BHARATHIDASANUNIVERSITY, TIRUCHIRAPPALLI-620024
UNDER GRADUATE – MICROBIOLOGY - CURRICULUM STRUCTURE
CHOICEBASEDCREDITSYSTEM– LEARNING OUTCOMES BASED CURRICULUM FRAMEWORK (CBCS - LOCF)
(Applicable to the candidates admitted from the academic year 2026 – 2027 onwards)

Sem	Part	Courses	Title	Ins. Hrs.	Credits	Exam. Hours	Maximum Marks		
							Int.	Ext.	Total
I	I	Ability Enhancement Course – I (AEC - I)	(Tamil / Other Languages)	6	3	3	30	70	100
	II	Ability Enhancement Course – II (AEC - II)	English Course - I	6	3	3	30	70	100
	III	Core Course -1 (CC - 1)	Fundamentals of Microbiology	4	4	3	30	70	100
		Core Practical - 1 (CP - 1)	Fundamentals of Microbiology (P)	4	4	3	40	60	100
		Allied Course - 1 (AC - 1)	Fundamentals of Biological Sciences	4	4	3	30	70	100
		Allied Course Practical - 1 (ACP-I)	Fundamentals of Biological Sciences & Basic Biochemistry (P)	2	**	**	**	**	**
	IV	Value Education		2	2	3	30	70	100
		Interdisciplinary Course – 1 (IDC - 1) #	One Course from Outside Department	2	2	3	30	70	100
	Total			**30**	**22**	--	--	--	**700**
II	I	Ability Enhancement Course – III (AEC - III)	(Tamil / Other Languages)	6	3	3	30	70	100
	II	Ability Enhancement Course – IV (AEC - IV)	English Course – II	6	3	3	30	70	100
	III	Core Course- 2 (CC - 2)	Microbial Physiology	4	4	3	30	70	100
		Core Practical - 2 (CP - 2)	Microbial Physiology (P)	4	4	3	40	60	100
		Allied Course - 2 (AC - 2)	Basic Biochemistry	4	4	3	30	70	100
		Allied Course Practical - 1 (ACP - 1)	Fundamentals of Biological Sciences & Basic Biochemistry (P)	2	4	3	40	60	100
	IV	Skill Enhancement Course - 1 (SEC - 1) ##	Naan Mudhalvan Course	2	2	3	30	70	100
		Interdisciplinary Course - 2 (IDC - 2) #	One Course from Outside Department	2	2	3	30	70	100
	Total			**30**	**26**	--	--	--	**800**

III	I	Ability Enhancement Course – V(AEC - V)	(Tamil / Other Languages)	6	3	3	30	70	100
	II	Ability Enhancement Course – VI (AEC - VI)	English Course – III	6	3	3	30	70	100
	III	Core Course- 3(CC - 3)	Molecular biology	4	4	3	30	70	100
		Core Practical - 3 (CP - 3)	Molecular biology (P)	4	4	3	40	60	100
		Allied Course - 3 (AC - 3)	Biostatistics	4	4	3	30	70	100
		Allied Course Practical - 2 (ACP - 2)	Biostatistics & Bioinformatics and Computational Biology	2	**	**	**	**	**
	IV	Skill Enhancement Course - 2 (SEC - 2) ##	Naan Mudhalvan Course	2	2	3	30	70	100
		Interdisciplinary Course – 3 (IDC - 3) $$	One Course from Outside Department	2	2	3	30	70	100
		Health & Wellness @		--	1	--			100
	Total			**30**	**23**	--	--	--	**800**
IV	I	Ability Enhancement Course – VII (AEC - VII)	(Tamil/ Other Languages)	6	3	3	30	70	100
	II	Ability Enhancement Course – VIII (AEC - VIII)	English Course - IV	6	3	3	30	70	100
	III	Core Course- 4(CC - 4)	Immunology	4	4	3	30	70	100
		Core Practical - 4 (CP - 4)	Immunology	4	4	3	40	60	100
		Allied Course - 4 (AC - 4)	Bioinformatics and Computational Biology	4	4	3	30	70	100
		Allied Course Practical - 2 (ACP - 2)	Biostatistics & Bioinformatics and Computational Biology	4	4	3	40	60	100
	IV	Skill Enhancement Course - 3 (SEC - 3) ##	Naan Mudhalvan Course	2	2	3	30	70	100
		Interdisciplinary Course – 4 (IDC - 4) $$	One Course from Outside Department	2	2	3	30	70	100
	Total			**30**	**26**	--	--	--	**800**
	Summer Internship / Industrial Activity during the Summer Vacation after II Year								

V	III	Core Course - 5 (CC - 5)	Medical Microbiology	4	4	3	30	70	100
		Core Course - 6 (CC - 6)	General Virology	5	4	3	30	70	100
		Core Course - 7 (CC - 7)	Environment and Agricultural Microbiology	5	4	3	30	70	100
		Core Course - 8 (CC - 8)	Industrial Microbiology	5	4	3	30	70	100
		Core Practical – 5 (CP - 5)	Medical Microbiology, General Virology, Environment and Agricultural Microbiology and Industrial Microbiology (P)	5	4	3	40	60	100
	IV	Skill Enhancement Course - 4 (SEC - 4)	Vaccinology	2	2	3	30	70	100
		Skill Enhancement Course - 5 (SEC - 5) ##	Naan Mudhalvan Course	2	2	3	30	70	100
		Introduction to Disaster Management		2	2	3	30	70	100
		Summer Internship / Industrial Activity	(with Viva-Voce)	--	2	--	20	80	100
	Total			**30**	**28**	--	--	--	**900**
VI	III	Core Course - 9 (CC - 9)	Food Microbiology	4	4	3	30	70	100
		Core Course - 10 (CC - 10)	Recombinant DNA Technology	5	4	3	30	70	100
		Core Course - 11 (CC - 11)	Microbial Biotechnology & Bioethics	5	4	3	30	70	100
		Core Project Work (CPW) - Group project @@	Project Work (with Viva-Voce)	6	4	3	20	80	100
	IV	Value Added Course	Life Science Skills for Competitive Examination	2	1	--	30	70	100
		Skill Enhancement Course - 6 (SEC - 6)	Artificial Intelligence in Microbiology	2	2	3	30	70	100
		Skill Enhancement Course - 7 (SEC - 7) ##	Naan Mudhalvan Course	2	2	3	30	70	100
		Environmental Studies		2	2	3	30	70	100
		Gender Studies		2	1	3	30	70	100
		Extension Activities *		--	1	--	--	--	--
	Total			**30**	**25**	**--**	**--**	**--**	**900**
	Grand Total			**180**	**150**	--	**--**	**--**	**4900**

ALLIED COURSE

First Year	Second Year
1. Fundamentals of Biological Sciences 2. Basic Biochemistry	1. Biostatistics 2. Bioinformatics and Computational Biology

SKILL ENHANCEMENT COURSE (SEC)			
Sl. No.	**Title of paper**	**Sl. No.**	**MANDATORY Naan Mudhalvan Scheme ##**
1.	Microbial Cosmetics	1.	**2nd Semester:**
2.	Microbial Quality Control and Testing		
3.	Algal Cultivation Techniques	2.	**3rd Semester:**
4.	Microbiome Biology		
5.	Next Generation Sequencing Techniques	3.	**4th Semester:**
6.	Entrepreneurial Microbiology		
7.	Vaccinology	4.	**5th Semester:**
8.	Artificial Intelligence in Microbiology	5.	**6th Semester:**

INTERDISCIPLINARY COURSE (IDC) FOR WHO OPT TAMIL AS PART – I (for other Department Students only)	
1st Semester	Microbiological Techniques
2nd Semester	Biofertilizer Production Techniques
3rd Semester	Composting Techniques
4th Semester	Mushroom cultivation techniques

INTERDISCIPLINARY COURSE (IDC) # FOR WHO HAVE NOT OPTED TAMIL AS PART - I		
Those who have studied Tamil upto 10th+2 but opt for other languages in degree	1st Semester	Special Tamil - I
	2nd Semester	Special Tamil - II
Those who have not studied Tamil in school level	1st Semester	Basic Tamil - I
	2nd Semester	Basic Tamil – II
Those students who opt for either special Tamil (or) Basic Tamil as IDCs, have to choose 2 more IDCs courses in their 3rd and 4th Semester from Outside his/her department.		

INTERDISCIPLINARYCOURSE (IDC) $$ FOR NCC CADETS ONLY	
NCC Course is a Compulsory Course for the NCC Cadets in the 3rd Semester:	**NCC Course is a Compulsory Course for the NCC Cadets in the 4th Semester:**
Introduction to NCC	1. Special Subject Army **(or)** 2. Special Subject Navy **(or)** 3. Special Subject Air force
Those students who opt for NCC Courses as IDCs, have to choose 2 more IDCs courses in their 1st and 2nd Semester from Outside his/her department.	

SUMMARY OF CURRICULUM STRUCTURE OF UG PROGRAMMES

Sl. No.	Part	Types of the Courses	No. of Courses	Credits for each Course	Total Credits	Marks
1.	I	Ability Enhancement Course	4	3	12	400
2.	II	Ability Enhancement Course	4	3	12	400
3.	III	Core Course	11	4	44	1100
4.		Core Practical	5	4	20	500
5.		Allied Course (AC)	4	4	16	400
6.		Allied Course Practical (ACP)	2	4	8	200
7.		Core Project Work (CPW)	1	4	4	100
8.	IV	Skill Enhancement Course (SEC)	7	2	14	700
9.		Interdisciplinary Course (IDC)	4	2	8	400
10.		Value Education	1	2	2	100
11.		Health and Wellness	1	1	1	100
12.		Introduction to Disaster Management	1	2	2	100
13.		Summer Internship / Industrial Activity	1	2	2	100
14.		Value Added Course	1	1	1	100
15.		Environmental Studies	1	2	2	100
16.		Gender Studies	1	1	1	100
17.		**EXTENSIONACTIVITIES** (NCC / NSS / SPORTS / ANTI DRUG CELL / YRC / Red Ribbon Club& Any Other Activities	--	1	1	--
Total			**49**	**-**	**150**	**4900**

$ For those who have studied Tamil upto10th+2 (Regular Stream)

\+ Syllabus for other Languages should be on par with Tamil at degree level

\# Those who have studied Tamil upto 10th+2 but opt for other

languages in degree level under Part –I should study special Tamil and those who have not studied Tamil in the school level should study Basic Tamil in Part– IV under the Interdisciplinary Course.

** Examination at the end of the next semester

Naan Mudhalvan Scheme: As per the Naan Mudhalvan Scheme instructions, 5 courses from 2nd to 6th semester should be studied under Skill Enhancement Course.

$$ NCC Course is one of the Choices in the Interdisciplinary Course. Only the NCC Cadets are eligible to choose this course. However, NCC Course is a Compulsory Course for the NCC Cadets.

@ **Health and Wellness: Assessments:**

- Use self-reflective worksheets to assess their understanding
- Submit the worksheets to internal audit / external audit
- Every student's activity report should be documented and the same has to be assessed by the Physical Director with a Mentor. The evaluation should be for 100 marks. No examination is required.

Scheme of Evaluation:

Part	Description	Marks
A	Report	40
B	Attendance	20
C	Activities (Observation During Practice)	40
Total		**100**

@@ **Summer Internship / Industrial Activity**

Internship will be carried out during the summer vacation after the second year. Viva-Voce should be conducted by the college and Marks should be sent to the University and the same will be included in the 5th semester Mark Statement.

Summer Internship / Industrial Activity& Project Work

Scheme of Evaluation:

Description	Marks
Report	80
Viva-Voce	20
Total	**100**

* Extension Activities shall be outside the instruction hours.

PROGRAM OUTCOMES (POs)

PO1 **Communication Skill:** Mandatory language courses facilitate to become proficient in communication, culturally aware, and more employable in both Indian and global contexts. Improve presentations skill, debates, and professional communication.

PO 2 **Disciplinary Knowledge:** Learn in-depth complex scientific concepts, demonstrate their ability to explain and apply their knowledge. Consistent in learning by earning extra credits in specialized courses within the science domain and enhance disciplinary knowledge.

PO 3 **Critical thinking:** Field and academic visits will help students to develop observation skills, grasping ability, collect and interpret data and propose models that will help them to understand hypotheses and conclusions.

PO 4 **Analytical Reasoning:** Through the interactions, students will develop skills of critical reading of texts, identifying gaps in knowledge, formulating scientific questions, and on will recognizing the synthesis of new ideas.

PO 5 **Scientific Reasoning:** Skill oriented courses will provide details on principles, conduct of proper calibration and use of scientific instrumentation and appropriate use of scientific techniques in experimental design

PO 6 **Self-directed Learning:** Preparation of field reports helps them to present their results and discussion in a written format that is typically required for their future professions.

PO 7 **Reflective Thinking:** All core courses with laboratory components will provide exposure to a wide range of research techniques, therein enhancing their understanding of the application of techniques in their domain.

PO 8 **Problem Solving:** Students will develop the ability to reason, apply numerical concepts, and equations in their fields of study for interpreting scientific data and drawing relevant scientific conclusions.

PO 9 **Research-related Skills:** Students undertaking a internship will have the opportunity to design, develop and execute their own research ideas in their experiments, thus expanding their knowledge of research methods and laboratory skills.

PO 10 **Lifelong Learning:** Ability to understand the gaps in knowledge and skill, adapt to technological change, engage in self-directed learning.

PROGRAMME SPECIFIC OUTCOME (PSO)

PSO1 **Academic competence for critical thinking and problem solving**: Analyse the fundamental concepts and biodiversity of microorganisms, enabling critical thinking in different fields of Microbiology. Study the cytology, biochemistry, growth as well as application of environmentally and industrially important microbes with a specific emphasis on improving environmental sustainability and human health. Describe and understand the concepts of role of microorganisms in geochemical processes

like leaching of metals and bioremediation methods.

PSO2 **Transdisciplinary Knowledge:** Demonstrate the importance of immunity, pathogenesis, cultivation, diagnosis and control of pathogens through therapeutics and prophylaxis in various Health and Pharmaceutical domains. Describe microbial processes that can be used for the development of biochemical and immunological tools to improve the quality of human life.

PSO3 **Effective citizenship and ethics:** Evaluate and Identify the needs, potentials and impact of microorganisms relevant to food, soil and agriculture, ensuring environmental conservation and food safety.

PSO4 **Personal and professional competence:** Evaluate industrially important microbial products in terms of their purity, safety and ethically acceptable application for the benefit of mankind. Design appropriate strategies in bio-processing and fermentation technology, with emphasis on industrial production of biomass and their products. Combine public presentation skills of effective articulation and nonverbal communication with a sound understanding of microbial science to effectively communicate ideas.

PSO5 **Social competence:** Apply the concepts of Genomics and Proteomics through analytical, molecular and *in silico* techniques for the betterment of society. Employ skill sets related to Quality assurance and testing of pharmaceutically important products in accordance with internationally accepted standards. Evaluate the importance of new groups of consumer goods such as prebiotics, probiotics and nutraceuticals. Apply the concepts of microbial interactions in basic and advanced treatment of waste water treatment processes.

PSO6 **Research related skills and scientific temper:** Examine the significance of research using statistical tools and communicate the findings in research forums.

PSO7 **Environment and sustainable development:** Ensure bio-safety and bioethics for social responsibility, environmental sensitization and obtain Intellectual Property Rights for various research findings.

PSO8 **Self-directed and Life-long learning:** Apply computing, communicative and entrepreneurial skills for employability and lifelong learning.

PSO9 **Acquire specialized technical expertise and advanced laboratory skills** through hands-on industrial or institutional internship training, enabling the independent design, optimization, and execution of experimental research workflows to address real-world biotechnological and microbial challenges.

PSO10 **Recognize individual knowledge gaps** and adapt dynamically to ongoing technological advancements in the biosciences, engaging in continuous, self-directed professional development and active learning to remain competitive in academic and industrial research landscapes.

SEMESTER –I
FUNDAMENTALS OF MICROBIOLOGY

Course Code	CC - 1	Course Type	Core	L	T	P	C	Syllabus version	2026-2027
				4	-	-	4		
Pre-requisite	Foundational knowledge of biological sciences, cell structure, and a basic understanding of how environmental factors and chemical agents influence the survival and growth of living organisms.								

Course Objectives:

- ✓ Understand the historical evolution of microbiology and the critical role of pioneering scientists in establishing the germ theory of disease.
- ✓ Demonstrate proficiency in the principles of microscopy and the application of diverse staining techniques for microbial characterization.
- ✓ Analyze the ultra-structure and functional components of prokaryotic cells, focusing on the differences between Gram-positive and Gram-negative bacteria.
- ✓ Evaluate microbial growth dynamics and the physiological requirements for cultivating bacteria in various synthetic and natural media.
- ✓ Develop expertise in microbial control by implementing physical and chemical sterilization methods and understanding the mechanism of antibiotic action.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Exploring the history and evolution of microbiology and its diverse applied branches.	K1, K2
CO2	To learn about the principles of microscopy and staining techniques.	K1 – K3
CO3	To characterize the morphology and ultra-structure of bacteria in prokaryotic and eukaryotic systems.	K1 – K3
CO4	Exploring reproduction strategies in different microflora.	K1 -K4
CO5	Understanding the importance of nutritional types and various culture media for microbial cultivation.	K1, K2
CO6	To demonstrate methods of microbial control through sterilization, disinfection and antibiotic action.	K5, K6
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit - I: History, Taxonomy and Microscopy
(12 hours)

History, scope of Microbiology, Concepts of Microbiology, Major contribution of microbiologists. Classification – Taxonomy, Taxonomic ranks – Three kingdom concept, five kingdom concept, three domain concepts. Microscopy: Principles and applications of microscopes: brightfield, dark field, phase contrast, fluorescent, SEM and TEM. Micrometry – measurement of bacterial size.

Unit - II: Classification and Ultrastructure (12 hours)	Difference between prokaryotic and eukaryotic microorganisms. Outline classification of bacteria on the basis of Bergey's manual of systemic bacteriology. Structural organization of bacteria – Size, shape and arrangement of bacterial cells - Ultrastructure of a bacterial cell - cell wall, cell membrane, ribosomes, nucleoid, slime, capsule, flagella, fimbriae, spores, cysts, plasmid, mesosomes and cytoplasmic inclusions.
Unit - III: General Characters, Eucaryotic Classification and Staining (12 hours)	General characteristics and nature of Archaeobacteria, Cyanobacteria, Mycoplasma, Rickettsiae, Chlamydia, Spirochaetes, Actinobacteria, Protozoa, Algae, Fungi, lichens and Viruses. Basic understanding of classification of algaeFritch, fungi-Alexopoulos and protozoa. Principles and types of staining– Simple, gram, acid fast, spore and Capsule staining.
Unit - IV: Control of Microorganisms(12 hours)	Physical methods of Sterilization - Moist heat, dry heat and filtration and radiation – Chemical methods of sterilization – phenolics, alcohols, heavy metals, aldehydes and gaseous chemicals. Antimicrobial chemotherapy – Mode of action of antibiotics. Factors affecting the growth of microorganisms.
Unit - V: Culture Media and Microbial Growth (12 hours)	Culture media – Types of Medium, simple, enriched, enrichment, selective, differential and transport medium. Classification medium. Common ingredients of culture media – peptone Sodium chloride, yeast extract beef extract and agaragar. Pure culture techniques – Serial dilution, pour plate, spread plate and streak plate technique. Aerobic and Anaerobic culture techniques. Preservation of microorganisms.
Unit - VI: Current Contours (For Continuous Internal Assessment only):	Daily News & Literature: Review of daily news and latest research papers on fundamental microbiology discoveries (e.g., new bacterial species, antibiotic resistance trends). Public Awareness: Creating awareness of the importance of microbes in daily life, hygiene, and fermented foods for human and animal health. Scientific Models: Developing physical or digital scientific models explaining bacterial ultra-structure, growth curves, or mechanisms of sterilization. Web Resources:

Mapping with Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	S	S	S	S	S	M	S	S	M	S
CO2	S	S	S	S	S	M	S	S	M	S
CO3	S	S	S	S	S	M	S	S	M	S
CO4	S	S	S	S	S	M	S	S	M	S
CO5	S	S	S	S	S	M	S	S	M	S
CO6	S	S	S	S	S	M	S	S	M	S

Recommended References:

1. Willey, J.M., Kathleen M, S., Wood, D.H. and Prescott, L.M., 2020. *Prescott's microbiology Eleventh edition*. McGraw-Hill.New York.
2. Tortora, G., Tortora, G.J., Funke, B.R., Case, C.L., Weber, D. and Bair, W.B., 2024. *Microbiology: an introduction*.New Jersey.
3. Madigan, M. T., Martinko, J. M., & Parker, J. (1997). Brock biology of microorganisms (8th ed.). Prentice Hall, Upper Saddle River, NJ.
4. Pommerville, J. C. (2022). Fundamentals of microbiology (12th ed.). Jones & Bartlett Learning, Burlington, MA.
5. Talaro, K. P., & Chess, B. (2021). Talaro's foundations in microbiology (11th ed.). McGraw-Hill Education, New York, NY.
8. Black, J. G., & Black, L. J. (2023). Microbiology: Principles and explorations (11th ed.). John Wiley & Sons, Hoboken, NJ.
9. Leboffe, M. J., & Pierce, B. E. (2015). Microbiology: Laboratory theory & application (4th ed.). Morton Publishing Company, Englewood, CO.
10. Cornelissen, C. N., & Gleason, M. M. (2022). Lippincott illustrated reviews: Microbiology (4th South Asian ed.). Wolters Kluwer India, New Delhi, India.
11. Pelczar MJ, Chan ECS and Kreig NR. 2009. Microbiology, 5th Edition. McGraw- Hill. Book Co.Singapore.
12. Rajan S and Selvi Christy R. 2018. Essentials of Microbiology, CBS Publishers, NewDelhi.

Related Online Contents:

1. nptel.ac.in (NPTEL - Intro to Microbiology)
2. coursera.org (Coursera - The Microbial World)
3. nih.gov (NCBI - Microbial Genomes)
4. microbenotes.com (MicrobeNotes - Study Notes)
5. qiime2.org (QIIME 2 - Computational Analysis)
6. biorender.com (BioRender - Microbial Models)

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SEMESTER –I
FUNDAMENTALS OF MICROBIOLOGY (P)

Course Code	CP - 1	Course Type	Core	L	T	P	C	Syllabus version	2026-2027
				-	-	4	4		
Pre-requisite	Basic knowledge of laboratory safety, cell biology concepts, and a fundamental understanding of aseptic handling to perform microbial staining, cultivation, and control experiments.								

Course Objectives:

- ✓ Master the technical skills of operating microscopes and mastery in differential staining techniques for microbial identification.
- ✓ Addresses challenges in aseptic techniques by mastering sterilization protocols using Autoclave and Hot Air Oven.
- ✓ Creative problem solver of microbial isolation from diverse samples using streak, pour, and spread plate methods.
- ✓ Understand the physiological dynamics of bacterial growth curves and the impact of environmental factors on microbial populations.
- ✓ Demonstrate proficiency in antimicrobial assays to evaluate the efficacy of disinfectants and antibiotic sensitivity patterns.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Demonstrate proficiency in operating microscopes and applying staining techniques for microbial visualization.	K3
CO2	To execute various sterilization protocols and handle laboratory instruments safely to maintain aseptic conditions.	K3
CO3	To formulate culture media and isolate pure cultures using streak, pour, and spread plate techniques.	K3, K4
CO4	To quantify microbial growth and analyze the influence of environmental factors like temperature and pH.	K3, K4
CO5	To evaluate the efficacy of antimicrobial agents and disinfectants using standardized sensitivity testing methods.	K5
CO6	To analyze microbial data from web resources and maintain precise laboratory records with sample metadata and OTU mapping.	K4, K5
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Experiments

1. Laboratory rules and regulations.
2. Basic requirements of Microbiology laboratory.
3. Illustrate contributions of Antony Von Leuwenhoek Louis Pasteur, Sergi Winogradsky, Alexander Fleming, Robert Koch, Joseph Lister and Edward Jenner.
4. Principles and operations – Autoclave, Hot Air Oven, Incubators, Laminar Air Flow, Filtration, colony counter, Centrifuge, pH meter, Colorimeter and Spectrophotometer
5. Cleaning and sterilization of glasswares.
6. Principles and parts of a compound Light Microscope.
7. Staining techniques – Simple staining, Gram's staining, Spore-staining, Capsular staining and LPCB.
8. Preparation of Basal media, Selective and Differential media.
9. Isolation of Bacteria: Streak plate, Pour plate, and Spread plate methods.
10. Components and uses of Peptone, sodium chloride, Yeast extract, agar-agar, Nutrient agar, EMB agar, Mac Conkey agar, Mueller Hinton Agar and Potato Dextrose agar.
11. Hanging drop method to observe bacterial motility.
12. Calibration of Microscope using Ocular and Stage Micrometers.
13. Observation of permanent slides to study the structural characteristics of algae (*Anabena, Nostoc, Spirulina, Oscillatoria*), fungi (*Rhizopus, Saccharomyces, Penicillium, Aspergillus, Agaricus*) and protozoa (*Entamoeba histolytica, Giardia lamblia* and *Plasmodium* sp.).
14. Maintenance and preservation of cultures.
15. Establishment of ubiquitous nature of microorganisms – isolation of bacteria and fungi from spoiled food - vegetables, fruits, and bottled beverages.

