॥ 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

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

website: srtmun.ac.in

Fax : (02462) 215572

Phone: (02462)215542

Academic-1 (BOS) Section

E-mail: bos@srtmun.ac.in

विज्ञान व तंत्रज्ञान विद्याशाखे अंतर्गत राष्ट्रीय शैक्षणिक धोरण–२०२० नुसार पदवी तृतीय वर्षाचे अभ्यासक्रम (Syllabus) शैक्षणिक वर्ष २०२६–२७ पासून लागू करण्याबाबत.

प रि प त्र क

या परिपत्रकान्वये सर्व संबंधितांना कळविण्यात येते की, दिनांक २२ एप्रिल २०२६ रोजी संपन्न झालेल्या मा.विद्यापरिषद बैठकीतील विषय क्र.०८/६४–२०२६ च्या ठरावानुसार विज्ञान व तंत्रज्ञान विद्याशाखेतील राष्ट्रीय शैक्षणिक धोरण–२०२० नुसार पदवी तृतीय वर्षाचे अभ्यासक्रम (Syllabus) शैक्षणिक वर्ष २०२६–२७ पासून लागू करण्यास मा.विद्यापरिषदेने मान्यता प्रदान केली आहे. त्यानुसार विज्ञान व तंत्रज्ञान विद्याशाखेतील बी.एस्सी. तृतीय वर्षाचे खालील विषयाचे अभ्यासक्रम (Syllabus) शैक्षणिक वर्ष २०२६–२७ पासून लागू करण्यात येत आहे.

01	B.Sc. III Year Botany	10	B.Sc. III Year Biochemistry
02	B.Sc. III Year Chemistry	11	B.Sc. III Year Agriculture Microbiology
03	B.Sc. III Year Mathematics	12	B.Sc. III Year Electronics
04	B.Sc. III Year Zoology	13	B.Sc. III Year Seed Technology
05	B.Sc. III Year Microbiology	14	B.Sc. III Year Horticulture
06	B.Sc. III Year Geology	15	B.Sc. III Year Analytical Chemistry
07	B.Sc. III Year Enviornment & Earth Science	16	B.Sc. III Year Agrochemical & Fertilizers
08	B.Sc. III Year Statistics	17	B.Sc. III Year Industrial Chemistry
09	B.Sc. III Year Dairy Science	18	B.Sc. III Year Industrial Microbiology

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/परिपत्रक/पदवी/बीएस्सी/२०२६–२७/60
दिनांक : १९.०६.२०२६

सहा.कुलसचिव
शैक्षणिक (१–अभ्यासमंडळे) विभाग

प्रत माहिती व पुढील कार्यवाहीस्तव :–
१) मा. कुलगुरू महोदयांचे कार्यालय, प्रस्तुत विद्यापीठ.
२) मा. प्र.कुलगुरू महोदयांचे कार्यालय, प्रस्तुत विद्यापीठ
३) मा. अधिष्ठाता, विज्ञान व तंत्रज्ञान विद्याशाखा, प्रस्तुत विद्यापीठ.
४) मा. संचालक, परिक्षा व मुल्यमापन मंडळ, प्रस्तुत विद्यापीठ.
५) मा. प्राचार्य, सर्व संबंधित संलग्नित महाविद्यालये, प्रस्तुत विद्यापीठ.

SWAMI RAMANAND TEERTHMARATHWADA UNIVERSITY, NANDED - 431 606 (MS)

UNDERGRADUATE PROGRAMME OF

SCIENCE & TECHNOLOGY

B.Sc. Third Year

MICROBIOLOGY

(For Affiliated Colleges)

Effective from the Academic year 2026 – 2027

(As per NEP-2020)

Framed by

Board of Studies in Microbiology

S.R.T.M. University, Nanded - 431 606

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 firsthand 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

From Desk of Chairman, Board of Studies of the Subject Microbiology

Preamble:

The emergence of microbiology many centuries ago is considered one of many of the most important scientific achievements. Since then, it has become a leading field in the biological sciences and a popular course of study in higher institutions worldwide. Like every other B.Sc. programme in tertiary education, B.Sc. microbiology has its own set of different syllabi, which students must cover before they are allowed to graduate.

The New Education policy presents an opportunity to shift paradigm from a teacher – centric to student centric higher education system in India. It caters for skill-based education. The learning outcomes-based curriculum framework for a degree in B. Sc. (Honors) microbiology is intended to provide a comprehensive foundation to the subject and to help students develop the ability to successfully continue with further studies and research in the subject while they are equipped with required skills at various stages. Efforts has been made to integrate use of recent technology in teaching and learning. The syllabus is designed to equip students with valuable cognitive abilities and skills so that they are successful in meeting diverse needs of professional careers in a developing and knowledge-based society. The curriculum considers the need to maintain globally competitive standards of achievement in terms of knowledge and skills in Microbiology as well as develop scientific orientation, problem solving skills, human and professional values which foster rational and critical thinking in the students. This course serves a good opportunity in different fields in Microbiology.

In addition to these Program Educational Objectives, for each course of undergraduate program, objectives and expected outcomes from learner's point of view are also included in the curriculum to support the philosophy of outcome-based education. I believe strongly that small step taken in right direction will definitely help in providing quality education to the stake holders.

…….

B. Sc. Microbiology Program Objectives and Outcomes

PROGRAMME OBJECTIVES:

- To enrich students with knowledge and understanding of the different disciplines of Microbiology such as medical Microbiology, immunology, biochemistry, fermentation technology, environmental Microbiology, genetics, agricultural and food Microbiology, Waste management.
- To make students learn advanced fields of microbiology such as Nanobiotechnology and Marine microbiology.
- To introduce the concepts of application and research in Microbiology and inculcate sense of scientific responsibilities.
- To help student's build-up a progressive and successful career in Microbiology.
- To take a step ahead for the holistic development of students through activities like lectures from eminent personalities, Visits, and various competitions.
- It makes the students competent enough to use Microbiology knowledge and skills to analyze problems involving microbes and undertake remedial measures.
- In addition, students are to be trained to use this knowledge in day-today applications and get a glimpse of research.

- The students graduating in B.Sc. Microbiology degree must have thorough understanding the fundamentals of Microbiology as applicable to wide ranging contexts.
- They should have the appropriate skills of Microbiology so as to perform their duties as microbiologists.
- They must be able to analyze the problems related to Microbiology and come up with most suitable solutions.
- As Microbiology is an interdisciplinary subject the students might have to take inputs from other areas of expertise. So, the students must develop the spirit of team work.

PROGRAM SPECIFIC OBJECTIVES [PSOB]: Programme Specific Objectives for B.Sc. Microbiology are as follows:

- PSOB-1. The broad goal of the teaching to under graduate students in Microbiology is to provide knowledge and skills in Microbiology to develop practical skills through the laboratory work, their presentation and articulation skills, exposure to industry and interaction with industry experts, write short research - based projects.
- PSOB-2. To learn basic concepts of amazing world of Microorganisms, Techniques in Microbiology, basics of Bacteriology, Cultivation, and growth of Micro-organisms.
- PSOB-3. To understand concepts of Medical Microbiology, Epidemiology, Immunology, Bacterial Physiology, Fermentation Technology, Bacterial Genetics, Air, Water and Soil Microbiology.
- PSOB-4. To strengthen the fundamentals of various fields of Microbiology.
- PSOB-5.To develop scientific aptitude and motivate students to take up higher studies like B. Sc. (Hons. / Hons. with Research) microbiology and Research.
- PSOB-6. To realize and appreciate the applicability of knowledge and Interdisciplinary approach in everyday life.
- PSOB-7. The graduate students of microbiology should have basic skills such as culturing microbes, maintaining microbes, safety issues related to handling of microbes, Good Microbiological practices etc.

PROGRAMME SPECIFIC OUTCOMES [PSOC]: Programme specific outcomes for B.Sc. Microbiology are as follows:

- PSOC-1. The student will be able to explain various fields of Applied Science including Medicine, Pharmacy, Cell biology, Biotechnology, Industrial Production, Biochemistry, Nanotechnology, Environmental Management, Food, Dairy, Immunology, Agriculture and Bioinformatics
- PSOC-2. The students will be able to design and execute experiments related to Basic Microbiology, Immunology, Molecular Biology, Recombinant DNA Technology, and Microbial Genetics, etc.
- PSOC-3. The students will be able to execute a short research project incorporating techniques of Basic and Advanced Microbiology under supervision.
- PSOC-4. The students will be able to acquire sound knowledge of classification, taxonomy, structure , types of microorganisms and various fields of microbiology.
- PSOC-5. The students will be able to do experiment in microbiology laboratory to identify the microorganisms in various samples including clinical, environmental, water and food samples.

- PSOC-6. The students will be able to acquire knowledge about various diseases thereby can create awareness to the public.
- PSOC-7. The students will be able to provide knowledge on food processing, and fermented food products.
- PSOC-8. The students will be able to utilize various agricultural waste, marine sources as raw material for production of various fermented products to reduce accumulation of waste in the environment.
- PSOC-9. The students will be able to check the quality of water, dairy and food products by various learnt microbiological techniques
- PSOC-10. The students will be able to provide knowledge about history of Microbiology and contribution of various scientists. branches of Microbiology, basic structure of organism in details, microbial nutrition requirement for organism and microbial growth, microbiological techniques and control, different type of staining techniques used to distinguish between different type of bacteria and its organelles.
- PSOC-11. The students will be able to acquire knowledge about the different types of bacteria and viruses, microbial interaction, prevention of food from spoilage, preservation of food from food borne disease and food standards. also study the testing and preservation of milk and milk product in dairy industries.
- PSOC-12. The students will be able to acquire knowledge about the basic structure like Nucleic acid, carbohydrates metabolism, amino acids, enzymology in details and various vitamins. also study the fermentation at industrial level and upstream and downstream processing of fermentation
- PSOC-13. The students will be able to acquire knowledge about different types of metabolic pathways and its regulation related to carbohydrates amino acid. also study about different type of waste water treatment methods and water testing methods. this also cover air and agriculture microbiology with bioremediation and biomagnification.
- PSOC -14. The students will be able to acquire knowledge about the epidemiology and host parasites, disease transmitted and their various sources, control and prevention & spreading of infection, learn about normal flora present in body, study of pathogenic and non-pathogenic organism, morphology, cultural and biochemicals characteristic, pathogenesis, serology test and lab diagnosis, gene mutation and regulation of gene.
- PSOC-15. The students will be able to acquire knowledge about Immunity, various defense mechanism, organs of immune system, adaptive immunity, and cell mediated immune response. tools and techniques of genetic engineering. also come to know about health care, agriculture, and industrial biotechnology.
- PSOC-16 The students will be able to Explain why microorganisms are ubiquitous in nature; inhabiting a multitude of habitats and occupying a wide range of ecological habitats, their role in these ecological niches, influence of microbiome on our health, environmental cleanup, variety of industrial product development, and their significance in human wellbeing.
- PSOC-17. The students will be competent enough to use microbiology knowledge and skills to analyze problems involving microbes, learning use of microbes as a model organisms to understand facts about living systems, analyze the genetic makeup of different types understand of microbes, articulate these with peers/ team members/ other stake holders through effective communication, and undertake remedial

measures/ studies etc.

- PSOC-18. The students will take up a suitable position in academia or industry and to pursue a career in research.
- PSOC-19. The students will be able to develop their skills to start small scale business in various microbiological laboratories and in the field of research and health.

Dr. Santosh M. More
Chairman,
Board of Studies of the Microbiology
Swami Ramanand Teerth Marathwada University,
Nanded

Details of the Board of Studies Members in the subject Microbiology under the faculty of Science & Technology of S. R. T. M. University, Nanded

Sr No	Name of the Member	Designation	Address	Contact No.
1.	**Dr. Santosh M. More**	**Professor & BOS, Chairman**	**Yeshwant Mahavidyalaya, Nanded**	**9422871533**
2.	**Dr. Rajendraprasad S. Awasthi**	**Principal**	**Shivaji Mahavidyalaya, Renapur**	**8275924462**
3.	**Dr. Prashant Wakte**	**Professor**	**DSM's College of Arts, Commerce and Science, Parbhani**	**8669062962**
4.	**Dr. Anupama P. Pathak**	**Professor**	**School of Life Sciences, SRTM University Nanded**	**9404732162**
5.	**Dr. Shiva C. Aithal**	**Professor**	**DSM's College of Arts, Commerce and Science, Parbhani**	**7483715560**
6.	**Dr. Deepak Vedpathak**	**Professor**	**Rajarshi Shahu Mahavidyalaya, Latur**	**9822757890**
7.	**Dr. Sanjivkumar V. Kshirsagar**	**Assistant Professor**	**Sant Janabai Education Society's ACS College, Gangakhed**	**9421448741**
8.	**Dr. Hemlata J. Bhosle**	**Professor**	**School of Life Sciences, SRTM University Nanded**	**8698809434**
9.	**Dr. Sunita Mukkawar**	**Associate Professor**	**B. Raghunath ACS College, Parbhani**	**9422415911**
10.	**Dr. Ravindra R. Rakh**	**Associate Professor**	**Shri Guru Buddhiswami Mahavidyalaya, Purna**	**9545335680**
11.	**Dr. Prashant P. Dixit**	**Professor**	**Dr. B.A.M. Uni. Aurangabad, Sub-camps, Osmanabad**	**9421335704**
12.	**Dr. M. K. Ranjekar**		**Green Vitlas Biotech, Ranje Village, Pune**	**9422015217**
13.	**Dr. Prita S. Borkar**	**Professor**	**Science College, Nanded**	**9921121194**
14.	**Dr. Abhay B. Solunke**	**Associate Professor**	**Shri Govindrao Munghate Arts & Science College, Kurkheda, Gadchiroli**	**9403579999**
15.	**Dr. M. S. Dharne**	**Principal Scientist**	**National Collection of Industrial Microorganisms, CSIR- NCL, Pune**	**9730257991**

Swami Ramanand Teerth Marathwada University, Nanded

Faculty of Science and Technology

Credit Framework for B. Sc. III Year

Multidisciplinary Degree Program with Multiple Entry and Exit

Subject: Microbiology (Major)

Year & Level	Semester	Major *(From the same Faculty)*		Minor 1 *(From the same Faculty)*	Minor 2 *(From the same Faculty)*	Generic Elective (GE) (select from Basket 3 of *Faculties other than Science and Technology*)	Vocational & Skill Enhancement Course	Ability Enhancement Course (AEC) (Basket 4) Value Education Courses (VEC) / Indian Knowledge System (IKS) (Basket 5)	Field Project/ Case Study/ OJT/	Credits	Total Credits
1	2	3		4	5	6	7	8	9	10	11
3 (5.5)	V	SMICCT1301 (3cr) SMICCT1302 (3cr) SMICIK1303 (2cr) SMICCP1301 (2cr) SMICCP1302 (2cr) 12 Credits	Major Elective SMICET1301 (2cr) SMICEP1301 (2cr) 04 Credits	--	--	--	SMICVC1301 02 Credits	--	FP/CS SMICFP1301 Or SMICCS1301 04 Credits	22	132
	VI	SMICCT1351 (3cr) SMICCT1352 (3cr) SMICCT1353 (2cr) SMICCP1351 (2cr) SMICCP1352 (2cr) 12 Credits	Major Elective SMICET1351 (2cr) SMICEP1351 (2cr) 04 Credits	--	--	--	SMICVC1351 02 Credits	--	OJT SMICOJ1351 04 Credits	22	
	Cum. Cr.	56		16	08	08	08+4=12	22	08+2=10	44	

***Exit option*: UG Diploma in Major Microbiology and Minor Microbiology on completion of 88 credits and** additional **4 credits NSQF / internship in Microbiology**

