M.Sc. Microbiology Course Structure (CBCS) and Curriculum

ELIGIBILITY CRITERIA:

Eligibility Criteria: Candidates who have passed a B.Sc. degree with Chemistry/ Botany/ Zoology/ Biochemistry/ Microbiology/Biotechnology/ Bio Science and other allied subjects as core/cognate subject with 50 % aggregate for general students and 45 % for SC/ST/OBC/CAT-1 students are eligible for M.Sc. in Microbiology. Additionally, candidates who have Bachelor's degree in Agriculture/Veterinary/Pharmacy/Horticulture/Dairy from any University recognized by UGC and other statutory bodies having Microbiology as one of the core/cognate subjects with 50 % aggregate for general students and 45 % for SC/ST/OBC/CAT-1 students are also eligible for admission to M.Sc. in Microbiology

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Strategic Approach for Programme Curriculum Revision

Over the past decade, Microbiology has grown into a discipline of strategic importance, with daily applications in health, food, agriculture, industry and the environment. Being dynamic and interdisciplinary, it advances rapidly, making periodic curriculum revision essential to keep the M.Sc. Microbiology programme relevant and to foster skill development, entrepreneurship and academic excellence. Effective from 2026–27, this revision follows the Tumkur University postgraduate CBCS regulations. It draws on the DBT model curricula, the latest developments across microbiology, an analysis of student skill gaps and industry requirements, and extensive stakeholder feedback. Accordingly, the programme integrates contemporary, application-oriented courses—including molecular systematics, synthetic microbiology, microbial informatics and systems biology, metagenomics and microbiome science, molecular diagnostics and pandemic biology. A structured Artificial Intelligence (AI) component is embedded in each course to complement core microbiology, and every course is framed on OBE principles with defined outcomes and updated resources.

A non-credit Foundation Course in Microbiology ensures a common base for students from diverse backgrounds, while non-credit value-added courses in Intellectual Property and Patenting, Clinical Research and Data Management, and Innovation and Bio-Entrepreneurship, together with a mid-term Industry Internship, strengthen employability. The eligibility criteria have also been broadened to encourage interdisciplinary participation. Collectively, these revisions prepare graduates with the knowledge, skills and professional competencies needed for careers in academia, research, healthcare, biotechnology, pharmaceuticals and allied life-science sectors.

The pedagogical methods for the Programme will include:

- Face-to-Face Lectures
- Tutorials
- Mentoring
- Group Discussion
- Demonstrations
- Journal Club
- Case Study Analysis
- Virtual Labs and Simulations
- Hands-on Experiments
- Analytical and Computational Problem-Solving Methods
- AI and Data-Driven Learning Tools
- Dry-Lab and Bioinformatics Exercises
- Group Projects
- Mock Interview Skills
- Field and Industrial Visits
- Industry Internship
- Special Lectures and Seminars
- Extension and Enrichment Activities
- Hypothesis-Based Own Experiment Design

PROGRAMME OUTCOMES (POS)

On successful completion of the M.Sc. Microbiology programme, graduates will be able to:

- **PO1: Disciplinary expertise:** Demonstrate advanced knowledge of core and applied microbiology and apply it to scientific and real-world problems.
- **PO2: Research competence:** Design, conduct and report independent, ethical research, developing into researchers of the highest quality.
- **PO3: Critical thinking:** Identify new hypotheses and scientific problems and address them through critical analysis and evidence-based reasoning.
- **PO4: Innovation and entrepreneurship:** Translate scientific knowledge into innovative products, processes and solutions, and pursue bio-entrepreneurial and industry opportunities.
- **PO5: Ethics and societal responsibility:** Uphold research integrity, biosafety and professional ethics, applying microbiology towards health, sustainability and societal welfare.

PROGRAMME SPECIFIC OUTCOMES (PSOS)

On successful completion of the M.Sc. Microbiology programme, graduates will be able to:

- **PSO1: Core microbiology:** Demonstrate in-depth understanding of microbial cell biology, biochemistry, physiology, genetics and molecular systematics.
- **PSO2: Microbial diversity:** Characterize and classify bacteria, archaea, viruses, fungi, algae, protozoa and parasites, and appreciate cultured and uncultured microbial diversity.
- **PSO3: Molecular biology and genetic engineering:** Apply the principles and tools of molecular biology, recombinant DNA technology, genome editing and synthetic biology.
- **PSO4: Laboratory and analytical skills:** Perform conventional, molecular and instrumentation-based techniques for the isolation, characterization and diagnosis of microorganisms, following biosafety norms.
- **PSO5: Computational and data competence:** Apply bioinformatics, omics, systems biology and AI/data-driven tools to analyse and interpret microbiological data.
- **PSO6: Immunology and health:** Apply the principles of immunology, vaccinology, medical microbiology and molecular diagnostics to infectious-disease and healthcare contexts.
- **PSO7: Environmental and agricultural microbiology:** Apply microbial ecology, metagenomics, bioremediation and agricultural microbiology towards sustainability and a One Health perspective.
- **PSO8: Industrial and applied microbiology:** Apply bioprocess technology, and food, dairy and pharmaceutical microbiology to product development and quality management.
- **PSO9: Research and scientific communication:** Design and execute independent research and communicate findings ethically through scientific writing and presentation.
- **PSO10: Innovation and entrepreneurship:** Translate microbiological knowledge into innovative products, diagnostics and bio-entrepreneurial ventures, with awareness of IPR and regulatory practice.

PO–PSO Mapping Matrix

PSO ↓ / PO →	PO1 Disciplinary expertise	PO2 Research competence	PO3 Critical thinking	PO4 Innovation & entrepreneur ship	PO5 Ethics & societal responsibility
PSO1: Core microbiology	3	2	2	1	1
PSO2 : Microbial diversity	3	2	2	1	1
PSO3 : Molecular biology & genetic engineering	3	3	2	2	1
PSO4: Laboratory & analytical skills	3	3	2	2	2
PSO5: Computational & data competence	2	3	3	2	1
PSO6: Immunology & health	3	2	2	2	2
PSO7: Environmental & agricultural microbiology	2	2	2	2	3
PSO8: Industrial & applied microbiology	3	2	2	3	2
PSO9: Research & scientific communication	2	3	3	2	2
PSO10: Innovation & entrepreneurship	2	3	3	3	2
Average	**2.6**	**2.5**	**2.3**	**2.0**	**1.7**

(Correlation: 3 = High, 2 = Moderate, 1 = Low, "–" = no significant correlation)

COURSE STRUCTURE AND CURRICULUM

I SEMSTER

Sl. No	Paper Code	Title of the Paper	Instruction Hours per Week	No. of credits	Duration of the Examination	Marks		
						Internal Assessment	Semester End Exam	Total Marks
1	CPT-1.1	Microbial Cell Biology and Molecular Systematics	4	4	3 h	30	70	100
2	CPT-1.2	Biochemistry and Microbial physiology	4	4	3 h	30	70	100
3	CPT-1.3	Microbial Diversity I: Bacteriology and Virology	4	4	3 h	30	70	100
4	SPT-1.4A	Environmental Microbiology and Microbial Remediation	4	4	3 h	30	70	100
	SPT-1.4B	Food Microbiology	4	4	3 h	30	70	100
5	SEC	Foundations of Microbiology	4	2	3 h	15	35	50
6	CPP-1.5	Practical based on CPT-1.1	4	2	3 h	15	35	50
7	CPP-1.6	Practical based on CPT-1.2	4	2	3 h	15	35	50
8	CPP-1.7	Practical based on CPT-1.3	4	2	3 h	15	35	50
9	SPP-1.8A	Practical based on SPT-1.4A	4	2	3 h	15	35	50
	SPP-1.8B	Practical based on SPT-1.4B	4	2	3 h	15	35	50
		Total	34	26		195	455	650

Note:

CPT: Core paper theory **CPP:** Core paper practical **SEC:** Skill Enhancement Course

SPT: Special paper Theory **SPP:** Special Paper Practical

II SEMSTER

Sl. No	Paper Code	Title of the Paper	Instruction Hours per Week	No. of credits	Duration of the Examination	Marks		
						Internal Assessment	Semester End Exam	Total Marks
1	CPT-2.1	Molecular Biology and Genetic Engineering	4	4	3 h	30	70	100
2	CPT-2.2	Microbial Diversity II: Mycology, Phycology, Protozoology and Parasitology	4	4	3 h	30	70	100
3	SPT-2.3A	Agriculture Microbiology and Molecular Plant Pathology	4	4	3 h	30	70	100
	SPT-2.3B	Synthetic Microbiology and Nanotechnology	4	4	3 h	30	70	100
4	OEPT-2.4	Exploratory Microbiology	4	4	3 h	30	70	100
5	SEC	Intellectual Property and Patenting in Lifesciences	4	2	3 h	15	30	50
6	CPP-2.5	Practical based on CPT-2.1	4	2	3 h	15	35	50
7	CPP-2.6	Practical based on CPT-2.2	4	2	3 h	15	35	50
8	SPP-2.7A	Practical based on SPT-2.3A	4	2	3 h	15	35	50
	SPP-2.7B	Practical based on SPT-2.3B	4	2	3 h	15	35	50
9	OEPP-2.8	Practical based on OEPT-2.4	4	2	3 h	15	35	50
		Total	34	26		195	455	650
Mid-term Industry Internship								

Note:

CPT: Core paper theory **CPP:** Core paper practical **SEC:** Skill Enhancement Course

SPT: Special paper Theory **SPP:** Special Paper Practical

OEPT: Open Elective paper theory **OEPP:** Open Elective Paper Practical

III SEMSTER

Sl. No	Paper Code	Title of the Paper	Instruction Hours per Week	No. of credits	Duration of the Examination	Marks		
						Internal Assessment	Semester End Exam	Total Marks
1	CPT-3.1	Immunology and Vaccine Biology	4	4	3 h	30	70	100
2	CPT-3.2	Microbial Informatics and systems biology	4	4	3 h	30	70	100
3	SPT-3.3A	Medical Microbiology and pandemic biology	4	4	3 h	30	70	100
	SPT-3.3B	Microbial ecology and Metagenomics	4	4	3 h	30	70	100
4	OEPT-3.4	Microbial applications and sustainability	4	4	3 h	30	70	100
5	SEC	Clinical Research and data management	4	2	3 h	15	35	50
6	CPP-3.5	Practical based on CPT-3.1	4	2	3 h	15	35	50
7	CPP-3.6	Practical based on CPT-3.2	4	2	3 h	15	35	50
8	SPP-3.7A	Practical based on SPT-3.3A	4	2	3 h	15	35	50
	SPP-3.7B	Practical based on SPT-3.3B	4	2	3 h	15	35	50
9	OEPP-3.8	Practical based on OEPT-3.4	4	2	3 h	15	35	50
		Total	34	26		195	455	650

Note:

CPT: Core paper theory **CPP:** Core paper practical **SEC:** Skill Enhancement Course

SPT: Special paper Theory **SPP:** Special Paper Practical

OEPT: Open Elective paper theory **OEPP:** Open Elective Paper Practical

IV SEMSTER

Sl. No	Paper Code	Title of the Paper	Instruction Hours per Week	No. of credits	Duration of the Examination	Marks		
						Internal Assessment	Semester End Exam	Total Marks
1	CPT-4.1	Bioprocess Technology	4	4	3 h	30	70	100
2	CPT-4.2	Research Methodology, Scientific Communications and Biostatistics	4	4	3 h	30	70	100
3	SPT-4.3A	Pharmaceutical Microbiology	4	4	3 h	30	70	100
	SPT-4.3B	Dairy Microbiology and Microbial product development	4	4	3 h	30	70	100
4	CPPD-4.4	Project Dissertation	4	4	3 h	30	70	100
5	SEC	Innovation and Bio-Entrepreneurship	4	2	3 h	15	35	50
6	CPP-4.5	Practical based on CPT-4.1	4	2	3 h	15	35	50
7	CPP-4.6	Practical based on CPT-4.2	4	2	3 h	15	35	50
8	SPP-4.7A	Practical based on SPT-4.3A	4	2	3 h	15	35	50
	SPP-4.7B	Practical based on SPT-4.3B	4	2	3 h	15	35	50
9	CPPP-4.8	Practical's Based on Project	4	2	3 h	15	35	50
		Total	32	24		180	420	600

Note:

CPT: Core paper theory **CPP:** Core paper practical **SEC:** Skill Enhancement Course

SPT: Special paper theory **SPP:** Special paper practical

CPPD: Core paper project Dissertation **CPPP:** Core paper project practical

Every theory paper carries 64 hours of teaching, with each of its four units taught over 16 hours. For the practical papers (CPP/SPP), the number of experiments may vary from semester to semester. A core set of common experiments is retained for each CPP/SPP paper, while up to 50% of the experiments may be changed in number and nature. Such changes are made at the start of each semester, following a review of recent research articles and the availability of laboratory kits, consumables, protocols and virtual demonstration tools.