Mapping with Programme Specific Outcomes

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	S	S	S	S	S	M	S	S	M	S
CO2	S	S	S	S	S	M	S	S	M	S
CO3	S	S	S	S	S	M	S	S	M	S
CO4	S	S	S	S	S	M	S	S	M	S
CO5	S	S	S	S	S	M	S	S	M	S
CO6	S	S	S	S	S	M	S	S	M	S

Recommended References:

1. Leboffe, M. J., & Pierce, B. E. (2015). Microbiology: Laboratory theory & application (4th ed.). Morton Publishing Company, Englewood, CO
2. Kannan, N. (2002). Laboratory manual in general microbiology. Panima Publishing Corporation, New Delhi, India.
3. Smith, H. R., & Brown, A. E. (2022). Benson's microbiological applications: Laboratory manual in general microbiology (15th ed.). McGraw-Hill LLC, New York, NY.
4. Dubey, R. C., & Maheshwari, D. K. (2023). Practical microbiology (4th ed.). S. Chand Publishing, New Delhi, India.
5. Rajan, S., & Christy, R. S. (2018). Experimental procedures in life sciences. CBS Publishers & Distributors, New Delhi, India.
6. Aneja, K. R. (2023). Experiments in microbiology, plant pathology, tissue

culture and microbial biotechnology (6th ed.). New Age International Publishers, New Delhi, India
7. Rajan S and Selvi Christy R.2018. Experimental Procedures in Life Sciences. CBS Publishers, New delhi.
8. Cappuccino, J. G., & Welsh, C. T. (2020). Microbiology: A laboratory manual (12th global ed.). Pearson, New York, NY.

Related Online Contents:

1. amrita.edu
2. jove.com
3. nptel.ac.in

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SEMESTER –I
FUNDAMENTALS OF BIOLOGICAL SCIENCES

Course Code	AC-1	Course Type	Allied	L	T	P	C	Syllabus version	2026-2027
				4	-	-	4		
Pre-requisite	A basic understanding of the diversity of life, taxonomic hierarchies, and the general characteristics that distinguish living organisms from non-living matter.								

Course Objectives:

- ✓ To gain the basic knowledge about plants and animals.
- ✓ To study the biological concepts of plant and animal evolution and establishments.
- ✓ To understand the biological sciences' importance to human society.
9. To enhance the student knowledge from current biological diversity to safe earth.
- ✓ To introduce the recent research topics as to stimulate the learners' interest towards higher studies.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Gain knowledge about plants and animals on a par with their higher education.	K1,K2
CO2	Understand the biological concepts of plant and animal evolution and their establishments.	K1-K4
CO3	Imbibe the biological sciences' importance to human society.	K1,K2, K3
CO4	Enhance their knowledge of existing biological diversity and of a safe earth.	K1-K4
CO5	Know the current research topics that could stimulate them towards higher studies.	K5
CO6	To critically evaluate and communicate recent global advancements in biological sciences through modern research tools and real-world observations.	K5, K6
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit-I: Origin, Evolution, Diversity of Biological Sciences (12 hours)

Origin of life theory, history and evolution of biology. Chemical basis of life and diversity of life forms. General characteristic features of living organisms: Plants, animals and microorganisms. Hierarchical levels of organization in living organisms; difference between prokaryotes and eukaryotes.

Unit-II: Plant Diversity and Taxonomy (12 hours)	Introduction, plant nomenclature - Binomial system, International Code of Botanical Nomenclature (ICBN). Types of classification and plant taxonomy. Salient features and distribution of lichens, bryophytes, pteridophytes, gymnosperms and angiosperms.
Unit-III: Plant Functional Traits and Values (12 hours)	Physiology and reproduction of plants: photosynthesis; anatomy and embryological features; pollination biology; micropropagations. Economic importance of plants and value-added products.
Unit-IV: Animal Diversity and Taxonomy (12 hours)	Introduction to animal kingdom and evolutionary theories. International code of zoological nomenclature (ICZN). Types of classification and nomenclatures of animals. Salient features and distribution of invertebrates and vertebrates.
Unit – V: Animal Functional Traits and Values (12 hours)	Introduction to animal physiology. Growth and homeostasis. Animal behaviour. Brief on comparative anatomy and physiology. Animal reproductive biology and endocrinology. Biological importance of diverse animals.
Unit-VI: Current Contours (For Continuous Internal Assessment only):	Importance of biological sciences and their study with relevance to the existence of life on planet earth. Integration of biological sciences with various fields for human welfare. Stem cells and regenerations research.

Mapping with Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	S	S	S	S	M	M	S	S	S	S
CO2	S	S	S	S	M	M	S	S	S	S
CO3	S	S	S	S	M	M	S	S	S	S
CO4	S	S	S	S	M	M	S	S	S	S
CO5	S	S	S	S	S	M	S	S	S	S
CO6	S	S	S	S	S	S	S	S	S	S

Recommended References:

1. Dubey, R. C., and Maheshwari, D. K. (2023). Practical microbiology (4th ed.). S. Chand Publishing, New Delhi, India.
2. Kumaresan, V. (2009). Horticulture and plant breeding. Saras Publication, Nagercoil, India.
3. Pandey, B. P. (1999). Taxonomy of angiosperms. S. Chand and Company Ltd., New Delhi, India.
4. Ragland, A., and Kumaresan, V. (2013). Angiosperms. Saras Publication, Nagercoil, India
5. Jain, V. K. (2006). Fundamentals of plant physiology. S. Chand & Company Ltd., New Delhi, India.
6. Pandey, B. P. (2009). Plant pathology. S. Chand & Company Ltd., New Delhi,

India.
7. Pandey, S. N., and Sinha, B. K. (2006). Plant physiology (4th ed.). Vikas Publishing House, New Delhi, India.
8. Sharma, P. D. (2001). Microbiology and plant physiology. Rastogi Publications, Meerut, India.
9. Rajan S and Selvi Christy R.2018. Experimental Procedures in Life Sciences. CBS Publishers, New Delhi.
10. Verma, V. (2007). Text book of plant physiology. Ane Books India, New Delhi, India.
11. Balinsky, B. I. (1981). An introduction to embryology (5th ed.). Saunders College Publishing, Philadelphia, PA.
12. Futuyma, D. J. (1986). Evolutionary biology (2nd ed.). Sinauer Associates, Sunderland, MA.

Related Online Contents:

1. khanacademy.org/science/biology
2. bio.libretexts.org
3. nature.com

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SEMESTER –I
FUNDAMENTALS OF BIOLOGICAL SCIENCES & BASIC BIOCHEMISTRY (P)

Course Code	ACP-1	Course Type	Allied	L	T	P	C	Syllabus version	2026-2027
				-	-	2	-		
Pre-requisite	A basic understanding of the diversity of life, taxonomic hierarchies, and the general characteristics that distinguish living organisms from non-living matter.								

Course Objectives:

- ✓ Understand the foundational anatomical structures of plant tissues and their comparative vegetative characteristics.
- ✓ Address challenges in microbial isolation, with a specific focus on harvesting endophytic microorganisms from medicinal plants.
- ✓ Become a creative problem solver in utilizing microscopes, various staining techniques.
- ✓ Understand the basic separation and pigment profiling methods to evaluate morphological and biochemical properties.
- ✓ Understand laboratory safety protocols, equipment calibration procedures, and advanced molecular techniques to drive innovative findings in microbial mechanisms.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Apply standard laboratory safety protocols, calibrate basic analytical instruments, and demonstrate proficiency in handling microscopes.	K3
CO2	Prepare plant tissue specimens and perform various staining techniques to observe and differentiate microscopic morphology.	K3, K4
CO3	Perform the isolation and cultivation of both aerobic and anaerobic microorganisms using appropriate microbiological methods.	K3, K4
CO4	Execute extraction, purification, and molecular separation techniques to recover value-added compounds from plant sources.	K4, K5
CO5	.Characterize biological materials by deriving specific pigmentation profiles and estimating their polysaccharide levels.	K4, K5
CO6	Maintain comprehensive laboratory records, interpret experimental data, and synthesize findings into structured scientific reports.	K5, K6
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

EXPERIMENTS:

1. Stem, leaf and root sections of a monocot and a dicot plant.
2. Study morphological properties using permanent slides and specimens (vegetative and reproductive structures) of *Coleacheate, Vaucheria, Polysiphonia*, *Fucus*; *Rhizopus*, *Penicillium* and *Agaricus*; *Riccia, Anthoceros, Funaria; Cycas,* and *Pinus*.
3. Study of the characteristic features of any two flowers for each family: (a)Malvaceae/Fabaceae/Cruciferae (any one family), (b) Compositae, (c) Euphorbiaceae, (d) Poaceae/Liliaceae (any one family)
4. Extraction of compound from medicinal plant.
5. Enumeration of red blood cells and white blood cells using haemocytometer.
6. Estimation of haemoglobin using Sahli's haemoglobinometer.
7. Safety measures in laboratories, use and calibration of pipettes.
8. Preparation of normal, molar and percent solutions.
9. Concept of pH and preparation of buffers.
10. Assay of enzyme activity of alkanine phosphatases, SGOT, SGPT.
11. Qualitative analyses of carbohydrate and amino acids.
12. Estimation of polysaccharide (starch or glycogen) from the biological material.
13. Separation of amino acids by paper chromatography and identification of amino acid.

Mapping with Programme Specific Outcomes

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	S	S	S	S	S	M	S	S	S	S
CO2	S	S	S	S	S	M	S	S	S	S
CO3	S	S	S	S	S	M	S	S	S	S
CO4	S	S	S	S	S	M	S	S	S	S
CO5	S	S	S	S	S	M	S	S	S	S
CO6	S	S	S	S	S	M	S	S	S	S

Recommended References:

1. Burran and DesRochers. 2021. Principles of Biology I Lab Manual
2. Jerry G. Chmielewski and David Krayesky General Botany Laboratory Manual. 2013. Publisher: Author House ISBN: 978-1-4772-9653-0
3. Naveena Varghese and P.P. Joy Microbiology Laboratory Manual. 2014 Edition: 1 Publisher: Aromatic and Medicinal Plants Research Station
4. Pakpour and Horgan. 2021.General Microbiology Lab Manual
5. Josephine A. Morello Paul A. Granato Helen and Eckel Mizer. 2003. Laboratory Manual and Workbook in Microbiology Applications to Patient Care. ISBN: 0-07 246354-6.
6. Pattabiraman, 2015. Laboratory manual in biochemistry fourth edition. All Indian Publisher
7. Sattanathan, S.S. Padmapriya, B. Balamuralikrishnan. 2020. Practical Manual of Biochemistry. Skyfox Publishing Group Skyfox Press
8. DM Vasudevan and Subir Kumar Das. 2013. Practical Textbook of Biochemistry for Medical Students. Jaypee Brothers Medical Publishers (P) Ltd
9. Gyorgy H, Jozsef K, Mihaly, K. Introduction to Practical. 2013. Eötvös

Loránd University
10. Rajan S and Selvi Christy R.2018. Experimental Procedures in Life Sciences. CBS Publishers, New Delhi.

Related Online Contents:

1. MicrobeNotes - Staining Techniques: https://microbenotes.com/category/staining-techniques/
2. American Society for Microbiology (ASM) MicrobeLibrary: https://asm.org/Protocols
3. JoVE (Journal of Visualized Experiments) - Basic Microbiology: https://www.jove.com/education/biology

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SEMESTER –I
MICROBIOLOGICAL TECHNIQUES

Course Code	IDC-1	Course Type	Interdisciplinary	L	T	P	C	Syllabus version	2026-2027
				2	-	-	2		
Pre-requisite	A fundamental understanding of high-school level biology and chemistry, along with a general interest in laboratory sciences.								

Course Objectives:

- ✓ Understand the principles of optics, microscopy, and the biophysics of sterilization and biosafety equipment.
- ✓ Address challenges in formulating nutritional media and isolating pure microbial cultures from complex environmental or clinical samples.
- ✓ Become a creative problem solver by applying specific chemical stains.
- ✓ Address the biochemical assays to identify and classify unknown microorganisms.
- ✓ Understand the intersection of microbiology with molecular biology and diagnostic techniques.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Recall principles of microscopy, sterilization methods, staining chemistry, and basic biochemical testing parameters.	K1,K2
CO2	Explain the relationship between microbial nutritional media properties, culture growth isolation, and chemical fixation.	K2, K3
CO3	Perform qualitative assays, pure culture isolation techniques, and differential staining procedures from biological samples.	K3, K4
CO4	Differentiate between structural cell features and metabolic capabilities using systematic biochemical profiles.	K4
CO5	Formulate a functional standard operating workflow or minor project layout combining basic isolation, staining, and separation methods.	K2, K4
CO6	To demonstrate the ability to design an interdisciplinary workflow using microbial techniques for environmental or industrial problem-solving.	K5, K6
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit-I: Microscopy and Sterilization (6 hours)	Principles of optics and magnification. Working mechanism and applications of Bright-field, Dark-field, and Phase-contrast. Principles of sterilization and disinfection: physical methods (autoclaving, hot air oven, radiation, membrane filtration) and chemical agents. Working principle of the Laminar Air Flow chamber and biosafety cabinets.
Unit-II: Cultivation of Microorganisms (6 hours)	Nutritional requirements of microorganisms. Types of culture media based on consistency and application -Basal, Enriched, Selective, and Differential media. Aseptic techniques and inoculation methods. Isolation of pure cultures: Streak plate, Pour plate, and Spread plate techniques. Cultivation of anaerobic bacteria. Short-term and long-term preservation methods for microbial cultures -lyophilization, cryopreservation.
Unit-III: Staining Techniques (6 hours)	The chemistry of biological dyes and stains. Preparation of bacterial smears and the physics of heat fixation. Simple staining and Negative staining techniques. Differential staining: Gram staining and Acid-fast staining. Structural staining: Endospore, Capsule, and Flagella staining.
Unit-IV: Biochemical and Analytical Assays (6 hours)	Using enzymatic reactions for bacterial identification. The IMViC test series. Carbohydrate fermentation assays. Detection of specific enzymes: Catalase, Oxidase, Urease, and Amylase tests.
Unit-V: Applied Molecular and Separation Techniques (6 hours)	Intersection of microbiology with molecular biology: Basic principles of DNA extraction from bacteria and Polymerase Chain Reaction. Analytical separation of microbial metabolites using Thin Layer Chromatography and Spectrophotometry.
Unit-VI: Current Contours (For Continuous Internal Assessment only):	Public science initiatives like the "Foldscope". Computational exploration of virtual microbiology labs. Drafting a standard operating procedure (SOP) or a miniature project proposal applying a specific microbial technique to a problem in the student's core discipline.

Mapping with Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	S	S	S	S	S	M	M	S	S	S
CO2	S	S	S	S	S	S	S	S	S	S
CO3	S	S	S	S	S	S	S	S	S	S
CO4	S	S	S	S	S	S	S	S	S	S
CO5	S	S	S	S	S	M	S	S	S	S
CO6	S	S	S	S	S	S	M	S	S	S

Recommended References:

1. Cappuccino, J. G., & Welsh, C. (2017). *Microbiology: A Laboratory Manual*, 11th Edition. Pearson.
2. Benson, H. J. (2001). *Microbiological Applications: Laboratory Manual in General Microbiology*, 8th Edition. McGraw-Hill.
3. Harley, J. P., & Prescott, L. M. (2002). *Laboratory Exercises in Microbiology*, 5th Edition. McGraw-Hill.
4. Willey, J., Sherwood, L., & Woolverton, C. J. (2016). *Prescott's Microbiology*, 10th Edition. McGraw-Hill Education. (For theoretical backing of the techniques).
5. Aneja, K. R. (2007). *Experiments in Microbiology, Plant Pathology and Biotechnology*, 4th Edition. New Age International Publishers.
6. Rajan S and Selvi Christy R.2018. Experimental Procedures in Life Sciences. CBS Publishers, New Delhi.

Related Online Contents:

1. https://vlab.amrita.edu/?sub=3 (Amrita Vishwa Vidyapeetham Virtual Lab - Microbiology Virtual Lab II)
2. https://microbiologyonline.org/ (Society for General Microbiology - Educational resources)
3. https://www.foldscope.com/ (Explore the application of ultra-affordable paper microscopes in field techniques)

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SEMESTER –II
MICROBIAL PHYSIOLOGY

Course Code	CC-2	Course Type	Core	L	T	P	C	Syllabus version	2026-2027
				4	-	-	4		
Pre-requisite	Basic understanding of biology and microorganisms. Knowledge of fundamental biochemistry and cellular processes. Familiarity with basic laboratory techniques and microbiological methods.								

Course Objectives:

- ✓ To understand the physiology and growth patterns of microorganisms.
- ✓ To study the nutritional requirements and factors influencing microbial growth.
- ✓ To gain knowledge of microbial metabolism, energy production, and fermentation processes.
- ✓ To explain the principles of photosynthesis in microorganisms.
- ✓ To understand recent advances and applications of microorganisms in physiology, biotechnology, environmental sustainability, and antimicrobial resistance.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Describe microorganisms based on nutrition.	K1,K2
CO2	Know the concept of microbial growth and identify the factors affecting bacterial growth.	K2, K3
CO3	Explain the methods of nutrient uptake.	K1, K2
CO4	Explore about the anaerobic and aerobic energy production.	K1, K2
CO5	Elaborate on the process of bacterial photosynthesis and reproduction.	K1-K4
CO6	Demonstrate comprehensive understanding of microbial growth, metabolism, and their applications in biotechnology, environmental sustainability, and disease control.	K4,K5
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit-I: Microbial growthand Growth Curve
(12 hours)

Microbial nutrition and growth: Nutritional requirements of microbes - Autotrophs, Heterotrophs, Photoautorophs, Chemoautotrophs, Copiotrophs, Oligotrophs, Factors influencing microbial growth – pH, temperature, substrate and osmotic condition. Bacterial growth curve & importance of the growth phases – Generation time - Growth measurements – batch, continuous and synchronous. Diauxic growth.

Unit-II: Microbial Enzymes (12 hours)

Bacterial enzymes – classification & nomenclature, properties, kinetics of enzyme action – Michaelis-Menton equation for simple enzymes - coenzymes and cofactors, isozymes. Factors affecting enzyme activity.

Unit-III: Photosynthesis (12 hours)

Photosynthesis - An Overview of chloroplast structure. Photosynthetic Pigments, Light Reaction- Cyclic and non-cyclic Photophosphorylation. Dark Reaction - Calvin Cycle.ATP synthesis.

Unit-IV: Carbohydrates: Catabolism of Glucose (12 hours)

Carbohydrate catabolism of glucose – glycolysis – HMP – ED pathways, TCA cycle – electron transport system, Phosphorylation, oxidative and substrate level phosphorylations. Anaerobic Respiration. Fermentations – alcoholic, propionic, mixed acid, lactic acid fermentation.

Unit – V: Protein and Lipid Metabolism (12 hours)

Protein metabolism – synthesis and degradation of amino acids – glycine tyrosine, cysteine, serine, glutamine, synthesis of peptides and proteins – urea cycle. Lipids metabolism – biosynthesis of fatty acids and cholesterol – oxidation of fatty acids.

Unit-VI: Current Contours (For Continuous Internal Assessment only):

Demonstration on the role of nutrients & individual components of nutrient agar, nutrient broth, Mac Conkey Agar, Salmonella–Shigella Agar, Mueller-Hinton Agar, Mannitol Salt Agar, Robertson Cooked Meat Broth – assignments on types of microbial nutrients – bacterial growth curve - Diauxic growth – classification & nomenclature of enzymes – factors affecting enzyme activity - EMP – HMP – ED pathways.

Mapping with Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	S	S	S	S	S	M	M	M	S	S
CO2	S	S	S	S	S	M	M	S	S	S
CO3	S	S	S	S	S	M	M	M	S	S
CO4	S	S	S	S	S	M	M	S	S	S
CO5	S	S	S	S	S	M	S	S	S	S
CO6	S	S	S	S	S	S	S	S	S	S

Recommended References:

1. Robert K. Poole 2004. Advances in Microbial Physiology, Elsevier Academic Press, New York, Volume 49.
2. Kim B.H., and Gadd G.M. 2008. Bacterial Physiology and Metabolism. Cambridge University Press, Cambridge.
3. Daniel R. Caldwell. 1995. Microbial Physiology and Metabolism Wm.C. Brown Communications, Inc. USA.
4. Moat, A.G and J.W Foaster, 1995. Microbial Physiology, 3rd edition. Wiley – LISS, A John Wiley and Sons. Inc. Publications.

5. Bhanu Shrivastava. 2011. Microbial Physiology and Metabolism: Study of Microbial Physiology and Metabolism. Lambert academic Publication, Maldova.
6. Mathews CK and Holde KEV. (2003) Biochemistry – The Benjamin/Cummings Publishing company, Inc., New York..
7. Pelczar TR M J Chan ECS and Kreig N R (2006). Microbiology. Tata Mc GrawHill INC., New York
8. Nelson David L, Albert L Lehninger and Michael M Cox. Lehninger (2008) Principles of biochemistry. Macmillan.
9. Dubey RC and Maheswari DK (2022). A Text of Microbiology. Revised edition, S. Chand and Company Ltd., New Delhi
10. Lansing M. Prescott JP, Harley and Donald A Klein. (2003) Microbiology, 5th edition, McGraw-Hill Company, New York.

Related Online Contents:

1. https://sites.google.com/site/microbial physiology odd sem /teaching-contents
2. https://courses.lumenlearning.com/boundless-microbiology/chapter/microbial-Nutrition
   https://onlinecourses.swayam2.ac.in/cec20_bt14/preview
3. http://web.iitd.ac.in/~amittal/2007_Addy_Enzymes_Chapter.pdf
4. https://www..frontiersin.org.microbial-physiology-and-metabolism

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SEMESTER –II
MICROBIAL PHYSIOLOGY (P)

Course Code	CP-2	Course Type	Core	L	T	P	C	Syllabus version	2026-2027
				-	-	4	4		
Pre-requisite	Knowledge of fundamental microbial cell structure, theoretical concepts of microbial metabolism, and general laboratory safety protocols.								