B. Sc. Third Year Semester V*(Level 5.5)*

Teaching Scheme

	Course Code	Course Name	Credits Assigned			Teaching Scheme (Hrs/ week)	
			Theory	Practical	Total	Theory	Practical
Major	**SMICCT1301**	**Microbial Genetics**	03	--	**12**	03	--
	SMICCT1302	**Microbial Metabolism**	03	--		03	--
	SMICIK1303	**Ethnomicrobiology (IKS)**	02	--		02	--
	SMICCP1301	**Practical Based on SMICCT1301**	-	02		--	04
	SMICCP1302	**Practical Based on SMICCT1302**		02		--	04
Elective	**SMICET1301**	Nitrogen Metabolism	02	--	**04**	02	--
	SMICEP1301	**Practical Based on SMICET1301**	-	02		--	04
	SMICET1302	Bioinstrumentation	02	--		02	--
	SMICEP1302	**Practical Based on SMICET1302**	-	02		--	04
Vocational Course	**SMICVC1301**	Microbial Enzyme Technology	--	02	**02**	--	04
Field Project Case Study	**SMICFP1301 Or SMICCS1301**	**Field Project / Case Study**	--	04	**04**	--	08
Total Credits 22			**10**	**12**	**22**	**10**	**24**

B. Sc. Third Year Semester V*(Level 5.5)*

Examination Scheme

[40% Continuous Assessment (***CA***) and 60% End Semester Assessment (***ESA***)]

(For illustration we have considered a paper of 02 credits, 50 marks, need to be modified depending on credits assigned to individual paper)

Subject (1)	Course Code (2)	Course Name (3)	Theory				Practical		Total Col (6+7) / Col (8+9) (10)
			Continuous Assessment (CA)			ESA			
			Test I (4)	Test II (5)	Total of T1 & T2 (6)	Total (7)	CA (8)	ESA (9)	
Major	**SMICCT1301**	**Microbial Genetics**	15	15	30	45	--	--	75
	SMICCT1302	**Microbial Metabolism**	15	15	30	45	--	--	75
	SMICIK1303	**Ethnomicrobiology (IKS)**	10	10	20	30	--	--	50
	SMICCP1301	**Practical Based on SMICCT1301**	--	--	--	--	20	30	50
	SMICCP1302	**Practical Based on SMICCT1302**	--	--	--	--	20	30	50
Elective	**SMICET1301**	Nitrogen Metabolism	10	10	20	30	--	--	50
	SMICEP1301	**Practical Based on SMICET1301**	--	--	--	--	20	30	50
	SMICET1302	Bioinstrumentation	10	10	20	30	--	--	50
	SMICEP1302	**Practical Based on SMICET1302**	--	--	--	--	20	30	50
Vocational Course	**SMICVC1301**	Microbial Enzyme Technology	--	--	--	--	20	30	50
Field Project / Case Study	**SMICFP1301 Or SMICCS1301**	**Field Project / Case Study**	--	--	--	--	40	60	100

B. Sc. Third Year Semester VI *(Level 5.5)*

Teaching Scheme

	Course Code	Course Name	Credits Assigned			Teaching Scheme (Hrs/ week)	
			Theory	Practical	Total	Theory	Practical
Major	SMICCT1351	Molecular Biology	03	--	12	03	--
	SMICCT1352	Industrial Microbiology	03	--		03	--
	SMICCT1353	Agricultural Microbiology	02	--		02	--
	SMICCP1351	Practical Based on SMICCT1351	-	02		--	04
	SMICCP1352	Practical Based on SMICCT1352		02		--	04
Elective	SMICET1351	Pharmaceutical Microbiology	02	--	04	02	--
	SMICEP1351	Practical Based on SMICET1351	-	02		--	04
	SMICET1352	Environmental Microbiology	02	--		02	--
	SMICEP1352	Practical Based on SMICET1352	-	02		--	04
Vocational Course	SMICVC1351	Agrobioprocessing Technology	--	02	02	--	04
OJT	SMICOJ1351	OJT	--	04	04	--	08
Total Credits 22			**10**	**12**	**22**	**10**	**24**

B. Sc. Third Year Semester VI *(Level 5.5)*

Examination Scheme

[40% Continuous Assessment (***CA***) and 60% End Semester Assessment (***ESA***)]

(For illustration we have considered a paper of 02 credits, 50 marks, need to be modified depending on credits assigned to individual paper)

Subject (1)	Course Code (2)	Course Name (3)	Theory				Practical		Total Col (6+7) / Col (8+9) (10)
			Continuous Assessment (CA)			ESA			
			Test I (4)	Test II (5)	Total of T1 & T2 (6)	Total (7)	CA (8)	ESA (9)	
Major	SMICCT1351	Molecular Biology	15	15	30	45	--	--	75
	SMICCT1352	Industrial Microbiology	15	15	30	45	--	--	75
	SMICCT1353	Agricultural Microbiology	10	10	20	30	--	--	50
	SMICCP1351	Practical Based on SMICCT1351	--	--	--	--	20	30	50
	SMICCP1352	Practical Based on SMICCT1352	--	--	--	--	20	30	50
Elective	SMICET1351	Pharmaceutical Microbiology	10	10	20	30	--	--	50
	SMICEP1351	Practical Based on SMICET1351	--	--	--	--	20	30	50
	SMICET1352	Environmental Microbiology	10	10	20	30	--	--	50
	SMICEP1352	Practical Based on SMICET1352	--	--	--	--	20	30	50
Vocational Course	SMICVC1351	Agrobioprocessing Technology	--	--	--	--	20	30	50
OJT	SMICOJ1351	OJT	--	--	--	--	40	60	100

Syllabus for B. Sc. Microbiology

Third Year

Semester – V

As Per National Education Policy- 2020

To be implemented from

Academic Year 2026-2027

National Education Policy 2020

B.Sc. Microbiology, III Year (Semester - V)

Major Core Theory Course

Course Code – SMICCT1301

Title of the Course: Microbial Genetics

[No. of Credits: 3 Credit] **[Total: 45 Hours]**

Course pre-requisite:

1. The course is designed for students enrolled in the undergraduate second-year programme in the Faculty of Science and Technology. It is intended for those who have received foundational training in Microbiology at the first-year undergraduate level and serves as an entry-level core course for students opting for Microbiology as their major subject.
2. The students should possess basic knowledge of Microbiology, including an understanding of microbial cell structure (prokaryotic and eukaryotic), classification of microorganisms (bacteria, fungi, viruses, and algae), and their general characteristics. They should be familiar with fundamental concepts such as microbial growth, metabolism, and reproduction. In addition, a preliminary understanding of aseptic techniques, sterilization methods, and the role of microorganisms in environment, industry, and human health is desirable for better comprehension of the course.

Course objectives:

1. To understand the structure, organization, and function of genetic material in microorganisms.
2. To explain the molecular mechanisms of DNA replication, transcription, and translation in prokaryotes.
3. To study the principles and mechanisms of genetic recombination and gene transfer in bacteria.
4. To introduce the concepts of gene regulation and operon systems in microorganisms.
5. To understand the role of plasmids, transposable elements, and other mobile genetic elements.
6. To develop practical skills in basic molecular biology and microbial genetics techniques.

Course outcomes:

After successful completion of this course, students will be able to:

1. Describe the structure, organization, and properties of genetic material in microorganisms.
2. Explain the molecular mechanisms of DNA replication, transcription, and translation.
3. Illustrate different types of genetic recombination and gene transfer in bacteria (transformation, transduction, and conjugation).
4. Understand gene regulation mechanisms, including operon models in prokaryotes.
5. Explain the role of plasmids, transposable elements, and other mobile genetic elements.
6. Perform basic laboratory techniques related to microbial genetics and interpret experimental results.

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1.0		**The Genetic Material**	
	1.1	**Historical Experiments Establishing DNA as Genetic Material** • Frederick Griffith experiment • Oswald Avery, Colin MacLeod and Maclyn McCarty experiment • Alfred Hershey and Martha Chase experiment	**09**
	1.2	**Evidence for RNA as Genetic Material in Viruses** • Gierer and Schramm Experiment – Tobacco Mosaic Virus	
	1.3	**DNA as Genetic Material** • Structure and Properties of DNA	
	1.4	**Structure of Prokaryotic Chromosomes:** • *Escherichia coli* as a Model Organism	

2.0		**Prokaryotic DNA replication**	
	2.1	**General Concepts of DNA Replication**	**12**
	2.2	**Semi-Conservative DNA Replication** Concept and experimental proof (Meselson and Stahl experiment)	
	2.3	**Replicon Model (Cairns Model)**	
	2.4	**Precursors and Enzymes of DNA Replication**	
	2.5	**Mechanism of DNA Replication:** • Initiation, • Elongation (Beta Clamp and Progressive Polymerases) • Termination	
3.0		**Molecular Recombination in Bacteria**	
	3.1	**General Perspective of Genetic Recombination**	**12**
	3.2	**Homologous Recombination in** *E. coli* Initiation, Synapsis, Branch Migration, and resolution	
	3.3	**Types of Recombination** • Site Specific Recombination (Integrative and Excessive Recombination) • Illegitimate Recombination (Non- Homologous Recombination) • Transposition: o Transposable elements in Prokaryotes o Insertion Sequence	
4.0		**Genetic Exchange in bacteria**	
	4.1	**Transformation:** • Definition • Discovery of Transformation • Mechanism of Transformation: o Competence o DNA Binding o DNA penetration o Synapsis o Integration	**12**
	4.2	**Conjugation** • Definition • Discovery of Conjugation in Bacteria • Properties of F plasmid /Sex factor • Hfr strains and their formation • Mechanism of Conjugation • F′ (F prime) factor and sexduction	
	4.3	**Transduction** • Definition • Discovery of Transduction in Bacteria • Types of Transduction o Generalized Transduction o Specialized Transduction • Abortive Transduction	
		Total	**45**

Textbooks and Reference Books:

1. Essentials of Molecular Biology by David Freifelder (2002), Publisher: Narosa Publishing House.
2. Fundamental Bacterial Genetics by Nancy Trun and Jenanine Trumphy (2003),Publisher: Blackwell Publishing
3. General Microbiology (5th edn.) Stanier R. Y., Ingraham, J.L., Wheelis, M. L., Painter, P.R.(2008), Publisher: Macmillan Press Ltd, London
4. General Microbiology (Vol. I and II) Powar, C.B. and Daginawala, H. F.(2008), Publisher: Himalaya publishing house
5. Genetics a conceptual approach (3rd ed.) by Benjamin A. Pierce (2008) Publisher: W.H. Freeman and Company.
6. Genetics-A molecular approach (2nd /3rd ed.) by Peter J. Russell (2006)
7. Modern Microbial Genetics, Second Edition. Edited by Uldis N. Streips, Ronald E. Yasbin. Publisher: Wiley-Liss, Inc.
8. Principles of Genetics by R. H. Tamarin, (2004) Publisher: Tata McGraw Hill.
9. Willey, Joanne M. Prescott, Harley, and Klein's Microbiology / Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton. — 7th ed. Published by McGraw- Hill, a business unit of The McGraw-Hill Companies, Inc., 1221 Avenue of the Americas, New York, NY 10020.
10. Brock Biology of Microorganisms, Thirteenth Edition by Michael T. Madigan, John M. Martinko, David A. Stahl, David P. Clark, Benjamin Cummings, 1301 Sansome Street, San Francisco, CA 94111.
11. Molecular Genetics of Bacteria (2013) by Larry Snyder, Joseph E. Peters, Tina M. Henkin and Wendy Champness 4th Edition, ASM Press

National Education Policy 2020

B.Sc. Microbiology, III Year (Semester - V)

Major Core Practical Course

Course Code – SMICCP1301

Title of the Course: Practical Based on SMICCT1301

[No. of Credits: 2 Credit] **[Total: 60 Hours]**

Course pre-requisite:

1. The course is designed for students enrolled in the undergraduate second-year programme in the Faculty of Science and Technology. It is intended for those who have received foundational training in Microbiology at the first-year undergraduate level and serves as an entry-level core course for students opting for Microbiology as their major subject.
2. The students should possess basic knowledge of Microbiology, including an understanding of microbial cell structure (prokaryotic and eukaryotic), classification of microorganisms (bacteria, fungi, viruses, and algae), and their general characteristics. They should be familiar with fundamental concepts such as microbial growth, metabolism, and reproduction. In addition, a preliminary understanding of aseptic techniques, sterilization methods, and the role of microorganisms in environment, industry, and human health is desirable for better comprehension of the course.

Course objectives:

1. To develop practical skills in isolation, purification, and characterization of genomic DNA from bacterial sources such as Escherichia coli.
2. To train students in quantitative and qualitative analysis of nucleic acids using spectrophotometric and chemical methods.
3. To understand the principles and application of DNA denaturation, melting temperature (Tm), and G+C content analysis.
4. To provide hands-on experience in agarose gel electrophoresis for separation and visualization of DNA.
5. To enable students to perform extraction, purification, and characterization of RNA from eukaryotic systems such as yeast.
6. To familiarize students with colorimetric assays (Diphenylamine and Orcinol methods) for nucleic acid estimation.
7. To demonstrate fundamental mechanisms of genetic exchange in bacteria, including transformation, transduction, and conjugation.
8. To enhance laboratory skills, data interpretation, and scientific reporting in molecular microbiology experiments.

Course outcomes:

After successful completion of this course, students will be able to:

1. Isolate and purify genomic DNA from bacteria and total RNA from yeast using standard laboratory techniques.
2. Assess the purity and concentration of DNA and RNA using spectrophotometric methods.
3. Perform quantitative estimation of nucleic acids using Diphenylamine (DNA) and Orcinol (RNA) assays.
4. Determine the melting temperature (Tm) of DNA and correlate it with G+C content.
5. Carry out agarose gel electrophoresis and interpret banding patterns for nucleic acid analysis.
6. Demonstrate and explain mechanisms of bacterial genetic exchange including transformation, transduction, and conjugation.
7. Analyze experimental data, troubleshoot laboratory procedures, and maintain proper laboratory records.

8. Apply molecular biology techniques in research areas such as microbial genetics, biotechnology, and biomedical sciences.

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1.0		**Molecular Characterization of DNA**	
	1.1	Cell Lysis, Extraction and Purification of Genomic DNA from Escherichia coli	**20 [5 practicals]**
	1.2	Spectrophotometric Confirmation and Purity Assessment of DNA	
	1.3	Spectrophotometric Quantification of DNA Using Diphenylamine Reagent	
	1.4	Determination of DNA Denaturation Temperature (Tm) and G+C Content	
	1.5	Separation and Visualization of DNA by Agarose Gel Electrophoresis	
2.0		**Molecular Characterization of DNA**	
	2.1	Pure culture growth and Harvesting of Yeast for RNA Extraction	**16 [4 Practicals]**
	2.2	Cell Lysis, Extraction and Purification of total RNA from Yeast	
	2.3	Spectrophotometric Confirmation and Purity Assessment of RNA	
	2.4	Spectrophotometric quantification of RNA Using Orcinol-Based Assay	
3.0		**Genetic Exchange in bacteria**	
	3.1	Demonstration of Transformation in Bacteria	**24 [6 Practicals]**
	3.2	Demonstration of Transduction in Bacteria	
	3.3	Demonstration of Conjugation in Bacteria	
		Total	**60**

Textbooks and Reference Books:

1. Gautam, A. (2022). DNA and RNA Isolation Techniques for Non-experts (pp. 79-84). Cham: Springer.
2. Willey, Joanne M. Prescott, Harley, and Klein's Microbiology / Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton. — 7th ed. Published by McGraw- Hill, a business unit of The McGraw-Hill Companies, Inc., 1221 Avenue of the Americas, New York, NY 10020.
3. Brock Biology of Microorganisms, Thirteenth Edition by Michael T. Madigan, John M. Martinko, David A. Stahl, David P. Clark, Benjamin Cummings, 1301 Sansome Street, San Francisco, CA 94111.
4. Molecular Genetics of Bacteria (2013) by Larry Snyder, Joseph E. Peters, Tina M. Henkin and Wendy Champness 4th Edition, ASM Press

National Education Policy 2020

B.Sc. Microbiology, III Year (Semester - V)

Major Core Theory Course

Course Code – SMICCT1302

Title of the Course: Microbial Metabolism

[No. of Credits: 3 Credit] **[Total: 45 Hours]**

Course pre-requisite:

1. The course is designed for students enrolled in the undergraduate second-year programme in the Faculty of Science and Technology. It is intended for those who have received foundational training in Microbiology at the first-year undergraduate level and serves as an entry-level core course for students opting for Microbiology as their major subject.
2. The students should possess basic knowledge of Microbiology, including an understanding of microbial cell structure (prokaryotic and eukaryotic), classification of microorganisms (bacteria, fungi, viruses, and algae), and their general characteristics. They should be familiar with fundamental concepts such as microbial growth, metabolism, and reproduction. In addition, a preliminary understanding of aseptic techniques, sterilization methods, and the role of microorganisms in environment, industry, and human health is desirable for better comprehension of the course.