I SEMESTER

CPT-1.1 MICROBIAL CELL BIOLOGY AND MOLECULAR SYSTEMATICS

Course Objectives:

The objectives of this course are to introduce the students to:

- The ultrastructure and functional organization of prokaryotic, archaeal and eukaryotic microbial cells.
- Mechanisms of membrane transport, cell division, signalling and cellular dynamics in microorganisms.
- Principles and techniques of microscopy, staining and cytometry for the study of microbial cells.
- Modern molecular and genome-based approaches to microbial classification, identification and phylogeny.

Course Outcomes:

At the end of the course, students should be able to:

- Describe the morphology and ultrastructure of prokaryotic, archaeal and eukaryotic cells and relate structure to function.
- Explain membrane transport, cell-cycle regulation and signalling across microbial groups.
- Apply staining, microscopy and flow-cytometric methods to examine and differentiate microbial cells.
- Analyse microbial phylogeny using molecular markers and genome-based methods.
- Evaluate modern taxonomic frameworks (polyphasic, ANI/GTDB, MALDI-TOF) for classifying and identifying microbes.

Unit I

Prokaryotic and Archaeal Cell Architecture

Shape, size and arrangement of bacterial cells; cell envelope of Gram-positive and Gram-negative bacteria — peptidoglycan, teichoic and lipoteichoic acids, outer membrane, lipopolysaccharide, lipoproteins and periplasmic space; archaeal envelopes — pseudomurein, S-layers and ether-linked lipids. Capsule and slime layer; plasma membrane and the fluid-mosaic model (mesosomes as artefacts). Flagella and motility, pili and fimbriae, and chemotaxis. Nucleoid, plasmids, ribosomes, chaperones and inclusions (gas vesicles, magnetosomes, carboxysomes, chlorosomes, phycobilisomes); endospores — structure, sporulation and germination. Bacterial cytoskeleton (FtsZ, MreB, crescentin) and cell-shape control; microcompartments as metabolic organelles; the envelope as an antibiotic target and its link to resistance; cryo-EM and cryo-tomography of the envelope. AI/ML classification of bacterial morphology from micrographs.

Unit II

Eukaryotic Microbial Cell and Cell Cycle

Organisation of the eukaryotic microbial cell; endomembrane system — ER, Golgi, lysosomes, peroxisomes and ribosomes; mitochondria and chloroplasts, their genetic organisation and endosymbiotic origin; nucleus, nucleolus and chromatin. Cytoskeleton and motility; protein trafficking, sorting and secretion. Cell-cycle regulation by cyclins and CDKs; mitosis, meiosis and cytokinesis; cell-cycle analysis by FACS; signalling and cell junctions. Programmed cell death and autophagy in microbial eukaryotes; comparative cell biology of yeast and protozoan models; single-cell approaches. Machine-learning classification of cell-cycle stages from flow-cytometry and imaging data.

Unit III

Membrane Transport and Cellular Dynamics

Membrane composition, architecture, fluidity and dynamics; solute movement — passive and facilitated diffusion, osmosis and aquaporins; primary active transport by P-, F-, V- and ABC-type ATPases; the proton-motive force in transport. Secondary transport — symport, antiport and uniport — and group translocation (phosphotransferase system); ion pumps; iron acquisition and siderophores; endocytosis, exocytosis and transcytosis; mitochondrial shuttles; liposomes. Transporters and efflux pumps in antimicrobial resistance; nutrient sensing and transport regulation; transporters as drug targets; lipid adaptations in extremophiles; nano-carriers for drug delivery. In-silico prediction of transporter proteins and substrate specificity by machine learning.

Unit IV

Molecular Microbial Systematics

Definitions of taxonomy, systematics, nomenclature and phylogeny; rules of nomenclature and hierarchy; classification schemes — Haeckel's three-kingdom and Whittaker's five-kingdom leading to Woese's three-domain system — and the prokaryotic species concept. Polyphasic taxonomy — morphological, physiological, metabolic and chemotaxonomic characters (FAME, cell-wall composition) with molecular characters — G+C ratio, DNA–DNA hybridisation, protein comparison, 16S rRNA and ITS sequencing and MLSA; significance of rRNA. Genome-based taxonomy — average nucleotide identity, digital DNA–DNA hybridisation, core-genome phylogeny and GTDB; MALDI-TOF identification; uncultured taxa via metagenome-assembled genomes; candidate phyla radiation and the reshaping of the tree of life. AI-assisted phylogenetic inference and taxonomic classification.

CPT-1.2 BIOCHEMISTRY AND MICROBIAL PHYSIOLOGY

Course Objectives:

The objectives of this course are to introduce the students to:

- The structure, classification and functions of biomolecules and the properties of enzymes.
- The principles of bioenergetics and the diverse energy-yielding pathways of microorganisms.
- Microbial nutrition, growth kinetics and physiological adaptation to the environment.
- Regulation of microbial metabolism and the analytical techniques used to study biomolecules and metabolites.

Course Outcomes:

At the end of the course, students should be able to:

- Describe the structure–function relationships of biomolecules and the kinetics and regulation of enzymes.
- Explain microbial bioenergetics, respiration, photosynthesis and diverse energy metabolism.
- Analyse central and peripheral metabolic pathways and their regulation.
- Apply analytical and enzyme-kinetic methods to characterise biomolecules and metabolites.
- Evaluate microbial physiological and stress adaptations and their applied significance.

Unit I

Biomolecules and Enzymology

Carbohydrates — general properties, structure, classification and functions. Lipids — classification, structure, properties and functions. Proteins — structure (primary, secondary, tertiary and quaternary); chemical and Merrifield solid-phase peptide synthesis. Nucleic acids — structure of DNA and RNA and their importance in the evolution of DNA as the genetic material; prokaryotic and eukaryotic ribosomes. Enzymes — IUBMB classification and nomenclature; chemical nature and properties; active site, allosteric site, coenzymes and cofactors; types of enzyme specificity and units of enzyme activity; mechanism of enzyme action — lock-and-key model, induced-fit hypothesis and substrate-strain theory; mechanisms of catalysis — acid–base and covalent catalysis; chemical kinetics, derivation of the Michaelis–Menten equation, K_m and V_{max} and their significance, Lineweaver–Burk plot; first- and second-order reaction kinetics; enzyme inhibition — reversible and irreversible; regulation of enzyme activity; isozymes, ribozymes, abzymes and extremozymes. Enzyme engineering (directed evolution and rational design) and immobilisation; industrial and diagnostic enzymes; enzymes as drug targets and biosensor elements. AI-based enzyme-function and EC-number prediction and the use of AlphaFold structures for active-site and substrate analysis.

Unit II

Microbial Bioenergetics and Central Metabolism

Laws of thermodynamics; concept of free energy; standard free energy, enthalpy, entropy and the equilibrium constant; determination of ΔG for a reaction; relationship between the equilibrium constant and standard free-energy change; ATP as the universal currency of free energy; redox potentials and electron carriers. Glycolysis, the pentose-phosphate pathway and the Entner–Doudoroff pathway; the TCA cycle; gluconeogenesis. Electron transport and its carriers (Complexes I–IV); determination of the P:O ratio; ATP synthesis by F_1F_0-ATP synthase; chemiosmosis. Anaerobic respiration and diverse terminal electron acceptors; anoxygenic and oxygenic photosynthesis; bacteriorhodopsin — photocycle and significance; chemolithotrophy; energy conservation in methanogens; differences in energy metabolism across microbial groups. Genome-scale metabolic reconstruction; constraint-based and flux-balance analysis and AI-assisted prediction of metabolic fluxes from genome-scale models.

Unit III

Microbial Nutrition, Growth and Physiology

Nutritional requirements and nutritional types of microorganisms; growth factors; uptake of nutrients by the microbial cell; microbial culture media and their types. Microbial growth — the growth curve, generation time and the mathematical expression of growth; measurement of microbial growth by cell number, turbidity and biomass; diauxic growth; continuous culture (chemostat and turbidostat); influence of temperature, pH, water activity and oxygen on growth; the Crabtree effect; introduction to quorum sensing. Stress physiology — heat, cold, osmotic and oxidative stress; sigma factors and the stringent response; sporulation and dormancy; the viable-but-non-culturable state; biofilm physiology; persister cells and antibiotic tolerance and their relevance to antimicrobial resistance. AI/ML-based predictive microbiology for modelling and forecasting microbial growth under varying conditions.

Unit IV

Metabolic Regulation and Analytical Techniques

Principles of metabolic regulation — feedback inhibition, induction and repression; catabolite repression; two-component signal-transduction systems; nitrogen and phosphate regulation; regulation of secondary metabolism; global regulatory networks; introduction to fluxomics and metabolomics. Analytical techniques — principles and applications of chromatography (TLC, column, ion-exchange, affinity, gas chromatography and HPLC); electrophoresis (agarose and PAGE); spectroscopy (UV/visible, fluorescence, infrared, X-ray diffraction, NMR, ESR and mass spectrometry); autoradiography; calorimetry; protein-purification methods; centrifugation — types and importance. AI/ML in metabolomics data processing and pathway-enrichment analysis.

CPT-1.3 MICROBIAL DIVERSITY I: BACTERIOLOGY AND VIROLOGY

Course Objectives:

The objectives of this course are to introduce the students to:

- The diversity, classification, structure and physiology of major groups of bacteria and archaea.
- Analytical, microscopic and molecular techniques for the study and safe handling of bacteria.
- The structure, classification and replication of animal, plant and bacterial viruses.
- Methods for the cultivation, assay and molecular diagnosis of viruses, and the applied significance of phages and antivirals.

Course Outcomes:

At the end of the course, students should be able to:

- Describe the classification, structure and physiology of major bacterial and archaeal groups.
- Apply culture, microscopy and molecular methods to characterise bacteria safely.
- Explain the structure, classification and replication of viruses.
- Apply virological methods — cultivation, assay, serology and molecular diagnostics.
- Analyse host–microbe interactions, emerging pathogens and antimicrobial resistance.

Unit I

Bacterial and Archaeal Diversity

History of bacteriology and the position of bacteria in the living world; occurrence, shape, arrangement and general characteristics of bacterial cells. Approaches to bacterial classification — morphological, phenotypic, genotypic and numerical; nomenclature; Bergey's Manual and genome-based taxonomy. Characteristics, classification, ultrastructure, reproduction and economic importance of Eubacteria, Actinobacteria, Cyanobacteria, Mycoplasma, Rickettsia, Chlamydia, photosynthetic, bioluminescent bacteria and extremophiles; Archaea — general features and major groups (methanogens, halophiles, thermophiles). Ecological distribution and introduction to microbiomes; culturomics and the unculturable majority; candidate phyla radiation; metagenomic view of diversity; bacteria as reservoirs of antimicrobial resistance. AI-assisted taxonomic assignment and machine-learning classification from sequence data.

Unit II

Analytical Bacteriology

Microscopy — bright-field, dark-field, phase-contrast, fluorescence and confocal; electron microscopy — TEM, SEM, STEM and AFM. Isolation, cultivation and preservation of bacteria; culture media; growth kinetics, continuous culture and measurement of growth; nutritional classification and nutrient transport. Simple, differential and structural staining; sterilisation and disinfection; biosafety, biosecurity, biosafety levels (BSL-1 to BSL-4) and good microbiological practice. Cryo-EM and cryo-tomography; flow cytometry and cell sorting; single-cell genomics;

MALDI-TOF identification; culture-independent detection. Automated colony counting, image-based identification and AI-assisted reading of antimicrobial-susceptibility tests.

Unit III

General and Molecular Virology

History and distinctive properties of viruses; host range, tissue tropism and transmission; chemical composition; morphology and ultrastructure — capsid symmetry and envelopes; genome organisation. ICTV nomenclature and Baltimore classification; replication strategies of representative families; bacteriophages (lytic and lysogenic), archaeal, plant, animal and giant viruses, viroids and prions. Emerging and re-emerging viruses; viral evolution — mutation, recombination, reassortment, antigenic drift and shift; quasispecies; viromics and the virome; oncolytic viruses; SARS-CoV-2 as a case study. AI-assisted comparative analysis of viral genomes and variant/lineage assignment for surveillance.

Unit IV

Analytical and Applied Virology

Cultivation of viruses in embryonated eggs, laboratory animals and cell cultures (primary, diploid, continuous and organoid systems); virus identification. Assay — plaque assay, $TCID_{50}$, haemagglutination, physical and biological assays; serology — ELISA, neutralisation, immunofluorescence and western blot; viral databases. Molecular diagnostics — RT-qPCR, digital PCR, LAMP, next-generation sequencing, metaviromics and CRISPR-based detection (SHERLOCK/DETECTR). Phage therapy and phage display; CRISPR–Cas systems and virus–host interactions; antivirals and vaccine linkage; laboratory biosafety and biosecurity. AI/ML in viral genome annotation, phylogenetics, outbreak prediction and genomic epidemiology.