Course Objectives:

- ✓ To provide the students hands-on practice on the first-line microbial physiology experiments.
- ✓ To train the learners to independently test various carbohydrate fermenting abilities of microbes.
- ✓ To make the students to understand the principles of significant biochemical tests done to identify bacterial isolates.
- ✓ To educate microbial growth experiments and their impacting factors.
- ✓ To provide hands-on experience of microbial cultivations by different methods.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Test and determine sugar fermenting / utilizing abilities of different bacterial species.	K3
CO2	Understand the principles behind important biochemical tests done to identify/characterize bacterial species.	K3,K4
CO3	Determine growth stages of a test bacterial species.	K3
CO4	Evaluate the impact of various external components on the microbial growth	K5
CO5	Grow anaerobic bacteria in a conventional microbiology laboratory.	K4
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

EXPERIMENTS:

1. Bacteria and carbohydrate fermentation tests: Glucose, Lactose, Sucrose and Mannitol.
2. Biochemical tests to identify bacterial isolates - IMViC test, Oxidase test, Catalase test, Urease test and TSI test.
3. Enzymatic hydrolysis of starch and casein by selective bacterial isolates.
4. Bacterial growth curve: Cell count.
5. Measurement of microbial growth –Turbidity methods, colony count and Haemocytometer.
6. Effect of temperature and pH on the growth of bacteria, fungi, and algae.
7. Anaerobic bacteria cultivation - Candle jar method.

8. Determine cyanobacterial and algal photosynthetic pigments.

Mapping with Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	S	S	S	S	S	S	M	S	S	S
CO2	S	S	S	S	S	S	M	S	S	S
CO3	S	S	S	S	S	S	M	S	S	S
CO4	S	S	S	S	S	S	M	S	S	S
CO5	S	S	S	S	S	S	M	S	S	S
CO6	S	S	S	S	S	S	M	S	S	S

Recommended References:

1. Aneja KR, 2017. Experiments in Microbiology, Plant pathology and Biotechnology. 4th edition, New Age International Publishers, Chennai.
2. Mudili J, 2020, Introductory Practical Microbiology, Narosa publishers, New Delhi.
3. Amita Jain, Jyotsna Agarwal and Vimala Venkatesh, 2018. Microbiology Practical Manual, 1st edition, India
4. James G. Cappuccino, 2014. Microbiology: A Laboratory Manual, 10th Edition, Pearson, London, UK.
5. Dubey RC and Maheswari DK 2004. Practical Microbiology 1st edition, S. Chand & Company Ltd., New Delhi.
6. Kannan N 2003. Handbook of Laboratory Culture Media, Reagents, Stains and Buffers. Panima Publishing Corporation, New Delhi.
7. Rajan S and Selvi Christy R. 2018. Experimental Procedures in Life Sciences. CBS Publishers, New Delhi.
8. Sundararaj T. Microbiology laboratory manual. Revised and published by Aswathy Sundararaj, Chennai.

Related Online Contents:

1. https://sites.google.com/site/microbial physiology odd sem /teaching-contents
2. https://courses.lumenlearning.com/boundless-microbiology/chapter/microbial-Nutrition
   https://onlinecourses.swayam2.ac.in/cec20_bt14/preview
3. https://www.frontiersin.org/books/Microbial_Physiology_and_Metabolism
   https://onlinelibrary.wiley.com/doi/book/10.1002/0471223867

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SEMESTER –II
BASIC BIOCHEMISTRY

Course Code	AC-2	Course Type	Allied	L	T	P	C	Syllabus version	2026-2027
				2	-	-	4		
Pre-requisite	A basic understanding of chemistry and the fundamental structure of plant and animal cells.								

Course Objectives:

- ✓ To understand the molecules involved in metabolic functional systems.
- ✓ To provide a comprehensive understanding of biological macromolecules, micronutrients, catalysts, and signaling molecules.
- ✓ To analyze structures and relevant functions of biomolecules, vitamins, enzymes and hormones
- ✓ To evaluate catalytic and metabolic mechanisms of these molecules
- ✓ To apply this foundational knowledge to solve clinical, industrial, and biological problems.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Recall the classifications, functions and basic chemical structures of monosaccharides, amino acids, fatty acids, nucleotides, enzymes vitamins and hormones.	K1, K2
CO2	Explain the relationship between the higher-order structures of macromolecules, their biological functionsand mechanism of enzyme substrate interaction, hormone action	K1, K2
CO3	Perform qualitative and quantitative assays to isolate and estimate biomolecules from biological samples	K1 - K3
CO4	Differentiate between various metabolic roles and structural organizations of biomolecules	K3, K4
CO5	Formulate a connection between biomolecule/enzyme/vitamin/hormonal imbalances (hyper/hypo-secretion) and metabolic disorders	K5, K6
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit-I: Chemical Foundations, Amino Acids, and Proteins
(6 hours)

Composition of living matter. Basic concepts of acids, bases, pH, Henderson-Hasselbalch equation, and biological buffer systems. Amino acids: Nomenclature, classification, chemical structure, and biological functions. Proteins: Classification, properties, and biological functions. Elucidation of protein structure: determination and structural features of primary, secondary, tertiary, and quaternary organizations.

Unit-II: Carbohydrates, Lipids, and Biomembranes (6 hours)	Carbohydrates: Classification, structure, occurrence, and biological functions of monosaccharides, disaccharides, and polysaccharides. Lipids: Structure, classification, properties, and biological functions of saturated and unsaturated fatty acids. Structural features of biomembranes: fluid mosaic model, lipid bilayer dynamics, and membrane transport mechanisms.
Unit-III: Enzymes and Bioenergetics (6 hours)	Enzymes as biocatalysts, enzyme classification, specificity, active site, unit activity, and isozymes. Enzyme kinetics: Michaelis-Menten equation for simple enzymes and enzyme inhibition models. Bioenergetics: Oxidation-reduction reactions, coupled reactions, and high-energy group transfer. Thermodynamic concepts in biochemistry: free energy, spontaneity of reactions, equilibrium states, and the significance of G, G° and G’
Unit-IV: Nucleic Acid Structure and Biosynthesis (6 hours)	Nucleic acids: Detailed chemical structure of purine and pyrimidine bases, nucleosides, and nucleotides. Structural organization and functional properties of DNA and RNA types. Biosynthesis of nucleic acids: Outlines of the *de novo* and salvage pathways for both purine and pyrimidine nucleotide synthesis; regulatory steps and inhibitors of nucleotide biosynthesis.
Unit-V: Animal Hormones, Vitamins, and Minerals (6 hours)	Hormones: Types, functions, and dysfunctions of hormones synthesized from the Pituitary, Thyroid, Parathyroid, Pancreas, Adrenal, Gonads, and Thymus glands. Vitamins and minerals: Classification, sources, requirements, functions, and deficiency disorders of fat-soluble and water-soluble vitamins. Biological functions of dietary minerals.
Unit-VI: Current Contours (For Continuous Internal Assessment only)	Different biochemical pathways. Types of Diabetes mellitus. Promotion and inhibition mechanisms of drug functions. Biochemical limitations, clinical biomarkers, and modern diagnostic solutions in metabolic disease management.

Mapping with Programme Specific Outcomes

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	S	S	M	S	M	M	S	S	S	S
CO2	S	S	M	S	M	M	S	S	S	S
CO3	S	S	M	S	M	M	S	S	S	S
CO4	S	S	M	S	M	M	S	S	S	S
CO5	S	S	M	S	M	M	S	S	S	S

Recommended References:

1. Christopher K Mathews and Van Holde KE.1996. Biochemistry. 2nd edition. The Benjamin / Cummings publishing company, Inc.
2. David E Metzler and Carol M Metzler.2001. Biochemistry -The chemical reactions of living cells- Vol. 1and2.2nd edition. Harcourt/Academic press, New york.
3. Donald Voet and Judith G. Voet. 1995. Biochemistry – 2nd Edition. John Willey and Sons, Inc.
4. Freifelder D.1996. Molecular Biology, 2nd Edition, Narosa Publishing House, New Delhi.
5. Geofferey L and Zubay.1998. Biochemsitry. 4th Edition. Wm. C. Brown Publishers.
6. Jeremy M Berg, John L Tymoczko and Lubert stryer.2002. Biochemistry.5th edition. W.H. Freeman and company, New York.
7. Stryer L Berg JM and Tymoczko JL.2002. Biochemistry. 5th edition.W. H. Freeman, New York.
8. Rajan S and Selvi Christy R. 2018. Experimental Procedures in Life Sciences. CBS Publishers, New Delhi.
9. Lehninger, Albert L, David L Nelson and Michael M Cox.2000. Lehninger Principles of Biochemistry. Worth Publishers. New York.

Related Online Contents:

1. https://vlab.amrita.edu/?sub=3&brch=63
2. https://courses.lumenlearning.com/boundless-microbiology/chapter/microbial-Nutrition
3. http://web.iitd.ac.in/~amittal/2007_Addy_Enzymes_Chapter.pdf
4. https://www..frontiersin.org.microbial-physiology-and-metabolism

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SEMESTER –II
BIOFERTILIZER PRODUCTION TECHNIQUES

Course Code	IDC-2	Course Type	Interdisciplinary	L	T	P	C	Syllabus version	2026-2027
				2	-	-	2		
Pre-requisite	A fundamental understanding of sustainable agriculture, environmental conservation, or rural entrepreneurship.								

Course Objectives:

- ✓ Understand the vital role of beneficial soil microbes in enhancing soil fertility and plant growth.
- ✓ Address challenges associated with the ecological and economic impacts of excessive chemical fertilizer usage.
- ✓ Become a creative problem solver in selecting, culturing, and formulating appropriate microbial strains for bio-fertilizer production.
- ✓ Understand the commercialization process, quality control standards.
- ✓ Address the optimal field application methods for organic agricultural products.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Exploring the basic concepts of the rhizosphere, soil microflora, and the classification of bio-fertilizers.	K1, K2
CO2	To learn the biology and isolation techniques of nitrogen-fixing microbes like *Rhizobium* and *Azotobacter*.	K2, K3
CO3	To characterize the mechanisms of phosphate-solubilizing microbes (PSB) and mycorrhizal fungi.	K3, K4
CO4	Exploring the mass multiplication processes, carrier material selection, and formulation of bio-fertilizers.	K1 - K4
CO5	Understanding the quality control parameters, BIS standards, and methods of field application.	K2, K4
CO6	To demonstrate the ability to design a small-scale bio-fertilizer production unit or an integrated organic farming model.	K5, K6
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit-I:
Soil Health and Bio-fertilizers
(6 hours)

The soil ecosystem: physical and chemical properties affecting microbial life. The Rhizosphere concept and plant-microbe interactions. Definition, history, and scope of bio-fertilizers. Comparative analysis: Chemical fertilizers vs. Organic fertilizers vs. Bio-fertilizers. Environmental impacts of chemical farming and the shift towards sustainable agriculture.

Unit-II: Nitrogen-Fixing Bio-fertilizers (6 hours)	Biological Nitrogen Fixation (BNF). Symbiotic nitrogen fixers: *Rhizobium* and *Frankia*. Asymbiotic/Free-living nitrogen fixers: *Azotobacter* and *Azospirillum*. Cyanobacteria (Blue-Green Algae) and their symbiotic association with the water fern *Azolla*. Importance of *Azolla* in paddy cultivation.
Unit-III: Phosphate Mobilizing and Solubilizing Microbes (6 hours)	The phosphorus cycle in soil and the problem of phosphorus fixation. Phosphate Solubilizing Microorganisms: *Bacillus*, *Pseudomonas*, and *Aspergillus* species - mechanisms of organic acid production. Phosphate Mobilizing Microbes: Vesicular Arbuscular Mycorrhizae / Arbuscular Mycorrhizal Fungi. Role of VAM in nutrient uptake, drought resistance, and soil aggregation.
Unit-IV: Mass Production Technology (6 hours)	Laboratory setup for a bio-fertilizer unit. Preparation of mother culture. Scaling up: Principles of fermenter/bioreactor operation for mass multiplication of bacterial inoculum. Carrier-based formulations: selection and processing of carrier materials. Mixing, curing, and packaging of solid bio-fertilizers. Introduction to liquid bio-fertilizers and their advantages.
Unit – V: Quality Control and Field Application (6 hours)	Bureau of Indian Standards and Fertilizer Control Order specifications for bio-fertilizers. Quality checks: testing for viable cell counts, contamination limits, and moisture content. Factors affecting the shelf-life and storage of bio-fertilizers. Methods of application: Seed treatment, root dipping, seedling treatment, and direct soil application.
Unit-VI: Current Contours (For Continuous Internal Assessment only):	Daily news on government subsidies for organic farming (e.g., Paramparagat Krishi Vikas Yojana - PKVY). Public awareness of organic food certification and eco-labelling. Field visit reports or virtual tours of local bio-fertilizer production units. Drafting a basic business proposal and cost-benefit analysis for establishing a community-level vermicompost and bio-fertilizer facility.

Mapping with Programme Specific Outcomes

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	S	S	S	S	S	S	S	M	S	S
CO2	S	S	S	S	S	S	S	M	S	S
CO3	S	S	S	S	S	S	S	M	S	S
CO4	S	S	S	S	S	S	S	M	S	S
CO5	S	S	S	S	S	S	S	M	S	S
CO6	S	S	S	S	S	S	S	M	S	S

Recommended References:

1. Subba Rao, N. S. (2017). *Soil Microbiology*, 5th Edition. Oxford & IBH Publishing, UK.
2. Kannaiyan, S. (2002). *Biotechnology of Biofertilizers*. Narosa Publishing House, India.
3. Somani, L. L., Bhandari, S. C., Vyas, K. K., and Saxena, S. N. (1990). *Biofertilizers*. Scientific Publishers, India.
4. Gaur, A. C. (1990). *Phosphate Solubilizing Microorganisms as Biofertilizers*. Omega Scientific Publishers, India.
5. Niwas, R., and Singh, R. (2015). *Biofertilizers Technology*. Pointer Publishers, India.

Related Online Contents:

1. https://ncof.dacnet.nic.in/ (National Centre of Organic Farming, India - Guidelines and manuals)
2. https://agricoop.nic.in/ (Department of Agriculture & Farmers Welfare - Schemes on organic farming)
3. https://nptel.ac.in/courses/126104003 (NPTEL Course - Organic Farming for Sustainable Agricultural Production)

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SEMESTER –III
MOLECULAR BIOLOGY

Course Code	CC-3	Course Type	Core	L	T	P	C	Syllabus version	2026-2027
				4	-	-	4		
Pre-requisite	Understanding of macromolecules - DNA, RNA & Proteins.								

Course Objectives:

- ✓ To provide the principles and concepts of nucleic acid types (DNA, RNA, Plasmids & Transposons) and their molecular structure.
- ✓ To study about the types, models/mechanisms & molecules of nucleic acid replication.
- ✓ To impart the knowledge of the central dogma of molecular biology.
- ✓ To deeply learn the types of gene expression regulation with special reference of operon models.
- ✓ To adequately teach about the mutation & their types; mutagens and their laboratory testings, agents of DNA damage and types of repairing.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Explain about nucleic acids types and structure.	K1, K2
CO2	Understand DNA & RNA models of replication.	K4
CO3	Possess a deeper knowledge on the steps and stages in gene expression.	K1 – K3
CO4	Have a familiarity of gene expression regulation models.	K1, K2
CO5	Command on gene mutation, testing of mutants and molecular mechanism of DNA repair.	K4
CO6	Create models of learnt components and to evaluate them.	K6, K7
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit-I: Genomes, Types and Structure (12 hours)

Molecular biology – Introduction & historical milestones; DNA, RNA as the genetic material – experimental evidence. Structure of DNA double helix. Types and forms of DNA – Molecular structure of RNA – Genetic RNA – Non- genetic RNA, structure & types of Plasmids and transposon.

Unit-II: Genome (DNA & RNA) and its Replication (12 hours)

Central Dogma - Replication of DNA: Types: Semi-conservative, Conservative & Dispersive; Models of DNA replication: Rolling circle, D-loop & Uni-directional & Bi-directional - Mechanism, enzymes and proteins of replication – Replication of RNA – reverse transcriptase.

Unit-III: Transcription and

DNA Transcription - Transcriptional machinery and mechanism of transcription -post-transcriptional

Translation (12 hours)	processing – Genetic code – RNA Translation: Translational machinery and mechanism of translation - Post-translational processing.
Unit-IV: Regulation of Gene Action (12 hours)	Regulation of gene expression in prokaryotes: Regulation of enzyme & Regulation of transcription – types and mechanism – Operon model – *lac* operon and *trp* operon.
Unit-V: Mutation and Mutagenesis (12 hours)	Definitions of mutation, mutagenesis and mutant – genome mutations & gene mutations; Physical and chemical mutagens. Transposons - Applications of mutations, Carcinogenicity testing – Ames test & Devoret's test. DNA damage sources & DNA damage repair types.
Unit-VI: Current Contours (For Continuous Internal Assessment only):	Learners shall be given 'permanent models' & 'posters' making with respect to DNA / RNA structure, operon concept, mutation etc., for assignment work so as to facilitate their complete understanding of the topics. Seminar topics shall additionally be provided across the syllabus. Swayam- NPTEL courses on Basics of molecular biology topics shall be recommended for an enhanced understanding.

Mapping with Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	S	S	M	S	M	S	M	M	S	S
CO2	S	S	M	S	M	S	M	M	S	S
CO3	S	S	M	S	M	S	M	M	S	S
CO4	S	S	M	S	M	S	M	M	S	S
CO5	S	S	M	S	M	S	M	M	S	S
CO6	S	S	M	S	M	S	M	S	S	S

Recommended References:

1. David Frifelder.2008. Molecular Biology,2nd edition. Narosa publishing house, New Delhi.
2. George M Malacinski.2008. Freifelder's Essentials of Molecular Biology. 4th edition. Narosa Publishing House,New Delhi.
3. Malacinski G.M. (2008). Freifelder's Essentials of Molecular Biology. 4th Edition. Narosa Publishing House, New Delhi.
4. Jayanthi G P. (2009) Molecular Biology, MJP Publications, India.
5. De Robertis EDP and De Robertis EMF.2006. Cell and Molecular Biology, 8th edition. Lippincott Williams and Wilkins, Philadelphia.
6. Sambaurthy AVSS.2008. Molecular biology. Narosa publishing house, New Delhi.
7. Channarayappa A.2010. Molecular Biology, Universities Press, (India) Pvt. Ltd, Hyderabad, India.
8. Watson JD, Tania AB, Stephen PB, Alexander G, Michael L, Richard L 2017. Molecular Biology of the Gene. 7th Edition. Pearson Education. UK.

9. Wilson K, Walker J 2010 Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press, Cambridge. UK.
10. Verma P S. and Agarwal V.K. 2012. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology, S. Chand & Company Ltd. India
11. Stanly R Maloy, John E Cronan Jr. and David Freifelder.2006. Microbial Genetics, 2nd edition, Narosa publishing house, New Delhi.
12. Larry Synder and Wendy Champness.2003. Molecular Genetics of Bacteria, 2nd edition, American Society for Microbiology, Washington.
13. Karp G.2010. Cell and Molecular Biology: Concepts and Experiments, 6th edition, John Wiley and Sons. Inc. USA.
14. Gardner E. J. Simmons M. J. and SnustedD.P.2006. Principles of Genetics. 8th Edition. Wiley India Pvt. Ltd. USA.
15. Dale J. W., Schantz M.V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3rd Edition). John Wileys and Sons Ltd. USA.

Related Online Contents:

1. https://bio.libretexts.org/Bookshelves/Introductory_and_General_Biology/General_Biology_1e_(OpenStax)/3%3A_Genetics/14%3A_DNA_Structure_and_Function/14.4%3A_DNA_Replication_in_Prokaryotes
2. https://jackwestin.com/resources/mcat-content/control-of-gene-expression-in-prokaryotes/operon-concept-jacob-monod-model
3. https://evolution.berkeley.edu/dna-and-mutations/
4. https://microbenotes.com/dna-damage-and-repair/
5. https://microbenotes.com/dna-replication-steps/
6. https://microbenotes.com/lac-operon/
7. http://cshprotocols.cshlp.org/site/Taxonomy/molecular_biology_l1.xhtml
8. https://facultystaff.richmond.edu/~lrunyenj/bio554/lectnotes/chapter11.pdf
9. https://swayam.gov.in/nc_details/NPTEL

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SEMESTER –III
MOLECULAR BIOLOGY (P)

Course Code	CP-3	Course Type	Core	L	T	P	C	Syllabus version	2026-2027
				-	-	4	4		
Pre-requisite	Provide a fundamental knowledge and primary techniques of molecular biology.								

Course Objectives:

- ✓ To provide a fundamental knowledge and primary techniques of molecular biology.
- ✓ To skill-impart isolation of bacterial chromosomal and plasmid DNA.
- ✓ To orient isolation of bacterial RNA.
- ✓ To skill- acquire the quality and quantity estimation of DNA / RNA/ Plasmids.
- ✓ To be able to perform agarose gel electrophoresis, SDS- PAGE & PCR.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Isolation and purification DNA from bacteria.	K3
CO2	Isolation and purificationplasmids from bacteria.	K3, K4
CO3	Isolation and purificationRNA from bacteria.	K3, K4
CO4	Determine the concentration of DNA/ RNA & plasmid macromolecules of a sample.	K4, K5
CO5	Handle instruments as to visualize macromolecules in a sample as well as to amplify DNA/ RNA of a sample.	K4, K5
CO6	Train others with respect to DNA/ RNA isolation, quantification, visualization and amplification procedures.	K5, K6
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

EXPERIMENTS:

1. Isolation of chromosomal DNA from bacteria, fungi.
2. Isolation of plasmid DNA from bacteria, fungi.
3. Isolation of RNA from bacteria, fungi.
4. Quantification of genomic DNA and RNA & Plasmid by UV- Visible Spectrophotometric method.
5. Separation of DNA/ RNA & Plasmids by Agarose gel electrophoretic technique.
6. Extraction of bacterial whole cell proteins and separation by SDS – PAGE technique.
7. Demonstration of DNA amplification by PCR.

Mapping with Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	S	S	M	S	M	S	S	M	S	S
CO2	S	S	M	S	M	S	S	M	S	S
CO3	S	S	M	S	M	S	S	M	S	S
CO4	S	S	M	S	M	S	S	M	S	S
CO5	S	S	M	S	M	S	S	M	S	S
CO6	S	S	M	S	M	S	S	M	S	S

Recommended References:

1. John Vennison. 2009. Laboratory Manual for Genetic Engineering. PHI Learning Private Ltd, New Delhi – 110001.
2. Sambrook J and Russell DW. 2001. Molecular cloning - A laboratory manual, 3rd Edition. Cold Spring Laboratory Press, New York.
3. Surzyeki S. 2000. Basic Techniques in Molecular Biology, Springer.
4. Anbalagan K. 1999. An Introduction to Electrophoresis. The Electrophoresis Institute, Biotech- Yercaud, Yercaud – 636 601
5. Atlas RM and Bartha R. 1993.Microbial Ecology: Fundamentals and Applications, 3rd Ed., Benjamin and Cummings Pub. Co. New York.
6. Rajan S and Selvi Christy R. Experimental Procedures in Life Sciences. Anjanaa Book House, Chennai.
7. Monica Cheesbrough. 2011. District Laboratory Practice in Tropical Countries - Part I and II, 2nd edition, Cambridge University Press, New Delhi.
8. Betty A Forbes, Daniel F Sahm and Alice S Weissfeld. 2007. Bailey and Scott's Diagnostic Microbiology, 12th Edition.Mosby Elsevier.

Related Online Contents:

1. http://www.ncbi.nlm.nih.gov/ 2./www.yeastgenome.org
2. http://sequence-ww.stanford.edu/group/yeast_deletion_project /deletions3.html
3. https://biotechyercaud.com/product-videos/
4. https://www.iitg.ac.in/biotech/MTechLabProtocols/SDS%20PAGE.pdf
5. https://biotechyercaud.com/wp-content/uploads/2023/09/Biotech-Electrophoresis-Catalog.pdf

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SEMESTER –III
BIOSTATISTICS

Course Code	AC-3	Course Type	Allied	L	T	P	C	Syllabus version	2026-2027
				4	-	-	4		
Pre-requisite	Basic mathematics and a foundational understanding of biological experimental design and data collection.								

