
	1.2	Microbial Resistance to antibiotics and antimicrobial agents (Types and Mechanism).	
	1.3	Types of Antibiotics: Classification of antibiotics with example. General characteristics of a	
	1.4	Secondary Metabolites: Types and Medicinal Applications	
2		**Chemotherapeutics Agents**	**15**
	2.1	Structure, Mechanism of Action and Applications of Antibacterial drug: Sulfonamides, Quinolones.	
	2.2	Antiviral drug: Amantadine, Azido thymidine. Antifungal drug: Nystatin, Griseofulvin.	
	2.3	Mechanism of action of Anticancer drugs, Drugs acting on CNS, Insulin, Blood factor VIII.	
	2.4	Detailed account on Corona and Ebola viruses. Detailed account on COVID-2019	

3		**Protein Engineering**	**15**
	3.1	Methods of protein sequencing: mass spectrometry, Edman degradation, Tryptic and/or Chymotryptic Peptide Mapping.	
	3.2	Isolation and purification of proteins, Stability and activity based approaches of protein engineering,	
	3.3	Chemical and Physical Considerations in Protein and Peptide Stability, Different methods for protein engineering, Site-directed mutagenesis, gene shuffling, and direct evolution.	
	3.4	Mapping of protein interactions: Two hybrid, phage display etc.	
4		**Computer aided drug design & Clinical Trials**	**15**
	4.1	Overview of computer assisted drug discovery (CADD), Concept and steps involved in pharmacophore modeling, Molecular modelling functions, types of molecular modeling, limitations of CADD	
	4.2	Phases of Clinical trials of drugs, Preclinical drug evaluation of its biological activity,	
	4.3	Potency and Toxicity-Toxicity test in animals including acute, sub-acute and chronic toxicity, ED50 and LD50 determination, special toxicity test like teratogenicity and mutagenicity.	
	4.4	Introduction to Indian, International Pharmacopoeia and global regulatory guidelines.	
			60

Text and Reference Books:

1. Glick, B. R., & Pasternak, J. J. (Eds.). Molecular biotechnology: Principles and applications (Vol. 1). ASM Press. 2009
2. Kar, A. Pharmacology and pharmacobiotechnology. New Age International Publishers. 2003.
3. Razdan, B. Medicinal chemistry. CBS Publishers & Distributors. 2019.
4. Doble, M. Drug designing. McGraw Hill Education. 2005.
5. Hugo, W. B., & Russell, A. D. (2009). Pharmaceutical microbiology. Wiley India Pvt. Limited.
6. Barar, F. S. K. (2010). Essentials of pharmaceuticals. S. Chand & Company Ltd.
7. Satoskar, R. S., & Bhandarkar, S. D. Pharmacology and pharmacotherapeutics. Popular Prakashan. 1988.
8. Vyas, S. P., & Dixit, V. K. Pharmaceutical biotechnology. CBS Publishers & Distributors. 2018.
9. Walsh G. Biopharmaceuticals: biochemistry and biotechnology. John Wiley & Sons; 2013.
10. Sambamurthy K. Pharmaceutical biotechnology. New Age International; 2006.

SBTTP-552 LAB COURSE PHARMACEUTICAL BIOTECHNOLOGY

1. Estimation of penicillin/streptomycin by biological assay.
2. Estimation of penicillin/streptomycin by chemical assay.
3. Assay of antimicrobial activity of Penicillin, Chloramphenicol, streptomycin
4. Determination of Minimum Inhibitory Concentration (MIC) of Antibiotic
5. Determination of shelf life of antibiotics (Expired drugs)
6. Sterility testing of commercial pharmaceuticals.
7. Study of microbial spoilage of pharmaceuticals.
8. Sterility testing of injectable as per IP.
9. Effect of chemical disinfectant on growth of bacteria
10. Study of Pharmacopeia and global regulatory guidelines in pharma industry
11. Study of dug action by using Zebra fish (Danio rerio) as model organism
12. Visit to Pharmaceutical industry

SBTTE-551 ENVIRONMENTAL BIOTECHNOLOGY

Teaching Scheme

CourseCode	Course Name	Teaching Scheme (Hrs.)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
SBTTE-551	Environmental Biotechnology	03	--	03	--	03