Course objectives:

1. To provide fundamental knowledge of **enzyme structure, properties, classification, and mechanisms of action**.
2. To develop understanding of **enzyme kinetics**, including the Michaelis–Menten equation and factors affecting enzyme activity.
3. To explain different types of **enzyme inhibition and regulatory mechanisms** such as allosteric control and isoenzymes.
4. To introduce the concepts of **microbial metabolism**, including catabolism and anabolism.
5. To highlight the role of **nucleotides (ATP, NAD, FAD)** in cellular metabolic processes.
6. To impart knowledge of major **metabolic pathways** such as glycolysis (EMP), HMP pathway, Entner–Doudoroff pathway, TCA cycle, and β-oxidation.
7. To understand mechanisms of **energy generation and transformation** in microorganisms, including respiration, fermentation, and photosynthesis.
8. To explain the structure and function of the **bacterial electron transport chain (ETC)**.
9. To familiarize students with various **industrial and microbial fermentation processes** and their biochemical basis.

Course outcomes:

After successful completion of this course, students will be able to:

1. Describe the **structure, classification, and physicochemical properties of enzymes**.
2. Explain **enzyme kinetics**, interpret the Michaelis–Menten model, and evaluate factors influencing enzyme activity.
3. Differentiate between **types of enzyme inhibition** and mechanisms of enzyme regulation.
4. Understand and explain **microbial metabolic pathways** and their significance in energy production.
5. Describe the role of **ATP and coenzymes** in metabolic reactions.
6. Illustrate major pathways of **carbohydrate and lipid metabolism** in microorganisms.
7. Explain mechanisms of **ATP generation** through oxidative phosphorylation, photophosphorylation, and substrate-level phosphorylation.
8. Describe the **bacterial electron transport chain** and its components.
9. Compare different types of **microbial fermentations** such as ethanol, lactic acid, mixed acid, and butanediol fermentation.

10. Apply the knowledge of enzymes and metabolism in areas such as **biotechnology, industrial microbiology, and research**.

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1.0		**Enzymes**	
	1.1	Definition, Physicochemical properties of enzymes	**15**
	1.2	Coenzymes and Cofactors Nomenclature and Classification of enzymes	
	1.3	Mechanisms of enzyme action Specificity of enzymes	
	1.4	Enzyme kinetics: Michaelis-Menten equation	
	1.5	Factors affecting enzyme activity	
	1.6	Inhibition of enzyme activity: Competitive, Non-competitive and Uncompetitive inhibition	
	1.7	Regulation of enzyme activity: Allosteric enzymes, Multienzyme system and Isoenzymes.	
2.0		**Microbial Metabolism**	
	2.1	Introduction to metabolism, catabolism and anabolism with examples.	**15**
	2.2	Role of nucleotides in metabolism: Nucleotides as building blocks of nucleic acids; ATP as currency of cell; Pyridine and Flavin nucleotides	
	2.3	Basic pathways of carbohydrate catabolism: EMP, HMP, ED, and PKP, TCA cycle	
	2.4	β-Oxidation of saturated and unsaturated fatty acids	
3.0		**Mechanisms of Energy Transformations in Microorganisms**	
	3.1	Respiration, Photosynthesis and Fermentation (Basic concepts)	**08**
	3.2	Generation of ATP: Oxidative Phosphorylation, Photophosphorylation and Substrate level Phosphorylation	
	3.3	Biochemical mechanisms of respiration in Heterotrophs and Chemoautotrophs	
	3.4	Respiratory electron transport chain in bacteria	
	3.5	Characteristics of Bacterial RETC and It's Components	
4.0		**Microbial Fermentations**	
	4.1	Ethanol fermentation by Yeasts and Bacteria.	**07**
	4.2	Lactic acid fermentation: Homo and Heterolacta fermentation	
	4.3	Mixed acid fermentation	
	4.4	Acetone-Butanol fermentation	
	4.5	Butanediol fermentation.	
	4.6	Succinic acid fermentation	
		Total	**45**

Textbooks and Reference Books:

1. D. L. Nelson and M. M. Cox. '*Lehninger Principles of Biochemistry*', Macmillan Int.
2. J. M. Berg, J. L. Tymoczko and L. Stryer. '*Biochemistry*' 6th edition, W. H Freeman and Company.
3. S. C. Rastogi. '*Biochemistry*'. Tata McGraw Hill Publishing Company, New Delhi.
4. Gottschalk G. '*Bacterial Metabolism*'. Springer, New York.
5. Doelle H. W. '*Bacterial Metabolism*'. Elsevier, New Delhi.
6. Moat A. G., Foster J. W. and Spector M. P. '*Microbial Physiology*'. Wiley-India.
7. Conn E. E. and Stmph P. K. 'Outlines of Biochemistry' John Wiley & Sons, New Delhi.
8. Brock Biology of Microorganisms, Thirteenth Edition by Michael T. Madigan, John M. Martinko, David A. Stahl, David P. Clark, Benjamin Cummings, 1301 Sansome Street, San Francisco, CA 94111.
9. Brock Biology of Microorganisms, Thirteenth Edition by Michael T. Madigan, John M. Martinko, David A. Stahl, David P. Clark, Benjamin Cummings, 1301 Sansome Street,San Francisco, CA 94111.

National Education Policy 2020

B.Sc. Microbiology, III Year (Semester - V)

Major Core Practical Course

Course Code – SMICCP1302

Title of the Course: Practical Based on SMICCT1302

[No. of Credits: 2 Credit] **[Total: 60 Hours]**

Course pre-requisite:

1. The course is designed for students enrolled in the undergraduate second-year programme in the Faculty of Science and Technology. It is intended for those who have received foundational training in Microbiology at the first-year undergraduate level and serves as an entry-level core course for students opting for Microbiology as their major subject.
2. The students should possess basic knowledge of Microbiology, including an understanding of microbial cell structure (prokaryotic and eukaryotic), classification of microorganisms (bacteria, fungi, viruses, and algae), and their general characteristics. They should be familiar with fundamental concepts such as microbial growth, metabolism, and reproduction. In addition, a preliminary understanding of aseptic techniques, sterilization methods, and the role of microorganisms in environment, industry, and human health is desirable for better comprehension of the course.

Course objectives:

1. To develop practical skills in the **detection and characterization of microbial enzymes** such as Lecithinase, Gelatinase, Urease, Caseinase, and Catalase.
2. To provide hands-on experience in **microbial production of industrially important enzymes** like amylase using fermentation techniques.
3. To understand the influence of **environmental factors (pH and temperature)** on enzyme activity and stability.
4. To train students in determining **enzyme activity parameters**, including the achromic point of amylase.
5. To impart knowledge and practical skills in **measurement of microbial growth** using different methods.
6. To enable calculation and interpretation of **growth kinetics**, including growth rate and generation time.
7. To demonstrate important microbial growth patterns such as the **diauxic growth curve**.
8. To provide experience in **biochemical analysis of metabolites**, including estimation of reducing sugars and proteins.
9. To enhance analytical, observational, and laboratory skills in **microbial physiology and biochemistry experiments**.

Course outcomes:

After successful completion of this course, students will be able to:

1. Perform and interpret tests for **detection of extracellular enzymes** in microorganisms.
2. Carry out **microbial production of amylase** and evaluate factors affecting its activity.
3. Analyze the effect of **pH and temperature on enzyme activity** and determine optimal conditions.
4. Determine the **achromic point of amylase activity** and understand its significance in starch hydrolysis.
5. Measure microbial growth using **direct and indirect methods**, including haemocytometer counting.
6. Calculate **growth rate, generation time**, and interpret microbial growth curves.
7. Demonstrate and explain **diauxic growth behavior** in bacteria such as *E. coli*.
8. Perform biochemical estimation of **reducing sugars and proteins** using standard methods

(Sumner's and Lowry's methods).

9. Analyze experimental data, construct graphs, and draw scientific conclusions from laboratory results.
10. Apply practical knowledge in fields such as **industrial microbiology, biotechnology, and clinical microbiology**..

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1.0		**Study of Enzymes**	
	1.1	Detection of Lecithinase Activity in Microorganisms	**20 [5 practicals]**
	1.2	Detection of Gelatinase Activity in Microorganisms	
	1.3	Detection of Urease Activity in Microorganisms	
	1.4	Detection of Caseinase Activity in Microorganisms	
	1.5	Detection of Catalase Activity in Microorganisms	
2.0		**Microbial Amylase Production and Environmental Effects on its activity (pH & Temperature)**	
	2.1	Microbial Production of Amylase by Fermentation	**16 [4 Practicals]**
	2.2	Effect of pH and Temperature on Amylase Activity	
	2.3	Effect of pH and Temperature on Amylase Activity	
	2.4	Determination of the Achromic Point of Amylase Activity	
3.0		**Measurement of Microbial Growth**	
	3.1	Calculation of Growth rate and generation time of *E. coli*	**16 [4 Practicals]**
	3.2	Demonstration of Diauxic growth curve of *E. coli*	
	3.3	Measurement of Microbial Growth by Cell Number using Haemocytometer	
	3.4	Acid and Gas production from Carbohydrates: Demonstration of Fermentation of Glucose by Kuhn's Fermentation Vessel	
4.0		**Biochemical Estimation of Metabolites**	
	4.1	Estimation of reducing sugar by Sumner's method.	**8 [2 Practicals]**
	4.2	Estimation of Protein by Folin Lowry's Method	
		Total	**60**

Textbooks and Reference Books:

1. Sulieman, A. M. E., & Sulieman, A. M. E. (2025). *Microbial Enzymes: Classification, Biochemistry, Production and Applications*. Elsevier Science & Technology.
2. Ray, R. C., & Rosell, C. M. (Eds.). (2017). *Microbial enzyme technology in food applications*. CRC Press.
3. Brahmachari, G., Demain, A. L., & Adrio, J. L. (Eds.). (2016). *Biotechnology of microbial enzymes: production, biocatalysis and Industrial applications*. Academic Press.
4. Gopinath, S. C., Anbu, P., Arshad, M. M., Lakshmipriya, T., Voon, C. H., Hashim, U., & Chinni, S. V. (2017). Biotechnological processes in microbial amylase production. *BioMed research international*, *2017*(1), 1272193.
5. Yadav, D., Chowdhary, P., Anand, G., & Gaur, R. K. (Eds.). (2024). *Microbial Enzymes: Production, Purification, and Industrial Applications, 2 Volume Set*. John Wiley & Sons.

National Education Policy 2020

B.Sc. Microbiology, III Year (Semester - V)

Major Core Theory Course

Course Code – SMICIK1301

Title of the Course: Ethnomicrobiology

[No. of Credits: 2 Credit] **[Total: 30 Hours]**

Course pre-requisite:

1. The course is designed for students enrolled in the undergraduate second-year programme in the Faculty of Science and Technology. It is intended for those who have received foundational training in Microbiology at the first-year undergraduate level and serves as an entry-level core course for students opting for Microbiology as their major subject.
2. The students should possess basic knowledge of Microbiology, including an understanding of microbial cell structure (prokaryotic and eukaryotic), classification of microorganisms (bacteria, fungi, viruses, and algae), and their general characteristics. They should be familiar with fundamental concepts such as microbial growth, metabolism, and reproduction. In addition, a preliminary understanding of aseptic techniques, sterilization methods, and the role of microorganisms in environment, industry, and human health is desirable for better comprehension of the course.

Course objectives:

1. To introduce the concept, scope, and interdisciplinary nature of **ethnomicrobiology**.
2. To understand the relationship between **microbiology, anthropology, and indigenous knowledge systems**.
3. To explore the role of microorganisms in **traditional fermentation practices across different regions of India**.
4. To study the importance of **green manuring, biofertilizers, and natural farming practices** in sustainable agriculture.
5. To provide knowledge of **traditional bio-formulations** such as Bijamrut, Jivamrut, Panchagavya, and botanical pesticides.
6. To understand the role of microorganisms in **traditional medicine and health practices**.
7. To explain the concepts and applications of **prebiotics and probiotics** in maintaining gut health.
8. To integrate traditional knowledge with **modern microbiological and biotechnological approaches**.

Course outcomes:

After successful completion of this course, students will be able to:

1. Define and explain the **scope and significance of ethnomicrobiology**.
2. Analyze the contribution of **indigenous knowledge systems** to microbial applications.
3. Identify and describe **region-specific fermented foods of India** and their microbial significance.
4. Explain the role of microorganisms in **traditional fermentation and food preservation**.
5. Understand the principles and applications of **green manuring and biofertilizers** in sustainable agriculture.
6. Describe preparation and applications of **traditional bio-formulations and natural pest control methods**.
7. Explain the role of microorganisms in **traditional medicine systems and health promotion**.
8. Differentiate between **prebiotics and probiotics** and explain their importance in gut microbiota.
9. Evaluate the health benefits of **traditional probiotic-rich foods**.

10. Apply ethnomicrobiological knowledge in areas such as **sustainable agriculture, food technology, and healthcare**.

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1.0		**Introduction to Ethnomicrobiology**	
	1.1	Definition, scope, and importance of ethnomicrobiology	**07**
	1.2	Historical background and development	
	1.3	Relationship between microbiology, anthropology, and traditional knowledge	
	1.4	Role of indigenous knowledge in microbial applications	
2.0		**Traditional Fermentation Practices in India**	
	2.1	Fermented Foods from North East India: Bamboo shoot products: Khorisa, Fermented soybean foods: Axone	**07**
	2.2	Fermented Foods from South West India: Cereal-legume foods: Idli, Dosa, Uttapam; Fermented dairy products: Curd (Dahi), Buttermilk	
	2.3	Fermented Foods from the Himalayas: Cereal-based foods: Chilra, Bhaturu Vegetable products: Gundruk, Sink	
3.0		**Green Manure and Bio-fertilizers Mechanism of Green Manuring**	
	3.1	Concept of growing the manure and the role of nitrogen-fixing bacteria	**08**
	3.2	Key Crops: Characteristics and cultivation of Sunnhemp (Crotalaria juncea), Dhaincha (Sesbania), and leguminous pulses	
	3.3	In-situ vs. Ex-situ: Benefits of burying green crops directly into the soil versus bringing in green leaf mulch.	
	3.4	Ecological Impact: Effect on soil texture, weed suppression, and long-term sustainability.	
	3.5	Bio-formulations and Natural Pest Control Seed Treatment: Preparation and application of Bijamrut for protecting young seedlings	
	3.6	Nutrient Boosters: Standard procedures for making Jivamrut (liquid fertilizer) and Panchagavya (growth promoter)	
	3.7	Natural Pesticides: Formulation of Dashparni Ark and other botanical extracts for pest management	
4.0		**Traditional Medicine Practices**	
	4.1	Introduction to Traditional Medicine and Microbial Role: Concept of traditional medicine systems; Role of microorganisms in traditional health practices; Historical use of fermented foods in health promotion	**08**
	4.2	Prebiotics: Definition and concept of prebiotics ; Types: inulin, oligosaccharides, resistant starch; Natural sources: cereals, pulses, fruits, vegetables; Role in promoting growth of beneficial gut microbiota: Synergistic effect with probiotics (synbiotics)	
	4.3	Probiotics: Definition and concept of probiotics; Common probiotic microorganisms (*Lactobacillus*, *Bifidobacterium*, *Saccharomyces*); Mechanisms of probiotic action: Gut microbiota modulation; Competitive exclusion of pathogens; Enhancement of immune response	
	4.4	Traditional probiotic-rich foods: curd, buttermilk, fermented cereals, pickles Health benefits: digestion, immunity, prevention of gastrointestinal disorders	
		Total	**30**

Textbooks and Reference Books:

1. Tamang, J. P. (Ed.). (2020). *Ethnic fermented foods and beverages of India: science history and culture*. Springer Nature.
2. Akanksha Dhananjay Dambare, Harsha Prasanna Gatne (2025) Indian Knowledge System-Ethno-Microbiology, by International Journal of Microbial Science

National Education Policy 2020

B.Sc. Microbiology, III Year (Semester - V)

Elective Theory Course

Course Code – SMICET1301

Title of the Course: Nitrogen Metabolism

[No. of Credits: 2 Credit] **[Total: 30 Hours]**

Course pre-requisite:

1. The course is designed for students enrolled in the undergraduate second-year programme in the Faculty of Science and Technology. It is intended for those who have received foundational training in Microbiology at the first-year undergraduate level and serves as an entry-level core course for students opting for Microbiology as their major subject.
2. The students should possess basic knowledge of Microbiology, including an understanding of microbial cell structure (prokaryotic and eukaryotic), classification of microorganisms (bacteria, fungi, viruses, and algae), and their general characteristics. They should be familiar with fundamental concepts such as microbial growth, metabolism, and reproduction. In addition, a preliminary understanding of aseptic techniques, sterilization methods, and the role of microorganisms in environment, industry, and human health is desirable for better comprehension of the course.