Course Objectives:

- ✓ Understand the fundamental concepts of descriptive statistics, data organization, and graphical visualization in biological research.
- ✓ Address challenges in experimental design, sampling methods, and the application of probability rules to biological phenomena.
- ✓ Become a creative problem solver in analyzing complex biological datasets using parametric and non-parametric inferential statistical methods.
- ✓ Understand the principles of correlation, regression.
- ✓ Address the hypothesis testing to validate clinical and experimental data accurately.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Exploring the basic concepts of biological data collection, classification, and graphical representation.	K1, K2
CO2	To learn about measures of central tendency, dispersion, and variations in biological data.	K2, K3
CO3	To characterize sampling methods, standard errors, and standard probability distributions.	K1,K2
CO4	Exploring hypothesis testing frameworks, level of significance, and the identification of statistical errors.	K3, K4
CO5	Understanding the application of parametric (t-test, ANOVA) and non-parametric tests (Chi-square) in experiments.	K4, K5
CO6	To demonstrate the ability to calculate correlation coefficients, perform regression analysis, and interpret *p*-values.	K5, K6
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit-I:
Introduction and Data Visualization
(12 hours)

Definition, scope, and applications of biostatistics in life sciences and clinical research. Variables in biology - qualitative, quantitative, discrete, and continuous. Methods of data collection, classification, and tabulation. Graphical and diagrammatic representation of biological data: Bar charts, Pie diagrams.

Unit-II: Descriptive Statistics (12 hours)	Measures of Central Tendency: Arithmetic Mean, Geometric Mean, Harmonic Mean, Median, and Mode. Measures of Dispersion: Range, Mean Deviation, Variance, Standard Deviation.
Unit-III: Probability and Distributions (12 hours)	Basic concepts of probability, mutually exclusive events, and independent events. Addition and multiplication rules of probability. Theoretical probability distributions and their biological relevance: Binomial distribution, Poisson distribution, and Normal distribution. Concept of Skewness and Kurtosis.
Unit-IV: Sampling and Hypothesis Testing (12 hours)	Concept of Population vs. Sample. Sampling techniques: Random, Stratified, and Systematic sampling. Principles of experimental design. Framework of Hypothesis Testing: Formulation of the Null Hypothesis and Alternative Hypothesis. Level of significance, Degrees of freedom, One-tailed vs. Two-tailed tests.
Unit-V: Inferential Statistics and Correlation (12 hours)	Parametric tests: Student's *t*-test. Analysis of Variance - One-way and Two-way ANOVA for comparing multiple experimental groups. Non-parametric tests: Chi-square test for goodness of fit and independence of attributes. Correlation analysis: Pearson's correlation coefficient and Spearman's rank correlation. Simple Linear Regression: finding the line of best fit for biological variables.
Unit-VI: Current Contours (For Continuous Internal Assessment only):	Daily reading of scientific literature to analyze the "Methods and Statistical Analysis" sections. Public awareness of statistical manipulation ("p-hacking") and the reproducibility crisis in science. Computational analysis: Introduction to data entry and basic statistical functions using spreadsheet software or statistical languages.

Mapping with Programme Specific Outcomes

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	S	S	M	S	M	S	M	M	S	S
CO2	S	S	M	S	M	S	M	M	S	S
CO3	S	S	M	S	M	S	M	M	S	S
CO4	S	S	M	S	M	S	M	M	S	S
CO5	S	S	M	S	M	S	M	M	S	S
CO6	S	S	M	S	M	S	M	M	S	S

Recommended References:

1. Zar, J. H. (2010). *Biostatistical Analysis*, 5th Edition. Pearson. UK.
2. Daniel, W. W., and Cross, C. L. (2018). *Biostatistics: A Foundation for Analysis in the Health Sciences*, 11th Edition. Wiley. UK.
3. Rosner, B. (2015). *Fundamentals of Biostatistics*, 8th Edition. Cengage Learning.

4. Mahajan, B. K. (2018). *Methods in Biostatistics for Medical Students and Research Workers*, 9th Edition. Jaypee Brothers Medical Publishers. India
5. Sokal, R. R., & Rohlf, F. J. (2012). *Biometry: The Principles and Practice of Statistics in Biological Research*, 4th Edition. W. H. Freeman.

Related Online Contents:

1. StatQuest with Josh Starmer (YouTube): (Highly recommended for visual and intuitive explanations of complex statistical concepts, p-values, and distributions).
2. Coursera - Mathematical Biostatistics Boot Camp (Johns Hopkins University): https://www.coursera.org/learn/biostatistics
3. OpenIntro Statistics: https://www.openintro.org/ (Free, open-source statistics textbooks and datasets excellent for self-study).

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SEMESTER –III
BIOSTATISTICS & BIOINFORMATICS AND COMPUTATIONAL BIOLOGY (P)

Course Code	ACP-II	Course Type	Allied	L	T	P	C	Syllabus version	2026-2027
				-	-	2	-		
Pre-requisite	Basic theoretical knowledge of biostatistics, molecular biology, and foundational computer literacy, including familiarity with spreadsheet software.								

Course Objectives:

- ✓ Understand the fundamental statistical tools and software used for organizing, visualizing, and analyzing biological data.
- ✓ Address challenges in experimental design by executing appropriate parametric and non-parametric statistical tests on real-world datasets.
- ✓ Become a creative problem solver in utilizing computational biology pipelines for sequence alignment, phylogenetic analysis, and molecular modeling.
- ✓ Understand the navigation, data extraction protocols, and architecture of major primary and secondary biological databases.
- ✓ Understand the pairwise sequence alignment to determine sequence identity and similarity.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Execute data entry, calculate descriptive statistics, and generate graphical visualizations using statistical software.	K3
CO2	Perform hypothesis testingand correlation analyses to derive statistical inferences.	K3, K4
CO3	Navigate primary biological databases to retrieve and format nucleotide and protein sequences.	K3
CO4	Apply pairwise and multiple sequence alignment tools to identify molecular homologies.	K4, K5
CO5	Construct and evaluate phylogenetic trees using computational algorithms to deduce evolutionary relationships.	K5, K6
CO6	Characterize 3D protein structures using visualization tools and maintain comprehensive records of computational workflows.	K4, K6
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

EXPERIMENTS:

1. Organization of biological data: Data entry, formatting, and mathematical functions using MS Excel or Google Sheets.
2. Graphical representation: Creation of Bar diagrams, Pie charts, and Scatter plots.
3. Calculation of Measures of Central Tendency (Mean, Median, Mode) for grouped and ungrouped experimental data.
4. Exploring the National Center for Biotechnology Information (NCBI) portal.
5. Retrieving nucleotide sequences (e.g., 16S rRNA genes) from GenBank and saving them in FASTA format.
6. Retrieving and translating protein sequences using the UniProtKB (Swiss-Prot/TrEMBL) database.
7. Performing local alignment and homology searching using NCBI BLAST (blastn and blastp); interpreting E-values and bit scores.
8. Pairwise sequence alignment to determine sequence identity and similarity.
9. Executing Multiple Sequence Alignment (MSA) of microbial sequences using Clustal Omega or MUSCLE algorithms.
10. Downloading, installing, and navigating MEGA (Molecular Evolutionary Genetics Analysis) software for constructing a phylogenetic tree (Neighbor-Joining method) from aligned sequences and performing bootstrap statistical evaluation.

Mapping with Programme Specific Outcomes

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	S	S	M	S	M	S	M	M	S	S
CO2	S	S	M	S	M	S	M	M	S	S
CO3	S	S	M	S	M	S	M	M	S	S
CO4	S	S	M	S	M	S	M	M	S	S
CO5	S	S	M	S	M	S	M	M	S	S
CO6	S	S	M	S	M	S	M	M	S	S

Recommended References:

1. Baxevanis, A. D., and Ouellette, B. F. F. (2004). *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins*. John Wiley & Sons. USA.
2. Hall, B. G. (2018). *Phylogenetic Trees Made Easy: A How-To Manual*, 5th Edition. Sinauer Associates. USA.
3. Zar, J. H. (2010). *Biostatistical Analysis*, 5th Edition. Pearson. UK.
4. Field, A. (2013). *Discovering Statistics Using IBM SPSS Statistics*. Sage. USA.
5. Pevsner, J. (2015). *Bioinformatics and Functional Genomics*, 3rd Edition. Wiley-Blackwell. USA.

Related Online Contents:

1. NCBI BLAST: https://blast.ncbi.nlm.nih.gov/Blast.cgi
2. Clustal Omega (EMBL-EBI): https://www.ebi.ac.uk/Tools/msa/clustalo/
3. MEGA Software: https://www.megasoftware.net/
4. PAST Statistical Software: https://past.en.lo4d.com/windows (Free software excellent for life science statistics)

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SEMESTER –III
COMPOSTING TECHNIQUES

Course Code	IDC-3	Course Type	Interdisciplinary	L	T	P	C	Syllabus version	2026-2027
				2	-	-	2		
Pre-requisite	A general awareness of environmental issues, strong interest in sustainability, waste management, and organic gardening.								

Course Objectives:

- ✓ Understand the fundamental ecological principles of organic waste decomposition and global nutrient cycling.
- ✓ Address challenges in municipal, agricultural, and household solid waste management through sustainable, nature-based solutions.
- ✓ Become a creative problem solver in designing, troubleshooting, and scaling up traditional composting and vermicomposting systems.
- ✓ Understand the quality standards, agronomic benefits, and entrepreneurial potential of organic compost products in the circular economy.
- ✓ Understand the basics of packaging, branding, and marketing organic compost

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Exploring the basic concepts of biodegradable waste, nutrient cycles, and the ecological role of decomposers.	K1, K2
CO2	To learn the setup, maintenance, and mechanisms of household and traditional aerobic/anaerobic composting methods.	K2, K3
CO3	To characterize the biology and practical application of earthworms in vermicomposting systems.	K1 - K3
CO4	Exploring the physical and chemical parameters required to optimize the composting process and troubleshoot common issues.	K3, K4
CO5	Understanding the quality assessment of mature compost and its application in soil health restoration.	K2, K4
CO6	To demonstrate the ability to formulate a small-scale community waste management plan or a green entrepreneurship proposal.	K5, K6
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit-I:
Waste and Decomposition
(6 hours)

Definition, classification, and generation of solid waste. The concepts of the Circular Economy and "Waste-to-Wealth." Segregation of waste at the source -biodegradable vs. non-biodegradable. The carbon and nitrogen cycles. Microbiology of decomposition. Environmental impacts of landfilling vs. composting-mitigation of methane and greenhouse gases.

Unit-II: Basic Composting Methods (6 hours)	Aerobic versus anaerobic decomposition processes. Household and backyard composting techniques: bin composting and pit composting. Traditional large-scale Indian methods: Indore method and Bangalore method. Windrow composting for managing agricultural crop residues and garden waste. Bokashi composting for kitchen scraps.
Unit-III: Vermicomposting Technology (6 hours)	Introduction to vermiculture and its historical significance. Types of earthworms used in composting (epigeic, endogeic, anecic) with a focus on *Eisenia fetida* (Red wiggler). The digestive mechanism of earthworms and cast production. Setup, bedding materials, and maintenance of a vermicompost bin. Harvesting vermicompost and extracting vermiwash-liquid bio-fertilizer.
Unit-IV: Composting Optimization and Troubleshooting (6 hours)	Critical parameters for successful composting: Carbon-to-Nitrogen (C:N) ratio, maintaining optimal moisture content, and the importance of aeration (turning the pile). Understanding the temperature phases: Mesophilic, Thermophilic, and Curing phases. Troubleshooting common problems: foul odors, excessive moisture, slow decomposition, and managing pests/flies.
Unit-V: Compost Quality and Entrepreneurship (6 hours)	Characteristics of mature, stable compost-color, earthy odor, texture, pH. Simple phytotoxicity tests-seed germination index. Agronomic value: how compost improves soil structure, water-holding capacity, and plant immunity. Economics of composting: Basics of packaging, branding, and marketing organic compost. Exploring green entrepreneurship and rural livelihood generation through organic farming inputs.
Unit-VI: Current Contours (For Continuous Internal Assessment only):	Daily news on zero-waste city models (e.g., the Indore municipal model) and local civic body regulations on solid waste management. Public awareness campaigns regarding single-use plastics and household waste segregation. Field visit/virtual tour of a municipal solid waste management plant or an organic farm. Drafting a community-level composting initiative for the college campus or a residential society.

Mapping with Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	S	S	S	S	S	M	S	M	S	S
CO2	S	S	S	S	S	M	S	M	S	S
CO3	S	S	S	S	S	M	S	M	S	S
CO4	S	S	S	S	S	M	S	M	S	S
CO5	S	S	S	S	S	M	S	M	S	S
CO6	S	S	S	S	S	M	S	M	S	S

Recommended References:

1. Epstein, E. (1997). *The Science of Composting*. CRC Press. USA.
2. Apphof, M. (1997). *Worms Eat My Garbage: How to Set Up and Maintain a Worm Composting System*. Flower Press. USA.
3. Diaz, L. F., Savage, G. M., and Eggerth, L. L. (2007). *Composting and Recycling Municipal Solid Waste*. CRC Press. USA.
4. Gaur, A. C. (1999). *Microbial Technology for Composting of Agricultural Residues by Improved Methods*. Indian Council of Agricultural Research (ICAR). India.
5. Nancarrow, L., and Taylor, J. H. (1998). *The Worm Book: The Complete Guide to Gardening and Composting with Worms*. Ten Speed Press. USA.

Related Online Contents:

1. US EPA Composting at Home Guide: https://www.epa.gov/recycle/composting-home
2. NPTEL Course - Municipal Solid Waste Management: https://nptel.ac.in/courses/120108005 (Focus on biological treatment modules).
3. FAO Resources on Organic Agriculture: https://www.fao.org/organicag/en/

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SEMESTER –IV
IMMUNOLOGY

Course Code	CC-4	Course Type	Core	L	T	P	C	Syllabus version	2026-2027
				4	-	-	4		
Pre-requisite	A basic understanding of the pathogenic microorganisms including viral pathogenicity, tumors and host defence mechanism. Foundational idea of human lymphoid system.								

Course Objectives:

- ✓ Impart knowledge on antigen, antibody, cytokine, chemokine, innate, adaptive and identify the major organs, tissues, and cell types of the immune system.
- ✓ Explain the stages of an immune response, from pathogen recognition to memory formation and describe the mechanisms of antigen presentation and MHC restriction.
- ✓ Applying the knowledge of antibody-antigen interactions to understand diagnostic tests and predict the outcome of immunological scenarios, such as vaccination or allergic reactions.
- ✓ Differentiation of innate and adaptive immune mechanisms and their integration and analyze the roles of cytokines in inflammation and disease.
- ✓ Evaluate experimental data to draw conclusions about immunological mechanisms and assess the role of immune dysfunction in autoimmunity, immunodeficiency, and cancer.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Define key terminology: antigen, antibody, cytokine, chemokine, innate, adaptive and identify the major organs, tissues, and cell types of the immune system.	K1
CO2	Explain the stages of an immune response, from pathogen recognition to memory formation and describe the mechanisms of antigen presentation and MHC restriction.	K1,K2
CO3	Use knowledge of antibody-antigen interactions to understand diagnostic tests and predict the outcome of immunological scenarios, such as vaccination or allergic reactions.	K1-K3
CO4	Differentiate between innate and adaptive immune mechanisms and their integration and analyze the roles of cytokines in inflammation and disease.	K1-K4
CO5	Assess the role of immune dysfunction in autoimmunity, immunodeficiency, and cancer	K1-K5
CO6	Develop strategies for manipulating the immune system for vaccines or therapies	K1-K6
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit-I: Immune System (12 hours)	History of Immunology, Immunity - innate and acquired. Inflammation. Haematopoiesis – Blood Group System, Cells of the immune system lymphocytes, macrophages, mononuclear phagocytes- dendritic cells, granulocytes, NK cells and mast cells Central and peripheral lymphoid organs- Thymus, bone marrow, spleen, lymph nodes, MALT and GALT.
Unit-II: Antigen and Antibody (12 hours)	Antigen and immunogen – Types, factors determining immunogenicity. Toxoid-vaccines. Antibody – structure, types and function. Immune response- primary and secondary - Cell mediated immunity – Humoral immunity – Theories of antibody formation.
Unit-III: T and B Cell (12 hours)	Structure and development of B cell and T cell – receptors - Activation of T and B cells- Maturation of T cell and B cell. Cytokines and Plasma cells. Organization of the genes for B and T cell receptors. Genetic organization of MHC - I and MHC-II complex.
Unit-IV: Ag-Ab Interactions (12 hours)	Antigen antibody reactions - Precipitation, agglutination, complement fixation, RIA, ELISA, Western blotting and immunofluorescence. Production of polyclonal and monoclonal antibodies.
Unit-V: Immune Mechanisms (12 hours)	Complement system: Basics of complement protein - different pathways of complement activation - classical and alternative. Hypersensitivity reaction and their types. Auto immune disorders, transplantation and cancer immunology. Deficiencies / defects of T cells, B cells, and phagocytic cells. Immunity to tuberculosis, malaria and HIV.
Unit-VI: Current Contours (For Continuous Internal Assessment only):	Review and debate on latest discovery on immunology like Spatial Immune Mapping through transcriptomics, Regulatory Immune Cells (Tregs) as therapy for autoimmunity, AI and Imaging for automated segmentation of 3D structure during infection, next generation vaccine design. Seminar on immune responses against SARS-CoV2 and vaccination for COVID19.

Mapping with Programme Specific Outcomes

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	S	S	M	S	M	S	S	M	S	S
CO2	S	S	M	S	M	S	S	M	S	S
CO3	S	S	M	S	M	S	S	M	S	S
CO4	S	S	M	S	M	S	S	M	S	S
CO5	S	S	M	S	M	S	S	M	S	S
CO6	S	S	M	S	M	S	S	M	S	S

Recommended References:

1. Stites D.P.,Abba I.Terr, Parslow T.G.(1997).9thedn, Medical Immunology. Prentice-HallInc. USA.
2. Tizard, R.I.(2000) Immunology- An Introduction. 4thedn. Saunders College Publishing,Philadelphia. USA.
3. Nairn, R., & Helbert, M.(2006). Immunology for Medical Students. 2nd edn. MosbyInternational limited.
4. Humphrey, J.H. and White, R.G. (1995). Immunology for Students of Medicine, 5th edn.ELBS, London
5. Ananthanarayanan, R, and Panicker,C.K.J. (2013). Textbook of Microbiology. OrientLongman. India.
6. Owen, J.A., Punt, J., Stranford, S.A. and Jones, P.P., 2013. *Kuby immunology* (Vol. 27, p. 109). WH Freeman.New York.

Related Online Contents:

1. https://www.mechanobio.info › Development
2. https://www.ncbi.nlm.nih.gov › pmc › articles › PMC2581910
3. https://microbiologybook.org/mayer/ab-ag-rx.htm

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SEMESTER –IV
IMMUNOLOGY (P)

Course Code	CP-4	Course Type	Core	L	T	P	C	Syllabus version	2026-2027
				-	-	4	4		
Pre-requisite	Basic understanding of the human immune system, antigen-antibody interactions, and proficiency in standard biological laboratory safety and aseptic techniques.								

Course Objectives:

- ✓ Understand the foundational principles of antigen-antibody interactions through classical serological and precipitation assays.
- ✓ Address challenges in blood typing, cellular separation, and the safe handling of human or mammalian biological samples.
- ✓ Become a creative problem solver in applying advanced immunodiagnostic techniques, such as ELISA and Immunoelectrophoresis, to detect specific biomarkers.
- ✓ Understand the rigorous quality control and data plotting.
- ✓ Address the diagnostic interpretation required for clinical immunology and medical laboratory testing.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Execute standard serological tests to detect the presence of specific antigens or antibodies in simulated biological samples.	K3
CO2	Perform blood grouping, Rh typing, and blood cell enumeration using microscopy and hemocytometry.	K3, K4
CO3	Apply radial and double immunodiffusion techniques to visualize and interpret immune precipitation reactions in gel matrices.	K3
CO4	Evaluate specific molecular targets using advanced electrophoretic techniques and Enzyme-Linked Immunosorbent Assay (ELISA).	K4, K5
CO5	Perform basic cellular immunology techniques, including cell isolation and cell viability determination.	K5, K6
CO6	Maintain accurate laboratory records, handle biohazardous waste safely, and synthesize diagnostic data into structured clinical reports.	K4, K6
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

EXPERIMENTS:

1. Preparation of serum and plasma from blood.
2. ABO blood grouping.

3. Agglutination reactions (qualitative and quantitative) – WIDAL, RPR, CRP test.
4. Total Leucocyte Count (TLC) and Differential Leucocyte Count (DLC) making blood smears using Leishman's stain.
5. Radial Immunodiffusion (Mancini method) for the quantitative estimation of an antigen.
6. Ouchterlony Double Immunodiffusion technique: Determining antigen-antibody cross-reactivity and identifying patterns of identity, partial identity, and non-identity.
7. Performing the Rheumatoid Arthritis (RA) factor latex agglutination test.
8. Separation and identification of serum proteins by Immunoelectrophoresis (IEP).
9. Antigen quantitation by Rocket Immunoelectrophoresis.
10. Counter-current immunoelectrophoresis (CIEP).
11. Direct or indirect Enzyme-Linked Immunosorbent Assay (ELISA).

Mapping with Programme Specific Outcomes

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	S	S	M	S	M	S	S	M	S	S
CO2	S	S	M	S	M	S	S	M	S	S
CO3	S	S	M	S	M	S	S	M	S	S
CO4	S	S	M	S	M	S	S	M	S	S
CO5	S	S	M	S	M	S	S	M	S	S
CO6	S	S	M	S	M	S	S	M	S	S

Recommended References:

1. Hay, F. C., and Westwood, O. M. (2002). *Practical Immunology*, 4th Edition. Wiley-Blackwell. USA.
2. Talwar, G. P., and Gupta, S. K. (2017). *Hand Book of Practical and Clinical Immunology*, 2nd Edition. CBS Publishers. India.
3. Rose, N. R., Hamilton, R. G., and Detrick, B. (2002). *Manual of Clinical Laboratory Immunology*, 6th Edition. ASM Press. USA.
4. Cappuccino, J. G., and Welsh, C. (2017). *Microbiology: A Laboratory Manual*, 11th Edition. Pearson. UK.
5. Monica Cheesbrough. District Laboratory Practice in Tropical Countries - Part I and II (Second Edition). Cambridge University Press, UK.

Related Online Contents:

1. Amrita Vishwa Vidyapeetham Virtual Lab (Immunology): https://vlab.amrita.edu/?sub=3&brch=69
2. Bio-Rad Explorer Series (YouTube): Visual tutorials for classroom ELISA setups and Western Blotting techniques.
3. CDC Laboratory Training: https://www.cdc.gov/laboratory/

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SEMESTER –IV
BIOINFORMATICS AND COMPUTATIONAL BIOLOGY

Course Code	AC-4	Course Type	Allied	L	T	P	C	Syllabus version	2026-2027
				2	-	-	4		
Pre-requisite	Basic understanding of molecular biology (DNA, RNA, proteins), genetics, and fundamental computer literacy.								