SPT-1.3A ENVIRONMENTAL MICROBIOLOGY AND MICROBIAL REMEDIATION

Course Objectives:

The objectives of this course are to introduce the students to:

- The distribution, diversity and ecological roles of microorganisms in air, soil and aquatic environments.
- Biogeochemical cycling and the role of microorganisms in maintaining environmental balance.
- The principles and practices of bioremediation and the microbial treatment of wastes and pollutants.
- Modern molecular, omics and biotechnological approaches to environmental monitoring and remediation.

Course Outcomes:

At the end of the course, students should be able to:

- Describe the distribution and ecological functions of microorganisms in different environments.
- Explain biogeochemical cycles and the microbial contribution to environmental sustainability.
- Apply bioremediation and waste-treatment technologies to environmental problems.
- Analyse microbial communities using molecular and metagenomic tools.
- Evaluate emerging strategies such as microbial fuel cells, biosensors and engineered bioremediation.

Unit I

Microorganisms in the Environment

Air microbiology — factors affecting air spora; important airborne microorganisms and toxins; techniques for sampling airborne microorganisms (vertical cylinder, Rotorod, Burkard and Andersen samplers, filtration, electrostatic and thermal precipitation, impingement, gravitational settling); air sanitation. Soil microbiology — characteristics and classification of soil; the soil microbiome; microbial interactions (mutualism, commensalism, amensalism, synergism, parasitism, predation, competition); the rhizosphere and beneficial soil microflora; geomicrobiology. Aquatic microbiology — distribution of microorganisms in freshwater and marine ecosystems (estuaries, mangroves, deep sea, hydrothermal vents, salt pans, coral reefs); zonation of aquatic ecosystems; biofilms — types, mechanism and significance. Metagenomic and single-cell approaches to environmental diversity; AI/ML analysis of environmental-microbiome data.

Unit II

Biogeochemical Cycles and Microbial Interactions

Biogeochemical cycling of carbon, hydrogen, nitrogen, phosphorus, sulphur, iron and manganese; detrimental effects of disrupted cycles. Biological nitrogen fixation — symbiotic, asymbiotic and associative; structure, function and genetic regulation of nitrogenases; viable but non-culturable microorganisms. Water pollution — sources, biological indicators and source tracking of aquatic pollutants; determination of the sanitary quality of water; microbial assessment of potable water; advances in potable-water purification. Wastewater microbiology — primary, secondary and tertiary treatment and reclamation. Molecular tools for monitoring functional genes and microbial activity; AI-based water-quality prediction and environmental-monitoring models.

Unit III

Bioremediation and Pollution Control

Principles and types of bioremediation — in-situ and ex-situ methods, biostimulation and bioaugmentation. Microbial degradation of pollutants — pesticides, xenobiotics, hydrocarbons, lignin, cellulose and pectin. Biosorption, bioaccumulation and biomagnification of heavy metals; microbes in metal extraction, mineral leaching and mining; microbial enhanced oil recovery. Treatment of solid and liquid industrial wastes; composting and landfill microbiology. Degradation of emerging contaminants (pharmaceuticals, microplastics) and plastic-degrading microbes and enzymes; genetically engineered microorganisms for bioremediation and associated biosafety considerations. AI in the prediction of biodegradation pathways and the design of remediation strategies.

Unit IV

Microbes in Environmental Sustainability and Bioenergy

Role of microbiology in achieving a sustainable environment; global environmental problems — global warming, acid rain and ozone depletion — and the microbial dimension of climate change. Microbial fuel cells and bioelectrochemical systems; biohydrogen, biogas and biofuel production; biofertilizers and biopesticides for sustainable ecosystems; biodegradable polymers and bioplastics from microorganisms. Microbial biosensors for pollutant detection; the circular bioeconomy and waste valorisation; alignment of environmental microbiology with the Sustainable Development Goals. AI and biosensor integration for real-time environmental sensing and management.

SPT-1.4B FOOD MICROBIOLOGY

Course Objectives:

The objectives of this course are to introduce the students to:

- The microorganisms important in foods and the intrinsic and extrinsic factors governing their growth.
- The principles and technologies of food preservation and fermentation.
- Food spoilage, foodborne pathogens and the investigation of foodborne outbreaks.
- Food-safety management systems, rapid detection methods and national and international regulatory standards.

Course Outcomes:

At the end of the course, students should be able to:

- Describe the microorganisms important in foods and the factors governing their growth.
- Apply preservation and fermentation technologies to food systems.
- Analyse food spoilage, foodborne pathogens and outbreaks.
- Apply food-safety management systems, standards and rapid detection methods.
- Evaluate emerging trends such as probiotics, the food microbiome and novel foods.

Unit I

Fundamentals of Food Microbiology

History and scope of food microbiology and its relevance to everyday life; primary sources and types of microorganisms in foods; food as a microbial substrate; general food composition and the effect of food constituents — carbohydrates, proteins, lipids, vitamins, minerals and water (forms of water and water activity) — on quality and preservation. Intrinsic factors (water activity, pH, redox potential, nutrient content, antimicrobial constituents) and extrinsic factors (temperature, relative humidity, gaseous atmosphere) influencing microbial growth in foods; basics of predictive microbiology. Stress responses of foodborne microorganisms; biofilms in food-processing environments; the food microbiome and metagenomics of fermented foods. Machine-learning predictive models for microbial growth and shelf-life estimation.

Unit II

Food Spoilage and Foodborne Diseases

Concepts of food spoilage; indicator organisms and microbiological criteria; contamination, preservation and spoilage of milk, meat, poultry, fish, fruits and vegetables, canned foods and bakery products. Foodborne infections and intoxications — Salmonella, Listeria monocytogenes, Escherichia coli O157:H7, Campylobacter, Staphylococcus aureus, Clostridium botulinum and norovirus; symptoms, sources and control; mycotoxins and their control. Emerging foodborne pathogens and antimicrobial resistance in the food chain (One Health perspective); whole-genome sequencing in outbreak tracing (GenomeTrakr/PulseNet). AI in outbreak detection, traceability and the genomic epidemiology of foodborne pathogens.

Unit III

Food Preservation and Fermentation Technology

Principles of food preservation. Thermal methods — pasteurisation, sterilisation, canning and retorting; low-temperature preservation (chilling and freezing); dehydration; chemical and bio-preservation; irradiation; traditional methods (salting, syruping, pickling); hurdle technology. Non-thermal processing — high-pressure processing, pulsed electric field, cold plasma and modified-atmosphere packaging; membrane processes (microfiltration, ultrafiltration, nanofiltration and reverse osmosis). Fermented foods and starter cultures (dairy, vegetable, cereal and beverage fermentations); probiotics, prebiotics, synbiotics and postbiotics; single-cell protein; precision fermentation and cultured/alternative proteins. AI-guided fermentation monitoring and starter-culture and process optimisation.

Unit IV

Food Safety, Quality and Regulation

Food-safety concepts and microbiological criteria; relevance of microbial standards for food safety. Hazard Analysis and Critical Control Points (HACCP), Good Manufacturing Practices and Good Hygiene Practices; food-quality analysis; sampling and rapid detection methods — ELISA, PCR/qPCR, biosensors and lateral-flow assays. Regulatory frameworks — FSSAI, Codex Alimentarius, ICMSF, ISO 22000, FAO, WHO, FDA and USDA; national and international food-testing laboratories; nanotechnology and smart/active packaging; blockchain-based traceability; safety assessment of novel foods. AI/ML and computer vision in food-quality inspection and safety compliance.

II SEMESTER

CPT-2.1 MOLECULAR BIOLOGY AND GENETIC ENGINEERING

Course Objectives:

The objectives of this course are to introduce the students to:

- The organization of genomes and the molecular mechanisms of replication, transcription and translation.
- The regulation of gene expression and the principles of epigenetics in prokaryotes and eukaryotes.
- The tools, vectors and techniques of genetic engineering and recombinant DNA technology.
- Modern genome-editing, sequencing and gene-manipulation approaches and their research and industrial applications.

Course Outcomes:

At the end of the course, students should be able to:

- Explain genome organization and the molecular processes of replication, transcription and translation.
- Describe the regulation of gene expression and epigenetic mechanisms.
- Apply the enzymes, vectors and techniques used in recombinant DNA technology.
- Analyse genome-editing and sequencing strategies for research and industrial problems.
- Evaluate the applications and ethical implications of genetic engineering.

Unit I

Genome Organization and Molecular Processes

History and scope of molecular genetics; organisation of viral, prokaryotic and eukaryotic genomes; genome organisation in mitochondria and chloroplasts; the gene concept and units of function. Structure of chromatin, the nucleosome, chromatin organisation and remodelling; higher-order organisation — chromosome, centromere and telomere; histones and their effect on chromatin structure and function; extrachromosomal genetic elements (plasmids and transposons). DNA replication in prokaryotes and eukaryotes (Meselson–Stahl experiment, enzymes and mechanism); transcription and its regulation, including transcription factors; post-transcriptional modifications — nuclear splicing and rRNA/tRNA processing; translation in prokaryotes and eukaryotes and post-translational modification. Recombination — homologous and site-specific recombination, the Holliday junction, non-homologous end joining and the proteins involved (RecA, RuvABC).

Unit II

Regulation of Gene Expression and Epigenetics

Principles of gene regulation in prokaryotes — the operon concept; positive and negative regulation; the lac, trp and ara operons; attenuation; catabolite repression; the stringent response; riboswitches.

Regulation in eukaryotes — promoters and enhancers, transcription factors, chromatin-level control and RNA processing. Epigenetics — DNA methylation, histone modifications and chromatin remodelling; non-coding and regulatory RNAs — small RNAs, microRNA and small interfering RNA; RNA interference and gene silencing; CRISPR interference (CRISPRi) and activation (CRISPRa) as tools for gene regulation. Single-cell transcriptomics for the study of gene expression. AI/ML prediction of promoters, regulatory elements and gene-expression patterns from sequence data.

Unit III

Tools and Vectors of Genetic Engineering

General requirements for a genetic-engineering experiment; restriction endonucleases and methylases; DNA ligase, Klenow fragment, T4 DNA polymerase, polynucleotide kinase and alkaline phosphatase; cohesive- and blunt-end ligation; linkers, adaptors and homopolymeric tailing; labelling of DNA (nick translation, random priming; radioactive and non-radioactive probes); hybridisation techniques — Southern, northern, colony and fluorescence in-situ hybridisation; determination of stringency. Cloning vectors — plasmids (pBR322, pUC19), Ti and Ri plasmids, bacteriophage, cosmid, phagemid, shuttle and expression vectors; artificial chromosomes (BAC, YAC) and baculovirus and yeast (Pichia) systems; isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; construction and screening of cDNA and genomic libraries; chromosome walking. AI-assisted vector design and codon optimisation for cloning and expression.

Unit IV

Genome Editing, Sequencing and Applications

Introduction of foreign DNA into host cells — direct and indirect gene-transfer methods; screening and selection of recombinants; the polymerase chain reaction — principles, primer design, types and applications; DNA fingerprinting; DNA markers (RFLP, RAPD, AFLP, SSR and SNP). DNA sequencing — enzymatic (Sanger) and automated sequencing and an introduction to next-generation and third-generation (long-read) platforms; RNA sequencing; microarrays; study of protein–DNA interactions (electrophoretic mobility-shift assay, DNase footprinting, chromatin immunoprecipitation). Genome-editing tools — zinc-finger nucleases, TALENs and CRISPR-Cas systems (Cas9 and base/prime editing); applications of recombinant DNA technology in medicine, industry and agriculture; biosafety, bioethics and regulatory aspects of genetic engineering. AI in guide-RNA design, off-target prediction and sequence analysis.

CPT-2.2 MICROBIAL DIVERSITY II: MYCOLOGY, PHYCOLOGY, PROTOZOOLOGY AND PARASITOLOGY

Course Objectives:

The objectives of this course are to introduce the students to:

- The diversity, structure, reproduction and classification of fungi and algae.
- The biology, classification and economic importance of protozoa and parasites of medical significance.
- Modern molecular, genomic and imaging approaches to the study of eukaryotic microorganisms.
- The applied importance of fungi, algae, protozoa and parasites in health, industry and the environment.

Course Outcomes:

At the end of the course, students should be able to:

- Describe the structure, reproduction and classification of fungi and algae.
- Explain the biology, life cycles and pathogenicity of medically important protozoa and parasites.
- Apply molecular and genomic methods to the identification of eukaryotic microorganisms.
- Analyse the economic, ecological and clinical significance of these groups.
- Evaluate emerging developments such as fungal genomics, algal biotechnology and parasite diagnostics.