Course objectives:

1. To provide in-depth knowledge of **biological nitrogen fixation** and the diversity of nitrogen-fixing microorganisms.
2. To understand the **biochemical mechanism of nitrogen fixation** and the structure and function of the nitrogenase enzyme.
3. To explain the processes of **nitrification and denitrification** and their significance in the nitrogen cycle.
4. To study the **electron transport mechanisms** involved in ammonia and nitrite oxidation.
5. To impart knowledge of **nucleotide metabolism**, including biosynthesis and degradation of purines and pyrimidines.
6. To understand the **biosynthetic pathways of amino acids** and their metabolic interrelationships.
7. To develop the ability to integrate biochemical pathways with **microbial physiology and environmental processes**.

Course outcomes:

After successful completion of this course, students will be able to:

1. Identify and describe **nitrogen-fixing microorganisms** and their ecological importance.
2. Explain the **mechanism of nitrogen fixation** and the role of the nitrogenase enzyme.
3. Describe the structure, properties, and **regulation of nitrogenase activity**.
4. Explain the biochemical pathways involved in **nitrification and denitrification**.
5. Understand the role of **electron transport systems** in ammonia and nitrite oxidation.
6. Describe the pathways of **purine and pyrimidine biosynthesis and catabolism**.
7. Explain the biosynthesis of **different families of amino acids** and their metabolic significance.
8. Integrate knowledge of nitrogen metabolism with **environmental and agricultural applications**.
9. Analyze biochemical pathways and apply them in **microbial biotechnology and research**.

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1.0		**Fixation of Molecular Nitrogen**	
	1.1	Nitrogen Fixing Organisms	**07**
	1.2	Biochemical mechanism of Nitrogen Fixation	
	1.3	Structure and properties of Nitrogenase	
	1.4	Regulation of Nitrogenase	
2.0		**Biochemistry of Bacterial Nitrification/Denitrification**	
	2.1	Microbiology and Biochemistry of Oxidation of Ammonia and Hydroxyl amine	**07**
	2.2	Microbiology and Biochemistry of Electron transport pathway couples to oxidation of Ammonia	
	2.3	Microbiology and Biochemistry of Oxidation of Nitrite	
	2.4	Microbiology and Biochemistry of Denitrification	
3.0		**Nucleotide Metabolism**	
	3.1	Biosynthesis of Purine	**08**
	3.2	Biosynthesis of Pyrimidine	
	3.3	Catabolism of Nucleotides	
4.0		**Biosynthesis of Amino acids**	
	4.1	Biosynthesis of Oxaloacetate and Pyruvate families of amino acids	**08**
	4.2	Phosphoglycerate family of amino acids	
	4.3	α – oxoglutarate family of amino acids	
	4.4	Aromatic amino acids	
	4.5	Histidine Synthesis	
		Total	**30**

Textbooks and Reference Books:

1. Kochhar, S. L., & Gujral, S. K. (2020). *Plant Physiology: Theory and Applications: Theory and Applications*. Cambridge University Press.
2. D. L. Nelson and M. M. Cox. '*Lehninger Principles of Biochemistry*', Macmillan Int.
3. J. M. Berg, J. L. Tymoczko and L. Stryer. '*Biochemistry*' 6th edition, W. H Freeman and Company.
4. S. C. Rastogi. '*Biochemistry*'. Tata McGraw Hill Publishing Company, New Delhi.
5. Gottschalk G. '*Bacterial Metabolism*'. Springer, New York.
6. Doelle H. W. '*Bacterial Metabolism*'. Elsevier, New Delhi.
7. Moat A. G., Foster J. W. and Spector M. P. '*Microbial Physiology*'. Wiley-India.
8. Conn E. E. and Stmph P. K. 'Outlines of Biochemistry' John Wiley & Sons, New Delhi.
9. Brock Biology of Microorganisms, Thirteenth Edition by Michael T. Madigan, John M. Martinko, David A. Stahl, David P. Clark, Benjamin Cummings, 1301 Sansome Street, San Francisco, CA 94111.

National Education Policy 2020

B.Sc. Microbiology, III Year (Semester - V)

Elective Practical Course

Course Code – SMICEP1301

Title of the Course: Practical Based on SMICET1301

[No. of Credits: 2 Credit] **[Total: 60 Hours]**

Course pre-requisite:

1. The course is designed for students enrolled in the undergraduate second-year programme in the Faculty of Science and Technology. It is intended for those who have received foundational training in Microbiology at the first-year undergraduate level and serves as an entry-level core course for students opting for Microbiology as their major subject.
2. The students should possess basic knowledge of Microbiology, including an understanding of microbial cell structure (prokaryotic and eukaryotic), classification of microorganisms (bacteria, fungi, viruses, and algae), and their general characteristics. They should be familiar with fundamental concepts such as microbial growth, metabolism, and reproduction. In addition, a preliminary understanding of aseptic techniques, sterilization methods, and the role of microorganisms in environment, industry, and human health is desirable for better comprehension of the course.

Course objectives:

The course is designed to:

1. Develop practical skills for the **isolation and identification of nitrogen-fixing bacteria**, including free-living (*Azotobacter*) and symbiotic (*Rhizobium*) forms.
2. Provide hands-on training in **microbiological techniques** such as enrichment culture, staining, and biochemical testing.
3. Enable understanding of the **nitrogen cycle microorganisms** and their functional roles in nitrification, ammonification, and denitrification.
4. Familiarize students with **biochemical assays** used in nitrogen metabolism, including estimation of DNA, RNA, and amino acids.
5. Introduce analytical techniques such as **paper chromatography** for separation and identification of nitrogenous compounds.
6. Demonstrate the **activity of key enzymes (nitrogenase)** and qualitative detection of important metabolites.
7. Develop analytical and interpretative skills through **qualitative and quantitative experiments** related to microbial metabolism.

Course outcomes:

After successful completion of this course, students will be able to:

1. **Isolate and identify nitrogen-fixing bacteria** from environmental and plant sources using appropriate culture techniques.
2. Perform **microbiological and biochemical tests** to study nitrifying, ammonifying, and denitrifying bacteria.
3. Demonstrate and interpret **nitrogenase activity** using the acetylene reduction assay.
4. Apply **qualitative and quantitative biochemical methods** for estimation of DNA, RNA, and amino acids.
5. Use **chromatographic techniques** for separation and identification of amino acids and nitrogenous bases.
6. Analyze and interpret results of **metabolic assays** and correlate them with microbial functions in the nitrogen cycle.
7. Develop competency in **laboratory practices, data recording, and result interpretation** in microbiology.

8. Understand the **significance of nitrogen metabolism** in agriculture and environmental sustainability.

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1.0		**Isolation of Nitrogen fixing Bacteria**	
	1.1	Isolation of Free-Living Nitrogen Fixing Bacteria (*Azotobacter*): • Use of nitrogen-free medium (Ashby's agar) • Identification based on colony morphology and pigmentation	**20 [5 practicals]**
	1.2	Isolation of Symbiotic Nitrogen Fixing Bacteria (*Rhizobium*) from Root Nodules: • Surface sterilization and crushing of nodules • Streaking on Yeast Extract Mannitol Agar (YEMA)	
	1.3	Microscopic Observation of Root Nodules: • Temporary mounts of legume root nodules • Identification of bacteroids	
	1.4	Estimation of Nitrogenase Activity by Acetylene Reduction Assay (Demonstration): • Principle of ethylene production • Interpretation of nitrogenase enzyme activity	
	1.5	Qualitative Detection of Amino Acids (Ninhydrin Test): • Purple color formation (Ruhemann's purple) • General test for amino acids	
2.0		**Isolation and Study of Nitrogen Cycle Bacteria**	
	2.1	Isolation of Nitrifying Bacteria: • Enrichment culture using ammonium sulfate medium • Detection of nitrite formation	**20 [5 Practicals]**
	2.2	Detection of Ammonia Oxidation: • Use of Nessler's reagent • Color development indicating ammonia presence	
	2.3	Detection of Nitrite Oxidation: • Use of Griess-Ilosvay reagent • Pink color indicates nitrite	
	2.4	Detection of Nitrate Reduction (Nitrate Reduction Test) • Use of sulfanilic acid and α-naphthylamine • Confirmation with zinc dust	
	2.5	Demonstration of Denitrification: • Nitrate broth with Durham tube • Gas formation as evidence of denitrification	
3.0		**Nitrogen Metabolism**	
	3.1	Estimation of DNA using Diphenylamine Method: • Acid hydrolysis of DNA • Blue color development and interpretation	**16 [4 Practicals]**
	3.2	Estimation of RNA using Orcinol Method: • Reaction with ribose sugar • Green color formation	
	3.3	Paper Chromatography of Nitrogenous Bases: • Separation of purines and pyrimidines • Rf value calculation	
	3.4	Estimation of Amino Acids by Formol Titration: • Principle of neutralization after formaldehyde treatment • Calculation of amino acid concentration	

4.0		**Qualitative Analysis of Metabolites**	
	4.1	Paper Chromatography of Amino Acids: • Separation using suitable solvent system • Identification using ninhydrin spray	**4 [1 Practicals]**
		Total	**60**

Textbooks and Reference Books:

1. Laboratory Exercises in Microbiology, Fifth Edition Harley−Prescott
2. Cappuccino, J., Cappuccino, J. G., & Welsh, C. T. (2017). *Microbiology: A laboratory manual*. BoD–Books on Demand.
3. Microbiological Applications Lab Manual, Eighth Edition by Benson
4. Hiper Teaching Kit published by Himedia Laboratories Pvt. Ltd.
5. Dubey, R. C., & Maheshwari, D. K. (2002). *Practical Microbiology, 4/e*. S. Chand Publishing.

National Education Policy 2020

B.Sc. Microbiology, III Year (Semester - V)

Elective Theory Course

Course Code – SMICET1302

Title of the Course: Bioinstrumentation

[No. of Credits: 2 Credit] **[Total: 30 Hours]**

Course pre-requisite:

1. The course is designed for students enrolled in the undergraduate second-year programme in the Faculty of Science and Technology. It is intended for those who have received foundational training in Microbiology at the first-year undergraduate level and serves as an entry-level core course for students opting for Microbiology as their major subject.
2. The students should possess basic knowledge of Microbiology, including an understanding of microbial cell structure (prokaryotic and eukaryotic), classification of microorganisms (bacteria, fungi, viruses, and algae), and their general characteristics. They should be familiar with fundamental concepts such as microbial growth, metabolism, and reproduction. In addition, a preliminary understanding of aseptic techniques, sterilization methods, and the role of microorganisms in environment, industry, and human health is desirable for better comprehension of the course.

Course objectives:

The course is designed to:

1. Provide fundamental understanding of **bioinstrumentation principles**, including measurement systems, units, and performance characteristics such as accuracy, precision, sensitivity, and resolution.
2. Familiarize students with **calibration, standardization**, and the role of detectors and transducers in biological measurements.
3. Develop knowledge of **centrifugation techniques** and their application in separation of biological materials.
4. Introduce the principles and applications of **chromatographic and electrophoretic techniques** used in microbiological and biochemical analysis.
5. Explain the working principles and applications of **spectroscopic methods**, including UV-Visible spectrophotometry, fluorimetry, and IR spectroscopy.
6. Provide insight into **advanced instruments** such as PCR, gel documentation systems, ELISA readers, and biosensors.
7. Promote awareness of **laboratory safety and Good Laboratory Practices (GLP)** in handling sophisticated instruments.

Course outcomes:

After successful completion of this course, students will be able to:

1. Explain the **basic principles of bioinstrumentation**, measurement systems, and performance parameters.
2. Perform and understand **calibration and standardization** procedures in laboratory instruments.
3. Describe and apply **centrifugation techniques** for separation of biological components.
4. Demonstrate knowledge of **chromatographic and electrophoretic methods** for analysis of biomolecules.
5. Apply **spectroscopic techniques** and interpret results based on the Beer-Lambert law.
6. Understand the working and applications of **modern analytical instruments** such as PCR, ELISA, and biosensors.
7. Analyze experimental data generated using **bioanalytical instruments** in microbiology and

biotechnology.

8. Follow **Good Laboratory Practices (GLP)** and ensure safety while handling laboratory instruments.

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1.0		**Fundamentals of Bioinstrumentation**	
	1.1	Measurement systems and units; Accuracy, precision, sensitivity and resolution	**07**
	1.2	Calibration and standardization	
	1.3	Detectors and transducers	
	1.4	Laboratory safety and Good Laboratory Practices (GLP)	
2.0		**Centrifugation and Separation by Sedimentation**	
	2.1	Principles of centrifugation (RCF and sedimentation)	**07**
	2.2	Types: differential centrifugation	
	2.3	Density gradient centrifugation	
	2.4	Ultracentrifugation (basic idea)	
3.0		**Chromatography and Electrophoresis**	
	3.1	Principles of chromatography	**08**
	3.2	Types: Paper, TLC, Column chromatography	
	3.3	Basic idea of HPLC	
	3.4	Gel electrophoresis (agarose and PAGE)	
	3.5	Applications in microbial analysis	
4.0		**Spectroscopy and Advanced Instruments**	
	4.1	Principles of spectroscopy; UV-Visible spectrophotometer and colorimetry Fluorimetry and basics of IR spectroscopy	**08**
	4.2	Beer-Lambert Law and applications PCR (Thermocycler)	
	4.3	Gel documentation system ELISA reader and washer	
	4.4	Biosensors (basic concept) Introduction to automated instruments (RT-PCR, microbial analyzers)	
		Total	**30**

Textbooks and Reference Books:

1. Veerakumari, L. (2019). *Bioinstrumentation*. MJP Publisher.
2. Boyer, R. (2000). Modern Experimental Biochemistry. (3rd ed.). Addison Wesley Longman, New Delhi.
3. Chatwal, G.R., and Anand, S.K., (2003). Instrumental Methods of Chemical Analysis. (5th ed.). Himalaya Publishing House, Mumbai
4. Friedfelder, D. (2001). Physical Biochemistry: Applications to biochemistry and molecular biology. Oxford Publishers, New York.
5. Sharma, B.K. (2007). Instrumental Methods of Chemical Analysis, Krishna Prakashan Media (P) Ltd, India.
6. Wilson, K., and Walker, J., (2010). Principles and Techniques of Biochemistry and Molecular Biology, (7th Low Price ed.). Cambridge University Press, India.

National Education Policy 2020

B.Sc. Microbiology, III Year (Semester - V)

Elective Practical Course

Course Code – SMICEP1302

Title of the Course: Practical Based on SMICET1302

[No. of Credits: 2 Credit] **[Total: 60 Hours]**

Course pre-requisite:

1. The course is designed for students enrolled in the undergraduate second-year programme in the Faculty of Science and Technology. It is intended for those who have received foundational training in Microbiology at the first-year undergraduate level and serves as an entry-level core course for students opting for Microbiology as their major subject.
2. The students should possess basic knowledge of Microbiology, including an understanding of microbial cell structure (prokaryotic and eukaryotic), classification of microorganisms (bacteria, fungi, viruses, and algae), and their general characteristics. They should be familiar with fundamental concepts such as microbial growth, metabolism, and reproduction. In addition, a preliminary understanding of aseptic techniques, sterilization methods, and the role of microorganisms in environment, industry, and human health is desirable for better comprehension of the course.