Course Objectives:

- ✓ Understand the foundational concepts of bioinformatics, the centralization of biological data, and the role of computational tools in modern biology.
- ✓ Address challenges in storing, retrieving, curating, and interpreting vast amounts of genomic and proteomic data from public repositories.
- ✓ Become a creative problem solver by applying sequence alignment algorithms to determine evolutionary relationships and identify uncharacterized genes.
- ✓ Understand the principles of structural bioinformatics, molecular modeling, and their critical applications in computer-aided drug discovery.
- ✓ Understand the molecular docking-ligand-receptor interactions, virtual screening, and structure-activity relationships.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Exploring the scope, history, and essential terminology of bioinformatics and computational biology.	K1, K2
CO2	To learn about the architecture, navigation, and data retrieval methods from primary and secondary biological databases.	K2, K3
CO3	To characterize the underlying principles and algorithms of pairwise and multiple sequence alignments.	K3, K4
CO4	Exploring the methodologies used in phylogenetic analysis to construct and evaluate evolutionary trees.	K3, K4
CO5	Understanding the techniques for 3D protein structure prediction and molecular visualization.	K2, K4
CO6	To demonstrate the ability to design an *in silico* workflow for analyzing an unknown genetic sequence and deducing its function.	K5, K6
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit-I: Biological Databases (6 hours)	Definition, history, and scope of bioinformatics. The central dogma of molecular biology from an informatics perspective. Introduction to biological databases: Nucleotide sequence databases (NCBI GenBank, EMBL, DDBJ) and Protein databases (UniProt, Swiss-Prot, TrEMBL). Structural databases (PDB). Specialized databases (KEGG, OMIM). Data formats: FASTA, GenBank flat file, and PDB formats.
Unit-II: Sequence Alignment and Heuristics (6 hours)	Concept of sequence homology, identity, and similarity. Pairwise sequence alignment: Global alignment versus Local alignment. Gap penalties. Scoring matrices: PAM and BLOSUM. Heuristic alignment tools: Basic Local Alignment Search Tool (BLAST) and its variants (blastn, blastp, blastx).
Unit-III: Genomics and Gene Prediction (6 hours)	Overview of the Human Genome Project. Genome annotation processes. Structural genomics vs. Functional genomics. Computational methods for gene prediction in prokaryotes and eukaryotes. Identifying Open Reading Frames (ORFs), promoters, and regulatory elements.
Unit-IV: Molecular Phylogenetics (6 hours)	Concepts of molecular evolution and the molecular clock hypothesis. Anatomy of a phylogenetic tree-roots, branches, nodes, clades. Types of trees - rooted vs. unrooted. Methods of phylogenetic tree construction: Distance-based methods - UPGMA and Neighbor-Joining and Character-based methods-Maximum Parsimony and Maximum Likelihood.
Unit-V: Structural Bioinformatics and Drug Design (6 hours)	Protein structure hierarchy-primary, secondary, tertiary, and quaternary. Protein secondary structure prediction. Methods of tertiary structure prediction: Homology modeling, Threading, and Ab initio modeling. Introduction to Computer-Aided Drug Design: target identification, molecular docking-ligand-receptor interactions, virtual screening, and structure-activity relationships
Unit-VI: Current Contours (For Continuous Internal Assessment only):	Daily news and research reviews on Artificial Intelligence in biology (e.g., Google DeepMind's AlphaFold for protein structure prediction). Exploring personalized medicine and pharmacogenomics. Execution of a mini-project: Students select an uncharacterized hypothetical protein sequence and draft a comprehensive computational workflow to predict its functional domains and 3D structure.

Mapping with Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	S	S	S	S	M	S	L	M	S	S
CO2	S	S	S	S	M	S	L	M	S	S
CO3	S	S	S	S	M	S	L	M	S	S
CO4	S	S	S	S	M	S	L	M	S	S
CO5	S	S	S	S	M	S	L	M	S	S
CO6	S	S	S	S	M	S	L	M	S	S

Recommended References:

1. Lesk, A. M. (2019). *Introduction to Bioinformatics*, 5th Edition. Oxford University Press. UK.
2. Mount, D. W. (2004). *Bioinformatics: Sequence and Genome Analysis*, 2nd Edition. Cold Spring Harbor Laboratory Press. USA.
3. Baxevanis, A. D., and Ouellette, B. F. F. (2004). *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins*, 3rd Edition. John Wiley & Sons. USA.
4. Xiong, J. (2006). *Essential Bioinformatics*. Cambridge University Press. UK.
5. Rastogi, S. C., Mendiratta, N., and Rastogi, P. (2013). *Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery*, 4th Edition. PHI Learning. India.

Related Online Contents:

1. NCBI Education Resource: https://www.ncbi.nlm.nih.gov/home/learn/ (Tutorials on BLAST and GenBank).
2. EMBL-EBI Training: https://www.ebi.ac.uk/training (Free online courses for various bioinformatics tools).
3. NPTEL Course - Bioinformatics (Algorithms and Applications): https://nptel.ac.in/courses/102106065

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SEMESTER –IV
MUSHROOM CULTIVATION TECHNIQUES

Course Code	IDC-4	Course Type	Interdisciplinary	L	T	P	C	Syllabus version	2026-2027
				2	-	-	2		
Pre-requisite	Basic understanding of sustainable agriculture, mushroom cultivation techniques and small-scale business entrepreneurship.								

Course Objectives:

- ✓ Understand the nutritional, medicinal, and ecological importance of edible mushrooms in the human diet and the environment.
- ✓ Address challenges in preparing sterile biological inputs, specifically pure tissue cultures and commercial spawn (mushroom seed).
- ✓ Become a creative problem solver in utilizing cheap, locally available agricultural residues as substrates for mushroom farming.
- ✓ Understand the post-harvest preservation methods, value addition, and the economic frameworks required to establish a profitable mushroom enterprise.
- ✓ Understand the eco-friendly and biological control measures in the mushroom house.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Exploring the history, types, and nutritional/medicinal profile of edible versus poisonous mushrooms.	K1, K2
CO2	To learn the laboratory techniques for media preparation, tissue culturing, and mother spawn production.	K2, K3
CO3	To characterize the cultivation methods for Oyster, Button, and Milky mushrooms on various agro-wastes.	K3, K4
CO4	Exploring the environmental requirements, pest management, and disease control in a mushroom cropping room.	K3, K4
CO5	Understanding post-harvest technology, shelf-life extension, and the creation of value-added mushroom products.	K2, K4
CO6	To demonstrate the ability to calculate a cost-benefit analysis and draft a viable business plan for a mushroom farm.	K5, K6
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit-I: Introduction to Mushroom Biology (6 hours)	History of mushroom cultivation. Morphology and life cycle of a typical basidiomycete (mushroom). Classification of mushrooms: edible, poisonous, and medicinal. Differentiating features of common edible mushrooms (*Agaricus, Pleurotus, Volvariella, Calocybe*). Nutritional profile: protein content, amino acids, vitamins, and low glycemic index. Medicinal properties: immunity boosting, antioxidants, and anti-tumor compounds.
Unit-II: Spawn Production Technology (6 hours)	Concept of pure culture and sterile techniques. Equipment needed: Autoclave, Laminar Air Flow chamber, and BOD incubator. Preparation of Potato Dextrose Agar medium. Raising pure culture from mushroom tissue or spores. Spawn - Preparation of mother spawn using cereal grains. Multiplication of mother spawn into commercial bed spawn. Spawning methods and quality control of spawn.
Unit-III: Cultivation of Commercial Mushrooms (6 hours)	Selection and preparation of substrates (paddy straw, wheat straw, sawdust, sugarcane bagasse). Methods of substrate treatment: chemical sterilization, hot water pasteurization, and steam pasteurization. Detailed cultivation practices (bag preparation, spawning, incubation, and repining) for: Oyster Mushroom (*Pleurotus* spp.), Milky Mushroom (*Calocybe indica*), Button Mushroom (*Agaricus bisporus*) - including the basics of composting and casing soil preparation.
Unit-IV: Crop Management and Protection (6 hours)	Design and layout of a low-cost mushroom cropping room/shed. Managing crucial environmental parameters: temperature, relative humidity (hygrometer), ventilation (CO_2 levels), and light. Identifying and managing common fungal competitors and bacterial blotch. Managing insect pests and nematodes. Eco-friendly and biological control measures in the mushroom house.
Unit-V: Post-Harvest Technology and Entrepreneurship (6 hours)	Harvesting indices and techniques. Short-term storage - refrigeration, modified atmosphere packaging. Long-term preservation: sun drying, hot-air drying, canning, and pickling. Value-added products: mushroom powder, soup mixes, mushroom biscuits, and papad. Entrepreneurship: Cost estimation for a small-scale unit, calculating the Return on Investment, marketing channels, and exploring government subsidies - NHB, NABARD, MSME.
Unit-VI: Current Contours (For Continuous Internal Assessment only):	Daily news on the alternative protein market and vegan trends. Exploring innovative non-food uses of mushrooms (e.g., mycelium-based biodegradable packaging and "mushroom leather"). Field visit to a local commercial mushroom farm or agricultural university facility. Drafting a mock bank loan proposal for setting up a 1-ton/month capacity Oyster mushroom farm.

Mapping with Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	S	M	M	S	S	M	S	M	S	S
CO2	S	M	M	S	S	M	S	M	S	S
CO3	S	M	M	S	S	M	S	M	S	S
CO4	S	M	M	S	S	M	S	M	S	S
CO5	S	M	M	S	S	M	S	M	S	S
CO6	S	M	M	S	S	M	S	S	S	S

Recommended References:

1. Bahl, N. (2000). *Handbook on Mushrooms*, 4th Edition. Oxford & IBH Publishing Co. India.
2. Kapoor, J. N. (1989). *Mushroom Cultivation*. ICAR (Indian Council of Agricultural Research), New Delhi.
3. Chang, S. T., and Miles, P. G. (2004). *Mushrooms: Cultivation, Nutritional Value, Medicinal Effect, and Environmental Impact*, 2nd Edition. CRC Press. USA.
4. Pandey, R. K., and Ghosh, S. K. (1996). *A Handbook on Mushroom Cultivation*. Emkay Publications. India.
5. Pathak, V. N., Yadav, N., and Gaur, M. (2000). *Mushroom Production and Processing Technology*. Agrobios. India.

Related Online Contents:

1. ICAR - Directorate of Mushroom Research (DMR): https://dmr.icar.gov.in/
2. FAO (Food and Agriculture Organization): Make Money by Growing Mushrooms - https://www.fao.org/3/x4442e/x4442e00.htm
3. TNAU Agritech Portal (Mushroom Cultivation): https://agritech.tnau.ac.in/expert_system/mushroom/index.html

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SEMESTER –V
MEDICAL MICROBIOLOGY

Course Code	CC-5	Course Type	Core	L	T	P	C	Syllabus version	2026-2027
				4	-	-	4		
Pre-requisite	Basic knowledge of microbial diseases, transmission, diagnosis, prevention and treatment strategies.								

Course Objectives:

- ✓ To provide fundamental knowledge on the history, classification, and basic concepts of medical microbiology including host–pathogen interactions.
- ✓ To understand the etiology, pathogenesis, transmission, prevention, and treatment of major bacterial diseases affecting different organ systems.
- ✓ To develop knowledge on viral diseases, their mechanisms of infection, clinical manifestations, and control strategies.
- ✓ To impart understanding of medically important fungi, protozoa, and helminths, along with their role in human diseases.
- ✓ To familiarize students with clinical diagnostic methods, including specimen collection, isolation, and identification of pathogens.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Acquire knowledge on the normal flora of human body and infectious diseases.	K1, K2
CO2	Understand the concepts about bacterial diseases.	K2
CO3	Distinguish various types of viral diseases and their diagnosis.	K4
CO4	Diagnose protozoan and fungal infections.	K5
CO5	Expertise on various laboratory Procedures and Diagnostic Methods.	K6
CO6	Demonstrate the clinical diagnosis of microbial infections	K5, K6
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit-I: Infections and Host Microbe Interactions (12 hours)

History, Classification of Medically Important Microbes. Koch's and River's postulates. Normal microbial flora of the healthy human body, Host-pathogen interactions- virulence factors of human pathogens, infectious disease cycle.

Unit-II: Medical Bacteriology (12 hours)

Diseases of various organ systems: Causative agent, clinical symptoms, pathogenesis, mode of transmission, prevention and treatment of the following bacterial diseases (a) Streptococcal infections, (b) Staphylococcal infections, (c) Meningitis, (d) Leprosy, (e) Leptospirosis, (f) Lyme Disease, (g)Respiratory diseases: Tuberculosis (h) Gastrointestinal

	disorders: Typhoid, Cholera, Bacillary dysentery, (i) Sexually transmitted diseases: Syphilis, Gonorrhea. (j) Anaerobic wound infection: Tetanus, Gas gangrene.
Unit-III: Medical Virology (12 hours)	Diseases of various organ systems: Causative agent, clinical symptoms, pathogenesis, mode of transmission, prevention and treatment of the following viral diseases (a) Respiratory diseases: Common cold, Influenza, Measles, Corona virus and Ebola Viral Disease, (b) Neurological diseases: Rabies, Dengue (c) Liver diseases: Viral hepatitis (d) Immunodeficiency syndrome: AIDS.
Unit-IV: Medical Mycology and Parasitology (12 hours)	Causative agent, clinical symptoms, pathogenesis, mode of transmission, prevention and treatment of the following fungal and protozoan diseases (a) Fungal: Superficial and Subcutaneous mycoses, (b) Protozoan: Amoebiasis, Malaria (c) Helminths: Filariasis, Ascariasis, Zoonotic diseases and Nosocomial infection.
Unit-V: Clinical diagnostic methods (12 hours)	Isolation and identification of pathogens from an infected patient: Collection and transport of various clinical specimens for diagnosis – General methods of isolation and identification of bacterial, fungal, viral pathogens and protozoan parasites.
Unit-VI: Current Contours (For Continuous Internal Assessment only):	Emerging and re-emerging infectious diseases. Antimicrobial resistance (AMR) and its global impact. Advances in molecular diagnostic techniques – PCR, real-time PCR, ELISA, and next-generation sequencing (NGS). Role of bioinformatics in pathogen identification and epidemiology. Vaccine development strategies including recombinant vaccines and mRNA vaccines.

Mapping with Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	S	S	M	S	S	S	M	S	S	S
CO2	S	S	M	S	S	S	M	S	S	S
CO3	S	S	M	S	S	S	M	S	S	S
CO4	S	S	M	S	S	S	M	S	S	S
CO5	S	S	M	S	S	S	M	S	S	S
CO6	S	S	M	S	S	S	M	S	S	S

Recommended References:

1. Alexpoulos, C.J., Mims, C.W. and Blackwell, M. 2014. Introductory Mycology.4th Edition, John Wiley &Sons, New Delhi.
2. Collee JC, Duguid JP, Fraser AC,Marimon BP. Mackie and Mc Carteny, 1989. Practical Medical Microbiology,13th edition, Churchill Livingstone, London.
3. David Greenwood, Mike Barer, Richard Slack and Will Irving. 2012. Medical

Microbiology. A Guide to Microbial Infections: Pathogenesis, immunity, Laboratory investigation and Control, 18th edition, Churchill Livingstone. London.
4. Dimmock, N.J., Easton, A.J. and Lappard, K.N. 2009. Introduction to Modern Virology. Wiley Blackwell,USA.
5. Hugo W.B and Russell A.D. 1989. Pharmaceutical Microbiology, 4th edition, Blackwell Scientific Publications, Oxford, United Kingdom.
6. Errol Reiss, Jean Shadomy, H. and Marshall Lyon, G. 2011. Fundamental Medical Mycology. 1st edition,Wiley Blackwell. United States.
7. Flint, S.J., Enquist L.W., Racaniello, V.R. and Skalka, A.M. 2009. Principles of Virology: Molecular Biology, 3rd edition. ASM Press, Washington.
8. Stefan Riedal,Stephan A.Morse,Timothy Mietzner and Steve Miller,2001. Jawetz, Melnick and Adelberg's Medical Microbiology, 28th edition, McGraw Hill Medical Publication division, New York.
9. Joan stokes E, Ridgway G.L and Wren M.W.D. 1993. Clinical Microbiology 7th edition, Edward Arnold (A division of Hodder and Stoughton),London.
10. Morag, C. and Timbury, M.C. 1994. Medical Virology, 10th edition. Churchill Livingston, London.
11. Cary Engleberg,N, Victor,J, DiRita,Michale J.Imperiale, Schaechter's Mechanisms of Microbial Disease, 6th edition, Williams and Wilkins., Baltimore.
12. Topley and Wilson 1995. Principles of Bacteriology, Virology and Immunity, 9th edition. Edward Arnold, London.
13. Monica Cheesbrough. District Laboratory Practice in Tropical Countries - Part I and II (Second Edition). Cambridge University Press, New Delhi.
14. Rajan S and Selvi Christy J. 2018. Essentials of Microbiology, CBS Publishers, New Delhi.
15. VinayKumar, Abul.K Abbas and Jon C Aster. Robbins and Cotran, 2014. Pathologic Basis of Disease: South Asia Edition.

Related Online Contents:

1. http://www.mednotes.net/notes/microbiology/
2. http://dmoz.org/Science/Biology/Microbiology/
3. http://microbiology.mtsinai.on.ca/manual/default.asp
4. http://fdjpkc.fudan.edu.cn/_upload/article/files/4d/8a/0337d0b94956b709eaed117489c9/2e232f50-d708-4783-a40d-5e970d1142f0.pdf
5. https://www.aacc.org/store/books/8300/lecture-notes-medical-microbiology-and-infection-5th-edition
6. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2158889/

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SEMESTER –V
GENERAL VIROLOGY

Course Code	CC-6	Course Type	Core	L	T	P	C	Syllabus version	2026-2027
				5	-	-	4		
Pre-requisite	An outline exposure to prokaryotes, eukaryotes and viruses								

Course Objectives:

- ✓ To strengthen the understanding on the basics of viruses and their discovery.
- ✓ To impart the structure and classification of bacterial, plant & animal viruses.
- ✓ To provide the fundamentals of bacteriophages & their diversity.
- ✓ To instruct the important features of plant and animal viruses.
- ✓ To communicate various techniques/ approaches in virology with respect to cultivation, diagnostics, prevention and virus assay.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Have a competency in the basics of viruses	K1, K2
CO2	Explain bacterial virus discovery, life cycle, typing, cultivation and phage diversity.	K2, K3
CO3	Be proficient in human viruses multiplication, prevention & cultivation.	K2, K3
CO4	Elaborate plant viral life cycle, transmission, control, infection symptoms & cultivation methods.	K2, K3
CO5	Diagnose and assay viral infections / viruses, outline viral vaccines preparation and explain anti-viral drugs.	K3, K4
CO6	Teach the learnt facts among others as well as to learn from other sources.	K5, K6
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit-I:
Virus Properties and multiplication
(15 hours)

Virus – Milestones of Virology - Characteristics of Viruses – Classification of Viruses (LHT, Baltimore and ICTV) – Morphology & ultrastructure of Viruses – Sub-viral agents - viroids, prions, virusoids and satellite viruses – Common steps of viruses multiplication.

Unit-II:
Bacterial Viruses
(15 hours)

Bacteriophages – Discovery - Classification - Structure and lytic life cycle of T4, M13 and MS2, Lambda Phage - lytic and lysogenic life cycles - Bacteriophage typing - Cyanophages, Mycoviruses – Cultivation methods of phages.

Unit-III: Animal viruses (15 hours)	Classification - Structure, Multiplication, Pathogenesis, Laboratory Diagnosis, Prevention and Treatment of: Herpesviridae (HSV 1), Pox viridae (Small Pox), Polyomaviridae (Simian Virus – 40), Hepadnaviridae (HBV), Picornaviridae (HAV), Rhabdoviridae (Rabies virus), Orthomyxoviridae (Influenza Virus), Retroviridae (HIV), Filoviridae (Ebola virus), Flaviviridae (Dengue Virus), and Coronaviridae (SARS-CoV2). Cultivation methods of animal viruses - Embryonated eggs and Tissue cultures.
Unit-IV: Plant Viruses (15 hours)	Classification– Structure and lifecycle of TMV, CMV and CaMV - Transmission of plant viruses - Control of plant viral diseases - Symptoms of viral infection in plants. Common viral diseases in paddy, cotton, tomato and sugar cane - Name of diseases, pathogens and symptoms. Cultivation methods of Plant Viruses.
Unit – V: Diagnosis, prevention and antiviral drugs (15 hours)	Viral infection diagnosis: Serological methods- hemagglutination inhibition, Reverse passive hemagglutination, complement fixation, immunofluorescence, ELISA, RIA & CIEP. Genetic method: PCR. Purification, Characterization, Separation and Assay of Viruses. Viral Vaccines. Interferons. Antiviral drugs.
Unit-VI: Current Contours (For Continuous Internal Assessment only):	Assignments & Seminars: Case studies from reliable sources, scientific models making / poster preparation on viral transmissions, preventions, traditional methods of infection prevention. Group discussions in class rooms on methods of viral infection prevention/ control in a community and about emerging viruses. Pursuing a Swayam- NPTEL course on 'Techniques in Virology' shall be encouraged.

Mapping with Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	S	S	M	S	S	S	M	S	S	S
CO2	S	S	M	S	S	S	M	S	S	S
CO3	S	S	M	S	S	S	M	S	S	S
CO4	S	S	M	S	S	S	M	S	S	S
CO5	S	S	M	S	S	S	M	S	S	S
CO6	S	S	M	S	S	S	M	S	S	S

Recommended References:

1. Martinez J. Hewlett, David Camerini, David C. Bloom. 2021. Basic Virology, Fourth Edition, Wiley Blackwel. USA.
2. Shilpa U. Nair 2015. Virology – A condensed review, 3rd edition, CBS Publishers& Distributors. India.
3. Saravanan. P. 2006. Virology. MJP Publishers. India
4. Baijayanthimala Mishra. 2025. Textbook of Medical Virology. 2nd edition; CBS

Publishers& Distributors. India.
5. Rajan S and Kumaresan. S. 2007. Virology. Saras Publications. India.
6. Malik B.S. / Malik M. 2024. Objective & short answer questions in Vetrinary Virology. 2nd edition. CBS Publishers& Distributors. India
7. Flint, S. J., Enquist, L. W., Racaniello, V. R., and Skalka, A. M. 2015. Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses, 4th edition. ASM Press, Washington, DC.
8. Dimmock. N.J and Watson, A.J., Leppard, K.N. 2016. Introduction to Modern Virology. VII edition. 7th Edition.Blackwell Scientific Publications, Oxford. UK.
9. Kenneth M Smith. 1972. A text book of plant viral diseases, 3rd edition, Elsevier Inc, New York.
10. Maureen A Harrison and Ian F Rae. 2010. General techniques of cell cultures, Cambridge University Press, England.
11. Nicklin J, Greame Cook and Killington, R. 2003. Instant notes in Microbiology, 2nd Edition, Viva Books private Limited, New Delhi.
12. Michale J. Pelczar JR., ECS Chan, Noel R. Krieg. 2025. Pelczar Microbiology. 7th edition; EMP.
13. Michael T. Madigan, John M. Martinko, Kelly S. Bender, Daniel H. Buckley & David A. Stahl. 2017. Brock Biology of Microorganisms. 14th edition. Pearson. UK.
14. Rajan S and Selvichristy J. 2018. Essentials of Microbiology, CBS Publishers, New Delhi.
15. Robert I Krasner. 2002. The Microbial challenge: Human Microbe Interaction, American Society for Microbiology, 2nd edition, Washington.
16. Topley and Wilson's. 1990. Principles of Bacteriology, Virology and Immunity. VIII edition Vol. IV Virology, Edward Arnold, London.

Related Online Contents:

1. https://www.sciencedirect.com/science/article/pii/S0160412019305410.
2. https://journal.hep.com.cn/fese/EN/article/downloadArticleFile.do?attachType=PDF&id=28677.
3. https://www.nature.com/scitable/topicpage/the-origins-of-viruses-14398218/
4. https://www.sciencedirect.com/journal/virology
5. https://www.news-medical.net/health/What-is-Virology.aspx
6. https://www.coursera.org/courses?query=virus.
7. https://www.mlsu.ac.in/econtents/4144_Unit%204%20virus%20structure,%20replication.pdf
8. https://microbeonline.com/phage-typing-method/
9. https://cmb.i-learn.unito.it/pluginfile.php/3598/mod_resource/content/1/Laboratory%20diagnosis%20of%20viral%20infections.pdf

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SEMESTER –V
ENVIRONMENT AND AGRICULTURAL MICROBIOLOGY

Course Code	CC-7	Course Type	Core	L	T	P	C	Syllabus version	2026-2027
				5	-	-	4		
Pre-requisite	Basic knowledge of microbiology, including structure and classification of microorganisms. Understanding of fundamental concepts in ecology, environmental science, and biology. Familiarity with basic laboratory techniques and safety practices.								