Assessment Scheme

Course Code	Course Name	Theory				Practical		Total
		CA						
		Test I	Test II	Avg of (T1+T2)/2	ESA	CA	ESA	
SBTTE-551	Environmental Biotechnology	15	15	15	60	--	--	75

Course pre-requisite:

A prerequisite for a Environmental Biotechnology course will be knowledge of Solid foundation in basic biology, ecology, and environmental science is required. Courses in biochemistry, microbiology, and molecular biology are beneficial, fundamental knowledge of ecology and environmental will be helpful.

Course Objectives:

- To understand how biotechnology can help in monitoring or removing the pollutants
- To develop an understanding of new trends such as biofuels, renewable energy sources, or microbial technologies which can minimize the harmful impact of pollutants in the environment.

Course Outcomes: Students will be able to

- Comprehend environmental issues and role of biotechnology in the cleanup of contaminated environments
- Comprehend fundamentals of biodegradation, biotransformation and bioremediation of organic contaminants and toxic metals
- Apply biotechnological processes in wastewater and solid waste management.
- Comprehend biofuels/bioenergy systems; attributes for biofuel / bioenergy production.
- Demonstrate innovative biotechnological interventions to combat environmental challenges.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1		**Ecology & Environment:**	**12**
	1.1	Interactions between environment and biota; Concept of habitat and ecological niches;	
	1.2	Energy flow, food chain, food web and tropic levels; Ecological pyramids and recycling, N.P.C and S cycles in nature.	
	1.3	Concepts and theories of evolution -Population ecology - community structure.	
	1.4	Global environmental problems: ozone depletion, UV-B greenhouse effect and acid rain, their impact in biotechnological approaches for management.	
2		**Biofuels:**	**10**
	2.1	Environmental Biotechnology and biofuels: biogas; bioethanol; biodiesel; bio hydrogen;	
	2.2	Description of the industrial processes involved microorganisms and biotechnological interventions for optimization of production;	

	2.3	Microbiologically enhanced oil recovery (MEOR); Bioleaching of metals;	
	2.4	Production of bioplastics; Production of bio surfactants: bio emulsifiers.	
3		**Environmental pollution:**	**12**
	3.1	Types of pollution, Methods for the measurement of pollution. Methodology of environmental management - the problem-solving approach, its limitations.	
	3.2	Air pollution and its control through Biotechnology. Bioremediation of contaminated soils and wastelands.	
	3.3	Ecological considerations, decay behavior and degradative plasmids; hydrocarbons, substituted hydrocarbons, oil pollution, surfactants, pesticides. Environmental mutagenesis and toxicity testing.	
	3.4	Solid waste: Sources and management, Municipal waste management (composting, vermiculture and methane production).	
4		**Waste water treatment:**	**11**
	4.1	Water Pollution and control: Need for water management, Measurement and sources water pollution.	
	4.2	Waste water collection, Physico-chemical properties of water, physical, chemical and biological treatment processes. Activated sludge, oxidation ditches, trickling filter, towers, rotating discs, rotating drums, oxidation ponds. Anaerobic digestion, anaerobic filters, up flow anaerobic sludge blanket reactors.	
	4.3	Treatment schemes for waste waters of dairy, distillery, tannery, sugar, antibiotic industries.	
	4.4	Kind of aquatic habitats, (fresh and marine), distribution and impact of environmental factors on the aquatic biota, productivity, mineral cycles and biodegradation different aquatic ecosystems. Management of estuarine, coastal water systems and man-made reservoirs; Biology and ecology of reservoirs.	
			45

Text and Reference Books:

1. Odum, E. P., & Barrett, G. W. Fundamentals of ecology (5th ed.). Brooks/Cole. 2005
2. Verma, P. S., & Agarwal, V. K. (NA). Cell biology, genetics, molecular biology, evolution, ecology. S. Chand & Company Ltd. 2004.
3. Verma, P. S., & Agarwal, V. K. Environmental biology: Principles of ecology. S. Chand & Company Ltd. 2000.
4. Scragg, A. Environmental biotechnology (1st ed.). Pearson Education Limited. 1999.
5. Jogdand, S. N. Environmental biotechnology. Himalaya Publishing House. 2005.
6. Metcalf & Eddy, Inc. Wastewater engineering: Treatment, disposal, and reuse (4th ed.). McGraw-Hill. 2003.
7. De, A. K. Environmental chemistry. Wiley Eastern Ltd. 2003.
8. Allsopp, D., & Seal, K. J. Introduction to biodeterioration. ELBS/Edward Arnold. 1986
9. Rittmann, B. E., & McCarty, P. L. Environmental biotechnology: Principles and applications. McGraw-Hill. 2001.
10. Chatterji, A. K. Introduction to environmental biotechnology. Prentice-Hall of India. 2004
11. Thakur, I. S. Environmental biotechnology. I. K. International Publishing House. 2010.
12. Mohapatra, P. Text book of environmental biotechnology. I. K. International Publishing House. 2013.

SBTTE-552 LAB COURSE IN ENVIRONMENTAL BIOTECHNOLOGY

1. Measurement of sounds by DB meter in silent, industrial, residential, commercial zones.
2. Estimation of TS, T.D.S., form given water sample.
3. Estimation of Hardness, Ca and Mg from given water and soil sample.
4. Estimation of Chlorides by Silver nitrate method.
5. Estimation of Na and K from given water and soil sample by flame photometrically.
6. Estimation of Sulphate/ Phosphates from given water and soil
7. Determination of Dissolved Oxygen and Biological Oxygen Demand of polluted water.
8. Determination of Chemical Oxygen Demand of polluted water.
9. Demonstration of Total Nitrogen estimation by Kjeldahl's Method.
10. Field Visit to MSW management/ STP Sewage treatment plant (one day)

SBTTE-553 ANIMAL BIOTECHNOLOGY

Teaching Scheme

CourseCode	Course Name	Teaching Scheme (Hrs.)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
SBTTE-553	Animal Biotechnology	03	--	03	--	03

Assessment Scheme

Course Code	Course Name	Theory				Practical		Total
		CA						
		Test I	Test II	Avg of (T1+T2)/2	ESA	CA	ESA	
SBTTE-553	Animal Biotechnology	15	15	15	60	--	--	75

Course pre-requisite:

A prerequisite for an Animal Biotechnology course will be knowledge of Comprehensive understanding of animal biology, physiology, and genetics is crucial.

Courses in cell biology, embryology, and genomics are often recommended.

Course Objectives:

The objective of this course is to enable students to develop basic skills for vertebrate cell culture, maintenance of cell lines and in vitro application of cell and molecular techniques and also to understand the principles of animal cloning and its applications.

Course Outcomes: Students will be able to

- Explain the fundamental scientific principles that underlie cell culture.
- Acquire knowledge for isolation, maintenance, and growth of cells.
- Develop proficiency in establishing and maintaining cell lines.
- Acquire knowledge in animal cloning and its applications.

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1		**Animal Cell Culture**	**12**
	1.1	Equipment and Materials for animal Cell Culture Technology, Design of Tissue Culture Laboratory	
	1.2	Equipment: Laminar Flow Hoods, CO2 incubator, Microscopes, centrifuge, Refrigerators and Freezers, pipetting aids, Miscellaneous small items of Equipment, Materials, filters, Miscellaneous Items.	
	1.3	Basic Aseptic Techniques Cells and tissue types: Behavior of cells in culture: Primary cell lines permanent/Established cell lines/Transformed cell lines	
	1.4	Physical requirements and Nutritional Requirements of Cells and growth media. Natural media: Basal salt solution (BSS)-Various types, Minimum Essential Medium (MEM), Serum dependent and Serum independent defined media – Cell specific media, pH, CO2, O2 tension Ascorbic acid, sugars etc.	
2		**Animal Cell Culture**	**11**
	2.1	Basic Techniques of mammalian cell culture: Primary Cell culture – Isolation and separation of cells, viable cell count, maintenance of cell culture, maintenance of stock culture,	
	2.2	Types of cell cultures – Monolayer, Suspension and Embryonic	