Course objectives:

The course is designed to:

1. Provide hands-on training in the **use and operation of basic laboratory instruments** such as pipettes, volumetric flasks, weighing balances, and spectrophotometers.
2. Develop understanding of **measurement accuracy, precision, and calibration techniques** using standard laboratory equipment.
3. Familiarize students with the **principles and practical applications of centrifugation**, including calculation of RPM and relative centrifugal force (RCF).
4. Train students in **separation techniques** such as paper chromatography, thin layer chromatography (TLC), and agarose gel electrophoresis.
5. Introduce the practical aspects of **spectrophotometry and colorimetry**, including verification of Beer–Lambert law.
6. Enable estimation and analysis of **biomolecules (DNA, RNA, proteins)** using spectrophotometric methods.
7. Provide exposure to **modern analytical tools**, including biosensors such as glucose meters.
8. Develop skills in **experimental observation, data recording, and interpretation** of analytical results.

Course outcomes:

After successful completion of this course, students will be able to:

1. Operate and handle **basic laboratory instruments** with accuracy and follow standard procedures.
2. Perform **calibration and measurement exercises** and evaluate accuracy and precision of experimental data.
3. Calculate and apply **RPM and relative centrifugal force (RCF)** and perform centrifugation-based separation techniques.
4. Conduct and interpret **chromatographic techniques** (paper chromatography and TLC) for separation of biomolecules.
5. Perform **agarose gel electrophoresis** and understand its applications in biomolecular analysis.
6. Apply **spectrophotometric methods** for verification of Beer–Lambert law and estimation of biomolecules.

7. Analyze **UV absorption spectra** of nucleic acids and proteins for qualitative and quantitative assessment.
8. Understand the working principle and application of **biosensors**, such as glucose biosensors.
9. Record, analyze, and interpret experimental results and present findings in a **systematic scientific manner**.

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1.0		**Fundamentals of Bioinstrumentation**	
	1.1	Study of basic laboratory instruments available in your lab and their uses	**12 [3 practicals]**
	1.2	Demonstration of calibration concepts using simple measuring devices like Measuring cylinder, pipettes (graduated and volumetric), micropipettes, standard volumetric flask, thermometer in water bath.	
	1.3	Exercise on accuracy and precision (weighing repeated samples using balance	
2.0		**Centrifugation and Separation by Sedimentation**	
	2.1	Study of laboratory centrifuge and its components	**20 [5 Practicals]**
	2.2	Calculation of RPM and relative centrifugal force (numerical exercise)	
	2.3	Demonstration of differential centrifugation	
	2.4	Separation of particles using centrifugation (simple suspension)	
	2.5	Observation and interpretation of sedimentation results	
3.0		**Chromatography and Electrophoresis**	
	3.1	Paper chromatography (separation of amino acids or pigments)	**12[3 Practicals]**
	3.2	Thin Layer Chromatography (TLC)	
	3.3	Interpretation of chromatogram	
	3.4	Agarose gel electrophoresis (practical/demonstration as per availability)	
4.0		**Spectroscopy and Advanced Instruments**	
	4.1	Demonstration of colorimeter / spectrophotometer and verification of Beer-Lambert Law	**16 [4 Practicals]**
	4.2	Estimation of biomolecules using vis spectrophotometric method	
	4.3	UV absorption spectra of nucleic acids /proteins using UV spectrophotometer.	
	4.4	Demonstration and explanation of Biosensors using Glucose biosensors (blood glucometer).	
		Total	**60**

Textbooks and Reference Books:

1. Laboratory Exercises in Microbiology, Fifth Edition Harley−Prescott
2. Cappuccino, J., Cappuccino, J. G., & Welsh, C. T. (2017). *Microbiology: A laboratory manual*. BoD–Books on Demand.
3. Microbiological Applications Lab Manual, Eighth Edition by Benson
4. Hiper Teaching Kit published by Himedia Laboratories Pvt. Ltd.
5. Dubey, R. C., & Maheshwari, D. K. (2002). *Practical Microbiology, 4/e*. S. Chand Publishing.

National Education Policy 2020

B.Sc. Microbiology, III Year (Semester - V)

Elective Practical Course

Course Code – SMICVC1301

Title of the Course: Microbial Enzyme Technology

[No. of Credits: 2 Credit] **[Total: 60 Hours]**

Course pre-requisite:

1. The course is designed for students enrolled in the undergraduate second-year programme in the Faculty of Science and Technology. It is intended for those who have received foundational training in Microbiology at the first-year undergraduate level and serves as an entry-level core course for students opting for Microbiology as their major subject.
2. The students should possess basic knowledge of Microbiology, including an understanding of microbial cell structure (prokaryotic and eukaryotic), classification of microorganisms (bacteria, fungi, viruses, and algae), and their general characteristics. They should be familiar with fundamental concepts such as microbial growth, metabolism, and reproduction. In addition, a preliminary understanding of aseptic techniques, sterilization methods, and the role of microorganisms in environment, industry, and human health is desirable for better comprehension of the course.

Course objectives:

The course is designed to:

1. **Develop laboratory skills** for isolation and maintenance of enzyme-producing microorganisms from soil and water samples.
2. **Train students in screening techniques** for identifying industrially important enzymes such as amylase, protease, and lipase.
3. **Provide hands-on experience in microbial enzyme production** using fermentation techniques, particularly submerged fermentation.
4. **Enhance understanding of factors affecting enzyme activity**, including pH, temperature, and substrate concentration.
5. **Introduce basic downstream processing techniques**, including crude enzyme extraction and partial purification methods.
6. **Familiarize students with enzyme assay methods** such as DNS method and casein digestion assay.
7. **Develop analytical and quantitative skills** for evaluating enzyme efficiency and interpreting experimental data.

Course outcomes:

After successful completion of this course, students will be able to:

1. **Isolate and maintain enzyme-producing microorganisms** from environmental samples using standard microbiological techniques.
2. **Screen and identify potent enzyme producers** based on qualitative assays and zone of clearance measurements.
3. **Produce microbial enzymes under controlled laboratory conditions** using fermentation methods.
4. **Evaluate the influence of environmental parameters** (pH, temperature, substrate concentration) on enzyme activity and stability.
5. **Perform basic enzyme extraction and partial purification techniques**, including centrifugation, precipitation, and dialysis.
6. **Quantitatively estimate enzyme activity** using standard biochemical assays such as DNS and protease assays.

7. **Analyze experimental results and compare enzyme efficiencies** among different isolates.

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1.0		**Screening for Enzyme Producing Microorganisms**	
	1.1	Isolate Potential Enzyme-Producing Microorganisms from Soil Samples: • Perform serial dilution and plating techniques • Select and maintain isolates for enzyme screening	**24 [6 practicals]**
	1.2	Isolate Potential Enzyme-Producing Microorganisms from Water Samples • Apply dilution or direct plating methods • Select isolates for further enzymatic studies	
	1.3	Screen Microorganisms for Amylase Production • Utilize starch agar medium • Detect hydrolysis using iodine indicator	
	1.4	Screen Microorganisms for Protease Production • Employ casein agar medium • Observe protein degradation zones	
	1.5	Screen Microorganisms for Lipase Production • Use tributyrin agar plates • Identify lipid hydrolysis zones	
	1.6	Measure and Compare Enzyme Activity Using Zone of Clearance • Measure colony and halo diameter • Evaluate and select efficient strains	
2.0		**Production of Enzymes and effect of environment of its activity**	
	2.1	Prepare Inoculum for Enzyme Production • Develop actively growing culture • Ensure aseptic handling techniques	**20 [5 Practicals]**
	2.2	Producing Microbial Enzymes by Submerged Fermentation • Prepare and inoculate production medium • Maintain suitable incubation conditions	
	2.3	Evaluate the Effect of pH on Enzyme Activity • Perform assays at varying pH levels • Determine optimum pH conditions	
	2.4	Evaluating the Effect of Temperature on Enzyme Activity • Conduct assays at different temperatures • Identify optimum temperature range	
	2.5	Analyze the Effect of Substrate Concentration on Enzyme Activity • Vary substrate concentration systematically • Interpret enzyme activity trends	
3.0		**Preparation of Enzyme**	
	3.1	Extract Crude Enzyme from Fermentation Broth • Separate cells by centrifugation • Collect enzyme-containing supernatant	**08[2 Practicals]**
	3.2	Perform Partial Purification of Enzyme • Apply ammonium sulfate precipitation • Conduct dialysis and calculate yield	
4.0		**Estimation of Enzyme Activity**	

	4.1	Estimate Amylase Activity Using DNS Method • Perform colorimetric reaction with DNS reagent • Calculate enzyme activity from absorbance	**08 [2 Practicals]**
	4.2	Estimate Protease Activity Using Casein Digestion Method • Carry out enzyme-substrate reaction • Quantify released products	
		Total	**60**

Textbooks and Reference Books:

1. Laboratory Exercises in Microbiology, Fifth Edition Harley−Prescott
2. Cappuccino, J., Cappuccino, J. G., & Welsh, C. T. (2017). *Microbiology: A laboratory manual*. BoD–Books on Demand.
3. Microbiological Applications Lab Manual, Eighth Edition by Benson
4. Hiper Teaching Kit published by Himedia Laboratories Pvt. Ltd.
5. Dubey, R. C., & Maheshwari, D. K. (2002). *Practical Microbiology, 4/e*. S. Chand Publishing.
6. Chaplin, M. F., & Bucke, C. (1990). *Enzyme technology*. CUP Archive.
7. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2013). *Principles of fermentation technology*. Elsevier.

Syllabus for B. Sc. Microbiology

Third Year

Semester – VI

As Per National Education Policy- 2020

To be implemented from

Academic Year 2026-2027

National Education Policy 2020

B.Sc. Microbiology, III Year (Semester - VI)

Major Core Theory Course

Course Code – SMICCT1351

Title of the Course: Molecular Biology

[No. of Credits: 3 Credit] **[Total: 45 Hours]**

Course pre-requisite:

1. The course is designed for students enrolled in the undergraduate second-year programme in the Faculty of Science and Technology. It is intended for those who have received foundational training in Microbiology at the first-year undergraduate level and serves as an entry-level core course for students opting for Microbiology as their major subject.
2. The students should possess basic knowledge of Microbiology, including an understanding of microbial cell structure (prokaryotic and eukaryotic), classification of microorganisms (bacteria, fungi, viruses, and algae), and their general characteristics. They should be familiar with fundamental concepts such as microbial growth, metabolism, and reproduction. In addition, a preliminary understanding of aseptic techniques, sterilization methods, and the role of microorganisms in environment, industry, and human health is desirable for better comprehension of the course.

Course objectives:

After completion of this module, students will be able to:

1. **Understand the fundamental principles of gene expression**, including the genetic code, transcription, and translation in prokaryotic systems.
2. **Explain the structure and function of key molecular machinery**, such as RNA polymerase and ribosomes involved in protein synthesis.
3. **Analyze different types of mutations and their molecular mechanisms**, including spontaneous and induced mutagenesis.
4. **Describe various DNA repair mechanisms** and their role in maintaining genomic stability.
5. **Interpret regulatory mechanisms of gene expression in prokaryotes**, including operon models such as lac and trp operons.
6. **Understand tools and techniques used in molecular cloning and gene transfer**, along with their applications in biotechnology.
7. **Develop conceptual knowledge of recombinant DNA technology**, including screening strategies and expression of foreign genes.

Course outcomes:

Upon successful completion of this module, students will be able to:

1. **Describe the genetic code and mechanisms of transcription and translation**, including bacterial transcriptional and translational cycles.
2. **Explain the structure and role of RNA polymerase and ribosomes** in gene expression.
3. **Classify different types of mutations** and explain mechanisms of spontaneous and induced mutagenesis.
4. **Illustrate various DNA repair pathways** such as photoreactivation, NER, BER, and mismatch repair.
5. **Analyze gene regulation mechanisms in prokaryotes**, including the role of repressors, activators, sigma factors, and attenuation.
6. **Explain the working of operons**, particularly lac and trp operons in *E. coli*.
7. **Describe molecular cloning tools and vectors**, including restriction enzymes, ligases, plasmids, bacteriophages, and cosmids.
8. **Demonstrate understanding of gene transfer methods** such as transformation, electroporation, transduction, and liposome fusion.

9. **Explain screening methods used in recombinant DNA technology** such as insertional inactivation and colony hybridization.
10. **Apply knowledge of molecular techniques in biotechnology**, exemplified by the expression of the human insulin gene in *E. coli*.

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1.0		**Gene Expression**	
	1.1	Genetic code: Characteristics of Genetic code: Triplet code, comma free, non-overlapping, degenerate, start and stop signals and wobble hypothesis	**09**
	1.2	Structure of RNA Polymerase (RNAP)	
	1.3	Process of transcription	
	1.4	Structure of Ribosome: Process of Translation	
	1.5	Bacterial Transcriptional and Translational Cycle	
2.0		**Mutagenesis and DNA Repair**	
	2.1	Concept of Mutation Types of Mutations: Silent, Missense, base pair substitutions or switches and frameshift mutations, induced and spontaneous mutation	**12**
	2.2	Mechanism of Spontaneous Mutation: Mispairing of Bases due to Tautomerism, Deamination, Depurination and Damage due to Oxidative Metabolism	
	2.3	Mechanism of Induced Mutation: Physical and Chemical Mutagenic agents	
	2.4	Repair of DNA by • Photo-reactivation • Nucleotide Excision Repair (NER) • Base Excision Repair (BER) • iv. Mismatch Excision Repair (MER)	
3.0		**Regulation of Gene expression in Prokaryotes**	
	3.1	Gene regulation at Transcription level: Repressors, Activators, Sigma factor and Attenuation	**12**
	3.2	Gene regulation at Translation level	
	3.3	The lac Operon of *E. coli* The trp Operon of *E. coli*	
4.0		**Molecular Techniques and Applications**	
	4.1	Introduction, Definition and purpose of Cloning	**12**
	4.2	Tools for molecular cloning • Enzymes: Restriction endonucleases, DNA ligases, alkaline phosphatase, DNA Modifying enzymes • Vectors: PlasmidspBR322, Bacteriophage- Phage λ, Cosmids	
	4.3	Methods of Gene Transfer • Transformation • Electroporation • Liposome Fusion • Transduction	
	4.4	Screening Strategies (In short) • Insertional Inactivation • Immunochemical Methods • Colony hybridization	

	4.5	Application: Expression of Human insulin gene in *E. coli*	
		Total	**45**

Textbooks and Reference Books:

1. Genetics-A molecular approach (2nd /3rd ed.) by Peter J. Russell (2006)
2. Genetics a conceptual approach (3rd ed.) by Benjamin A. Pierce (2008) Publisher: W.H. Freeman and Company.
3. Principles of Genetics by R. H. Tamarin, (2004) Publisher: Tata McGraw Hill.
4. Essentials of Molecular Biology by David Freifelder (2002), Publisher: Narosa Publishing House.
5. General Microbiology (5th edn.) Stanier R. Y., Ingraham, J.L., Wheelis, M. L., Painter, P.R.(2008), Publisher: Macmillan Press Ltd, London
6. General Microbiology (Vol. I and II)Powar, C.B. and Daginawala,H.F.(2008), Publisher: Himalaya publishing house
7. Biotechnology by Satyanarayana U. (2007), Publisher: Books and Allied Pvt. Ltd.Kolkata.
8. Molecular Biology and Genetic Engineering by Narayanan, Moni, Selvaraj, Singh, Arumugam (2004) Publisher: Saras Publication, Nagercoil, Kanyakumari.
9. Modern Microbial Genetics, Second Edition. Edited by Uldis N. Streips, Ronald E.Yasbin. Publisher: Wiley-Liss, Inc.
10. Fundamental Bacterial Genetics by Nancy Trun and Jenanine Trumphy (2003),Publisher: Blackwell Publishing: Tata McGraw Hill.
11. Willey, Joanne M. Prescott, Harley, and Klein's Microbiology / Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton. — 7th ed. Published by McGraw- Hill, a business unit of The McGraw-Hill Companies, Inc., 1221 Avenue of the Americas, New York, NY 10020.
12. Brock Biology of Microorganisms, Thirteenth Edition by Michael T. Madigan, John M. Martinko, David A. Stahl, David P. Clark, Benjamin Cummings, 1301 Sansome Street,San Francisco, CA 94111.
13. Molecular Genetics of Bacteria (2013) by Larry Snyder, Joseph E. Peters, Tina M. Henkin and Wendy Champness 4th Edition, ASM Press

National Education Policy 2020

B.Sc. Microbiology, III Year (Semester - VI)

Major Core Practical Course

Course Code – SMICCP1351

Title of the Course: Practical Based on SMICCT1351

[No. of Credits: 2 Credit] **[Total: 60 Hours]**

Course pre-requisite:

1. The course is designed for students enrolled in the undergraduate second-year programme in the Faculty of Science and Technology. It is intended for those who have received foundational training in Microbiology at the first-year undergraduate level and serves as an entry-level core course for students opting for Microbiology as their major subject.
2. The students should possess basic knowledge of Microbiology, including an understanding of microbial cell structure (prokaryotic and eukaryotic), classification of microorganisms (bacteria, fungi, viruses, and algae), and their general characteristics. They should be familiar with fundamental concepts such as microbial growth, metabolism, and reproduction. In addition, a preliminary understanding of aseptic techniques, sterilization methods, and the role of microorganisms in environment, industry, and human health is desirable for better comprehension of the course.