Course Objectives:

- ✓ To understand microorganisms and their habitats in different environments.
- ✓ To study water quality, potability, and microbiological analysis methods.
- ✓ To learn microbial interactions and their role in agriculture.
- ✓ To understand waste treatment and bioremediation processes.
- ✓ To gain knowledge of plant diseases and their management.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Describe about the structure and function of ecosystems and understand the role of microbes in various environments.	K2, K3
CO2	Identify the cause of water pollution, and perform methods to assess the quality of water.	K2
CO3	Explain the production of biofertilizers and biopesticides.	K4
CO4	Explain about waste treatment process and microbial decomposition and bio-remediation process.	K4, K5
CO5	Describe about plant diseases caused by microbes and acquire a clear idea on plant pathogenic interaction.	K2, K3
CO6	Demonstrate comprehensive understanding of microbial growth, metabolism, and their applications in biotechnology, environmental sustainability, and disease control.	K5, K6
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit-I: Microorganisms and their habitats (15 hours)

Microorganisms and their Habitats: Structure and functions of ecosystems. Terrestrial Environment - Soil profile and soil microflora, Microbial succession in decomposition of soil organic matter. Role of microorganisms in elemental cycles in nature: Carbon, Nitrogen, Sulphur and Phosphorous cycle. Atmosphere - Aeromicroflora and dispersal of microbes, Assessment of air quality, Enumeration of microorganism in air, Air sanitation. Extreme Habitats – ExtremophilicMicrobes.

Unit-II: Water Potability, Sewage, and Bioremediation (15 hours)	Water potability: Sources and types of water, pollution pathways, and biological indicators of water pollution. Conventional bacteriological standards of water quality: MPN index, coliform test, and membrane filtration. Liquid waste management: Primary, secondary, and tertiary sewage treatment. Waste management: Principles and scope of bioremediation; microbial degradation of hydrocarbons, marine oil spills, and heavy metals.
Unit-III: Soil Ecology and Interactions (15 hours)	Rhizosphere, rhizoplane, and phyllosphere microflora; factors affecting the rhizosphere effect. Concepts of biological nitrogen fixation: Biochemistry of symbiotic and asymbiotic/associative nitrogen fixers; nodule formation and nitrogenase enzyme dynamics. General microbial interactions: Mechanisms and ecological significance of Symbiosis, Neutralism, Commensalism, Competition, Amensalism, Synergism, Parasitism, and Predation.
Unit-IV: Bio-inoculants and Bio-control (15 hours)	General account, types, and agricultural significance of biofertilizers. Mass production, formulation, quality control, and application strategies of Rhizobial, Cyanobacterial, and Azotobacter bio-inoculants. Mycorrhizae: Characteristics and functions of Vesicular Arbuscular Mycorrhizae. Biocontrol agents: Scope and mechanisms of bacterial, viral, and fungal agents against agricultural pests and weeds. Solid waste management.
Unit-V: Plant Pathology (15 hours)	Plant pathology: Mode of entry of pathogens, Microbial enzymes, toxins, growth regulators and suppressor of plant defence in plant diseases. Plant defence mechanisms. Bacterial diseases – Citrus canker, Blight of paddy. Viral disease – Bunchy top of banana virus. Fungal disease- red rot of sugarcane, Tikka disease. Plant disease management.
Unit-VI: Current Contours (For Continuous Internal Assessment only):	Current trends in environmental microbiology emphasize sustainability, molecular techniques, and eco-friendly solutions. The integration of advanced technologies, policy frameworks, and microbial applications plays a crucial role in addressing global challenges such as pollution, climate change, and food security.

Mapping with Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	S	S	S	S	S	M	S	M	S	S
CO2	S	S	S	S	S	M	S	M	S	S
CO3	S	S	S	S	S	M	S	M	S	S
CO4	S	S	S	S	S	M	S	M	S	S
CO5	S	S	S	S	S	M	S	M	S	S
CO6	S	S	S	S	S	M	S	M	S	S

Recommended References:

1. Dirk, J. Elasas, V., Trevors, J.T., Wellington, E.M.H. 1997. Modern Soil Microbiology, Marcel Dekker INC, New York, Hong Kong.
2. EcEldowney S, Hardman D.J., Waite D.J., Waite S. 1993. Pollution: Ecology and Biotreatment – Longman Scientific Technical, England.
3. Mitchel, R.1992. Environmental Microbiology. Wiley ¬John Wiley and Sons. Inc. Publications, New York.
4. Clescri, L.S., Greenberg, A.E. and Eaton, A.D. 1998. Standard Methods for Examination of Water and Wastewater, 20thEdition. American Public Health Association, Washington DC.
5. Atlas, R.M. and Bartha, R. 1992. Microbial Ecology: Fundamentals and Applications, 2nd Edition. The Benjamin / Cummings Publishing Co., Redwood City, CA.

Related Online Contents:

1. https://nptel.ac.in/courses/126105016
2. https://www.classcentral.com/course/swayam-plant-pathology-and-soil-health-14236
3. https://www.wasteonline.org.uk/resources/InformationSheets/WasteDisposal.htm
4. https://plantpath.cornell.edu/labs/enelson/PDFs/Hill_et_al_2000.pdf
5. https://onlinelibrary.wiley.com/doi/full/10.1111/j.1365-2389.2005.00781.x

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SEMESTER –V
INDUSTRIAL MICROBIOLOGY

Course Code	CC-8	Course Type	Core	L	T	P	C	Syllabus version	2026-2027
				5	-	-	4		
Pre-requisite	Basic understanding of industrially important microbial strains, media formulation and optimization parameters.								

Course Objectives:

- ✓ Understand the foundational principles of isolating, screening, and genetically improving industrially important microbial strains.
- ✓ Address challenges in bioreactor design, media formulation, and the optimization of fermentation parameters for maximum yield.
- ✓ Become a creative problem solver in designing downstream processing workflows for the efficient recovery and purification of microbial products.
- ✓ Understand the commercial manufacturing processes for a variety of primary and secondary metabolites, including organic acids, enzymes, and antibiotics.
- ✓ Understand the production and nutritional value of Single Cell protein.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Exploring the strategies for primary and secondary screening, preservation, and strain improvement of industrial microbes.	K1
CO2	To learn about the design, components, and operational modes (batch, continuous, fed-batch) of industrial bioreactors.	K2, K3
CO3	To characterize the sequential steps involved in downstream processing and the purification of bioproducts.	K4, K5
CO4	Exploring the microbial production processes for industrial enzymes, organic acids, and amino acids.	K3, K4
CO5	Understanding the biomanufacturing of secondary metabolites (antibiotics), beverages, and Single Cell Protein (SCP).	K3, K5
CO6	To demonstrate the ability to evaluate fermentation economics and conceptualize a pilot-scale bioprocessing pipeline.	K5, K7
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit-I: Microbial Strain and Media Development (15 hours)	Historical milestones and scope of industrial microbiology. Sources of industrially important microbes. Primary and secondary screening techniques. Maintenance and preservation of pure cultures. Strain improvement strategies: mutation, protoplast fusion, and recombinant DNA techniques. Formulation of industrial fermentation media: carbon sources, nitrogen sources, minerals, vitamins, precursors, inducers, and antifoaming agents.
Unit-II: Fermentation Technology and Bioreactors (15 hours)	Principles of microbial growth kinetics in batch, fed-batch, and continuous cultures. Basic anatomy and components of a standard stirred-tank bioreactor. Types of bioreactors. Solid-State and Submerged Fermentation. Sterilization of media, fermenter. Online and offline monitoring of bioprocess parameters - pH, temperature, dissolved oxygen, agitation.
Unit-III: Downstream Processing (15 hours)	Principles of downstream processing - Separation of microbial cells, flocculation, centrifugation, and filtration. Cell disruption techniques for intracellular products. Product concentration and purification: liquid-liquid extraction, precipitation, and chromatography. Final product formulation: crystallization and drying.
Unit-IV: Production of Primary Metabolites (15 hours)	Microbial production of Organic acids: Citric acid and Lactic acid. Microbial production of Amino acids: Lysine. Microbial production of Industrial enzymes: Amylases, Proteases, and Lipases.
Unit-V: Production of Secondary Metabolites and Foods (15 hours)	Microbial production of Antibiotics: Penicillin and Streptomycin. Microbial production of Vitamin B12 and Industrial production of Baker's yeast, brewing of beer, and winemaking. Production and nutritional value of Single Cell Protein-*Spirulina.*
Unit-VI: Current Contours (For Continuous Internal Assessment only):	Daily news and case studies on the transition from petrochemicals to bio-based chemicals (white biotechnology). Exploring the emerging market of precision fermentation for alternative proteins and lab-grown materials. Review of FDA/GMP regulations in biomanufacturing. Drafting a mock process flow diagram (PFD) for the pilot-scale scale-up of a novel microbial enzyme.

Mapping with Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	S	M	M	S	S	M	M	S	S	S
CO2	S	M	M	S	S	M	M	S	S	S
CO3	S	M	M	S	S	M	M	S	S	S
CO4	S	M	M	S	S	M	M	S	S	S
CO5	S	M	M	S	S	M	M	S	S	S
CO6	S	M	M	S	S	M	M	S	S	S

Recommended References:

1. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2016). *Principles of Fermentation Technology*, 3rd Edition. Butterworth-Heinemann. UK.
2. Casida, L. E. (2016). *Industrial Microbiology*. New Age International Publishers. India.
3. Crueger, W., & Crueger, A. (1990). *Biotechnology: A Textbook of Industrial Microbiology*. Sinauer Associates. USA.
4. Patel, A. H. (2011). *Industrial Microbiology*, 2nd Edition. Laxmi Publications. India.
5. Waites, M. J., Morgan, N. L., Rockey, J. S., & Higton, G. (2001). *Industrial Microbiology: An Introduction*. Wiley-Blackwell. USA.

Related Online Contents:

1. NPTEL Course - Industrial Biotechnology: https://nptel.ac.in/courses/102105058 (Excellent video lectures on bioreactor design and kinetics).
2. Bioprocessing Virtual Labs: Simulations detailing the operation of a stirred-tank fermenter and downstream processing chromatography.
3. FDA Good Manufacturing Practice (GMP) Guidelines: https://www.fda.gov/drugs/pharmaceutical-quality-resources/current-good-manufacturing-practice-cgmp-regulations

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SEMESTER –V

MEDICAL MICROBIOLOGY, GENERAL VIROLOGY, ENVIRONMENT AND AGRICULTURAL MICROBIOLOGY AND INDUSTRIAL MICROBIOLOGY (P)

Course Code	CP-5	Course Type	Core	L	T	P	C	Syllabus version	2026-2027
				-	-	5	4		
Pre-requisite	Understand the basic knowledge microbe culture method, identification of bacterial, fungal pathogens, virus cultivation methods and microbiological quality assessment of water, air and food.								

Course Objectives:

- ✓ To understand basic microbiological techniques for collection, handling, and processing of samples.
- ✓ To isolate, culture, and identify microorganisms using staining, cultural, and biochemical methods.
- ✓ To perform and interpret antimicrobial sensitivity tests and diagnostic procedures.
- ✓ To gain knowledge of virological methods and environmental microbiology techniques.
- ✓ To understand the fermentation, upstream and downstream process of antibiotics, organic acids, enzyme production.

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Acquire knowledge on the normal flora of human body and infectious diseases.	K1, K2
CO2	Demonstrate the ability to isolate and identify microorganisms using staining, cultural, and biochemical methods.	K3
CO3	Perform antimicrobial sensitivity testing and interpret the results accurately.	K4
CO4	Analyze environmental samples such as water, air, and soil using standard microbiological methods.	K4,K5
CO5	Execute basic molecular biology techniques including DNA isolation and gel electrophoresis.	K1, K2
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

MEDICAL MICROBIOLOGY

1. Collection, coding and transport of clinical specimen for microbiological examination.
2. Isolation of bacterial flora of skin swab, urine, stool and sputum.
3. Identification of Gram positive and Gram negative organisms - morphological, cultural and biochemical identification.

4. Saline and iodine wet mount to demonstrate protozoan parasites.
5. Giemsa staining for the demonstration of blood parasites.
6. KOH and Lactophenol cotton blue mount to demonstrate fungi.
7. Germ tube technique to identify *Candida albicans.*
8. Antibacterial sensitivity test–Kirby-Bauer method.
9. Observation of symptoms of diseases caused by bacterial, fungal, viral and protozoan pathogens using photographs.

GENERAL VIROLOGY

1. Isolation of Bacteriophage from sewage.
2. Demonstration of mechanical transfer of viruses in plants - Sap, aphid and graft transmission.
3. Demonstration of cultivation of viruses by embryonated egg method.
4. Study of virus infected plant material and observation of selected bacterial, plant and animal viruses – Pox Viruses, Rice Tungro Viruses, Cyanophages and Mycoviruses.

ENVIRONMENT AND AGRICULTURAL MICROBIOLOGY

1. Water analysis by MPN technique – Presumptive coliform test, Confirmed coliform test and Completed coliform test.
2. Microbial assessments of air quality – Open plate method and Air sampler technique.
3. Isolation and counting of faecal bacteria from water.
4. Isolation of Cyanobacteria from water.
5. Isolation of *Rhizobium* form legume nodule.
6. Isolation of phosphorus solubilizing bacteria (PSB) from soil.
7. Observation of VAM from plant roots.

INDUSTRIAL MICROBIOLOGY

1. Lab-scale fermentation of fruit juice into wine using *Saccharomyces cerevisiae.*
2. Submerged fermentation for the production of citric acid using *Aspergillus niger.*
3. Isolation of antibiotic producing bacteria by agar overlay and cross streak methods.
4. Production and assay of bacterial amylases by shake flask method.

Mapping with Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	S	S	S	S	S	S	S	M	S	S
CO2	S	S	S	S	S	S	S	M	S	S
CO3	S	S	S	S	S	S	S	M	S	S
CO4	S	S	S	S	S	S	S	M	S	S
CO5	S	S	S	S	S	S	S	M	S	S
CO6	S	S	S	S	S	S	S	M	S	S

Recommended References:

1. Tortora, G. J., Funke, B. R., and Case, C. L.2021. Microbiology: An introduction 13th edition. Pearson, London,UK.
2. Pelczar, M. J., Chan, E. C. S., and Krieg, N. R.1993. Microbiology,5th edition, McGraw-Hill, New York
3. Prescott, L. M., Harley, J. P., and Klein, D. A. 2017. Microbiology 10th edition. McGraw-Hill Education, New York.
4. Jawetz, E., Melnick, J. L., and Adelberg, E. A. 2019. Medical microbiology 28th edition, McGraw-Hill, New York.
5. Ananthanarayan, R., and Paniker, C. K. J. 2017. Textbook of microbiology 10th edition, Universities Press, UK.
6. Flint, S. J., Enquist, L. W., Racaniello, V. R., and Skalka, A. M. 2020. Principles of Virology 5th edition, ASM Press, Washington, D.C.
7. Atlas, R. M., and Bartha, R. 1998. Microbial ecology: Fundamentals and applications 4th edition. Benjamin/Cummings, USA.
8. Subba Rao, N. S. 2017. Soil microbiology 4th edition. Oxford and IBH Publishing company, UK.
9. Sambrook, J., and Russell, D. W. 2001. Molecular cloning: A laboratory manual 3rd edition. Cold Spring Harbor Laboratory Press, New York.
10. Monica Cheesbrough. 2006. District Laboratory Practice in Tropical Countries - Part I and II 2nd edition. Cambridge University Press, New Delhi.
11. Rajan S. 2012. Manual for Medical Laboratory Technology. Anajanaa Book House, Chennai.
12. Mackie and McCartney. 2006. Practical Medical Microbiology, South Asia Edition. 14th edition.
13. Rajan S and Selvi Christy R. 2018. Experimental Procedures in Life Sciences. CBS Publishers, New Delhi, 2018.
14. Brown, T. A. 2016. Gene cloning and DNA analysis: An introduction 7th edition. Wiley-Blackwell, USA.

Related Online Contents:

1. NCBI BLAST: https://blast.ncbi.nlm.nih.gov/Blast.cgi
2. Clustal Omega (EMBL-EBI):https://www.ebi.ac.uk/Tools/msa/clustalo/
3. MEGA Software: https://www.megasoftware.net/
4. PAST Statistical Software: https://past.en.lo4d.com/windows

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SEMESTER –V
VACCINOLOGY

Course Code	SEC-4	Course Type	Skill Enhancement Course	L	T	P	C	Syllabus version	2026-2027
				2	-	-	2		
Pre-requisite	A basic understanding of vaccines, immunity, immunization schedule.								

Course Objectives:

- ✓ Define key terminology and identify major vaccine types and their mechanisms of action. List the mandatory stages of vaccine clinical trials.
- ✓ Understand the immunology, microbiology, and historical context underpinning vaccine development.
- ✓ Analyze vaccine-induced immune responses, safety, immunogenicity, and efficacy.
- ✓ Evaluate vaccine technologies, regulatory pathways, and the impact of vaccination programs.
- ✓ Apply scientific principles to the design and development of novel vaccines, including mRNA and vector-based technologies.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Define key terminology and list the mandatory stages of vaccine clinical trials.	K1
CO2	Explain how different vaccines stimulate the immune system to create immunological memory and summarize the regulatory process for vaccine approval and licensing.	K1, K2
CO3	Apply epidemiological concepts to design surveillance studies for vaccine safety in the field.	K1- K3
CO4	Analyze factors contributing to vaccine hesitancy and devise strategies to increase acceptance.	K1- K4
CO5	Assess the efficacy of vaccination strategies in humanitarian emergencies.	K1- K5
CO6	Design a novel, context-specific vaccination strategy for a public health crisis.	K1- K6
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit-I:
Basics of vaccinology
(6 hours)

History of vaccination, Active and passive immunization; requirements for induction of immunity, Epitopes, linear and conformational epitopes, characterization and location of APC, MHC and immunogenicity.

Unit-II: Types of vaccines (6 hours)	Viral/bacterial/parasite vaccine differences, methods of vaccine preparation – Live, killed, attenuated, sub unit vaccines; Licensed vaccines, Viral vaccine - Poliovirus vaccine-inactivated & Live, Rabies vaccines, Hepatitis A & B vaccines, Bacterial vaccine - Anthrax vaccines, Cholera vaccines, Diphtheria toxoid, Parasitic vaccine - Malaria vaccine.
Unit-III: Vaccine Technology (6 hours)	Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein-based vaccines, plant-based vaccines, reverse vaccinology; Peptide vaccines, conjugate vaccines. Recent advances in Malaria, Tuberculosis, HIVimmuno prophylaxis
Unit-IV: Fundamental research in vaccine design (6 hours)	Fundamental research to rational vaccine design. Antigen identification and delivery, T-Cell expression cloning for identification of vaccine targets for intracellular pathogens, Rationale vaccine design based on clinical requirements: Scope of future vaccine strategies.
Unit-V: Quality control and Regulation of vaccine (6 hours)	Vaccine additives and manufacturing residuals, Regulation and testing of vaccines, Regulation of vaccines in developing countries, Quality control and regulations in vaccine research, Animal testing, Rational design to clinical trials, Large scale production, Commercialization. Vaccine safety ethics and Legal issues.
Unit-VI: Current Contours (For Continuous Internal Assessment only):	Debate and Discussion on mRNA and Next-Generation Platforms for vaccine development, Mucosal Immunity, Reverse Vaccinology and AI. Seminar on modern vaccinology challenges

Mapping with Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	S	M	S	S	S	M	M	S	S	S
CO2	S	M	S	S	S	M	M	S	S	S
CO3	S	M	S	S	S	M	M	S	S	S
CO4	S	M	S	S	S	M	M	S	S	S
CO5	S	M	S	S	S	M	M	S	S	S
CO6	S	M	S	S	S	M	M	S	S	S

Recommended References:

1. Stanley A. Plotkin, Walter Orenstein& Paul A. Offit.(2013). Vaccines, 6th Edition.Elsevier Publication. USA.
2. Coico, R. (2021). *Immunology: a short course*. John Wiley & Sons. USA.
3. Parham, Peter.(2005). The Immune System. 2nd Edition, Garland Science. USA.
4. Abbas, A.K., Lichtman, A.H. and Pillai, S., 2007. Cellular and molecular

immunology. 6th edition.WB Saunders, Philadelphia. USA.
5. Weir, D.M. and Stewart, John (2000). Immunology. 8th Edition, Churchill Pvt. Ltd. UK.

Related Online Contents:

1. https://www.slideshare.net/adammbbs/pathogenesis-3-rd-internal-updated-43458567
2. https://www.bio.fiocruz.br/en/images/stories/pdfs/mpti/2013/selecao/vaccine-processtechnology.pdf
3. https://www.dcvmn.org/IMG/pdf/ge_healthcare_dcvmn_introduction_to_pd_for_vaccine_ production_29256323aa_10mar2017.pdf
4. https://www.sciencedirect.com/science/article/pii/B9780128021743000059

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SEMESTER –VI
FOOD MICROBIOLOGY

Course Code	CC-9	Course Type	Core	L	T	P	C	Syllabus version	2026-2027
				4	-	-	4		
Pre-requisite	Basic understanding of food microbiology, food borne pathogens and food preservation.								

Course Objectives:

- ✓ Understand the intrinsic and extrinsic parameters of food environments that govern microbial growth, survival, and pathogenesis.
- ✓ Address challenges associated with specific spoilage mechanisms and food-borne pathogens across diverse food groups (dairy, meat, produce, and cereals).
- ✓ Become a creative problem solver in applying both conventional and advanced physical, chemical, and biological food preservation strategies.
- ✓ Understand the vital roles of beneficial microbes in food fermentation and the rigorous quality control systems (HACCP, GMP) required to ensure global food safety.
- ✓ Understand the fermentation of alcoholic beverages and fermented food products.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Exploring the primary sources of microorganisms in food and the intrinsic/extrinsic factors influencing their growth.	K1, K2
CO2	To learn about the biochemical mechanisms of food spoilage and identify specific spoilage agents in various food commodities.	K2, K3
CO3	To characterize the etiology, pathogenesis, and prevention of major bacterial, viral, and fungal food-borne diseases.	K3, K4
CO4	Exploring the microbiology of fermented foods, starter cultures, and the biochemical pathways of food bioprocessing.	K3, K4
CO5	Understanding the mechanisms of food preservation methods, including thermal processing, irradiation, and chemical additives.	K4, K5
CO6	To demonstrate the ability to evaluate food safety management systems and design a basic HACCP plan.	K5, K6
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit-I: Microorganisms and the Food Environment (12 hours)	Historical developments in food microbiology. Primary sources of microorganisms in food, Factors influencing microbial growth in foods: Intrinsic factors and Extrinsic factors.
Unit-II: Microbiology of Food Spoilage (12 hours)	Concept and biochemical mechanisms of food spoilage. Spoilage of specific food groups: Fresh meat, poultry, and seafood. Spoilage of milk and dairy products. Spoilage of fruits, vegetables, and fruit juices. Spoilage of cereals, grains, and baked goods. Spoilage of canned foods.
Unit-III: Food-Borne Diseases (12 hours)	Food-borne infections versus food intoxications. Bacterial food infections: *Salmonella*, *Listeria monocytogenes*, *Campylobacter jejuni*, *Vibrio cholerae*, and enteropathogenic *Escherichia coli*. Bacterial food intoxications: *Staphylococcus aureus* enterotoxin, and *Clostridium botulinum* neurotoxin. Mycotoxins and mycotoxicoses (Aflatoxins, Ochratoxins). Food-borne viruses and parasites.
Unit-IV: Food Fermentation and Bioprocessing (12 hours)	Beneficial uses of microorganisms in food. Types and maintenance of starter cultures. Microbiology of fermented dairy products: yogurt, cheese, kefir, and butter. Microbiology of fermented plant products: sauerkraut, pickles, and olives. Microbiology of bread making and alcoholic beverages-beer and wine. Fermented soy products.
Unit-V: Food Preservation and Quality Control (12 hours)	Principles of food preservation- Preservation by high temperature. Preservation by low temperature. Preservation by drying. Preservation by irradiation and chemical preservatives. Food safety management: Good Manufacturing Practices (GMP) and Hazard Analysis Critical Control Point (HACCP) systems.
Unit-VI: Current Contours (For Continuous Internal Assessment only):	Daily news on major food recalls and outbreaks. Exploring the rapidly growing market of functional foods, probiotics, and prebiotics. Literature review on advanced, rapid detection methods for food pathogens (PCR, biosensors, ELISA) bypassing traditional plate counts. Drafting a comprehensive sanitation standard operating procedure (SSOP) for a mock commercial kitchen.