Unit I

Mycology

History and scope of mycology; general characteristics, distribution and ultrastructure of fungal cells; nutrition in fungi; reproduction — vegetative, asexual and sexual; fungal spores and fruiting bodies; fungal interactions with other organisms, including mycorrhizae and endophytes. Classification and life cycles of Oomycota, Zygomycota (Mucoromycota), Ascomycota, Basidiomycota and Deuteromycota; molecular phylogeny and ITS-based identification. Medical, agricultural and industrial importance of fungi; mycotoxins; emerging fungal pathogens and antifungal resistance (Candida auris case study); fungal genomics and the mycobiome. AI-assisted identification of fungi from microscopic and colony images.

Unit II

Phycology

History and scope of phycology; general characteristics, distribution and classification of algae; morphology, ultrastructure and photosynthetic pigments; reproduction in algae; biology of the cyanophycean cell; differences between micro- and macro-algae; symbiotic associations — lichens, coral reefs and sea sponges. Economic and ecological importance — primary productivity, carbon sequestration, wastewater treatment, biofertilizers, food and pharmaceuticals; algal biotechnology — biomass, pigments, biofuels and high-value products; cultivation systems (open ponds and photobioreactors); harmful algal blooms; molecular and metagenomic approaches to algal diversity. AI and remote-sensing approaches to algal-bloom detection and monitoring.

Unit III

Protozoology

Salient features, diversity and classification of protozoa; morphology, ultrastructure and locomotory and feeding mechanisms. Reproduction — asexual (binary and multiple fission, schizogony, sporogony, plasmotomy) and sexual (conjugation, syngamy, autogamy, paedogamy); polymorphism and adaptive strategies; nutrition and life cycles. Free-living and symbiotic protozoa; ecological roles in aquatic, soil and rumen environments; economic and medical importance. Molecular systematics of protozoa; genomics of parasitic protists; introduction to apicomplexan biology (Plasmodium as a model). AI-assisted image-based identification of protozoan parasites in clinical samples.

Unit IV

Parasitology

General characters, systematics, transmission, pathogenicity, diagnosis, epidemiology and control of medically important parasites. Flagellates and amoebae — *Giardia intestinalis, Entamoeba histolytica, Trypanosoma, Leishmania* and *Toxoplasma gondii.* Trematodes and cestodes — *Fasciola, Paragonimus, Schistosoma, Taenia, Diphyllobothrium* and *Echinococcus*. Nematodes — *Ascaris, Wuchereria bancrofti, Trichinella* and *Dracunculus*. Plasmodium and apicomplexan biology, life cycle and phylogeny; host–parasite interactions and immune evasion; zoonoses and the One Health approach. Molecular diagnosis (PCR, LAMP, antigen-based rapid tests); parasite genomics; antiparasitic drug resistance; vaccine development. AI/ML in parasite diagnosis and in outbreak and vector-distribution modelling.

SPT-2.4A AGRICULTURE MICROBIOLOGY AND MOLECULAR PLANT PATHOLOGY

Course Objectives:

The objectives of this course are to introduce the students to:

- The composition and diversity of soil microbial communities and beneficial plant–microbe interactions.
- The production, formulation and application of biofertilizers, biopesticides and microbial inoculants.
- The principles of plant pathology, disease epidemiology and integrated disease management.

- Molecular plant–microbe interactions and modern biotechnological approaches to crop protection.

Course Outcomes:

At the end of the course, students should be able to:

- Describe soil microbial communities and beneficial plant–microbe interactions.
- Apply biofertilizer, biopesticide and PGPR technologies for crop production.
- Analyse plant-disease cycles, epidemiology and molecular plant–pathogen interactions.
- Evaluate omics-based and biocontrol strategies for plant-disease management.
- Apply molecular diagnostics and genome-editing approaches for crop protection.

Unit I

Soil Microbiology and Plant–Microbe Interactions

Composition of soil and the soil profile; physical, chemical and biological properties; distribution, diversity and biomass of soil microorganisms and factors affecting soil microflora; role of microbes in soil fertility. Plant–microbe interactions — rhizosphere, rhizoplane, phyllosphere, endosphere and spermosphere; root exudates; plant-growth-promoting rhizobacteria and fungi; mycorrhizae, endophytes and phosphate-solubilising microbes; biofilms and quorum sensing. Biogeochemical cycling and biological nitrogen fixation (symbiotic, asymbiotic, associative); structure, function and regulation of nitrogenases. The plant microbiome and holobiont concept; synthetic microbial communities (SynComs); soil metagenomics; microbiome-based approaches for sustainable and regenerative agriculture. AI/ML analysis of soil-microbiome data, crop-yield prediction and sensor-plus-AI precision agriculture.

Unit II

Bioinoculant, Biofertilizer and Biopesticide Technology

Concept, types and benefits of biofertilizers and biopesticides; screening and selection of potential strains. Mass production of Rhizobium, Azotobacter, Azospirillum, Frankia, phosphate-solubilising bacteria, cyanobacteria and Azolla and fungal biofertilizers; formulation, carrier-based inoculants, quality control and shelf-life; green manure, composting and vermicomposting. Biopesticides — Bacillus thuringiensis, Trichoderma, Beauveria bassiana and nuclear polyhedrosis virus; organic farming and soil fertility. Microbial consortia and carrier innovations (nano-formulation and encapsulation); Bt transgenics and RNAi-based crop protection; microbial biostimulants; regulatory and commercialisation aspects (CIB&RC, Fertilizer Control Order). AI in strain selection, formulation optimisation and shelf-life modelling.

Unit III

Plant Pathology and Epidemiology

Parasitism and disease development; pathogenicity; the disease triangle; the disease/infection cycle. Epidemiology and management of representative bacterial diseases (citrus canker, bacterial wilt, fire blight, potato scab), fungal diseases (rice blast, wheat stem rust, potato late blight, downy mildews, Fusarium wilt of tomato) and viral diseases (TMV, cucumber mosaic virus, tomato spotted wilt virus, banana bunchy top, papaya ring spot); role of viroids, phytoplasmas, oomycetes and nematodes. Emerging and re-emerging plant diseases and the effect of climate change; disease forecasting; integrated disease and pest management; quarantine; phytobiome-based disease management. Deep-learning image-based plant-disease diagnosis and AI forecasting models.

Unit IV

Molecular Plant–Microbe Interactions and Crop Protection

Mechanical forces, microbial enzymes and toxins in pathogenesis; pre-existing and induced structural and biochemical defences. Pattern-triggered and effector-triggered immunity (the zig-zag model); pathogen effectors; resistance (R) genes and pathogenesis-related proteins; defence signalling through salicylic acid, jasmonate and ethylene; systemic acquired and induced systemic resistance. Molecular diagnosis of pathogens — microscopy, ELISA, PCR, multiplex PCR, qPCR, LAMP, RPA, CRISPR-based detection, DNA barcoding and next-generation sequencing; molecular epidemiology, molecular markers, seed-health testing and certification. Marker-assisted selection; CRISPR genome-editing for disease resistance; pathogenomics, effectoromics, RNA interference and spray-induced gene silencing. AI in host–pathogen interactome prediction and resistance-gene mining.

SPT-2.3B SYNTHETIC MICROBIOLOGY AND NANOTECHNOLOGY

Course Objectives:

The objectives of this course are to introduce the students to:

- The principles and scope of synthetic biology and its foundations in molecular biology and engineering.
- The design of standardized biological parts, genetic circuits and engineered chassis organisms.
- The tools of DNA synthesis, assembly and genome engineering used to construct microbial systems.
- The applications of synthetic microbiology in health, industry, agriculture and the environment, and its biosafety and ethical dimensions.

Course Outcomes:

At the end of the course, students should be able to:

- Explain the principles, scope and engineering framework of synthetic biology.
- Describe standardized biological parts, genetic circuits and chassis organisms.
- Apply DNA assembly, genome-engineering and metabolic-engineering strategies.

- Analyse the design–build–test–learn cycle in the construction of synthetic microbial systems.
- Evaluate the applications, biosafety and ethical implications of synthetic microbiology.

Unit I

Foundations of Synthetic Microbiology

Definition, history, scope and significance of synthetic microbiology; comparison with industrial microbiology, biotechnology and genetic engineering; the engineering paradigm — abstraction, standardisation, modularity and decoupling; the design–build–test–learn (DBTL) cycle. Standardised biological parts — promoters, ribosome-binding sites, coding sequences and terminators; the BioBrick concept and registries of standard biological parts; measurement and characterisation of parts. Microbial chassis organisms and their characteristics; central-dogma foundations relevant to design; forward engineering versus classical genetic modification; the iGEM framework; biosafety, biosecurity and ethical considerations. AI and computational tools for the design and prediction of biological-part behaviour.

Unit II

Design of Synthetic Microbial Systems and Genetic Circuits

Principles of microbial engineering and gene-circuit design; transcriptional and translational control elements; inducible and constitutive systems. Engineered regulatory devices — switches, toggle switches, oscillators, logic gates and feedback/feedforward circuits; the repressilator and other landmark circuits; riboswitches and RNA devices; quorum sensing and population-level circuits. Microbial cell factories and metabolic engineering (basic concepts); engineering of microbial biofilms; microbial biosensors; modelling of genetic circuits — noise, robustness and orthogonality; computational tools and biological databases used in synthetic microbiology. AI/ML-guided genetic-circuit design and optimisation.

Unit III

Genome Engineering and Applications of Synthetic Microbiology

Chemical synthesis of DNA; oligonucleotide and gene synthesis; DNA-assembly methods — restriction–ligation, Gibson assembly, Golden Gate and modular cloning. Genome engineering — CRISPR-Cas systems (Cas9, Cas12, Cas13), base and prime editing, multiplex automated genome engineering (MAGE) and recombineering; genome minimisation and minimal/synthetic genomes; cell-free systems; xenobiology and expansion of the genetic code. Applications — sustainable agriculture and biocontrol; industrial enzymes, biomaterials and biodegradable plastics; medical applications (probiotics, microbial therapeutics, biosensors); environmental applications (bioremediation, wastewater treatment, pollutant degradation); the artemisinic-acid case study. AI in genome design, codon optimisation and metabolic-pathway optimisation.

Unit IV

Bio-Nanotechnology

Introduction to bio-nanotechnology and nanomaterials; classification and biological properties of nanoparticles. Green synthesis of nanoparticles using plants and microorganisms (bacteria, fungi and algae); characterisation of biologically synthesised nanoparticles — UV–visible spectroscopy, Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD) and scanning electron microscopy (SEM). Biosensors and their applications in microbial detection and diagnostics; applications of bio-nanotechnology in medical, agricultural and environmental microbiology, including antimicrobial nanoparticles; nano-formulations and targeted delivery; biosafety and ethical aspects of nanotechnology. AI-assisted nanoparticle design and characterisation

OEPT-2.4 EXPLORATORY MICROBIOLOGY

(Open Elective — offered by the Department for students of other departments)

Course Objectives:

The objectives of this course are to introduce the students to:

- The history, scope and fundamental concepts of microbiology as a modern science.
- The diversity of microorganisms and their beneficial and harmful roles in everyday life.
- The applications of microbes in food, agriculture, industry, health and the environment.
- Contemporary developments in microbiology and their relevance to society.

Course Outcomes:

At the end of the course, students should be able to:

- Describe the history, scope and major groups of microorganisms.
- Explain the roles of microbes in food, agriculture and the environment.
- Understand the causes, prevention and control of common microbial diseases.
- Appreciate the applications of modern microbiology in health, industry and sustainability.

Unit I

Introduction to the Microbial World

Microbes and the origin of life; history and scope of microbiology as a modern science; branches of microbiology; contributions of scientists (Antony van Leeuwenhoek, Louis Pasteur, Robert Koch, Edward Jenner, Joseph Lister, Alexander Fleming). Major groups of microbes — general characteristics and importance of bacteria, archaea, fungi, algae, protozoa and viruses; how microbes are observed, isolated and identified; the ubiquity of microbes and the concept of the microbiome. A simple overview of how AI and digital tools are used to identify and study microbes.

Unit II

Microbes in Food and Industry

Useful microbes in food — fermented foods (curd, idli, bread, cheese) and beverages; probiotics and their health benefits; food spoilage and simple methods of food preservation; foodborne illness and safe food practices. Industrially important microbial products — antibiotics, enzymes, vitamins, organic acids, alcohol and single-cell protein; an introduction to fermentation and how microbes are used in industry. Everyday applications of microbial products and the idea of a bio-based economy. AI and smart technologies in food safety and quality (in simple terms).