Course objectives:

1. **Develop practical skills in isolation and characterization of plasmid DNA**, including extraction, purification, and analytical techniques.
2. **Understand and apply spectrophotometric methods** for DNA quantification, purity assessment, and thermal denaturation studies.
3. **Gain experimental knowledge of mutation and DNA repair mechanisms** using model organisms such as *Escherichia coli* and yeast.
4. **Perform mutagenesis experiments using physical and chemical agents** and analyze their effects on microbial survival.
5. **Isolate and characterize different types of mutants**, including antibiotic-resistant and morphological mutants.
6. **Understand gene expression experimentally**, with reference to operon systems (lac operon in *E. coli*).
7. **Apply basic molecular biology techniques**, such as restriction digestion, agarose gel electrophoresis, and replica plating.
8. **Develop analytical, observational, and data interpretation skills** in molecular microbiology experiments.

Course outcomes:

After successful completion of this course, students will be able to:

1. **Isolate and purify plasmid DNA from *Escherichia coli*** and assess its quality using standard laboratory techniques.
2. **Quantify and evaluate purity of DNA** using spectrophotometric methods and chemical assays (Diphenylamine method).
3. **Determine DNA melting temperature (Tm) and estimate G+C content**, interpreting nucleic acid stability.
4. **Perform agarose gel electrophoresis** for separation and visualization of plasmid DNA.
5. **Analyze UV survival curves in yeast and *E. coli*** and interpret mutation frequency.
6. **Demonstrate DNA repair mechanisms**, including dark repair and photoreactivation in microbial systems.
7. **Induce mutations using physical and chemical mutagens** and evaluate their effects on microbial populations.

8. **Isolate and characterize antibiotic-resistant and morphological mutants** using appropriate screening techniques.
9. **Demonstrate gene expression studies in *E. coli***, particularly lac operon regulation.
10. **Perform restriction digestion and analyze DNA fragments**, interpreting banding patterns.
11. **Apply replica plating technique** to identify mutants and study mutation patterns.

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1.0		**Molecular Characterization of Plasmid DNA**	
	1.1	Cell Lysis, Extraction and Purification of Plasmid DNA from *Escherichia coli*	**20 [5 practicals]**
	1.2	Spectrophotometric Confirmation and Purity Assessment of plasmid DNA	
	1.3	Spectrophotometric Quantification of Plasmid DNA Using Diphenylamine Reagent	
	1.4	Determination of Plasmid DNA Denaturation Temperature (Tm) and G+C Content	
	1.5	Separation and Visualization of Plasmid DNA by Agarose Gel Electrophoresis	
2.0		**Mutation and Mutational Repair study**	
	2.1	To Study the UV survival pattern of Yeast	**16 [4 Practicals]**
	2.2	Repair mechanisms in Yeast (Dark and Photo reactivation)	
	2.3	To study the U.V survival pattern of *E.coli*	
	2.4	Repair mechanisms in *E.coli* (Dark and Photo reactivation)	
3.0		**Applications of Mutations**	
	3.1	Isolation of antibiotics resistant Bacterial Mutants by Chemical Mutagenic Agents	**16 [4 Practicals]**
	3.2	Isolation of antibiotics resistant Bacterial Mutants by Physical Mutagenic agents	
	3.3	Isolation of Morphological mutants by Physical Mutagenic agents	
	3.4	Studies on gene expression in *E. coli* with reference to Lac operon	
4.0		**Molecular Techniques**	
	4.1	Restriction digestion and Agarose gel electrophoresis of DNA	**08 [2 Practicals]**
	4.2	Replica Plating Techniques	
		Total	**60**

Textbooks and Reference Books:

1. Gautam, A. (2022). DNA and RNA Isolation Techniques for Non-experts (pp. 79-84). Cham: Springer.
2. Laboratory Exercises in Microbiology, Fifth Edition Harley−Prescott
3. Microbiology – A laboratory Manual 10th edition by James Cappuccino and Natalie Sherman
4. Microbiological Applications Lab Manual, Eighth Edition by Benson
5. Hiper Teaching Kit published by Himedia Laboratories Pvt. Ltd. Molecular Genetics of Bacteria (2013) by Larry Snyder, Joseph E. Peters, Tina M. Henkin and Wendy Champness 4th Edition, ASM Press

National Education Policy 2020

B.Sc. Microbiology, III Year (Semester - VI)

Major Core Theory Course

Course Code – SMICCT1352

Title of the Course: Industrial Microbiology

[No. of Credits: 3 Credit] **[Total: 45 Hours]**

Course pre-requisite:

1. The course is designed for students enrolled in the undergraduate second-year programme in the Faculty of Science and Technology. It is intended for those who have received foundational training in Microbiology at the first-year undergraduate level and serves as an entry-level core course for students opting for Microbiology as their major subject.
2. The students should possess basic knowledge of Microbiology, including an understanding of microbial cell structure (prokaryotic and eukaryotic), classification of microorganisms (bacteria, fungi, viruses, and algae), and their general characteristics. They should be familiar with fundamental concepts such as microbial growth, metabolism, and reproduction. In addition, a preliminary understanding of aseptic techniques, sterilization methods, and the role of microorganisms in environment, industry, and human health is desirable for better comprehension of the course.

Course objectives:

After completion of this module, students will be able to:

1. **Understand the scope and significance of Industrial Microbiology** and its role in modern biotechnology industries.
2. **Explain the design, operation, and types of bioreactors/fermenters**, including their industrial applications.
3. **Develop knowledge of microbial resources**, including screening, strain improvement, and preservation techniques.
4. **Understand the principles of inoculum development and fermentation media formulation**, along with sterilization methods.
5. **Gain insight into downstream processing techniques** for recovery and purification of microbial products.
6. **Understand the industrial production of important metabolites** such as organic acids, antibiotics, amino acids, and bio-products.
7. **Familiarize with computer applications and automation in fermentation technology**.
8. **Develop an integrated understanding of industrial fermentation processes from upstream to downstream stages**.

Course outcomes:

Upon successful completion of this module, students will be able to:

1. **Define and explain the scope of Industrial Microbiology** and the role of microbiologists in industrial processes.
2. **Describe the structure, components, and working of bioreactors**, including auxiliary equipment.
3. **Classify different types of fermenters** (batch, continuous, fed-batch, fluidized bed, etc.) and their applications.
4. **Explain microbial screening techniques and methods of strain improvement** for industrial use.
5. **Demonstrate knowledge of culture maintenance and preservation techniques**, including lyophilization and cryopreservation.
6. **Describe inoculum preparation, fermentation media composition, and sterilization methods** used in industries.

7. **Explain various downstream processing techniques**, including filtration, centrifugation, extraction, chromatography, and crystallization.
8. **Analyze the steps involved in production of industrial products** such as:
   i. Wine (beverage)
   ii. Citric acid (organic acid)
   iii. Penicillin (antibiotic)
   iv. Legume inoculants (biofertilizer)
   v. Thuricide (bioinsecticide)
   vi. Glutamic acid (amino acid)

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1.0		**Definition and Scope of Industrial Microbiology**	
	1.1	Introduction, Definition, Scope and Development of Industrial Microbiology	**10**
	1.2	Role of Microbiologist in Industrial Microbiology	
	1.3	Bioreactor (Definition, Ideal Design and characteristics, Working of Auxiliary equipment)	
	1.4	Types of Fermenter: laboratory fermenter, pilot plant fermenter, industrial fermenter, Horton sphere. Batch, continuous, Tubular, fed batch, fluidised bed reactor, tower fermenter (In brief)	
	1.5	Computer application in fermentation technology	
2.0		**Microbes in Industrial Microbiology**	
	2.1	Introduction, Screening Techniques (Primary and Secondary)	**09**
	2.2	Strain improvement	
	2.3	Stock culture and its maintenance (serial subculture, overlaying with mineral oil, lyophilization, liquid nitrogen, soil stock)	
	2.4	Inoculum development, Fermentation media (substances used as raw materials for formulation of fermentation media) and its sterilization (batch and continuous)	
3.0		**Downstream processing**	
	3.1	Introduction, Extraction of fermentation products, solids (Insoluble) removal (Filtration, centrifugation, coagulation and flocculation, foam fractionation,)	**12**
	3.2	Primary isolation of product (Cell disruption, liquid extraction, ion exchange adsorption, precipitation)	
	3.3	Purification (Chromatography, carbon decolorization, crystallization), Product Isolation(Crystalline processing, drying, packing etc).	
4.0		**Typical Fermentative production**	
	4.1	Production strain, Fermentation media, Fermentation conditions, Metabolic pathway involved	**14**
	4.2	Beverages: Wine	
	4.3	Organic acid: Citric acid	
	4.4	Antibiotics: Penicillin	
	4.5	Biofertilizers: Legume inoculants	
	4.6	Bioinsecticide: Thuricide	
	4.7	Amino acids: Glutamic acid	
		Total	**45**

Textbooks and Reference Books:

1. Industrial Microbiology by A.H. Patel.
2. Industrial Microbiology by Prescott & Dunn.
3. Industrial Microbiology by Casida
4. Biotechnology: A textbook of Industrial Microbiology by Cruger and Cruger
5. Modern Industrial Microbiology and Biotechnology by Nduka Okafor
6. Industrial Microbiology: An Introduction by Wastes, Morgan, Rockey and Higten
7. Practical Microbiology by Maheshwari and Dubey
8. Principles of Fermentation Technology by Peter F. Stanbury Allan Whitaker Stephen J. Hall publisher: Elsevier.

National Education Policy 2020

B.Sc. Microbiology, III Year (Semester - VI)

Major Core Practical Course

Course Code – SMICCP1352

Title of the Course: Practical Based on SMICCT1352

[No. of Credits: 2 Credit] **[Total: 60 Hours]**

Course pre-requisite:

1. The course is designed for students enrolled in the undergraduate second-year programme in the Faculty of Science and Technology. It is intended for those who have received foundational training in Microbiology at the first-year undergraduate level and serves as an entry-level core course for students opting for Microbiology as their major subject.
2. The students should possess basic knowledge of Microbiology, including an understanding of microbial cell structure (prokaryotic and eukaryotic), classification of microorganisms (bacteria, fungi, viruses, and algae), and their general characteristics. They should be familiar with fundamental concepts such as microbial growth, metabolism, and reproduction. In addition, a preliminary understanding of aseptic techniques, sterilization methods, and the role of microorganisms in environment, industry, and human health is desirable for better comprehension of the course.

Course objectives:

The course is designed to:

1. **Develop practical skills in screening useful microorganisms** for industrial applications such as antibiotic, enzyme, and organic acid production.
2. **Train students in primary and secondary screening techniques**, including methods like crowded plate and giant plate technique for selecting potent strains.
3. **Provide hands-on experience in fermentation technology**, including surface and submerged fermentation processes.
4. **Familiarize students with industrially important products** such as penicillin, citric acid, alcohol, and wine.
5. **Introduce quantitative estimation methods** such as titrable acidity, specific gravity, and bioassay techniques.
6. **Develop skills in production of value-added microbial products** like biofertilizers and single cell protein (SCP).
7. **Provide basic understanding of bioreactor design and operation** used in large-scale fermentation.

Course outcomes:

After successful completion of this course, students will be able to:

1. **Screen and isolate industrially important microorganisms** producing antibiotics, enzymes, and organic acids.
2. **Differentiate and apply primary and secondary screening methods** to select efficient microbial strains.
3. **Perform fermentation processes** (surface and submerged) for the production of antibiotics and organic acids.
4. **Estimate fermentation products quantitatively** using standard analytical methods such as titration and specific gravity measurement.
5. **Conduct bioassays** (e.g., disc diffusion method) to evaluate antimicrobial and enzyme activity.
6. **Produce and evaluate biofertilizers and single cell protein**, understanding their industrial and agricultural significance.
7. **Understand the basic principles and functioning of bioreactors** used in industrial microbiology.results.

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1.0		**Screening for Useful Microorganisms**	
	1.1	Primary screening of antibiotic producers,	**16[4 practicals]**
	1.2	Primary screening of amylase producers,	
	1.3	Primary screening of organic acid producers	
	1.4	Secondary Screening by Giant Pate Technique	
2.0		**Penicillin Fermentation**	
	2.1	Production of Penicillin (Surface) fermentation	**12 [3 Practicals]**
	2.2	Production of Penicillin (Submerged) fermentation	
	2.3	Bioassay of Penicillin by Disc Diffusion Method	
3.0		**Citric Acid and Alcohol Fermentation**	
	3.1	Production of Citric acid & its estimation by Titrable acidity (Surface Fermentation)	**16 [4 Practicals]**
	3.2	Production of Citric acid & its estimation by Titrable acidity (Submerged Fermentation)	
	3.3	Fermentative production of Wine & and its estimation by Titrable acidity	
	3.4	Fermentative Production of Alcohol and its Estimation by Specific Gravity method	
4.0		**Biofertilizer and Enzyme production**	
	4.1	Mass Production of Biofertilizer (*Azotobacter*)	**16 [4 Practicals]**
	4.2	Mass Production of Single Cell Protein (SCP)	
	4.3	Bioassay of therapeutic enzyme glucose oxidase	
	4.4	Demonstration of Ideal Bioreactor	
		Total	**60**

Textbooks and Reference Books:

1. Principles and Applications of Fermentation Technology by Arindam Kuila and Vinay Sharma, Scrivener Publisher.
2. Laboratory Exercises in Microbiology, Fifth Edition Harley−Prescott
3. Microbiology – A laboratory Manual 10th edition by James Cappuccino and Natalie Sherman
4. Microbiological Applications Lab Manual, Eighth Edition by Benson
5. Laboratory Manual in Microbiology by Balkrishna M, Sandikar and Shaileshkumar V. Mamdapure, Kripa Drishti Publications, Pune, 2021
6. Microbiology: A Laboratory Manual, by James G. Cappuccino, Natalie Sherman,Publisher :Pearson Benjamin Cummings; 10th edition

National Education Policy 2020

B.Sc. Microbiology, III Year (Semester - VI)

Major Core Theory Course

Course Code – SMICCT1353

Title of the Course: Agricultural Microbiology

[No. of Credits: 2 Credit] **[Total: 30 Hours]**

Course pre-requisite:

1. The course is designed for students enrolled in the undergraduate second-year programme in the Faculty of Science and Technology. It is intended for those who have received foundational training in Microbiology at the first-year undergraduate level and serves as an entry-level core course for students opting for Microbiology as their major subject.
2. The students should possess basic knowledge of Microbiology, including an understanding of microbial cell structure (prokaryotic and eukaryotic), classification of microorganisms (bacteria, fungi, viruses, and algae), and their general characteristics. They should be familiar with fundamental concepts such as microbial growth, metabolism, and reproduction. In addition, a preliminary understanding of aseptic techniques, sterilization methods, and the role of microorganisms in environment, industry, and human health is desirable for better comprehension of the course.