Mapping with Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	S	M	M	S	S	M	M	S	S	S
CO2	S	M	M	S	S	M	M	S	S	S
CO3	S	M	M	S	S	M	M	S	S	S
CO4	S	M	M	S	S	M	M	S	S	S
CO5	S	M	M	S	S	M	M	S	S	S
CO6	S	M	M	S	S	M	M	S	S	S

Recommended References:

1. Frazier, W. C., Westhoff, D. C., and Vanitha, N. M. (2013). *Food Microbiology*, 5th Edition. McGraw Hill Education. India.
2. Adams, M. R., Moss, M. O., and McClure, P. (2015). *Food Microbiology*, 4th Edition. Royal Society of Chemistry. UK.
3. Jay, J. M., Loessner, M. J., and Golden, D. A. (2005). *Modern Food Microbiology*, 7th Edition. Springer. USA.
4. Montville, T. J., Matthews, K. R., and Kniel, K. E. (2012). *Food Microbiology: An Introduction*, 3rd Edition. ASM Press. USA.
5. Ray, B., and Bhunia, A. (2013). *Fundamental Food Microbiology*, 5th Edition. CRC Press. USA.

Related Online Contents:

1. FDA Bad Bug Book: (A comprehensive handbook on foodborne pathogenic microorganisms and natural toxins) https://www.fda.gov/food/foodborne-pathogens/bad-bug-book-second-edition
2. WHO Food Safety Fact Sheets: https://www.who.int/health-topics/food-safety
3. NPTEL Course - Food Microbiology and Food Safety: https://nptel.ac.in/courses/126104004

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SEMESTER –VI
RECOMBINANT DNA TECHNOLOGY

Course Code	CC-10	Course Type	Core	L	T	P	C	Syllabus version	2026-2027
				5	-	-	4		
Pre-requisite	Basics of Microbiology, Biochemistry of DNA/ RNA, basics of plasmids and about electrophoresis.								

Course Objectives:

- ✓ To educate learners with the fundamental knowledge of recombinant DNA (rDNA) technology.
- ✓ To describe the jargons of genetic engineering/ rDNA technology.
- ✓ To impart various methods of gene isolation, purification & quantification techniques.
- ✓ To provide the molecular tools, techniques and methods employed in gene cloning and clone identification.
- ✓ To explain the applications of rDNA technology in health care, agriculture and others.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Outline the rDNA technology milestones, basic steps of gene cloning and methods of DNA isolation/ gene isolation.	K1, K2, K3
CO2	Acquire knowledge on the role of enzymes in Gene manipulation.	K2
CO3	Recognize the relevance of different kinds of gene cloning vectors in rDNA technology.	K2, K3
CO4	Acquaint techniques of gene transfer among bacteria.	K3, K4
CO5	Describe the role of various techniques [blotting, PCR, Molecular markers] in gene cloning.	K3, K4
CO6	Have hands-on skills with respect to the techniques of the course.	K6, K7
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit-I:
rDNA Technology – strategy & techniques (12 hours)

Recombinant DNA [rDNA] - Milestones in rDNA technology - Definition of gene cloning & gene manipulation – The basic steps in gene cloning - Isolation and Purification of Chromosomal and Plasmid DNA, Isolation and Purification of RNA – Quantification of DNA & RNA - Chemical Synthesis of DNA, Genomic Library and cDNA Library - applications.

Unit-II: Enzymology of rDNA technology (15 hours)

Restriction endonucleases: Discovery, Type I, II and III - Characteristics & Mode of action, Type II restriction endonucleases, sources, recognition sequences, nature of cuts & applications, Ligases & mode of action, DNA polymerases, DNA modifying enzymes and topoisomerases.

Unit-III: Gene cloning vectors (15 hours)

Cloning vectors: Definition and properties – Plasmid based vectors: Natural vectors - pSC101, pSF2124, pMB1, Artificial vectors - pBR322 and pUC - Phage based vectors- Lamda phage vectors and derivatives - Hybrid Vectors- Phagemid and Cosmid, BAC and YAC – Expression systems – *E. coli*.

Unit-IV: Gene/ DNA Transfer methods (15 hours)

Recombinant DNA transfer methods: Physical – Biolistic Method (Gene-gun), Electroporation, Microinjection. Chemical- Calcium chloride and DEAE Methods, Biological *in-vitro* packaging method in viruses - Selection and Screening of recombinants: Direct Method: Selection by Complementation, Marker inactivation methods - Indirect methods: Immunological and Genetic methods.

Unit-V: Techniques in rDNA technology (15 hours)

Blotting - Southern, Western and Northern techniques – PCR - basic steps in DNA amplification & applications. Molecular markers: RAPD, RFLP & VNTRs and their applications – DNA finger printing - DNA microarray analysis – Applications of recombinant DNA technology in health care & agriculture.

Unit-VI: Current Contours (For Continuous Internal Assessment only):

Internships relevant to gene cloning techniques shall be recommended. Assignments/ seminars shall be given as to cover recent advancements of recombinant DNA technology in medicine and agriculture - human recombinant insulin, growth hormone, blood clotting factors, recombinant COVID-19 Vaccines, golden rice, herbicide-resistant crops, and insect-resistant crops.

Mapping with Programme Specific Outcomes

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	S	S	S	S	S	M	S	M	S	S
CO2	S	S	S	S	S	M	S	M	S	S
CO3	S	S	S	S	S	M	S	M	S	S
CO4	S	S	S	S	S	M	S	M	S	S
CO5	S	S	S	S	S	M	S	M	S	S
CO6	S	S	S	S	S	M	S	M	S	S

Recommended References:

1. Brown, T.A. 2015. Gene Cloning and DNA Analysis- An Introduction, 7th edition, Wiley Blackwell. USA.

2. Primrose, S.B., Twyman, R.M. 2006. Principles of Gene Manipulation and Genomics, 7th edition. Wiley Blackwell, USA.
3. Monika Jain. 2020. Recombinant DNA Techniques: A Textbook, Alpha Science International. India.
4. Old, R.W., Primrose, S.B. 1995. Principle of Gene Manipulation, 5th edition. Blackwell Scientific Publication, Boston. USA.
5. Julia Lodge, Peter Lund., Steve Minchin.2006. Gene Cloning – Principles and Applications, Taylor and Francis. USA.
6. Firdos, A.K. 2019. Biotechnology Fundamentals, 3rd edition, CRC Press. USA.
7. Das, H.K. 2017. Text book of Biotechnology, 5th edition, Wiley. USA.
8. Ramdass P. 2019. Cloning, MJP Publishers. India,
9. Rajagopal K. 2012. Recombinant DNA technology and genetic engineering, McGraw Hill Education. India.
10. Prakash, S. L. 2019. Text book of Biotechnology, 1st edition, MJP publisher. India.
11. Arumugam N., Narayanan L M., Mani A., Selvaraj A.M., & Padmalatha Singh 2017. Genetic Engineering. Saras Publications. India.

Related Online Contents:

1. https://old.amu.ac.in/emp/studym/100002855.pdf
2. https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/
3. https://microbenotes.com/restriction-enzyme-restriction-endonuclease/
4. https://www.mlsu.ac.in/econtents/65_Enzymes%20used%20in%20GE.pdf
5. https://microbenotes.com/polymerase-chain-reaction-pcr-principle-steps-applications/
6. https://microbenotes.com/western-blotting-introduction-principle-and-applications/
7. https://www.geeksforgeeks.org/biology/vntr/
8. https://download.e-bookshelf.de/download/0007/2863/08/L-G-0007286308-0008738665.pdf

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SEMESTER –VI
MICROBIAL BIOTECHNOLOGY AND BIOETHICS

Course Code	CC-11	Course Type	Core	L	T	P	C	Syllabus version	2026-2027
				5	-	-	4		
Pre-requisite	Basics of rDNA technology, Industrial microbiology & their applications.								

Course Objectives:

- ✓ To enlighten the huge- role of various microbes in producing prophylactics & therapeutics by biotechnology industries.
- ✓ To enhance the understanding of microbial- technology in agricultural promotion and pollution remedy.
- ✓ To bring-out role of algae vs biotechnology in the industrial production of novel nutritional products & pharma-compounds and alternative-energy/ bio-energy.
- ✓ To create awareness on the role of genetic engineering in plant and animal biotechnology for man-kind.
- ✓ To understand the intellectual property rights, ethical concern in human and animal research.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Explain the basics of microbial production of pharmaceutically valuable products.	K1, K2, K4
CO2	Describe the role of microbial-technology in agriculture and pollution control.	K1, K2, K4
CO3	Take-up the skill on the biotechnological applications of producing microalgae-based products.	K1, K2, K4
CO4	Have the know-hows of plants and animals bioengineering for human betterment.	K3, K4
CO5	Understand the importance of IPR and bioethical responsibility.	K1, K2
CO6	Expertise with respect to the real-time potentials of the course.	K5, K7
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit-I: Bioproduction of Therapeutic Agents and Vaccines (15 hours)

Biotechnology & Microbial Biotechnology: Definition – Milestones in History - Scope of microbial biotechnology and its applications - Microbial production of pharmaceuticals – antibiotics, hormones (insulin), enzymes (streptokinase), recombinant vaccines (Hepatitis B vaccine) - Edible vaccine, Monoclonal antibodies.

Unit-II: Bioinoculants and biopolymers (15 hours)	Microbial production of biofertilizers – *Rhizobium* sp., *Azospirillum* sp., *Frankia* sp. and VAM. Microbial production of bio-pesticides-*Bacillus thuringiensis*. Microbial production of bioplastics. Microorganisms in bioremediation: Degradation of xenobiotics.
Unit-III: Algal Biotechnology (15 hours)	Single cell protein-algae and yeast. Microalgal technology – Industrial cultivation methods of *Spirulina* sp. – biotechnological potentials of *Spirulina* sp. as food and feed – fuel production from microalgae – pharmaceutically valuable compounds from microalgae. Commercial production of bioethanol and biodiesel using lignocellulosic waste.
Unit-IV: Genetic Engineering of Plants and Animals (15 hours)	Genetic engineering of plants: Ti plasmid vectors and plants transgenesis– Development of insect, virus and herbicide resistant plants. Transgenic animals: methods of creating transgenic mice and sheep. Human gene therapy – *in-vivo* and *ex-vivo* gene therapy.
Unit-V: IPR and Bioethics (15 hours)	Intellectual Property Rights - types of IPRs - Principles of Bioethics- Definition of Ethics and Bioethics. - Ethics committee -risks and ethics of modern biotechnology - Ethical concerns in human gene therapy - Ethical limits of animal use. Ethical issues at the beginning of life – Ethical issues at the end of life.
Unit-VI: Current Contours (For Continuous Internal Assessment only):	Learners shall register and pursue short- term Swayam-NPTEL courses on Basics of Biotechnology, Bioethics, IPR for an enhanced understanding. Learners can also visit nearby agricultural field (Rice, onion, cotton or any other) to enrich knowledge on the application of biofertilizers. Learners shall prepare posters and models on Biogas, biofuel, Organic farming, Panchagavya, dolly, knockout mice, double transgenic mouse for assignment/ seminar activities.

Mapping with Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	S	M	M	S	S	M	S	S	S	S
CO2	S	M	M	S	S	M	S	S	S	S
CO3	S	M	M	S	S	M	S	S	S	S
CO4	S	M	M	S	S	M	S	S	S	S
CO5	S	M	M	S	S	M	S	S	S	S
CO6	S	M	M	S	S	M	S	S	S	S

Recommended References:

1. Dubey R C., 2012. A text book of Biotechnology. S.Chand. India.

2. Desmond, S.T Nicholl. 2002. An Introduction to Genetic Engineering, 2nd edition, Cambridge university press. UK.
3. Das, H.K. 2017.Textbook of Biotechnology,5th edition, Wiley Press. USA.
4. Sivaji Mathivanan. 2020. Advances in Microbial Biotechnology, LAP Lambert Academic Publishing. India.
5. Kumaresan V. 2019. Biotechnology Saras Publication. India
6. Padma Singh 2010. Recent trends in Microbial Biotechnology. CBS Publishers & Distributers. India.
7. Sengar R S. & Reshu Chaudhary. 2015. Dictionary of Biotechnology. CBS Publishers & Distributers. India
8. Satyanarayana U. 2010. Biotechnology. Books and Allied (P) Ltd. India
9. Chandrani Sanyal Datta 2023. Essentials of Biotechnology. AITBS Publishers, India.
10. Chawla, H.S. 2020. Introduction to Plant Biotechnology, 3rd edition, Oxford &IBH Publishing. India
11. Glick, B.R., Pasternak, J.J., Patten, C.L. 2010. Molecular Biotechnology 4th edition, ASM Press. USA.
12. Mukesh Pasupuleti. 2006. Molecular Biotechnology. MJP Publishers, Chennai.
13. Ratledge C., Kristiansen, B. 2001. Basic Biotechnology, 2nd edition, Cambridge University Press. UK.
14. Willey, J.M., Sherwood, L.M., Woolverton, C.J. 2014. Prescott, Harley and Klein's Microbiology, 9th edition, Mc Graw Hill Publishers. USA.
15. Gupta, P.K. 2009. Elements of Biotechnology, 2nd edition, Rastogi Publications. India.
16. Glazer, A.N., Nikaido, H. 2007. Microbial Biotechnology, 2nd edition, Cambridge University Press. UK.
17. Stanbury, P.F., Whitaker, A., Hall, S.J. 2016. Principles of Fermentation Technology, 3rd edition, Butterworth-Heinemann Publisher. USA.
18. Nancy, S.J., Albert, R. J., Robert, A. P. 2010. Bioethics- An introduction the history, methods and practice, 2nd edition. Jones and Bartlett Publishers, USA.

Related Online Contents:

1. https://www.onlinebiologynotes.com/human-insulin-production-by-genetic-engineering/
2. https://www.biotechnologynotes.com/transgenic-plants/edible-vaccines-applications-advantages-and-limitations/627
3. https://www.biologydiscussion.com/microbiology-2/bioremediation/ xenobiotic -compounds-meaning-hazards-and-biodegradation/55625
4. https://www.drishtiias.com/to-the-points/paper3/intellectual-property-rights
5. https://www.wipo.int/en/web/about-ip
6. https://www.eolss.net/sample-chapters/c17/E6-58-03-04.pdf
7. https://www.agriculturejournal.net/archives/2024/vol6issue2/PartB/6-2-11-481.pdf
8. https://www.plantarchives.org/SPECIAL%20ISSUE%2020-1/2058-

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SEMESTER –VI
ARTIFICIAL INTELLIGENCE IN MICROBIOLOGY

Course Code	SEC-6	Course Type	Skill Enhancement Course	L	T	P	C	Syllabus version	2026-2027
				2	-	-	2		
Pre-requisite	Basics of Artificial Intelligence (AI) and Machine Learning (ML) and their transformative role in microbiological research.								

Course Objectives:

- ✓ Understand the fundamental concepts of Artificial Intelligence (AI) and Machine Learning (ML) and their transformative role in microbiological research.
- ✓ Address challenges in analyzing massive biological datasets, including microbiome sequences and antimicrobial resistance profiles.
- ✓ Become a creative problem solver in utilizing AI-driven tools for automated image analysis, drug discovery, and genomic predictions.
- ✓ Understand the ethical implications, data privacy concerns, and the practical application of modern generative AI models in the life sciences.
- ✓ Understand the microscopic imaging datasets in morphological diagnostics.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Exploring the basic terminology, algorithms, and scope of Machine Learning in microbiology.	K1
CO2	To learn about the preparation, feature extraction, and analysis of large-scale microbial genomic data.	K1, K2
CO3	To characterize microbial populations and predict antimicrobial resistance using predictive AI models.	K2, K4
CO4	Exploring computer vision applications for automated microscopic image analysis and morphological classification.	K3, K4
CO5	Understanding the role of AI in structural biology, protein modelling, and secondary metabolite discovery.	K3, K4
CO6	To demonstrate the ability to apply existing AI web servers to solve a simulated microbiological problem and optimize whole-genome data.	K5, K6
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit-I: Fundamentals of AI and Machine Learning (6 hours)	Introduction to Artificial Intelligence, Machine Learning, and Deep Learning. Understanding the data pipeline: data collection, cleaning, training sets, and testing sets. Types of Machine Learning: Supervised learning - Classification and Regression, Unsupervised learning and Reinforcement learning. Overview of standard algorithms used in biology - Random Forest, Support Vector Machines, and basic Neural Networks.
Unit-II: AI in Microbiome and Genomic Analysis (6 hours)	The data explosion in Next-Generation Sequencing. Applying ML to metagenomic data for taxonomic classification and functional profiling. Predictive models for identifying biomarker taxa in the human gut microbiome associated with health and disease. AI-driven whole-genome assembly optimization and the prediction of viral/phage sequences within bacterial genomes.
Unit-III: Predicting AMR and Biosynthetic Gene Clusters (6 hours)	The global threat of Antimicrobial Resistance (AMR). Using machine learning to predict Minimum Inhibitory Concentration values and identify novel AMR genes from genomic data. AI in drug discovery and the identification of secondary metabolites. Utilizing AI-augmented bioinformatics algorithms for the rapid mining and analysis of Biosynthetic Gene Clusters to discover novel antibiotics and bioactive compounds.
Unit-IV: Computer Vision in Clinical Microbiology (6 hours)	Computer Vision and Convolutional Neural Networks. Automating the clinical microbiology lab: AI tools for rapid automated colony counting and species identification on agar plates. Digital pathology: using AI to interpret and classify microbial morphology from Gram-stain and microscopic imaging datasets. Reducing human error in morphological diagnostics.
Unit-V: Generative AI and Protein Modeling (6 hours)	The revolution of DeepMind's AlphaFold and RoseTTAFold in predicting 3D protein structures from amino acid sequences. Using AI models to understand host-pathogen protein interactions and viral entry mechanisms. The application of Large Language Models in literature mining, experimental design, and the ethical use of prompt engineering for drafting scientific protocols.
Unit-VI: Current Contours (For Continuous Internal Assessment only):	Daily news on AI breakthroughs in biotechnology and pharmaceutical virtual screening. Discussion on the "Black Box" problem of AI and the bias present in genomic databases. Computational practice: Navigating user-friendly, web-based AI tools (like antiSMASH) for BGC prediction, and utilizing AI-assisted platforms to annotate an unknown whole-genome assembly.

Mapping with Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	S	S	S	S	S	M	M	S	S	S
CO2	S	S	S	S	S	M	M	S	S	S
CO3	S	S	S	S	S	M	M	S	S	S
CO4	S	S	S	S	S	M	M	S	S	S
CO5	S	S	S	S	S	M	M	S	S	S
CO6	S	S	S	S	S	M	M	S	S	S

Recommended References:

1. Baldi, P., and Brunak, S. (2001). *Bioinformatics: The Machine Learning Approach*, 2nd Edition. MIT Press. India.
2. Tarca, A. L., Carey, V. J., Chen, X. W., Romero, R., & Drăghici, S. (2007). *Machine Learning and Its Applications to Biology*. PLoS Computational Biology.
3. Ezziane, Z. (2006). *Applications of Artificial Intelligence in Bioinformatics: A Review*. Expert Systems with Applications.
4. Topol, E. (2019). *Deep Medicine: How Artificial Intelligence Can Make Healthcare Human Again*. Basic Books. Scientific Research Academic Publisher.

Related Online Contents:

1. Coursera - AI for Medicine Specialization: https://www.coursera.org/specializations/ai-for-medicine
2. AlphaFold Protein Structure Database: https://alphafold.ebi.ac.uk/ (Interactive 3D protein structure exploration)
3. antiSMASH Web Server: https://antismash.secondarymetabolites.org/ (For BGC analysis and genome mining).

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SKILL ENHANCEMENT COURSE (SEC)

1. MICROBIAL COSMETICS

Course Code	SEC	Course Type	SKILL ENHANCEMENT COURSE	L	T	P	C	Syllabus version	2026-2027
				2	-	-	2		
Pre-requisite	A basic understanding of microorganisms in cosmetic formulations.								

Course Objectives:

- ✓ To understand the role of microorganisms in cosmetic formulations, production preservation, and spoilage.
- ✓ To provide a comprehensive understanding of the skin microbiome, beneficial microflora, and cosmetic ingredients derived from microbial fermentation.
- ✓ To analyze methods for detecting, enumerating, and identifying microbial contaminants in cosmetic products according to international regulatory standards.
- ✓ To evaluate the efficacy of antimicrobial preservation systems and raw material safety in cosmetic formulations.
- ✓ To apply this foundational knowledge to develop bio-cosmetics and solve industrial compliance, safety, and quality control problems.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Recall the classifications of cosmetic ingredients, typical cosmetic spoiling organisms, types of skin microbiota, and relevant regulatory standards.	K1, K2
CO2	Explain the relationship between skin microbiome balance, the mechanism of preservative action, and the formulation dynamics of probiotic/postbiotic cosmetics.	K1, K2
CO3	Perform qualitative and quantitative assays to challenge, isolate, and estimate microbial bioburden or raw materials from cosmetic samples.	K1 - K3
CO4	Differentiate between structural/chemical liabilities of raw cosmetic matrices and their susceptibility to specific microbial contamination or degradation.	K3, K4
CO5	Formulate an intervention or protocol connecting preservation failure or microbial contamination to corrective industrial manufacturing strategies.	K5, K6
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit-I: Human Skin Microbiome and Cosmetic Interactions (6 hours)	Structure and ecology of human skin. Composition and distribution of resident and transient skin microflora. Factors influencing skin microbiome diversity. Concept of dysbiosis in skin disorders. The impact of conventional cosmetics versus microbiome-friendly formulations.
Unit-II: Microbial Raw Materials and Bio-Cosmetics (6 hours)	Microbial fermentation products in cosmetics: production and applications of hyaluronic acid, kojic acid, lactic acid, and biosurfactants. Microalgae and cyanobacterial extracts in skincare. Probiotics, prebiotics, and postbiotics in cosmetic formulations: mechanisms of skin barrier enhancement and anti-aging properties.
Unit-III: Cosmetic Spoilage and Contamination Pathways (6 hours)	Susceptibility of cosmetic matrices to microbial attack. Water activity and chemical composition as risk factors. Common cosmetic spoiling microorganisms and objectionable pathogens. Sources of industrial contamination: raw materials, manufacturing plant hygiene, packaging, and consumer usage.
Unit-IV: Preservation Systems and Efficacy Testing (6 hours)	Types, chemical classification, and mechanisms of action of traditional cosmetic preservatives. Trends in green, natural, and self-preserving cosmetic systems. Preservative Efficacy Testing.
Unit- V: Microbiological Quality Control of Cosmetics (6 hours)	Regulatory frameworks for cosmetic safety. Quantitative and qualitative evaluation: Total Aerobic Microbial Count and Total Combined Yeasts and Molds Count. Screening and identification methodologies for specified target pathogens. Validation of neutralizing agents used in cosmetic microbial testing.
Unit-VI: Current Contours (For Continuous Internal Assessment only)	Regulatory status and labeling claims for "Probiotic" and "Microbiome-Friendly" skincare products. Rapid automated methods for cosmetic bioburden screening. Application of genetic sequencing in tracking skin microbial shifts. Sustainable manufacturing protocols and eco-friendly preservation options.

Mapping with Programme Specific Outcomes

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	S	S	M	S	M	M	S	S	S	S
CO2	S	S	M	S	M	M	S	S	S	S
CO3	S	S	M	S	M	M	S	S	S	S
CO4	S	S	M	S	M	M	S	S	S	S
CO5	S	S	M	S	M	M	S	S	S	S

Recommended References:

1. Philip A. Geis.2020.*Cosmetic Microbiology: A Practical Approach*. 3rd Edition. CRC Press. USA.
2. Amparo Salvador and Alberto Chisvert.2007.*Analysis of Cosmetic Products*. Elsevier Science. Europe.
3. Barel, A.O., Paye, M., and Maibach, H.I. 2014. *Handbook of Cosmetic Science and Technology*. CRC Press. USA.