	2.3	cell synchronization. Cryopreservation. Biology and characterization of cultured cells: tissue typing; cell-cell interaction; Scale up,	
	2.4	measuring parameters of growth; measurement of cell death; Apoptosis and its determination; cytotoxicity assays	
3		**Molecular techniques in cell culture: -**	**12**
	3.1	Cell transformation; physical, chemical and biological methods;	
	3.2	Viral gene delivery systems: hybridoma technology and its applications;	
	3.3	cell fusion methods; vaccine production; gene therapy.	
	3.4	Application of animal cell culture - Engineered cell culture as source of valuable products and protein production	
4		**Transgenic:**	**10**
	4.1	Transgenic animal: production and application; transgenic animals as models for human diseases;	
	4.2	transgenic animals in live-stock improvement; expression of the bovine growth hormone;	
	4.3	transgenic in industry; chimera production;	
	4.4	Ethical issues in animal biotechnology.	
			45

Text & References

1. Freshney, R. I. Animal cell culture: A practical approach. John Wiley & Sons. 2000
2. Butler, M. (Ed.). Mammalian cell biotechnology: A practical approach. Oxford University Press. 2001.
3. Singer, M., & Berg, P. (Eds.). Exploring genetic mechanisms. W.H. Freeman and Company. 1991.
4. Old, R. W., & Primrose, S. B. Principles of gene manipulation (5th ed.). Blackwell Scientific Publications. 1985.
5. BIOTOL (Organization).Biotechnological innovations in animal productivity. Elsevier. 2006.
6. Balinsky, B. I. An introduction to embryology. W. B. Saunders Company. 1960
7. Arora, M. P. Biotechnology. Himalaya Publishing House. 2007.
8. Masters, J. R. Animal cell culture (3rd ed.). Oxford University Press. 2000
9. BIOTOL *In vitro* cultivation of animal cells. Butterworth-Heinemann. 2005.
10. Gilbert, S. F. Developmental biology (6th ed.). Sinauer Associates. 2000

SBTTE-554 LAB COURSE IN ANIMAL BIOTECHNOLOGY

1. Packing and sterilization of glass and plastic wares for cell culture.
2. Preparation of reagents and media for cell culture.
3. Primary culture technique for chicken embryo fibroblast.
4. Secondary culture of chicken embryo fibroblast.
5. Cultivation of continuous cell lines.
6. Quantification of cells by trypan blue exclusion dye.
7. Isolation of lymphocytes and cultivation of lymphocytes
8. Study of effect of toxic chemicals on cultured mammalian cells

SVECP-1551 PUBLICATION ETHICS

Teaching Scheme

Course Code	Course Name	Teaching Scheme (Hrs.)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
SVECP-551	Publication Ethics	02	--	02	--	02

Assessment Scheme

Course Code	Course Name	Theory				Practical		Total
		CA			ESA			
		Test I	Test II	Avg of (T1+T2)/2		CA	ESA	
SVECP-551	Publication Ethics	10	10	10	40	--	--	50

Course pre-requisite: General awareness regarding publication basics

Course objectives:

- To know rules, issues, options, and resources for research ethics.
- To familiarize with various institutional ethics review boards/academic integrity guidelines.
- To understand the purpose and value of ethical decision-making.
- To have a positive disposition towards continued learning about research ethics

Course outcomes:

- To have a positive disposition towards continued learning about research philosophy & ethics.
- To know Rules, Regulations, Issues, Options, and Scientific Resources of Research Ethics.
- To learn the culture of fairness, honesty and integrity in academic communications and to understand the purpose and value of ethical decision-making.
- Avoid wasteful and duplicate publications & encourage original contributions to advance Academic Research and Scholarship.
- Acquiring knowledge & professional competence and expertise about Patents, Copyrights, and other forms of Intellectual Property Rights.
- To promote social good and prevent or mitigate societal hazards through innovative ideas, creativity and research advocacy

Curriculum Details:

Module No.	Unit No.	Topic	Hrs.
1.0	**I**	**Publication ethics**	**08**
	1.1	Publication ethics: definition, introduction and importance, Best practices/standards setting initiatives and guidelines: COPE, WAME, etc. Conflicts of interest	
	1.2	Publication misconduct: definition, concept, problems that lead to unethical behavior and vice verse, types	
	1.3	Violation of publication ethics, authorship and contributor ship	
	1.4	Identification of publication misconduct, complaints and appeals. Predatory publishers and journals	

2.0	**II**	**Open access publishing**	
	2.1	Open access publications and initiatives.	**07**
	2.2	SHERPA/RoMEO online resource to check publisher copyright and self- archiving policies	
	2.3	Software tool to identify predatory publications developed by SPPU	
	2.4	Journal finder/ journal suggestion tools viz. JANE	
3.0	**III**	**Publication misconduct**	
	3.1	Subject specific ethical issues, FFP, authorship	**07**
	3.2	Conflicts of interest	
	3.3	Complaints and appeals: examples and fraud from India and abroad	
	3.4	Use of plagiarism software like Turnitin, Urkund and other open source software tools.	
4.0	**IV**	**Databases and research metrics**	
	4.1	Databases: Indexing databases	**08**
	4.2	Citation databases: Web of Science, Scopus, etc.	
	4.3	Research Metrics: Impact Factor of journal as per journal citation report, SNIP, SJR, IPP, Cite Score.	
	4.4	Metrics: h-index, g index, i10 index, altmetrics	
		Total	**30**

References:

1. Donna M. Mertens, Pauline E. Ginsberg The Handbook of Social Research Ethics, SAGE (2009).
2. Rose Wiles, Bloomsbury What are Qualitative Research Ethics? (2013).
3. Robin Levin Penslar, eds, Research Ethics: Cases and Materials, Indiana University Press (1995).
4. Gary Comstock, Research Ethics: A Philosophical Guide to the Responsible Conduct of Research, Cambridge University Press (2013)
5. Bird, A. Philosophy of Science. Routledge, 2006.
6. MacIntyre, Alasdair A Short History of Ethics London, 1967
7. P. Chaddah Ethics in Competitive Research: Do not get scooped; do not get plagiarized, 2018
8. National Academy of Sciences, National Academy of Engineering and Institute of Medicine,2009.
9. On being a Scientist: A Guide to Responsible Conduct in Research. Third Edition. National Academies Press.
10. Resnik, D. B. What is ethics in research & why is it important. National Institute of Environmental Health Sciences, 2018. Retrieved from https www.nichs.nih.gov/research/resources/bioethics/whatis/index.cfm
11. Beall, J. Predatory publishers are corrupting open access. Nature, 2012.
    a. https://doi.org/10.1038/489179a
12. Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance,2019.

http://www.insaindia.res.in/pdf/Ethics Book.pdf

SBTTR-551 RESEARCH PROJECT

Teaching Scheme

Course Code	Course Name	Teaching Scheme (Hrs.)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
SBTTR-551	Research Project	--	12	--	06	06

Assessment Scheme

Course Code	Course Name	Theory				Practical		Total
		CA						
		Test I	Test II	Avg of (T1+T2)/2	ESA	CA	ESA	
SBTTR-551	Research Project				--	30	120	150

Course pre-requisite:

A prerequisite for Publication ethics will be Completion of core courses in biochemistry, molecular biology, cell biology, genetics, and biostatistics.

Course Objectives:

- To equip students with the knowledge and skills necessary to independently plan, execute, and present a research project in biotechnology.
- To develop critical thinking and problem-solving skills in the context of a biotechnology investigation.
- To foster hands-on experience in various biotechnology techniques and methodologies.
- To strengthen laboratory safety awareness and responsible research practices.
- To enhance scientific communication through written and oral presentation of research findings.

Course Outcomes:

- Students will be able to select a relevant research topic in biotechnology and formulate a focused research question.
- Students will be able to demonstrate proficiency in current biotechnology techniques and laboratory protocols.
- Students will be able to effectively analyze and interpret experimental data obtained from their research project.
- Students will be able to communicate their research findings clearly and concisely in written reports and presentations.
- Students will be able to critically evaluate existing research in biotechnology and identify future research directions.

**********02.06.2024**********