Course objectives:

After completion of this module, students will be able to:

1. **Understand the scope and importance of Agricultural Microbiology** in sustainable agriculture and soil health.
2. **Gain knowledge of soil microbial diversity** and their ecological roles in different soil environments such as rhizosphere and phyllosphere.
3. **Explain plant–microbe interactions**, including symbiotic and non-symbiotic nitrogen fixation.
4. **Understand the role of beneficial microorganisms** such as PGPRs, biofertilizers, and biocontrol agents in crop productivity.
5. **Learn methods used in soil microbiological analysis**, including sampling, isolation, enumeration, and enzyme assays.
6. **Understand microbial transformations of essential nutrients** (C, N, P, S cycles) in soil ecosystems.
7. **Gain knowledge of modern agricultural practices**, including organic farming and agro-waste management.
8. **Familiarize with recent advances in agricultural biotechnology**, including transgenic plants and gene protection strategies.

Course outcomes:

Upon successful completion of this module, students will be able to:

1. **Describe the history, scope, and significance of Agricultural Microbiology** in crop production and soil fertility.
2. **Identify and classify major soil microorganisms** (bacteria, fungi, algae, actinomycetes, protozoa, viruses) and explain their roles.
3. **Explain microbial ecology of soil environments** such as rhizosphere and phyllosphere.
4. **Analyze the process of decomposition, humus formation, and their impact on soil health**.
5. **Differentiate between symbiotic and non-symbiotic nitrogen fixation systems**, including organisms like *Rhizobium*, *Azotobacter*, and *Azospirillum*.
6. **Explain the role of PGPRs, biofertilizers, and biocontrol agents (e.g., *Trichoderma*)** in sustainable agriculture.

7. **Describe microbial transformations of nutrients** and their significance in biogeochemical cycles.
8. **Perform soil microbiological techniques**, including soil sampling, dilution plating, enrichment culture, and microscopic examination.
9. **Apply techniques such as soil enzyme assays, antibiosis testing, and fluorescent staining** for microbial analysis.
10. **Explain agro-waste management strategies** and their applications in biofuel, bioenergy, and animal feed production.
11. **Evaluate the principles and benefits of organic farming practices**.
12. **Describe genetic engineering approaches in agriculture**, including *Agrobacterium*-mediated transformation and Bt cotton development.

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1.0		**Introduction to Agricultural Microbiology**	
	1.1	History, scope, development in agriculture	**07**
	1.2	soil microorganisms: bacteria, fungi, algae, actinomycetes, protozoa, viruses.	
	1.3	Microbial ecology of soil, rhizosphere, and phyllosphere	
	1.4	Decomposition of organic matter and humus formation and soil health	
2.0		**Plant-Microbe Interactions**	
	2.1	Symbiotic (Rhizobium, Mycorrhizae) and non-symbiotic (Azotobacter, Azospirillum) Nitrogen fixation	**07**
	2.2	PGPRs and their role in plant health	
	2.3	Microbial transformations of Carbon, Nitrogen, Phosphorus, Sulphur and minor nutrients.	
	2.4	Bio-fertilizers and their roles in agriculture. Biocomposting, Bio-control agents: Trichoderma sp.	
3.0		**Methods used in Soil Microbiological Studies**	
	3.1	Soil Sampling, Soil Dilutions and Plate counts, Enrichment cultures	**08**
	3.2	The Buried Slide, Direct microscopic examination of soil	
	3.3	Soil percolation techniques	
	3.4	Fluorescent staining	
	3.5	Soil enzymes estimation, Methods for assaying Antibiosis	
4.0		**Recent trends in Agricultural Microbiology**	
	4.1	Agro-waste management and its significance: Biofuel, Bioenergy, Animal Feed	**08**
	4.2	Organic farming: types, methods and advantages	
	4.3	Development of transgenic plants: *Agrobacterium*-mediated plant transformations with specific example of Bt cotton	
	4.4	Antisense RNA strategy; Tolerance to herbicides and insecticides and Gene protection technology	
		Total	**30**

Textbooks and Reference Books:

1. Alexander M. 1977. Soil Microbiology. John Wiley.
2. Bergerson FJ. 1980. Methods for Evaluating Biological Nitrogen Fixation. John Wiley and Sons.
3. Motsara, I.M.R., Bhattacharyya, P. and Srivastava, B. 1995. Biofertilizer Technology, Marketing and Usage- A Source Book-cum-glossary. FDCO, New Delhi.

4. SubbaRao, N.S. Biofertilizers in Agriculture and Forestry. 1993. Oxford and IBH. Publ. Co., New Delhi.
5. Burges, H.D. and Hussey, N.W. (1971). Microbial Control of Insects and mites. Academic Press, New York.
6. Burges, H.D. Formulation of microbial pesticides – Kluversep, ACB, Dordrecht-ISBN. 0412 625 202.
7. Coppel H.C. and J.W. Martin. (1977). Biological control of insect pest suppression. Springail.
8. De Bach P. 1964. Biological control of Insect Pest and Weeds Chapman and Hall, New York.
9. Gautam, R.D. (2006). Biological suppression of insect pests. Kalyani Publisher, New Delhi.
10. Huffaker, C.B. and Messenger, P.S. (1976). Theory and Practice of Biological control. Academic Press, New York.
11. Ignacimuthu, S.S. and Jayaraj, S. (2003). Biological Control of Insect Pests. Phoenix Publ. New Delhi.
12. Saxena, A.B. (2003). Biological Control of Insect Pests. Anmol Publ. New Delhi.
13. Huffaker, C.B. and Messenger, P.S. (1976). Theory and Practice of Biological control. Academic Press, New York.
14. Pepper HJ and Perlman D. 1979. Microbial Technology. 2nd Ed. Academic Press.
15. A century of Nitrogen Fixation Research Present status and Future propects. 1987. F.J. Bergersen and J.R. Postgate The Royal Soc., London.
16. Biology and Biochemistry of Nitrogen fixation. 1991. M.J. Dilworth,and A.R. Glenn, Elsevier, Amsterdam. .
17. Nitrogen Fixation in plants. 1986. R.O.D. Dixon,and C.T. Wheeler, Blackie USA, Chapman and Hall, New York.
18. A treatise on dinitrogen Fixation Section IV. Agronomy and Ecology 1977. R.W.F Hardy, and A.H. Gibson John Wiley & Sons, New York..
19. Bioresearches technology for sustainable agriculture. 1999. S. Kannaiyan, Assoc. Pub. Co., New Delhi.
20. Biofertilizer Technology, Marketing and usage- A source Book -cum-glossary 1995. Motsara, I. M.R., P. Bhattacharyya and BeenaSrivastava, FDCO, New Delhi.
21. Symbiotic nitrogen fixation in plants, 1976. P.S. Nutman, Cambridge Univ. Press, London.
22. Hand book for Rhizobia; Methods in legume Rhizobium Technology, 1994. P. Somasegaran and H.J. Hoben Springer-Verlag, New York.
23. Biofertilizers in Agriculture and Forestry 1993. N.S. Subba Rao Oxford and IBH Publ. Co., New Delhi.

National Education Policy 2020

B.Sc. Microbiology, III Year (Semester - VI)

Elective Theory Course

Course Code – SMICET1351

Title of the Course: Pharmaceutical Microbiology

[No. of Credits: 2 Credit] [Total: 30 Hours]

Course pre-requisite:

1. The course is designed for students enrolled in the undergraduate second-year programme in the Faculty of Science and Technology. It is intended for those who have received foundational training in Microbiology at the first-year undergraduate level and serves as an entry-level core course for students opting for Microbiology as their major subject.
2. The students should possess basic knowledge of Microbiology, including an understanding of microbial cell structure (prokaryotic and eukaryotic), classification of microorganisms (bacteria, fungi, viruses, and algae), and their general characteristics. They should be familiar with fundamental concepts such as microbial growth, metabolism, and reproduction. In addition, a preliminary understanding of aseptic techniques, sterilization methods, and the role of microorganisms in environment, industry, and human health is desirable for better comprehension of the course.

Course objectives:

After completion of this module, students will be able to:

1. **Understand the scope and applications of Pharmaceutical Microbiology** in drug development, quality control, and healthcare industries.
2. **Gain knowledge of microbiological testing methods** used in pharmaceutical analysis and quality assurance.
3. **Understand Good Laboratory Practices (GLP) and safety guidelines** essential for pharmaceutical laboratories.
4. **Learn concepts of bioburden determination and microbial limit testing** for pharmaceutical products.
5. **Develop understanding of contamination, infection control, and sterilization techniques** in pharmaceutical settings.
6. **Study the role and mechanisms of antimicrobial agents**, disinfectants, and preservatives.
7. **Understand the microbial production of pharmaceutical products** such as vitamins, enzymes, and polysaccharides.
8. **Gain knowledge of sterile product manufacturing and quality control**, including vaccines and immunological products.
9. **Familiarize with recombinant DNA technology applications** in pharmaceutical product development.

Course outcomes:

Upon successful completion of this module, students will be able to:

1. **Define and explain Pharmaceutical Microbiology** and its role in the pharmaceutical industry.
2. **Describe microbiological tests used in pharmaceuticals**, including microbial limit tests and sterility testing.
3. **Explain the role of a microbiologist in laboratory design, management, and regulatory compliance**.
4. **Apply Good Laboratory Practices (GLP) and safety procedures** in microbiological laboratories.
5. **Determine bioburden levels and interpret microbial counts** in pharmaceutical products.
6. **Identify specified and objectionable microorganisms** and assess their risk in

pharmaceutical preparations.

7. **Analyze sources of contamination and implement control measures** in pharmaceutical environments.
8. **Explain the mechanisms and applications of disinfectants, antiseptics, and preservatives**.
9. **Describe sterilization methods and sterility assurance procedures** used in pharmaceutical production.

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1.0		**Microbiology and Pharmaceuticals**	
	1.1	Introduction, Overview and application of Pharmaceutical Microbiology	**07**
	1.2	Microbiological tests useful for Pharmaceutical sector	
	1.3	Role of microbiologist in Laboratory Management and Design	
2.0		**Good Laboratory Practice and Safety techniques**	
	2.1	Introduction to Good Laboratory Practice and safety, Pharmacopeia, and microbiological test	**07**
	2.2	Bioburden determination – Total microbial count, units of Measurement, Non sterile products and microbial limit testing, In-process material assessment Presterilization bioburden assessment, alternative methods of bioburden Assessment	
	2.3	Specified and objectionable microorganisms- indicator microorganisms	
	2.4	Determining which microorganism are objectionable and assessing risk	
3.0		**Contamination and infection control**	
	3.1	Microbial spoilage, infection risk and contamination control	**08**
	3.2	Laboratory evaluation of non-antibiotic and antimicrobial agents	
	3.3	Chemical disinfectants, antiseptics and preservatives	
	3.4	Non-antibiotics, antimicrobial agents, mode of action and resistance	
	3.5	Sterilization procedures and sterility assurance	
4.0		**Pharmaceutical Product Manufacture**	
	4.1	Pharma products microbial origin: • Dextran • Vitamin (riboflavin) fermentation • Enzyme – Streptokinase	**08**
	4.2	Sterile Pharmaceutical Products • Injections, non-injectionable sterile fluids • Ophthalmic preparation • Absorbable haemostatics • Surgical ligatures and sutures	
	4.3	The manufacture and quality control of immunological products • Vaccines • Immune sera • Human immunoglobulin	
	4.4	Recombinant DNA techniques • Somatostatin • Insulin • Interferon	
		Total	**30**

Textbooks and Reference Books:

1. Good Manufacturing Practices for Pharmaceuticals by Sydney H. Willing,
2. Murray. M. Tuckerman, Willam S. Hitching IV. Second edition Mercel Dekker NC New York
3. Pharmaceutical Biotechnology by S. P. Vyas & V. K. Dixit. CBS publishers& distributors, New Delhi
4. Pharmaceutical Microbiology by W. B. Hugo & A. R. Russel Sixth Edition. Blackwell Scientific Publications
5. Pharmacognosy by Gokhle S. D., Kokate C.K. Edition: 18 Nirali Publication
6. Biotechnology – Expanding Horizon by B. D. Singh, First Edition, Kalyani Publication, Delhi

National Education Policy 2020

B.Sc. Microbiology, III Year (Semester - VI)

Elective Practical Course

Course Code – SMICEP1351

Title of the Course: Practical Based on SMICET1351

[No. of Credits: 2 Credit] **[Total: 60 Hours]**

Course pre-requisite:

1. The course is designed for students enrolled in the undergraduate second-year programme in the Faculty of Science and Technology. It is intended for those who have received foundational training in Microbiology at the first-year undergraduate level and serves as an entry-level core course for students opting for Microbiology as their major subject.
2. The students should possess basic knowledge of Microbiology, including an understanding of microbial cell structure (prokaryotic and eukaryotic), classification of microorganisms (bacteria, fungi, viruses, and algae), and their general characteristics. They should be familiar with fundamental concepts such as microbial growth, metabolism, and reproduction. In addition, a preliminary understanding of aseptic techniques, sterilization methods, and the role of microorganisms in environment, industry, and human health is desirable for better comprehension of the course.

Course objectives:

After completion of this module, students will be able to:

1. **Understand and apply Good Laboratory Practices (GLP)** and safety measures in pharmaceutical microbiology laboratories.
2. **Develop aseptic handling skills** required for microbiological analysis of pharmaceutical products.
3. **Perform microbial enumeration and bioburden analysis** as per pharmacopeial standards.
4. **Gain hands-on experience in microbial limit testing** for specified microorganisms in pharmaceutical samples.
5. **Understand principles and techniques of sterility testing** for various pharmaceutical products.
6. **Evaluate environmental contamination** through monitoring techniques such as air sampling.
7. **Assess antimicrobial activity of disinfectants and antibiotics** using standard bioassay methods.
8. **Develop analytical and interpretative skills** for quality control in pharmaceutical microbiology.

Course outcomes:

After successful completion of this course, students will be able to:

1. Upon successful completion of this module, students will be able to:
2. **Demonstrate Good Laboratory Practices (GLP) and safety procedures** in microbiology laboratories.
3. **Perform aseptic techniques effectively** to prevent contamination during microbiological work.
4. **Conduct microbial limit tests** for specified microorganisms such as *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Escherichia coli*, and *Salmonella* spp.
5. **Determine bioburden levels** in raw materials, in-process samples, and non-sterile pharmaceutical products.
6. **Perform sterility testing of pharmaceutical products** (injections, ophthalmic creams, antiseptic creams, saline) using direct inoculation methods.
7. **Carry out environmental monitoring** using settle plate techniques and interpret contamination levels.

8. **Evaluate disinfectant efficacy** using the phenol coefficient test.
9. **Perform antibiotic bioassay using the cylindrical cup method** and interpret potency.

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1.0		**Basic Laboratory Practices & Safety**	
	1.1	Introduction to Pharmaceutical Microbiology Laboratory & GLP Guidelines	**08 [2 practicals]**
	1.2	Study of Laboratory Safety Measures and Aseptic Techniques	
2.0		**Microbial Enumeration & Bioburden Analysis**	
	2.1	Microbial Limit Test (as per pharmacopeial guidelines) for *Staphylococcus aureus*	**24 [6 Practicals]**
	2.2	Microbial Limit Test (as per pharmacopeial guidelines) for *Pseudomonas aeruginosa*	
	2.3	Microbial Limit Test (as per pharmacopeial guidelines) for *E. coli*	
	2.4	Microbial Limit Test (as per pharmacopeial guidelines) for *Salmonella spp.*	
	2.5	Determination of Bioburden in Raw Materials / In-process Samples	
	2.6	Estimation of Microbial Load in Non-sterile Pharmaceutical Products	
3.0		**Sterility and Contamination Control**	
	3.1	Sterility Testing of Pharmaceutical Products – Injections by Direct inoculation method	**20 [5Practicals]**
	3.2	Sterility Testing of Pharmaceutical Products – Ophthalmic cream by Direct inoculation method	
	3.3	Sterility Testing of Pharmaceutical Products – Antiseptic cream by Direct inoculation method	
	3.4	Sterility Testing of Pharmaceutical Products – Saline by Direct inoculation method	
	3.5	Environmental Monitoring : Air sampling (settle plate method)	
4.0		**Antimicrobial Activity Evaluation**	
	4.1	Evaluation of Disinfectants: Phenol Coefficient Test	**08 [2 Practicals]**
	4.2	Bioassay of Antibiotic by Cylindrical cup method	
		Total	**60**

Textbooks and Reference Books:

1. Laboratory Exercises in Microbiology, Fifth Edition Harley−Prescott
2. Cappuccino, J., Cappuccino, J. G., & Welsh, C. T. (2017). *Microbiology: A laboratory manual*. BoD–Books on Demand.
3. Microbiological Applications Lab Manual, Eighth Edition by Benson
4. Hiper Teaching Kit published by Himedia Laboratories Pvt. Ltd.
5. Dubey, R. C., & Maheshwari, D. K. (2002). *Practical Microbiology, 4/e*. S. Chand Publishing.