Unit III

Microbes in Agriculture and the Environment

Role of microorganisms in soil fertility; biofertilizers and biopesticides; beneficial plant–microbe interactions (rhizosphere and mycorrhizae); microbes in composting and waste management. Microbes in the environment — biogeochemical cycles in simple terms; bioremediation and the clean-up of pollutants; microbes in water and sanitation; microbes and climate change. Microbial contributions to sustainability and the Sustainable Development Goals. AI and biosensors for environmental monitoring.

Unit IV

Microbes and Human Health

Concept of health and disease; normal microbial flora of the human body and its importance; how microbes cause disease (an introduction to pathogenicity); common bacterial, viral, fungal and parasitic diseases and their prevention. Basics of immunity and how the body defends itself; vaccines and immunization; antibiotics and the growing problem of antibiotic resistance; hygiene, sanitation and public health; lessons from recent pandemics. AI in disease detection, health monitoring and outbreak awareness (in simple terms).

III SEMESTER

CPT-3.1 IMMUNOLOGY AND VACCINE BIOLOGY

Course Objectives:

The objectives of this course are to introduce the students to:

- The structure, components and organization of the innate and adaptive immune systems.
- The molecular mechanisms of immune recognition, activation and regulation.
- Immunological techniques and their diagnostic and research applications.
- The principles, platforms and development of vaccines, including modern and next-generation approaches.

Course Outcomes:

At the end of the course, students should be able to:

- Describe the cells, organs and molecules of the innate and adaptive immune systems.
- Explain the mechanisms of immune recognition, response and regulation.
- Apply immunological techniques for diagnosis and research.
- Analyse the principles and platforms of vaccine design and development.
- Evaluate modern and next-generation vaccine technologies and immunotherapies.

Unit I

Innate and Adaptive Immunity

History and scope of immunology; innate and adaptive immunity; cells of the immune system — T cells, B cells, macrophages, dendritic cells, natural killer cells, neutrophils, eosinophils and mast cells; primary and secondary lymphoid organs. Innate immunity — physical and chemical barriers, pattern-recognition receptors (Toll-like receptors), the complement system and inflammation. Adaptive immunity — primary and secondary immune responses; ontogeny and maturation of B and T cells; B- and T-cell receptors; the major histocompatibility complex and antigen presentation; clonal-selection theory; generation of antigenic diversity. Immunoglobulins — structure, classes and functions; antigens, epitopes, immunogens and haptens; the role of cytokines in immune responses and memory. AI/ML in immune-repertoire analysis and epitope prediction.

Unit II

Immune Regulation and Clinical Immunology

Cytokines and chemokines — interleukins and interferons; their production, biological functions and assays. Hypersensitivity reactions — types I to IV, mechanisms, symptoms and immunodiagnosis; autoimmunity and autoimmune disorders; immunodeficiency (primary and acquired, including HIV/AIDS). Transplantation immunology and graft rejection; tumour immunology and immune surveillance; immunological tolerance and its breakdown. Mucosal and regional immunity; influence of the microbiome on immune regulation. AI in the analysis of clinical-immunology and single-cell immune data.

Unit III

Immunological Techniques

Antigen–antibody interactions; agglutination and precipitation reactions; immunodiffusion, radial immunodiffusion and immunoelectrophoresis; the enzyme-linked immunosorbent assay (ELISA) and its types; radioimmunoassay; immunofluorescence; immunoblotting (western blot); flow cytometry and fluorescence-activated cell sorting. Production and purification of antibodies; hybridoma technology and monoclonal antibodies; recombinant and engineered antibodies; determination of antibody titre. Modern platforms — multiplex and bead-based immunoassays, lateral-flow assays, biosensors and point-of-care diagnostics; CyTOF and single-cell immunophenotyping. AI-assisted analysis of flow-cytometry and immunoassay data.

Unit IV

Biology and Technology of Vaccines

Principles of vaccination and the immunological basis of protection; the process of vaccine development and clinical trials (phases I–IV); correlates of protection and adjuvants. Conventional vaccines — live-attenuated, inactivated, toxoid, subunit and conjugate vaccines. Modern and next-generation platforms — recombinant, peptide, DNA, mRNA–lipid-nanoparticle and viral-vector vaccines; virus-like particles; edible and plant-based vaccines; reverse vaccinology and structure-based antigen design. Therapeutic vaccines, cancer immunotherapy and monoclonal-antibody therapeutics; national immunization programmes; cold-chain and vaccine logistics; vaccine safety and pharmacovigilance. AI in antigen discovery, reverse vaccinology and vaccine design.

CPT-3.2 MICROBIAL INFORMATICS AND SYSTEMS BIOLOGY

Course Objectives:

The objectives of this course are to introduce the students to:

- The biological databases, tools and algorithms used in microbial bioinformatics.
- Sequence analysis, alignment, phylogenetics and next-generation-sequencing data analysis.
- The principles and applications of the omics sciences and their integration.
- The concepts of systems biology, biological networks and computational modelling of microbial systems.

Course Outcomes:

At the end of the course, students should be able to:

- Use biological databases and bioinformatics tools for the analysis of microbial data.
- Apply sequence-alignment, phylogenetic and NGS-analysis methods.

- Explain the principles and workflows of genomics, transcriptomics, proteomics and metabolomics.
- Analyse biological networks and interpret systems-level microbial data.
- Evaluate the role of computational modelling and AI in microbial systems biology.

Unit I

Biological Databases and Sequence Analysis

Introduction, scope and applications of bioinformatics; role of bioinformatics in drug design and discovery. Biological databases — nucleotide databases (NCBI/GenBank, EMBL, DDBJ) and protein databases (UniProt/Swiss-Prot, PIR, TrEMBL); specialised and microbial databases; data-retrieval and query systems (Entrez, SRS); sequence submission, genome centres and DNA barcoding. Sequence alignment — principles, scoring matrices (DNA and protein), pairwise alignment (dynamic programming) and multiple sequence alignment (CLUSTAL, MUSCLE); database-searching tools (BLAST, FASTA, HMMER); structural alignment (DALI, SSAP). Molecular phylogenetics — methods of tree construction and interpretation; genome annotation. AI and deep-learning tools in sequence analysis and structure prediction (AlphaFold and protein language models).

Unit II

Genomics and Next-Generation Sequencing

Genome organisation and model genomes; finding genes and regulatory regions; genome sequencing strategies; next-generation and third-generation sequencing platforms (short-read and long-read); overview of the NGS data-analysis workflow — quality control, read trimming, assembly, mapping and variant calling; genome annotation. Comparative and functional genomics; pan-genome analysis; microbial genome databases and browsers (UCSC). Command-line basics and reproducible workflows; introduction to programming for bioinformatics (R and Python). Structural bioinformatics — homology modelling, protein-structure prediction and molecular docking in drug discovery. AI/ML in genome annotation, variant interpretation and antimicrobial-resistance-gene prediction.

Unit III

Transcriptomics, Proteomics and Metabolomics

Transcriptomics — microarray principles and design (cDNA, oligonucleotide and expression arrays) and RNA sequencing; data processing, normalisation and differential-expression analysis; functional enrichment. Proteomics — gel-based and gel-free approaches; mass spectrometry (ionisation sources, analysers and detectors); peptide-mass fingerprinting; quantitative and clinical proteomics; protein–protein interaction studies (yeast two-hybrid, pull-down, phage display, surface plasmon resonance) and protein arrays. Metabolomics — sample preparation and analytical platforms (LC-MS, GC-MS, NMR); metabolite identification and metabolic databases (KEGG, HMDB, MetaCyc); metabolomics data-processing workflows and applications. Introduction to single-cell and spatial omics. AI/ML in omics data analysis, feature selection and biomarker discovery.

Unit IV

Systems Biology and Computational Modelling

Concepts and scope of systems biology; the hierarchy from molecules to networks to phenotypes; multi-omics data integration. Biological networks — gene-regulatory, protein–protein-interaction, signalling and metabolic networks; network topology, properties and visualisation (Cytoscape). Genome-scale metabolic models and constraint-based analysis (flux-balance analysis); kinetic modelling and simulation of microbial systems; the design–build–test–learn cycle in systems and synthetic biology. Applications of systems biology in strain design, drug-target identification and microbiome analysis. AI, machine learning and digital twins in systems biology and predictive microbiology.

SPT-3.3A MEDICAL MICROBIOLOGY AND PANDEMIC BIOLOGY

Course Objectives:

The objectives of this course are to introduce the students to:

- The major microbial pathogens of humans, their pathogenesis and the host–pathogen relationship.
- Modern molecular and rapid methods for the diagnosis of infectious diseases.
- Antimicrobial agents, the mechanisms and surveillance of antimicrobial resistance, and molecular therapeutics.
- The biology of epidemics and pandemics and the principles of outbreak preparedness and response.

Course Outcomes:

At the end of the course, students should be able to:

- Describe major human microbial pathogens and the mechanisms of pathogenesis.
- Apply conventional and molecular methods for the diagnosis of infectious diseases.
- Analyse antimicrobial action, resistance and stewardship within a One Health framework.
- Evaluate molecular therapeutics and modern approaches to infectious-disease control.
- Explain the biology of pandemics and the principles of preparedness and response.

Unit I

Infectious Diseases and Pathogenesis

Scope and importance of medical microbiology; concepts of disease, disorder and syndrome; epidemiology and environmental factors in infectious diseases; the normal microflora of the human body and its significance. Host–pathogen interactions; sources, reservoirs and routes of transmission;

portals of entry and exit; microbial pathogenicity and virulence factors (capsules, toxins, enzymes and adhesion factors); opportunistic and healthcare-associated infections; emerging and re-emerging infections. Overview of important microbial diseases — bacterial (pneumonia, tuberculosis, diphtheria, tetanus), fungal (aspergillosis, candidiasis, mucormycosis), protozoan (malaria, leishmaniasis, amoebiasis), helminthic (filariasis, taeniasis) and viral (influenza, hepatitis, rabies, HIV/AIDS, dengue); the human microbiome in health and disease. AI in clinical microbiology and in the prediction of host–pathogen interactions.

Unit II

Molecular and Rapid Diagnostics

Principles of the laboratory diagnosis of infectious diseases; specimen collection, transport and processing; conventional culture and biochemical identification; MALDI-TOF mass spectrometry. Molecular diagnostics — PCR, real-time PCR, digital PCR, loop-mediated isothermal amplification (LAMP), fluorescence in-situ hybridisation, DNA sequencing and next-generation sequencing; CRISPR-based diagnostics (SHERLOCK/DETECTR); multiplex syndromic panels. Immunodiagnostics — ELISA, lateral-flow assays, chemiluminescent immunoassays and immunofluorescence; biosensors and point-of-care testing. AI/ML in diagnostic image analysis, automated interpretation and antimicrobial-susceptibility prediction.

Unit III

Antimicrobial Agents, Resistance and Therapeutics

Antimicrobial agents — classification, mechanisms of action and clinical uses; antimicrobial-susceptibility testing and interpretation. Antimicrobial resistance — mechanisms, the resistome, horizontal gene transfer and the environmental dimension; surveillance, antimicrobial stewardship, the One Health framework and priority pathogens. Alternatives to antibiotics — bacteriophage therapy, antimicrobial peptides and anti-virulence strategies. Molecular therapeutics — gene therapy, RNA-based therapeutics and gene silencing, recombinant therapeutic proteins, monoclonal antibodies and immunotherapy; personalised and precision medicine in infection. AI in antimicrobial discovery and in the prediction of resistance.

Unit IV

Pandemic Biology and Outbreak Response

Principles of epidemiology; measures of disease occurrence; endemic, epidemic and pandemic diseases; the basic reproduction number and models of infectious-disease transmission; introduction to disease modelling and complex systems. Drivers of emergence — ecology, evolution, climate change, urbanisation, habitat loss and shifts in vector behaviour; zoonoses and spillover; the One Health approach. Case studies of major epidemics and pandemics — plague, cholera, the 1918 influenza pandemic, HIV/AIDS and COVID-19; therapeutics and vaccines in pandemic response;

mitigation strategies. Pandemic preparedness, surveillance, genomic epidemiology and global health governance; role of WHO, ICMR and CDC. AI in outbreak prediction, genomic surveillance and epidemic modelling..

SPT-3.3B MICROBIAL ECOLOGY AND METAGENOMICS

Course Objectives:

The objectives of this course are to introduce the students to:

- The principles of microbial ecology and the interactions of microorganisms with each other and their environment.
- The structure, function and quantification of microbial communities.
- The culture-independent and metagenomic approaches used to study microbial diversity.
- The concepts and applications of the microbiome and multi-omics in ecology, health and biotechnology.

Course Outcomes:

At the end of the course, students should be able to:

- Explain the principles of microbial ecology and species interactions.
- Analyse microbial community structure, diversity and function.
- Apply metagenomic and culture-independent methods to study microbial communities.
- Interpret microbiome and multi-omics data in ecological and applied contexts.
- Evaluate the applications of microbiome science in health, agriculture and the environment.