Related Online Contents:

1. https://www.iso.org/committee/48956/x/catalogue/
2. https://www.fda.gov/cosmetics/cosmetic-science-research/microbiology-cosmetics
3. https://www.personalcarecouncil.org/

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SKILL ENHANCEMENT COURSE (SEC)
2. MICROBIAL QUALITY CONTROL AND TESTING

Course Code	SEC	Course Type	Skill Enhancement Course	L	T	P	C	Syllabus version	2026-2027
				2	-	-	2		
Pre-requisite	A basic understanding of laboratory safety protocols, and foundational concepts of microbial quality assessment and testing.								

Course Objectives:

- ✓ To understand the principles of quality assurance and quality control in microbiological practices.
- ✓ To provide a comprehensive understanding of regulatory standards, cleanroom classifications, validation processes, and environmental monitoring.
- ✓ To analyze methods for detecting, isolating, and quantifying microbial contaminants in pharmaceuticals, food, and water.
- ✓ To evaluate the mechanisms of preservation, sterilization validation, and automated microbial identification systems.
- ✓ To apply this foundational knowledge to solve industrial contamination, safety compliance, and quality audit problems.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Recall the classifications of cleanrooms, types of microbial contaminants, validation parameters, and regulatory guidelines.	K1, K2
CO2	Explain the relationship between environmental monitoring data, facility design, and the mechanisms of sterilization/disinfection compliance.	K1, K2
CO3	Perform qualitative and quantitative assays to isolate, enumerate, and identify microbial bioburden from industrial and biological samples.	K1 - K3
CO4	Differentiate between various testing methodologies.	K3, K4
CO5	Formulate a connection between out-of-specification microbial results, root cause analysis, and corrective/preventive actions in production.	K5, K6
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit-I: Quality Control and Cleanroom Ecology (6 hours)

Introduction to Quality Assurance and Quality Control in microbiology. Cleanroom classifications. Air handling systems and laminar airflow units. Biology of cleanroom contaminants: sources of contamination. Personnel hygiene, gowning qualifications, and behaviour protocols.

Unit-II: Environmental Monitoring and Water Testing (6 hours)	Environmental Monitoring programs: viable and non-viable particle counting. Sampling techniques: active air sampling, passive air sampling, surface monitoring. Microbiological analysis of industrial water systems: sampling, membrane filtration, total viable count, and detection of specified objectionable pathogens.
Unit-III: Sterility Testing and Bioburden Estimation (6 hours)	Principles and methods of Sterility Testing: Membrane Filtration method and Direct Inoculation method. Media selection, growth promotion testing, and method validation. Bioburden testing of raw materials and finished products. Limits testing and microbial enumeration tests for non-sterile products.
Unit-IV: Endotoxin Testing and Preservative Efficacy (6 hours)	Bacterial Endotoxin Test: Pyrogen testing vs. Limulus Amebocyte Lysate assay. Gel-clot method, turbidimetric method, and chromogenic techniques. Antimicrobial Preservative Efficacy Testing: choice of challenge organisms, inoculation protocols, acceptance criteria for pharmaceutical, cosmetic, and food formulations.
Unit-V: Disinfection and Sterilization Validation (6 hours)	Disinfectants: classification, mechanisms of action, and selection criteria. Disinfectant efficacy testing. Validation of sterilization processes: thermal, chemical, and radiation. Biological Indicators and Chemical Indicators: selection, usage, and interpretation.
Unit-VI: Current Contours (For Continuous Internal Assessment only)	Rapid Microbiological Methods versus traditional cultural methods. Automated microbial identification systems. Out of Specification investigations for microbiological data. Root Cause Analysis and implementing CAPA in contamination events.

Mapping with Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	S	S	M	S	M	M	S	S	S	S
CO2	S	S	M	S	M	M	S	S	S	S
CO3	S	S	M	S	M	M	S	S	S	S
CO4	S	S	M	S	M	M	S	S	S	S
CO5	S	S	M	S	M	M	S	S	S	S

Recommended References:

1. Michael J. Miller (2019). *The Encyclopedia of Rapid Microbiological Methods*. Davis Healthcare International Books. India.
2. Tim Sandle (2015). *Pharmaceutical Microbiology: Essentials for Quality Assurance and Quality Control*. Woodhead Publishing. UK.
3. Saghee, M.R., Sandle, T., and Tidswell, E.C (2011). *Microbiology and Sterility Assurance in Pharmaceuticals and Medical Devices*. Business Horizons. India.

4. Denyer, S.P., Hodges, N., Gorman, S.P., and Gilmore,*B.*2011.Hugo and Russell'sPharmaceutical Microbiology. 8th Edition. Wiley-Blackwell. USA.

Related Online Contents:

1. https://www.fda.gov/drugs/guidances-drugs/pharmaceutical-quality-resources
2. https://www.iso.org/standard/cleanrooms-and-associated-controlled-environments
3. https://www.who.int/teams/health-product-policy-and-standards/standards-and-specifications/norms-and-standards-for-pharmaceuticals/guidelines/quality-control

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SKILL ENHANCEMENT COURSE (SEC)
3. ALGAL CULTIVATION TECHNIQUES

Course Code	SEC	Course Type	Skill Enhancement Course	L	T	P	C	Syllabus version	2026-2027
				2	-	-	2		
Pre-requisite	A basic understanding of algal cell biology, photosynthesis, open and closed cultivation of algae.								

Course Objectives:

- ✓ To understand the biological principles, nutritional requirements, and metabolic pathways governing microalgae and cyanobacteria growth.
- ✓ To provide a comprehensive understanding of upstream cultivation configurations, from isolation to large-scale open and closed culture systems.
- ✓ To analyze critical physiological parameters influencing biomass accumulation and biomolecule synthesis.
- ✓ To evaluate modern harvesting, dewatering, and downstream extraction technologies for algal biomass processing.
- ✓ To apply this foundational knowledge to optimize algal production for industrial, environmental, and bio-based applications.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Recall structural classifications, specific strain selection, media formulations, and growth kinetics of industrial microalgae and cyanobacteria.	K1, K2
CO2	Explain the functional relationships between environmental parameters, culture design choices, and bioprocess performance parameters.	K1, K2
CO3	Perform qualitative and quantitative assays to isolate axenic strains, monitor cell density, and measure physiological parameters in cultivation matrices.	K1 - K3
CO4	Differentiate between the metabolic efficiency, technical limitations, and structural costs of open vs. closed photobioreactor configurations.	K3, K4
CO5	Formulate an integrated process workflow connecting tailored mass cultivation strategies to high-efficiency biomass downstream processing.	K5, K6
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit-I: Biology, Isolation, and Maintenance of Algal Cultures (6 hours)	Introduction to economically important microalgae and cyanobacteria. Isolation strategies: serial dilution, agar plating, micromanipulation, and enrichment cultures. Maintenance and preservation of stock cultures: cryopreservation and subculturing techniques. Growth dynamics, calculation of specific growth rate and doubling time.
Unit-II: Nutritional Requirements and Media Formulation (6 hours)	Nutritional modes: photoautotrophic, heterotrophic, mixotrophic, and photoheterotrophic growth. Macronutrient requirements and Micronutrient/Trace element dynamics. Formulation, preparation, and sterilization of standard growth media. Physiological effects of nutrient limitation and starvation.
Unit-III: Open Cultivation Systems (6 hours)	Principles of large-scale outdoor mass cultivation. Design, architecture, and operation of open culture systems: natural ponds, unlined circular ponds, and high-rate raceway ponds. Engineering constraints: paddlewheel design, mixing dynamics, fluid velocity, and depth optimization.
Unit-IV: Closed Photobioreactors (6 hours)	Design and classification of high-density closed Photobioreactors. Control of critical cultivation factors: light attenuation and path-length optimization, temperature dissipation, carbon dioxide mass transfer, and dissolved oxygen stripping.
Unit-V: Harvesting and Downstream Biomass Processing (6 hours)	Principles and industrial mechanisms for algal biomass recovery. Primary harvesting techniques and Secondary concentration methods. Biomass dewatering and drying technologies. Overview of cell disruption and initial biomolecule extraction strategies.
Unit-VI: Current Contours (For Continuous Internal Assessment only)	Integration of algal cultivation with wastewater treatment and flue gas mitigation. Multi-product algal biorefineries: processing biomass for biofuels, high-value phyco-proteins, and thermochemical conversion into algal-derived biochar. Advancements in metabolic engineering, strain enhancement, and automated machine learning-driven modeling of large-scale cultivation facilities.

Mapping with Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	S	S	M	S	M	M	S	S	S	S
CO2	S	S	M	S	M	M	S	S	S	S
CO3	S	S	M	S	M	M	S	S	S	S
CO4	S	S	M	S	M	M	S	S	S	S
CO5	S	S	M	S	M	M	S	S	S	S

Recommended References:

1. Richmond, A. and Hu, Q. eds., 2013. *Handbook of microalgal culture*. John Wiley & Sons, Limited. USA.
2. Borowitzka, M.A., 2016. Algal physiology and large-scale outdoor cultures of microalgae. In *The physiology of microalgae* (pp. 601-652). Cham: Springer International Publishing. USA.
3. Becker, E.W., 1994. *Microalgae: biotechnology and microbiology* (Vol. 10). Cambridge University Press. UK.
4. Thajuddin, N., Sankaranarayanan, A., & Dhanasekaran, D. (Eds.). (2023). Protocols for cyanobacteria sampling and detection of cyanotoxin. Springer Nature, Singapore.
5. Vonshak, A. ed., 1997. *Spirulina platensis arthrospira: physiology, cell-biology and biotechnology*. CRC press. USA.

Related Online Contents:

1. https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/microalgae-cultivation
2. https://www.algaebase.org
3. https://www.frontiersin.org/journals/plant-science

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SKILL ENHANCEMENT COURSE (SEC)
4. MICROBIOME BIOLOGY

Course Code	SEC	Course Type	Skill Enhancement Course	L	T	P	C	Syllabus version	2026-2027
				2	-	-	2		
Pre-requisite	Knowledge on microbiome types, analysis and modulation microbiome in plant, animal and human system through diet and environmental factors								

Course Objectives:

- ✓ Understand the importance of Microbiome in Poultry health, Pig, ruminants
- ✓ Addresses challenges in Microbiome for Cancer therapy
- ✓ Creative problem solver of Rhizosphere microbiome engineering and *In-Situ* Phytomicrobiome
- ✓ Understanding the Probiotic Microbiome and human health.
- ✓ Understand the importance of Microbiome in Poultry health, Pig, ruminants

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Exploring the metagenomics and its application in microbiome research	K1, K2
CO2	To learn about the computational techniques in Microbiome Data analysis	K1, K2
CO3	To characterize human microbiome under healthy and disease condition	K1- K4
CO4	Exploring microbiome engineering under distinct climatic conditions, diet and geography.	K3, K4
CO5	Understanding the Importance of the plant microbiome in rhizosphere, drought	K1, K2
CO6	To demonstrate microbiome engineering in animal health improvement and modification microbiome by probiotics and diet	K5, K6
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit-I: Microbiome- An overview (6 hours)

Microbiome- Types of Microbiomes- Human, Gut, Animal, Plant microbiomes, Root, Environmental microbiomes, Microbiome modification in plants, animals and human system-diet, life style factor and geography.

Unit-II: Metagenomics(6 hours)

Metagenomics work flow- sample collection and processing, Metagenomic DNA isolation methods, Targeted, Shotgun Metagenomics, amplicon sequencing,Genome assembly annotation-Genome analysis tools.

Unit-III: Plant microbiome (6 hours)	Rhizosphere microbiome *In-Situ* Phytomicrobiome, Microbiome for Plant Growth and Improvement, Plant Microbiome Engineering to Improve Drought Stress Tolerance
Unit-IV: Animal Microbiome (6 hours)	Microbiome to improve Animal health, Gastro intestinal Microbiomein Poultry health, Gastro intestinal Microbiome in Pig, ruminants
Unit-V: Human microbiome (6 hours)	Dietary habitat in Human health enhancement, Skin Microbiome: A therapeutic approach, Microbiome therapy for Human health, Microbiomefor Cancer therapy, Orthopedic biomechanics, Probiotic engineered Microbiome and human health.
Unit-VI: Current Contours (For Continuous Internal Assessment only):	Daily news and research paper on Microbiome. Public awareness of microbiome importance in human and animal health. Scientific model on plant, animal, human microbiome concept. Computational analysis microbiome data, metagenomic data from Web Resources. Collection metadata about samples and creation mapping file for OTUS

Mapping with Specific Programme Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	S	S	M	S	S	M	S	S	L	L
CO2	S	S	M	S	S	M	S	S	L	L
CO3	S	S	M	S	S	M	S	S	L	L
CO4	S	S	M	S	S	M	S	S	L	L
CO5	S	S	M	S	S	M	S	S	L	L
CO6	S	S	M	S	S	M	S	S	L	L

Recommended References:

1. Angela E. Douglas. 2018. Fundamentals of Microbiome Science: How Microbes Shape Animal Biology, Princeton University Press, New Jersey, USA

2) Rodriguez R and Dura´n P (2020) Natural Holobiome Engineering by Using Native Extreme Microbiome to Counteract the Climate Change Effects. Front. Bioeng. Biotechnol.

3) Broberg et al. 2018. McDonald. Integrated multi-omic analysis of hostmicrobiota interactions in acute oak decline. Microbiome, 6:21

4) Bordenstein SR, Theis KR (2015) Host Biology in Light of the Microbiome: Ten Principles of Holobionts and Hologenomes. PLoS Biol 13(8):

5) Dhanasekaran D. Paul D, Amaresan N, Sankaranarayanan A, Shouche Y (2022) Microbiome-Host interactions. CRC press Taylor & Francis group,New York, USA.

6) Dhanasekaran D and A. Sankara Narayanan. 2024. Plant Microbiome Engineering, Springer Protocols, Humana New York.

7). Dhanasekaran D, A. Sankaranarayanan, Priyanka Sarkar. 2024. Human and Animal Microbiome Engineering, Elsevier.USA.

8) Tatusova T, DiCuccio M and Badretdin A. 2016. Prokaryotic Genome Annotation Pipeline.In: The NCBI Handbook. 2nd edition. Bethesda (MD): National Center for Biotechnology Information. USA

Related Online Contents:

1. http://qiime.org/tutorials/index.html
2.https://www.coursera.org/learn/microbiome
3. https://fn.academy/microbiome-course/

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SKILL ENHANCEMENT COURSE (SEC)
5. NEXT GENERATION SEQUENCING TECHNIQUES

Course Code	SEC	Course Type	Skill Enhancement Course	L	T	P	C	Syllabus version	2026-2027
				2	-	-	2		
Pre-requisite	Knowledge of traditional sequencing methods and high-throughput sequencing techniques.								

Course Objectives:

- ✓ Understand the fundamental principles, evolution, and chemistry behind various Next-Generation Sequencing (NGS) platforms.
- ✓ Address challenges in sample preparation, library construction, and quality control for high-throughput sequencing.
- ✓ Become a creative problem solver for primary and secondary NGS data analysis, including read mapping and genome assembly.
- ✓ Understand the applications of engineered sequencing approaches in transcriptomics, epigenomics, and clinical diagnostics.
- ✓ To understand RNA-Seq workflow and differential gene expression analysis

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Exploring the fundamental principles and various platforms of Next Generation Sequencing technologies.	K1, K2
CO2	To learn about the techniques for library preparation, targeted sequencing, and sample multiplexing.	K1, K2
CO3	To characterize and perform quality control on raw NGS data formats and preprocessing steps.	K1 - K3
CO4	Exploring computational pipelines for genome assembly, read alignment, and variant calling.	K3, K4
CO5	Understanding the importance of RNA-Seq, ChIP-Seq, and epigenomic sequencing applications.	K5, K6
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit-I:
DNA Sequencing – An Overview
(6 hours)

History of DNA sequencing- Sanger sequencing principles. First, Second, and Third-generation sequencing platforms. Chemistry and principles of Illumina, Ion Torrent, Pacific Biosciences, and Oxford Nanopore Technologies. Comparison of read lengths, error rates, and throughput.

Unit-II:
NGS Library Preparation
(6 hours)

Sample collection and DNA/RNA extraction quality control. NGS library preparation workflow- DNA fragmentation methods, end-repair, A-tailing, and adapter ligation. PCR amplification. Targeted sequencing vs. Whole-genome sequencing.

Unit-III: Primary Data Analysis & Quality Control (6 hours)	Introduction to NGS data formats- FASTA, FASTQ. Base calling and Phred quality scores. Raw data quality assessment using FastQC. Data preprocessing- adapter trimming, quality filtering, and read duplication.
Unit-IV: Genomics and Variant Analysis (6 hours)	Genome assembly approaches- De novo assembly vs. reference-guided assembly. Contigs and scaffolding. Variant calling pipelines- identifying Single Nucleotide Polymorphisms and Insertions/Deletions. The Variant Call Format. Variant annotation and predicting functional impact.
Unit-V: Transcriptomics and Advanced Applications (6 hours)	RNA-Seq workflow and differential gene expression analysis. Functional enrichment analysis. Epigenomics- ChIP-Seq for DNA-protein interactions and Bisulfite sequencing for DNA methylation. Clinical genomics, cancer genomics, and personalized medicine.
Unit-VI: Current Contours (For Continuous Internal Assessment only)	Daily news and research papers on NGS advancements. Public awareness of genomic sequencing in healthcare and data privacy. Computational analysis of sequence data from Web Resources. Collection of metadata about samples and running basic cloud-based NGS pipelines.

Mapping with Programme Specific Outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	PSO9	PSO10
CO1	S	S	M	S	M	M	S	S	S	S
CO2	S	S	M	S	M	M	S	S	S	S
CO3	S	S	M	S	M	M	S	S	S	S
CO4	S	S	M	S	M	M	S	S	S	S
CO5	S	S	M	S	M	M	S	S	S	S

Recommended References:

1. Brown, S. M. (2015). Next-Generation DNA Sequencing Informatics, 2nd Edition. Cold Spring Harbor Laboratory Press. USA.
2. Kieleczawa, J. (2006). DNA Sequencing II: Optimizing Preparation and Cleanup. Jones and Bartlett Publishers. India.
3. Kulski, J. K. (2016). Next Generation Sequencing: Advances, Applications and Challenges. InTech. Croatia.
4. Metzker, M. L. (2010). Sequencing technologies — the next generation. Nature Reviews Genetics, 11(1), 31-46.
5. Wang, Z., Gerstein, M., & Snyder, M. (2009). RNA-Seq: a revolutionary tool for transcriptomics. Nature Reviews Genetics, 10(1), 57-63.

Related Online Contents:

1. http://usegalaxy.org/ (Galaxy Project for web-based data analysis)
2. https://www.coursera.org/learn/genomic-tools (Genomic Data Science Specialization)
3. https://www.ebi.ac.uk/training/online/courses/next-generation-sequencing-practical-course/ (EMBL-EBI NGS Practical Course)

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SKILL ENHANCEMENT COURSE (SEC)
6. ENTREPRENEURIAL MICROBIOLOGY

Course Code	SEC	Course Type	Skill Enhancement Course	L	T	P	C	Syllabus version	2026-2027
				2	-	-	2		
Pre-requisite	Knowledge of entrepreneurial start up programme, cost-benefit analysis and marketing of microbial products								

Course Objectives:

- ✓ Describe the concepts of entrepreneurship and identify the various schemes of entrepreneurial start up programme.
- ✓ Develop the skills in various aspects to promote the success entrepreneur and interpret with business development, market need, goal setting as well as financial opportunities.
- ✓ Analyze the mass production, cost-benefit analysis and marketing of mushroom and SCP.
- ✓ Develop a large scale unit for the production of various biofertilizers and biopesticides and evaluate the marketing strategies and cost-benefit analysis.
- ✓ To understand small, large-scale production and cost benefit analysis.

Expected Course Outcomes:
On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Describe the concepts of entrepreneurship and identify the various schemes of entrepreneurial start up programme.	K1, K2
CO2	Develop the skills in various aspects to promote the success entrepreneur and interpret with business development, market need, goal setting as well as financial opportunities.	K1, K2
CO3	Analyze the mass production, cost-benefit analysis and marketing of mushroom and SCP.	K1 - K3
CO4	Develop a large-scale unit for the production of various bacterial and fungal based biofertilizers and evaluate the marketing strategies and cost-benefit analysis of the biofertilizers.	K3, K4
CO5	Manage the large-scale production, coat-benefit analysis, marketing of agar, dairy products and vermicomposting.	K5, K6
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit-I: Concept of Entrepreneur and Entrepreneurship(9 hours)	Definitions-concept of Entrepreneurship, development. Government and non-Govt. schemes for Entrepreneurship programmes. Structure of a biobased technology, start-up of biobased technology company and biobased business development.
Unit-II: Skills for Entrepreneurs (9 hours)	Communication skills, problem solving skills; Business plan development; Networking and Collaboration: Building partnerships. Market need - distribution, price, promotion and market goal setting. Financial plan - Financial support for business, business insurance. Legal and Ethical Considerations: Bioethics, sustainability.
Unit-III: Bio-industrial Projects (9 hours)	Identification, classification, formulation, appraisal. Small, large-scale production and cost benefit analysis and marketing of edible and medicinal mushroom cultivation-button, Oyster, Single cell protein - Production of Yeast and *Spirulina*. Quality Control, Good Manufacturing Practices, ISO standards.
Unit-IV: Commercial Production of Biofertilizers and Biopesticides (9 hours)	Mass multiplication, production cost analysis, Biofertilizer Formulations and marketing of Cyanobacterial biofertilizer, Bacterial Biofertilizer- *Rhizobium,* Fungal Biofertilizers-VAM. Seaweed liquid biofertilizer, Biopesticides - *Bacillus thuringiensis.*
Unit-V: Commercial Production of Agar, Food and Compost (9 hours)	Small, large-scale production and cost benefit analysis and marketing of agar - *Gellidium* and fermented foods - cheese, pickles and other probiotic food. CompostProduction - Mass production and marketing of compost - Vermicomposting and microbial compost - types of compost pits.
Unit-VI: Current Contours (For Continuous Internal Assessment only):	Entrepreneurship options in Biopharma – Drugs, vaccines, diagnostics; Bioindustries – Biofuels, nutraceuticals, enzymes; Bioagri – Hybrid crops; Bioservices – custom synthesis and manufacturing and contract research; Bioinformatics – data analytics and software and database services. Bioentrepreneurs – Success stories.

Mapping with Programme Specific Outcomes

	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**	**PSO9**	**PSO10**
CO1	S	S	M	S	M	M	S	S	S	S
CO2	S	S	M	S	M	M	S	S	S	S
CO3	S	S	M	S	M	M	S	S	S	S
CO4	S	S	M	S	M	M	S	S	S	S
CO5	S	S	M	S	M	M	S	S	S	S

Recommended References:

1. Nagendra S. (2008). Entrepreneurship and management. Sanguine technical publishers. India.
2. Bhatia, B.S. and G.S Batra. (2003). Entrepreneurship and small business management. Deep and deep publications. India.
3. Naidu, N.V.R. (2008). Management and Entrepreneurship. I.K. International Pvt. Ltd. India.
4. Tilak, K.V.B.R. (1990). Bacterial Biofertilizers. IARI Publications, New Delhi.
5. Sandera, F.E., B. Mosse and P.B. Tinke. (1975). Endomycorrhizae, Academic Press, London.
6. Rao, N.S. (1980). Biofertilizers in Agriculture. Oxford and IBHPublishing Co. Pvt. Ltd., Bombay.
7. Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies Shimasaki, CD (2014) Amsterdam: Elsevier. Europe.
8. Bunn, G.P. 2019. Good manufacturing practices for pharmaceuticals. CRC Press. USA.

Related Online Contents:

1. https://study.com/microbiology_courses.html
2.https://study.com/academy/lesson/what-is-an-entrepreneur-definitioncharacteristics examples.html
3.https://study.com/academy/lesson/institutional-entrepreneurship-theoryexamples.html
4.https://study.com/articles/Fermentation_Microbiologist_Job_Description_Salary _and_Career utlook.html

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