National Education Policy 2020

B.Sc. Microbiology, III Year (Semester - V)

Elective Theory Course

Course Code – SMICET1352

Title of the Course: Environmental Microbiology

[No. of Credits: 2 Credit] **[Total: 30 Hours]**

Course pre-requisite:

1. The course is designed for students enrolled in the undergraduate second-year programme in the Faculty of Science and Technology. It is intended for those who have received foundational training in Microbiology at the first-year undergraduate level and serves as an entry-level core course for students opting for Microbiology as their major subject.
2. The students should possess basic knowledge of Microbiology, including an understanding of microbial cell structure (prokaryotic and eukaryotic), classification of microorganisms (bacteria, fungi, viruses, and algae), and their general characteristics. They should be familiar with fundamental concepts such as microbial growth, metabolism, and reproduction. In addition, a preliminary understanding of aseptic techniques, sterilization methods, and the role of microorganisms in environment, industry, and human health is desirable for better comprehension of the course.

Course objectives:

After completion of this module, students will be able to:

1. **Understand the fundamental concepts of environment and ecosystems**, including physical, chemical, and biological components.
2. **Gain knowledge of microbial diversity and distribution** in natural habitats and their ecological roles as producers and decomposers.
3. **Differentiate between culture-dependent and culture-independent methods** for studying microbial diversity.
4. **Understand physiological adaptations of microorganisms** to environmental conditions and stress factors.
5. **Learn ecological principles governing microbial growth**, including Liebig's law of minimum and Shelford's law of tolerance.
6. **Understand microbial community dynamics**, including succession and biofilm formation.
7. **Develop knowledge of quantitative ecology**, including diversity indices and sampling strategies.
8. **Understand extremophiles and their adaptations**, including physiological and molecular mechanisms.

Course outcomes:

Upon successful completion of this module, students will be able to:

1. **Describe environmental components and microbial roles in ecosystems**, including nutrient cycling and decomposition.
2. **Explain microbial habitats and ecological functions** in various environmental niches.
3. **Compare culture-dependent and culture-independent approaches** for studying microbial diversity, including limitations and advantages.
4. **Explain the concept of viable but non-culturable (VBNC) microorganisms**.
5. **Analyze microbial adaptations to environmental conditions**, including stress responses and survival strategies.
6. **Apply ecological laws such as Liebig's law of minimum and Shelford's law of tolerance** to microbial growth.
7. **Describe microbial community interactions**, succession patterns, and biofilm formation.
8. **Calculate and interpret microbial diversity indices**, including Shannon and Simpson

indices.

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1.0		**Environment and Ecosystem**	
	1.1	Physical, chemical and biological aspects of environment	**07**
	1.2	Natural habitats of microorganisms; microorganisms in ecosystem as producers and decomposers	
	1.3	Culture- dependent and independent approaches for microbial diversity in environment	
	1.4	Culture- dependent approaches and their limitations, and culture-independent molecular approaches for understanding microbial diversity in the environment; Viable but non-culturable bacteria	
2.0		**Physiological Ecology of microorganisms**	
	2.1	Adaptation to environmental condition	**07**
	2.2	Abiotic growth limiting factors-Leibig's law of minimum	
	2.3	Shelford law of tolerance	
	2.4	Microbial community succession-biofilm communities	
3.0		**Quantitative Ecology**	
	3.1	Microbial diversity, Operational Taxonomic Units (OTUs)	**08**
	3.2	Diversity indices (Shannon, Shimpson)	
	3.3	Alpha and beta diversity, Richness and evenness	
	3.4	Samples and samplings, Concept of culturability	
	3.5	Determination of total and viable microbial number; Molecular analysis of function and diversity of microbial community, Metagenomics and microbiomics	
4.0		**Extremophiles**	
	4.1	Thermophiles, Psychrophiles, Osmophiles (halophiles, saccharophiles)	**08**
	4.2	Acidophiles, Alkalophiles, Barophiles, xerophiles	
	4.3	Physiology and metabolism of Archaea	
	4.4	Concept of stress and stress tolerance, signaling molecules and signal transducing machinery in microbial system. Transmitter and receiver proteins. Concept of free radicals	
		Total	**30**

Textbooks and Reference Books:

1. Environmental Microbiology and Biotechnology by Singh and Dwivedi. New Age Int. Sci. Publication. Environmental Microbiology by Riana.
2. Environmental Microbiology: Principles and Applications. Patrick K. Jjemba
3. Microbial Ecology by Alexander. Willey Publication.
4. Microbial Diversity: Form and Function of Prokaryotes. Wiley Blackwell Publication.
5. Biodiversity and Environmental Biotechnology by Dwivedi and M C Kalita. Scientific Publication.
6. Extremophiles, Springer Verlag
7. Statistics for Biologists by Campbell R C. Cambridge University Press.
8. Statistics in Biology by Bliss C I K. MGH Publication.
9. Environmental Microbiology By. P D Sharma

National Education Policy 2020

B.Sc. Microbiology, III Year (Semester - VI)

Elective Practical Course

Course Code – SMICEP1352

Title of the Course: Practical Based on SMICET1352

[No. of Credits: 2 Credit] **[Total: 60 Hours]**

Course pre-requisite:

1. The course is designed for students enrolled in the undergraduate second-year programme in the Faculty of Science and Technology. It is intended for those who have received foundational training in Microbiology at the first-year undergraduate level and serves as an entry-level core course for students opting for Microbiology as their major subject.
2. The students should possess basic knowledge of Microbiology, including an understanding of microbial cell structure (prokaryotic and eukaryotic), classification of microorganisms (bacteria, fungi, viruses, and algae), and their general characteristics. They should be familiar with fundamental concepts such as microbial growth, metabolism, and reproduction. In addition, a preliminary understanding of aseptic techniques, sterilization methods, and the role of microorganisms in environment, industry, and human health is desirable for better comprehension of the course.

Course objectives:

The course is designed to:

1. **Develop practical skills** for isolation, enumeration, and morphological characterization of cyanobacteria from environmental samples.
2. **Train students in microbial diversity analysis**, including qualitative and quantitative assessment using ecological indices (Shannon and Simpson).
3. **Provide hands-on experience in isolation and study of extremophiles** such as thermophiles, psychrophiles, halophiles, acidophiles, alkalophiles, and osmophiles.
4. **Enhance understanding of environmental factors** (temperature, pH, salinity, freezing stress) affecting microbial growth and survival.
5. **Introduce stress physiology of microorganisms**, including stress enzymes and adaptive mechanisms.
6. **Familiarize students with applied environmental microbiology techniques**, including studies on organisms from unique ecosystems (e.g., Lonar lake) and metal-oxidizing bacteria.

Course outcomes:

After successful completion of this course, students will be able to:

1. **Isolate, enumerate, and identify cyanobacteria** from environmental samples using standard microbiological techniques.
2. **Assess microbial diversity quantitatively** using ecological indices such as Shannon and Simpson indices.
3. **Isolate and characterize different groups of extremophiles** based on their physiological and environmental adaptations.
4. **Evaluate the effect of environmental stress factors** (temperature, pH, salinity, freezing) on microbial growth and survival.
5. **Demonstrate knowledge of microbial stress responses**, including production of stress enzymes and proteins.
6. **Perform specialized experiments** such as iron oxidation by *Thiobacillus ferrooxidans* and studies on alkalophiles from unique habitats.
7. **Analyze and interpret experimental data scientifically**, and present findings effectively in laboratory records and reports.

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1.0		**Cyanobacteria**	
	1.1	Isolation, Enumeration and Morphological Study of Cyanobacteria	**12 [3 practicals]**
	1.2	Study of Cyanobacterial Diversity in Environmental Samples	
	1.3	Quantitative Analysis of Cyanobacterial Diversity (Shannon & Simpson Indices)	
2.0		**Extremophiles - I**	
	2.1	Isolation of Thermophilic Bacteria	**20 [5 Practicals]**
	2.2	Isolation of Spore-Forming Thermophiles	
	2.3	Effect of pH on Thermophilic Growth	
	2.4	Isolation of Psychrophilic Microorganisms	
	2.5	Effect of Freezing and Thawing on Psychrophiles	
3.0		**Extremophiles - II**	
	3.1	Isolation of Halophiles	**16 [4Practicals]**
	3.2	Isolation of Acidophiles and Alkalophiles	
	3.3	Study of Osmophiles (Saccharophiles)	
	3.4	Effect of Environmental Stress on Microbial Growth	
4.0		**Stress Responses**	
	4.1	Demonstration of stress enzymes/ proteins from extremophiles	**12[3 Practicals]**
	4.2	Studies on Alkalophiles isolated from lonar water	
	4.3	Demonstration of iron oxidation rate of *Thiobacillus ferrooxidans*	
		Total	**60**

Textbooks and Reference Books:

1. Laboratory Exercises in Microbiology, Fifth Edition Harley−Prescott
2. Cappuccino, J., Cappuccino, J. G., & Welsh, C. T. (2017). *Microbiology: A laboratory manual*. BoD–Books on Demand.
3. Microbiological Applications Lab Manual, Eighth Edition by Benson
4. Hiper Teaching Kit published by Himedia Laboratories Pvt. Ltd.
5. Dubey, R. C., & Maheshwari, D. K. (2002). *Practical Microbiology, 4/e*. S. Chand Publishing.

National Education Policy 2020

B.Sc. Microbiology, III Year (Semester - VI)

Elective Practical Course

Course Code – SMICVC1351

Title of the Course: Agrobioprocessing

[No. of Credits: 2 Credit] **[Total: 60 Hours]**

Course pre-requisite:

1. The course is designed for students enrolled in the undergraduate second-year programme in the Faculty of Science and Technology. It is intended for those who have received foundational training in Microbiology at the first-year undergraduate level and serves as an entry-level core course for students opting for Microbiology as their major subject.
2. The students should possess basic knowledge of Microbiology, including an understanding of microbial cell structure (prokaryotic and eukaryotic), classification of microorganisms (bacteria, fungi, viruses, and algae), and their general characteristics. They should be familiar with fundamental concepts such as microbial growth, metabolism, and reproduction. In addition, a preliminary understanding of aseptic techniques, sterilization methods, and the role of microorganisms in environment, industry, and human health is desirable for better comprehension of the course.

Course objectives:

The course is designed to:

1. **Develop fundamental laboratory skills** including safety practices, GLP, aseptic handling, and sterilization techniques for agro-based samples.
2. **Train students in preparation and pretreatment of agro-waste substrates** for their effective utilization in bioprocessing.
3. **Provide hands-on experience in fermentation technologies**, including inoculum preparation, solid-state fermentation (SSF), and submerged fermentation (SmF).
4. **Familiarize students with production of bio-based products** such as bioethanol, organic acids, and microbial metabolites using agricultural resources.
5. **Introduce value-added product development** including single cell protein (SCP), biofertilizers, biopesticides, and composting techniques.
6. **Enhance knowledge of enzyme-based agrobioprocessing**, including enzyme production, extraction, and activity assays.
7. **Develop skills in downstream processing and product analysis**, including estimation of alcohol and organic acids.
8. **Promote sustainable and eco-friendly approaches** for agro-waste utilization and resource recycling.

Course outcomes:

After successful completion of this course, students will be able to:

1. **Apply laboratory safety, aseptic techniques, and GLP guidelines** in agrobioprocessing experiments.
2. **Prepare and process agro-waste substrates** for use in microbial fermentation and product development.
3. **Perform fermentation processes** (SSF and SmF) for the production of bioethanol, organic acids, and enzymes.
4. **Develop and evaluate value-added products** such as SCP, biofertilizers, biopesticides, and compost.
5. **Extract and assay enzymes** and analyze their activity using standard biochemical methods.
6. **Estimate fermentation products quantitatively** using techniques like titrable acidity and specific gravity.

7. **Interpret experimental data and optimize process parameters** for improved yield and efficiency.
8. **Apply agrobioprocessing knowledge in sustainable agriculture, waste management, and entrepreneurship.**
9. Analyze **UV absorption spectra** of nucleic acids and proteins for qualitative and quantitative assessment.
10. Understand the working principle and application of **biosensors**, such as glucose biosensors.
11. Record, analyze, and interpret experimental results and present findings in a **systematic scientific manner**.

Module No.	Unit No.	Topic	Hrs. Required to cover the contents
1.0		**Basic Techniques in Agrobioprocessing**	
	1.1	Laboratory Safety, GLP and Aseptic Techniques • Handling agro-based samples • Sterilization and contamination control	**08 [2 practicals]**
	1.2	Preparation of Agro-Waste Substrates • Processing of substrates (molasses, fruit waste, cereal waste) • Pretreatment (physical/chemical)	
2.0		**Fermentation-Based Agrobioprocessing**	
	2.1	Preparation of Inoculum for Fermentation: • Development of starter cultures (yeast/bacteria)	**20 [5 Practicals]**
	2.2	Solid State Fermentation (SSF) • Production of enzymes using agro-waste (bran, husk)	
	2.3	Submerged Fermentation (SmF) • Production of microbial metabolites using liquid media	
	2.4	Production of Bioethanol from Agricultural Waste • Fermentation of molasses/fruit waste • Distillation (demonstration)	
	2.5	Production of Organic Acids (Citric/Lactic Acid) • Fermentation using agro-substrates • Estimation by titration	
3.0		**Value-Added Products from Agro-Resources**	
	3.1	Production of Single Cell Protein (SCP) • Using yeast on molasses or waste substrate	**16[4 Practicals]**
	3.2	Production of Biofertilizers • Mass multiplication of Azotobacter / Rhizobium	
	3.3	Production of Biopesticides • Demonstration of Trichoderma / Bacillus formulation	
	3.4	Composting and Vermicomposting • Preparation and monitoring of compost • Microbial role in decomposition	
4.0		**Enzyme-Based Agrobioprocessing**	
	4.1	Production of Industrial Enzymes (Amylase/Cellulase) • Using agro-waste substrates • activity from absorbance	**16 [4 Practicals]**
	4.2	Enzyme Extraction and Activity Assay • Crude enzyme extraction • Activity measurement (DNS method, etc.)	
	4.3	Clarification of Fruit Juice using Enzymes • Use of pectinase • Measurement of clarity	
	4.4	Estimation of Fermentation Products	

		• Alcohol (specific gravity method) • Organic acids (Titrable acidity)	
		Total	**60**

Textbooks and Reference Books:

1. Laboratory Exercises in Microbiology, Fifth Edition Harley−Prescott
2. Cappuccino, J., Cappuccino, J. G., & Welsh, C. T. (2017). *Microbiology: A laboratory manual*. BoD–Books on Demand.
3. Microbiological Applications Lab Manual, Eighth Edition by Benson
4. Hiper Teaching Kit published by Himedia Laboratories Pvt. Ltd.
5. Dubey, R. C., & Maheshwari, D. K. (2002). *Practical Microbiology, 4/e*. S. Chand Publishing.
6. Chaplin, M. F., & Bucke, C. (1990). *Enzyme technology*. CUP Archive.
7. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2013). *Principles of fermentation technology*. Elsevier.