Unit I

Principles of Microbial Ecology

Introduction to microbial ecology — scope, history and applications; microbial habitats and ecological niches; abiotic and biotic factors influencing microbial communities; the laws of limiting factors (Liebig's law of the minimum, Shelford's law of tolerance); structure and composition of the atmosphere, hydrosphere, lithosphere and biosphere. Levels of ecological organisation — species, populations and communities; species interactions (mutualism, commensalism, amensalism, synergism, competition, predation, parasitism and syntrophy); microbial functions in ecosystems and global biogeochemical cycles; ecological succession. Microbial biodiversity and its conservation — hotspots, causes of depletion and conservation methods; ecosystem resilience. AI/ML approaches to ecological-data analysis and community modelling.

Unit II

Community Structure, Function and Quantitative Ecology

Microbial community structure and diversity; the operational taxonomic unit (OTU) and amplicon-sequence-variant (ASV) concepts; diversity indices (Shannon, Simpson); alpha, beta and gamma diversity; richness, evenness and rarefaction. Sampling and sample processing; determination of total and viable microbial numbers; culturability, the viable-but-non-culturable state and culturomics. Molecular analysis of community structure and function — qPCR, FISH, DGGE/TGGE and stable-isotope probing. Biofilms and microbial mats as model communities. AI and statistical/machine-learning tools in community-ecology analysis.

Unit III

Metagenomics and Culture-Independent Approaches

Rationale for culture-independent approaches; extraction and quality assessment of environmental nucleic acids. Amplicon-based metagenomics — 16S rRNA, ITS and functional-gene surveys; experimental design and sequencing. Shotgun metagenomics — assembly, binning, taxonomic and functional profiling and metagenome-assembled genomes (MAGs). Beyond metagenomics — metatranscriptomics, metaproteomics and metabolomics; single-cell genomics of uncultured microbes. Bioinformatics pipelines and tools (QIIME 2, mothur, MetaPhlAn, HUMAnN, Kraken). AI/ML in metagenomic data analysis, taxonomic classification and functional prediction.

Unit IV

Microbiome Science and Applications

The microbiome concept and the holobiont; the human microbiome (gut, skin, oral and respiratory) and its role in health and disease; the gut–brain axis; dysbiosis; faecal microbiota transplantation, probiotics, prebiotics, synbiotics and postbiotics. Host–microbiome interactions and multi-omics integration; microbiome engineering and synthetic microbial communities (SynComs). Environmental, plant, soil and built-environment microbiomes; global microbiome initiatives (Human Microbiome Project, Earth Microbiome Project). Applications in medicine, agriculture, environment and industry; ethical, legal and data-sharing considerations. AI and multi-omics data integration in microbiome research and precision-microbiome interventions.

OEPT-3.4 MICROBIAL APPLICATIONS AND SUSTAINABILITY

(Open Elective — offered by the Department for students of other departments)

Course Objectives:

The objectives of this course are to introduce the students to:

- The applications of industrially and environmentally important microorganisms.
- The role of microbes in producing useful products through fermentation and biotechnology.
- The contribution of microorganisms to bioenergy, waste management and pollution control.

Course Outcomes:

At the end of the course, students should be able to:

- Describe the applications of industrially and environmentally important microorganisms.

- Explain fermentation and the production of useful microbial products.
- Understand the role of microbes in bioenergy, bioremediation and waste management.
- Appreciate the contribution of microbial biotechnology to sustainability and the bioeconomy.

Unit I

Fundamentals of Applied Microbiology

Microbial biodiversity and its importance for sustainable development; isolation, preservation and improvement of industrially useful microorganisms; genetically modified organisms and their impact. Introduction to fermentation and its types and advantages; types of fermenters — stirred-tank, airlift, fluidised-bed, packed-bed and photobioreactors; an overview of upstream and downstream processing. Everyday applications of applied microbiology and the concept of a bio-based economy. A simple overview of how AI supports strain selection and bioprocess monitoring.

Unit II

Microbial Products for Human Welfare

Industrially important microbial products — antibiotics (penicillin, streptomycin), enzymes (amylase, protease), vitamins, organic acids and amino acids; monoclonal antibodies; production of alcoholic beverages; mushroom cultivation. Probiotics, prebiotics and functional foods; single-cell protein and single-cell oil; biofertilizers and biopesticides in agriculture. The role of microbial products in health, food and industry. AI and smart technologies in product development and quality control (in simple terms).

Unit III

Microbial Bioenergy and Bioremediation

History and global scenario of biofuels; alternative energy from microbes — bioethanol, methane and biogas, biohydrogen and biodiesel; microbial fuel cells; microbial enhanced oil recovery (MEOR). Bioremediation — methods and applications; biodegradation of pollutants, plastics and xenobiotics; biotransformation and microbial recovery of metals; microbial leaching of copper, gold and uranium; biodegradable polymers from microorganisms. Microbial approaches to a cleaner environment. AI and biosensors in environmental monitoring and bioremediation

Unit IV

Microbes, Sustainability and the Bioeconomy

Role of microorganisms in achieving environmental sustainability; microbes and climate change; the circular bioeconomy and the valorisation of waste into useful products; microbial contributions to clean water, sanitation and food security. Microbial biotechnology and the Sustainable Development Goals; biosafety, bioethics and public perception of microbial biotechnology; careers and opportunities in microbial biotechnology and bio-entrepreneurship. AI and emerging technologies for a sustainable bio-based future (in simple terms).

IV SEMESTER

CPT-4.1 BIOPROCESS TECHNOLOGY

Course Objectives:

The objectives of this course are to introduce the students to:

- The fundamental principles of bioprocess technology and the operation of bioreactors.
- The types, design and control of fermentation processes.
- The production of commercially important microbial products.
- Downstream processing and modern developments in biomanufacturing.

Course Outcomes:

At the end of the course, students should be able to:

- Explain the principles of bioprocess technology and bioreactor operation.
- Describe and compare the types and design of fermentation processes.
- Apply upstream and downstream processing methods to the production of microbial products.
- Analyse bioprocess parameters and evaluate strategies for optimization and scale-up.
- Evaluate modern developments in biomanufacturing, including quality and regulatory aspects.

Unit I

Principles of Bioprocess Technology and Microbial Kinetics

Basic principles of bioprocess technology; a brief history and the scope of industrial microbiology. Isolation, screening, selection and maintenance of industrially important microorganisms; strain improvement (mutagenesis and recombinant approaches); preservation of industrial cultures. Media formulation and optimisation; types of sterilisation — heat and air sterilisation; thermal death kinetics of microorganisms; inoculum development. Microbial growth and death kinetics; stoichiometry and models of microbial growth — elemental balance equations, metabolic coupling (ATP and NAD^+), yield coefficients, and unstructured and structured models; bioprocess monitoring and control variables (temperature, pH, dissolved oxygen, agitation and foam). AI and data-driven approaches to media optimisation and strain selection.

Unit II

Bioreactors and Fermentation Processes

Concepts, components and factors affecting the fermentation process; design and operation of a typical bioreactor; types of bioreactors — stirred-tank, airlift, bubble-column, packed-bed, fluidised-bed and membrane bioreactors and photobioreactors. Types of fermentation — batch, fed-batch and continuous; aerobic and anaerobic; surface, submerged and solid-state fermentation; fermentation versus biotransformation; fermentation media and economics. Aeration and agitation; oxygen transfer and the volumetric mass-transfer coefficient (kLa); mixing, rheology and scale-up/scale-down principles; large-scale animal and plant cell cultivation; single-use (disposable) bioreactor systems. AI/ML-based bioprocess monitoring, soft sensors and the digital twin.

Unit III

Downstream Processing and Product Recovery

Principles and economics of downstream processing; process integration. Removal of insoluble products — cell disruption (mechanical and non-mechanical), foam separation, sedimentation, flocculation, filtration (plate, depth, membrane and rotary-vacuum filters) and centrifugation (basket, tubular-bowl and continuous centrifuges). Recovery of soluble products — liquid–liquid extraction, precipitation, adsorption, aqueous two-phase extraction, and membrane separation (microfiltration, ultrafiltration, nanofiltration and reverse osmosis); concentration techniques; product stabilisation. Chromatographic techniques — ion-exchange, gel filtration, affinity, hydrophobic-interaction and HPLC; drying (spray, freeze and drum drying); crystallisation and formulation. AI and machine learning in downstream-process optimisation.

Unit IV

Microbial Products and Modern Biomanufacturing

Industrial production of representative products — antibiotics (penicillin, streptomycin); enzymes (amylase, protease, lipase, cellulase); organic acids (citric, lactic and gluconic); amino acids; vitamins; recombinant and therapeutic proteins. Biofuels — bioethanol, biodiesel, biogas and the biorefinery concept; single-cell protein; probiotics and prebiotics; biopolymers and biosurfactants; process economics and the selection of bioprocesses. Quality control and quality assurance; Good Manufacturing Practice; Process Analytical Technology and Quality-by-Design; continuous processing and process intensification; biosimilars and Industry-4.0 concepts in biomanufacturing. AI in bioprocess optimisation and the prediction of product yield.

CPT-4.2 RESEARCH METHODOLOGY AND BIOSTATISTICS

Course Objectives:

The objectives of this course are to introduce the students to:

- The principles of scientific research, experimental design and good research practice.
- The methods of scientific literature review, documentation and research communication.
- The fundamentals of biostatistics and the analysis and interpretation of biological data.
- The use of statistical software, computational tools and research ethics in modern research.

Course Outcomes:

At the end of the course, students should be able to:

- Explain the principles of research methodology and design a scientific study.
- Conduct literature reviews and communicate research through writing and presentation.

- Apply appropriate biostatistical methods to analyse biological data.
- Interpret statistical results and use statistical software for data analysis.
- Evaluate research ethics, publication practices and the responsible use of AI in research.

Unit I

Research Methodology and Scientific Writing

Nature and scope of scientific research; empirical science and the scientific method; deductive and inductive reasoning; manipulative experiments, controls and variables; reductionist and systems approaches; descriptive research. Types of research — basic, applied, translational and interdisciplinary; qualitative, quantitative and mixed-method research; types of research data. Formulating a research problem, hypothesis and objectives; identifying gaps in research; the literature review; choosing a research mentor and question; laboratory records and documentation; research ethics and good laboratory practice. Research metrics — citation index, h-index and i10-index and journal impact metrics; research databases and researcher identifiers (PubMed, Scopus, Web of Science, Google Scholar, ORCID). AI tools for literature retrieval, evidence synthesis, data collection and reference management, and their responsible use.

Unit II

Scientific Communication and Research Ethics

Principles and significance of scientific communication; technical and scientific writing. Structure of a scientific paper — title, abstract, keywords, introduction, materials and methods, results, discussion, conclusion and references; drafting titles and abstracts; preparation of tables, figures and graphical abstracts; reference management and citation styles. The publication process — journal selection, submission, peer review, revision and reviewer response; recent trends — open-access journals, preprints and open peer review. Scientific presentations and poster preparation. Research and publication ethics; authorship, copyright, plagiarism, self-plagiarism and scientific misconduct; plagiarism-detection software. Responsible use of AI in scientific writing — advantages, limitations and ethical concerns; AI-based tools for language editing, summarisation and figure preparation.

Unit III

Biostatistics

Scope and applications of biostatistics; population, sample, variables and parameters; primary and secondary data; data collection and presentation — frequency distribution, tabulation, bar diagrams, histograms, pie charts and cumulative-frequency curves. Measures of central tendency (mean, median, mode, quartiles and percentiles) and dispersion (range, variance, standard deviation and coefficient of variation). Probability and conditional probability; probability distributions (binomial, Poisson and normal). Hypothesis testing — null and alternative hypotheses, level of significance, P-value and types of error; t-test, F-test, chi-square test and analysis of variance (ANOVA); correlation and regression analysis; experimental design; statistical software (SPSS and R). AI/ML-assisted exploratory data analysis and visualisation.

Unit IV

Mathematical Models in Biology

Introduction to mathematical modelling in biology; population dynamics and growth models; oscillations and circadian rhythms; developmental patterns and pattern formation; symmetry in biological systems; fractal geometries in biology; size-limits and scaling (allometry). Modelling of chemical-reaction networks and metabolic networks; deterministic and stochastic modelling; introduction to systems-level simulation. Applications of modelling in microbiology and systems biology. Introduction to machine learning for biological data — classification, clustering and predictive modelling, and its responsible interpretation.

SPT-4.3A PHARMACEUTICAL MICROBIOLOGY

Course Objectives:

The objectives of this course are to introduce the students to:

- The role of microorganisms in the pharmaceutical industry, both beneficial and detrimental.
- Antimicrobial agents, drug development and modern drug-delivery and drug-discovery approaches.
- The control of microbial contamination and the microbiological quality of pharmaceutical products.
- The regulatory practices, quality systems and clinical-trial framework governing pharmaceutical products.

Course Outcomes:

At the end of the course, students should be able to:

- Identify microorganisms of relevance to healthcare and the pharmaceutical industry and their sources.
- Explain antimicrobial agents, drug action and modern drug-delivery and drug-discovery approaches.
- Apply methods for the microbiological control and quality assessment of pharmaceutical products.
- Describe Good Manufacturing Practice, quality assurance and sterility assurance.
- Evaluate regulatory practices and the clinical-trial process for pharmaceuticals.

Unit I

Antimicrobial Agents and Drug Discovery

Antibiotics — natural and synthetic; classification, mechanisms of action and clinical uses; antifungal, antiviral and antitumour agents; peptide antibiotics, chloramphenicol, sulphonamides and quinolones; chemical disinfectants, antiseptics and preservatives. Basic aspects of the structure and functioning of the immune system as it relates to anti-infective therapy; laboratory evaluation of antimicrobial agents; mechanisms of bacterial resistance to antibiotics and its clinical significance. Drug discovery and development — sources of drug leads, natural products from microbes, high-throughput screening; introduction to in-silico drug design, molecular docking and structure-based drug discovery. AI and machine learning in antimicrobial and drug discovery.

Unit II

Drug Delivery and Pharmacology

Molecular principles of drug targeting; drug-delivery systems — conventional formulations, sustained-release and targeted delivery; nanoparticle- and liposome-based delivery; drug delivery in gene therapy. Pharmacokinetics — principles of drug absorption, distribution, metabolism and excretion; bioavailability; LD_{50} and LC_{50}; chemotherapy. Pharmacogenomics and personalised medicine; biopharmaceuticals and biologics. AI in drug-delivery design and in pharmacokinetic/pharmacodynamic modelling.

Unit III

Microbial Control and Quality in the Pharmaceutical Industry

Ecology of microorganisms as it affects the pharmaceutical industry; microbial contamination and spoilage of pharmaceutical products; sources of contamination and contamination control; sterilisation methods and their validation. Bioassay of antimicrobial agents (Good Laboratory Practice guidelines); factors affecting bioassays; assessment of antimicrobial combinations (synergism, antagonism and additive effects); methods for testing antimycobacterial, antifungal, antiparasitic and antiviral drugs (in-vivo and in-vitro infectivity models). Sterility testing; microbial limit tests; endotoxin (LAL) testing; environmental monitoring of clean rooms; chemical and biological indicators. AI and rapid microbiological methods in pharmaceutical quality control.

Unit IV

Regulatory Practices and Clinical Trials

Government regulatory practices and policies; regulatory aspects of quality control; regulatory authorities for the introduction of medicines (FDA, CDSCO and other agencies); guidelines for drugs and biologicals. Good Manufacturing Practice, Good Laboratory Practice and Good Clinical Practice; validation and documentation. Clinical studies — phases I to IV of clinical trials; objectives, conduct and outcomes of trials; pharmacovigilance; introduction to biosimilars and regulatory affairs as a career. AI and data management in clinical trials and pharmacovigilance..

SPT-4.3B DAIRY MICROBIOLOGY AND PRODUCT DEVELOPMENT

Course Objectives:

The objectives of this course are to introduce the students to:

- The microbiology of milk, its spoilage and the microbiological quality and safety of dairy products.
- The role of starter cultures and fermentation in the manufacture of dairy products.
- The development of functional dairy products, probiotics and value-added microbial products.
- The processes, quality systems and regulations involved in microbial product development and commercialization.

Course Outcomes:

At the end of the course, students should be able to:

- Describe the microflora of milk and the microbiological quality and safety of dairy products.
- Explain the role of starter cultures and fermentation in dairy processing.
- Apply methods for the production and quality control of fermented and functional dairy products.
- Analyse the development of probiotics and value-added microbial products.
- Evaluate the quality, regulatory and commercialization aspects of microbial product development.

Unit I

Milk Microbiology and Quality

Composition, physical and chemical properties and nutritional value of milk; milk as a substrate for microbial growth; sources and types of microorganisms in milk. Normal microflora of milk and factors affecting microbial growth; microbial spoilage of milk and its defects; pathogens of concern in milk and dairy products and zoonotic considerations. Grading and microbiological quality testing — standard plate count, direct microscopic count, methylene-blue reduction test and coliform testing; pasteurisation, sterilisation, UHT processing and homogenisation; cold-chain management. AI and rapid methods in the assessment of milk quality and safety.

Unit II

Starter Cultures and Fermented Dairy Products

Lactic acid bacteria and dairy starter cultures — types, characteristics and functions; single-strain, mixed and defined cultures; propagation, preservation and starter distribution systems; starter failure and bacteriophage problems in the dairy industry. Manufacture and microbiology of fermented dairy products — dahi, yoghurt, cheese, butter, buttermilk, kefir, cultured and fermented milks; the biochemistry of milk fermentation (acid and flavour development). Probiotic dairy products and their health benefits. AI in starter-culture selection and fermentation-process monitoring.

Unit III

Functional Products and Microbial Product Development

Development of functional and value-added products — probiotics, prebiotics, synbiotics and postbiotics; microencapsulation of probiotics; nutraceuticals and bioactive peptides from milk; whey utilisation and valorisation. Microbial production of food ingredients and enzymes (rennet, lactase); single-cell protein; bio-preservatives (bacteriocins such as nisin). Concept and stages of microbial product development — from laboratory to market; strain selection and improvement, media formulation, fermentation and scale-up; precision fermentation and alternative-protein and dairy-analogue products. AI in product formulation, optimisation and shelf-life prediction.

Unit IV

Quality, Safety, Regulation and Commercialization

Quality assurance and quality control of dairy and microbial products; Good Manufacturing Practice and Good Hygiene Practice; HACCP and ISO 22000 in the dairy industry; cleaning and sanitation (CIP systems). Food-safety regulations and standards — FSSAI, Codex Alimentarius and international standards; labelling and claims for functional and probiotic products. Product development, market considerations, intellectual property and entrepreneurship in microbial and dairy products; packaging and traceability. AI, biosensors and digital traceability in dairy quality management and the supply chain.

Skill Enhancement Course 1:
FOUNDATIONS OF MICROBIOLOGY

Preamble

Students enter M.Sc. Microbiology from varied backgrounds — chemistry, botany, zoology, biochemistry, biotechnology and allied sciences — with unequal grounding in the subject. This non-credit course, taught over thirty hours, revisits the core ideas, terms and laboratory practices of microbiology in a plain, introductory form. Its aim is to bring every entrant to a common starting point, and to connect each concept to its relevance in health, food, agriculture, industry and the environment before the credit papers begin.

Objectives of the Course

The objectives of this course are to introduce the students to:

- The history, scope and major groups of microorganisms.
- The fundamentals of microbial cell structure, nutrition, metabolism and genetics.
- Basic laboratory practices — microscopy, staining, sterilisation and cultivation.
- The control of microorganisms and their significance in health, food, agriculture, industry and the environment.

Outcomes of the Course

On completion of this course, students should be able to:

- Describe the scope of microbiology and the major groups of microorganisms.
- Explain the structure, nutrition, metabolism and genetics of the microbial cell.
- Perform basic techniques — microscopy, staining, sterilisation and pure-culture methods.
- Outline the control of microbes and their beneficial and harmful roles.
- Enter the core papers with a shared foundation of knowledge and skills.

Unit I

The Microbial World and Basic Techniques

History and scope of microbiology; contributions of Leeuwenhoek, Pasteur and Koch; Koch's postulates. Major groups of microorganisms and their broad features — bacteria, archaea, fungi, algae, protozoa and viruses; prokaryotic versus eukaryotic cells; the ubiquity of microbes. Basic laboratory practice — biosafety and aseptic technique; principles of microscopy; simple and differential staining (Gram stain); sterilisation and disinfection; culture media; pure-culture and isolation methods; measurement of microbial growth and the growth curve.

Unit II

Microbial Cell, Metabolism and Genetics

Bacterial cell structure — cell wall, membrane, capsule, flagella, pili, nucleoid, plasmids, ribosomes, inclusions and endospores. Microbial nutrition and nutritional types; factors affecting growth (temperature, pH, oxygen, water activity). An outline of microbial metabolism — respiration, fermentation and photosynthesis; ATP as energy currency. Basics of microbial genetics — DNA as genetic material; the central dogma (replication, transcription, translation) in simple terms; mutation; gene transfer by transformation, transduction and conjugation; an introduction to recombinant DNA technology.

Unit III

Microbial Diversity and Control

General characteristics and significance of the major groups — bacteria and archaea, fungi (moulds and yeasts), algae, protozoa and viruses; a simple view of viral structure and multiplication. Beneficial and harmful microbes in everyday life. Control of microorganisms — physical and chemical methods; an introduction to antibiotics, their mode of action and the problem of antibiotic resistance; the concept of the normal microbial flora.

Unit IV

Applied Microbiology and Relevance

Microbes in food — fermented foods, spoilage and simple preservation; foodborne illness and safe food practices. Microbes in agriculture and the environment — biofertilizers, biopesticides, the nitrogen cycle in outline, bioremediation and waste treatment. Microbes in industry and health — antibiotics, enzymes, vaccines and other useful products; an introduction to immunity and vaccination; microbes and human disease. Emerging relevance of microbiology — the microbiome, recent pandemics and the scope of microbiology as a career.

Skill Enhancement Course 2:

INTELLECTUAL PROPERTY AND PATENTING: II SEMESTER

Preamble

Intellectual Property Rights (IPR) is essential for better identification, planning, commercialization, rendering, and thus the preservation of inventions or creativity. IPR is a strong tool, to protect the investment, time, money, and effort invested by the inventor/creator of the IP, as it gives the inventor/creator an exclusive right for a certain period of time for the use of its invention/creation. Thus, IPR affects the economic development of a country by promoting healthy competition and encouraging industrial growth and economic growth.

Objective of the Course

This value-added course is aimed for introducing fundamentals of Intellectual Property Rights (IPRs) to appreciate IPRs and its impact on innovation, trade, commerce and societal dynamics. This course also helps in sensitizing and igniting minds of students towards the fundamentals of IPRs and appreciate its presence in daily lives.

Outcome of the Course:

At the end of the course, students will be able to:

- Appreciate the uniqueness of the regional products and ways and means to protect and promote them using IPR tools.
- They will be able to connect with the inventiveness in the commercialized products and processes having IPR protection.
- Understand the processes of patenting and IP in the national and international platforms.

Unit I

Overview of Intellectual Property:

a) Introduction and the need for intellectual property right (IPR)
b) Kinds of Intellectual Property Rights: Patent. Copyright, Trade Mark, Design, Geographical Indication, Plant Varieties, Layout Design, Genetic Resources and Traditional Knowledge, Trade Secret
c) Major International Instruments concerning Intellectual Property Rights: Paris Convention, 1883, The Berne Convention, 1886, The Universal Copyright Convention, 1952, The WIPO Convention, 1967, The Patent Co-operation Treaty, 1970, The TRIPS Agreement, 1994.

Unit II

Patenting:

a) Elements of Patentability: Novelty, Non-Obviousness (Inventive Steps),
b) Industrial Application;

c) Non - Patentable Subject Matter;
d) Registration Procedure;
e) Rights and Duties of Patentee;
f) Assignment and licence;
g) Restoration of lapsed Patents;
h) Surrender and Revocation of Patents,
i) Infringement, Remedies & Penalties

Unit III

Patent Drafting, laws and Case Studies:

a) Patent application preparation, Fundamentals of claim drafting, Patent claim design, Drafting description, drawings, abstract, Filing patent applications: Prosecution and strategies, National/Regional Patent Laws of WIPO, WIPO Patent laws, Patent laws in India, United States patent law
b) Case studies

Unit IV

Biosafety, Policies, Laws and Bioethics:

a) International regulations – Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; Draft bill of Biotechnology
b) Regulatory authority of India - containments – biosafety levels and category of rDNA experiments; field trails – biosafety research trials – standard operating procedures - guidelines of state governments; GM labeling – Food Safety and Standards Authority of India (FSSAI).
c) Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation.
d) Bioethics in research – cloning and stem cell research, Human and animal experimentation, animal rights/welfare, Agricultural biotechnology – Genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations - Protection of environment and biodiversity – biopiracy.

Skill Enhancement Course 3:

CLINICAL RESEARCH: III SEMESTER

Preamble

Clinical Research involves scientific approach to establish the safety and effectiveness of specific health and medical products and practices. Clinical research is the study of health and illness in people and describes many different elements of scientific investigation. Clinical Research experiment designed to answer specific questions about possible new treatments or new ways of using existing (known) treatments. Clinical trials are part of a long and careful process to determine whether a new drugs or treatments are safe and effective for improved health outcomes. India is emerging as a global hub for clinical research. In view of above, a certificate program in Clinical Research will provide an essential platform to all students of DOSR in Biotechnology to have hands on experience in clinical research avenue to further opt for a career in clinical research. The present proposal will be an optional value-added course and certification.

Objectives of the Course:

- To promote a comprehensive understanding of the broad area of clinical research
- To develop a theoretical understanding of the concept and correlating into relevant practice area.
- To develop and perceive a rationale for the conduct of clinical research activities.
- To acquire sufficient preparatory knowledge for more detailed studies in clinical research.

Outcome of the Course:

At the end of the course, students will be able to:

- Demonstrate competencies in evaluating clinical research data and communicating results.
- Evaluate critical domestic and global regulatory and health care issues that challenge and influence biopharmaceutical product development
- Describe Good Clinical Practices as they apply to different aspects of the Clinical Trial.
- Incorporate ethical practices in all stages of the clinical trial.

Unit I

Introduction to Clinical Research:

Clinical Trial–Indian and Global Perspective, Career in Clinical Research, Drug discovery and development process, Clinical trials: Types and Phases of Clinical Trial, Investigational New Drug Application, New Drug Application and Approval, post marketing surveillance. Ethics and Guidelines in Clinical Research: Regulation in clinical research, ICHGCP, Schedule Y, ICMR, Indian GCP. Stake holders Role and Responsibilities in Clinical Research: Sponsor, Investigator, Ethics committee, Sponsor–Vendor, Regulatory body, Contract Research Organization (CRO), Site management organizations (SMO).

Unit II

Clinical Trial Design and Management:

Protocol and Clinical Trial Design, Informed Consent document and informed consent Form, Case Report Form, Investigator's Brochure (IB), Clinical Study report. Essential documents in Clinical Research and Regulatory Requirements: Essential documents before the study conduct, Essential documents during the study conduct, Essential documents after the study conduct.

Unit III

Study Setup Process and management:

Site Selection– Selection of an Investigator and Site, Site Initiation, Subject Recruitment and study conduct, Site Contract and Budgeting, Monitoring, Site closure.

Unit IV

Quality Assurance, Compliance & Auditing in Clinical Research:

Site Auditing, Sponsor Compliance and Auditing, SOP for Clinical Research. Clinical Monitoring: CRF Review & Source Data Verification, Drug Safety Reporting, Drug Accountability Work, Routine Site Monitoring, Site Close Out Visit, Data management and its components. Safety reporting: Adverse Event and Adverse drug reactions, serious adverse event, Case Narrative Writing**.** Personality development and communication skills

Skill Enhancement Course 4:

INNOVATION AND BIO-ENTREPRENEURSHIP

Total Teaching Hours: 30 (Four Units)

Preamble

Microbiology today opens into enterprise as much as into research. Diagnostics, biofertilizers, probiotics, enzymes, fermented foods and biotech services all begin as ideas that someone chooses to build into a product or venture. This non-credit course, taught over thirty hours, introduces students to that path. It sets out how a scientific idea becomes an innovation, how intellectual property is protected, how a bio-enterprise is planned and funded, and how products reach the market under regulation. The treatment is practical and example-led, and aims to give science graduates the confidence and vocabulary to pursue entrepreneurship alongside, or instead of, a conventional research career.

Objectives of the Course

The objectives of this course are to introduce the students to:

- The concepts of innovation, entrepreneurship and the bioeconomy.
- The protection and management of intellectual property in the life sciences.
- The planning, funding and operation of a bio-based enterprise.
- Product development, regulation and commercialisation in the microbiology and biotechnology sectors.

Outcomes of the Course

On completion of this course, students should be able to:

- Explain the ideas of innovation, entrepreneurship and the bioeconomy.
- Identify forms of intellectual property and the basics of their protection.
- Outline a business plan and the sources of funding for a start-up.
- Describe how a microbial or biotech product is developed and brought to market.
- Recognise entrepreneurial opportunities and career paths in microbiology.

Unit I

Foundations of Innovation and Entrepreneurship

Concepts of creativity, invention, innovation and entrepreneurship; the entrepreneurial mindset and traits of an entrepreneur. Types of entrepreneurship — small-scale, technology-based and social enterprise. The bioeconomy and opportunities in microbiology and biotechnology; success stories of bioscience start-ups. From idea to opportunity — identifying problems, generating and screening ideas, and assessing feasibility.

Unit II

Intellectual Property and Technology Management (≈7 h)

Intellectual property in the life sciences — patents, copyrights, trademarks, designs, trade secrets and geographical indications. Basics of patenting — patentability, the filing process and patent search; IPR in India and the international framework (WIPO, TRIPS). Protection of biological material and biosafety/bioethics considerations; technology transfer, licensing and commercialisation of research.

Unit III

Enterprise Planning and Financing

From laboratory to enterprise — the business-planning process; components of a business plan; market survey and feasibility study. Costing, pricing and basic financial planning; sources of funding — self-finance, loans, venture capital, angel investors and crowdfunding. Government schemes and support agencies for start-ups (Start-up India, BIRAC, MSME, incubation centres and bio-incubators); the roles of mentoring and networking.

Unit IV

Product Development, Regulation and Commercialisation

Product development in microbiology and biotechnology — from prototype to market-ready product; scale-up and quality considerations. Regulatory and licensing requirements for bio-based products (drugs, diagnostics, biofertilizers and foods); standards and certification. Branding, marketing and distribution; risk and its management. Careers in bio-entrepreneurship; case studies of microbial and biotech products taken to market.

MSc MICROBIOLOGY (Re-revised CBCS)

THEORY QUESTION PAPER PATTERN

Instructions to candidate: Write neat labeled diagram wherever necessary

Max. Marks = 70 **Time: 03 hours**

PART A

Answer in Brief (**Answer any Five)** **5x 2 = 10**

1.
2.
3.
4.
5.
6.
7.

PART B

Write Short Notes on the Following **(Answer any Six)** **6 x 5 = 30**

8.
9.
10.
11.
12.
13.
14.
15.

PART C

Essay Type Questions **(Answer in Three)** **3 x 10 = 30**

16.
17.
18.
19.
20.

<table>
<tr><td colspan="3"><u>EVALUATION RUBRICS</u></td></tr>
<tr><td colspan="3">THEORY (SEMESTER END EXAMS) 70M</td></tr>
<tr><td colspan="3">EVALUATION PATTERN: Answer in Brief: 2M×5Q = 10
Short Answers: 5M×6Q = 30
Essay Type: 10M×3Q = 30</td></tr>
<tr><td>Answer in Brief: 2 M
• Clear definition/description</td><td>1.0</td><td rowspan="3">2M×5Q = 10</td></tr>
<tr><td>• Importance</td><td>0.5</td></tr>
<tr><td>• Significance</td><td>0.5</td></tr>
<tr><td>Short Answers: 5M
• Introduction</td><td>01</td><td rowspan="4">5M×6Q = 30</td></tr>
<tr><td>• Description/classification/pathway/functions etc.</td><td>02</td></tr>
<tr><td>• Diagrams/ Flow charts/tables/charts/representation/general account</td><td>01</td></tr>
<tr><td>• Importance/Significance</td><td>01</td></tr>
<tr><td>Essay Type: 10M
• Introduction</td><td>02</td><td rowspan="4">10M×3Q = 30</td></tr>
<tr><td>• Description/classification/pathway/functions etc.</td><td>04</td></tr>
<tr><td>• Diagrams/ Flow charts/tables/charts/representation/general account</td><td>02</td></tr>
<tr><td>• Importance/Significance</td><td>02</td></tr>
</table>

THEORY INTERNAL ASSESSMENT -- 30M		
1. Continuous Theory Internal Assessment C1+ C2+ MCQ (5+5+5) (TEST)		
EVALUATION PATTERN: O - Outstanding: (Above 95%) A^+- Excellent: (85-95% % of the allotted Marks) A - Very Good: (80 -85 % of the allotted Marks) B^+- Good: (70-80 % of the allotted Marks) B - Above average (60- 70% of the allotted Marks) C - Average (50-60% of the allotted Marks) P - Pass (40-50% of the allotted Marks) F - Fail (Below 40%)		**15**
2. Assignments (MICROBIOLOGY Perspective)		
• Latest developments in that field	**1**	**05**
• Sentence structure and flow	**2**	
• Comparison between the recent technology developments	**2**	
3. Seminars (Journal Club)/ Seminar Based on Internship Visit		
• Concept communication	**1**	**05**
• PPT/Video visibility, clarity & organization	**1**	
• References	**1**	
• Time limit	**1**	
• Confidence in answering queries	**1**	
4. Do Your Own Experiment Report/Internship Report (for CPT 4.1) (OPEN ENDED EXP)		
• Concept understanding	**2**	**05**
• Technical/scientific supporting material		
• Objectives		
• Methodology: Experimental skills and/or mathematical skills/Analytical skills	**1**	
• Innovation Quotient	**1**	
• Reference	**1**	
• Importance/Significance		
• Grammar and Style		

<table>
<tr><th colspan="4">PRACTICALS / SEC (SEMESTER END EXAMS) 35M</th></tr>
<tr><th colspan="4">PRACTICALS Major (12) and Minor (7) Experiments- 19M</th></tr>
<tr><th></th><th>Major (12)</th><th>Minor (7)</th><th></th></tr>
<tr><td>• Understanding of the Objective</td><td>02</td><td rowspan="2">02</td><td rowspan="7">12+7</td></tr>
<tr><td>• Principle of the experiment</td><td>03</td></tr>
<tr><td>• Methods to be followed</td><td>03</td><td rowspan="3">02</td></tr>
<tr><td>• Formula</td><td>01</td></tr>
<tr><td>• Steps of Calculation</td><td>01</td></tr>
<tr><td>• Result</td><td>01</td><td>02</td></tr>
<tr><td>• Conclusion/Inference</td><td>01</td><td>02</td></tr>
<tr><td>SPOTTERS: 2M X 3Q
• Correct Identification</td><td>1</td><td colspan="2" rowspan="3">06</td></tr>
<tr><td>• Description</td><td>0.5</td></tr>
<tr><td>• Significance/Importance</td><td>0.5</td></tr>
<tr><td>PRACTICAL VIVA:
• Knowledge about the topic</td><td>05</td><td colspan="2" rowspan="3">10</td></tr>
<tr><td>• Depth in understanding</td><td>2.5</td></tr>
<tr><td>• Clarity in answers
• Relating Practical conducted</td><td>2.5</td></tr>
</table>

<table>
<tr><th colspan="3">PRACTICAL/SEC INTERNAL ASSESSMENT – 15 M</th></tr>
<tr><td colspan="3">1. Continuous Practical Internal Assessment: C1</td></tr>
<tr><td colspan="2">EVALUATION PATTERN:
Excellent: A (85-100 % of the allotted Marks)
Very Good: B (70 -85 % of the allotted Marks)
Good: C (55-70 % of the allotted Marks)
Inadequate: D (< 55 % of the allotted Marks)</td><td>5</td></tr>
<tr><td colspan="3">Do Your Own Experiment: 5M</td></tr>
<tr><td>• Selection of the problem</td><td rowspan="3">3</td><td rowspan="4">5</td></tr>
<tr><td>• Hypothesis</td></tr>
<tr><td>• Relevant Content</td></tr>
<tr><td>• Demonstration</td><td>2</td></tr>
<tr><td colspan="3">Record submission: 05 M (REPORT EVALUVATION)</td></tr>
<tr><td>• Content page</td><td rowspan="3">1</td><td rowspan="6">5</td></tr>
<tr><td>• Certificate</td></tr>
<tr><td>• Dates of experiments</td></tr>
<tr><td>• Content & legibility</td><td>1</td></tr>
<tr><td>• Diagrams /graphs</td><td>1.5</td></tr>
<tr><td>• Proper representation of results</td><td>1.5</td></tr>
</table>

GROUP PROJECT: 70 M		
• Project value • Project innovation and implementation of their ideas • Group coordination and involvement in the activities	**20**	**70**
• Plagiarism • Review of Literature • Introduction • Hypothesis • Gaps in Research	**15**	
• Materials and Methods • Results and Discussion • Summary and Conclusion	**25**	
• Scientific Knowledge produced • Societal Impact • References • Grammar/ Spelling	**10**	
PROJECT VIVA- 35 M		
• Introduction - Significance of topic, • Objectives	**7.5**	**35**
• Review - succinct explanation, current reviews • Methodology -selection of experiments	**7.5**	
• Results & Discussion- clear and lucid presentation, organization of data/ charts/ spectral data, highlight of key findings with suitable justification	**15**	
• Reference- Appropriate references	**05**	

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