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

Revised and Approved in the Board of Studies Meeting held on 17/09/2022

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

Strategic Approach for Programme Curriculum Revision

Microbiology has gained strategic importance over the past decade and its applications are relevant to the human kind on a daily basis. Microbiology as a discipline is also very dynamic, interdisciplinary and real time changes are occurring resulting in challenges for curriculum upgradation and delivery, Therefore, it is essential that curriculum of MSc. Microbiology is revised to make it relevant dynamic that will create an ecosystem for skill development, entrepreneurship and academic excellence. Tumkur University PG CBCS regulation and course pattern has been strictly followed while undertaking the current revision. The current revision has taken into account draft model cur;riculum released by DBT on various subjects as well as latest developments in different niches of microbiology. It has also considered skill gap of students, skill requirement of local industries and is also based on extensive feedback obtained from all the stake holders. Also, major emphasis on skills required for IPR and clinical research industries have been addressed in the form of non-credit compulsory certification courses. The eligibility criteria have been expanded to make interdisciplinary.

The pedagogical methods for the Programme will include:

- Face to Face Lectures
- Tutorials
- Mentoring
- Group Discussion
- Demonstrations
- Journal Club
- Case study Analysis
- Virtual Labs
- Hands on Experiments
- Analytical Problem-Solving Methods
- Group Projects
- Mock Interview Skills
- Field and Industrial Visits
- Special lectures and Seminars
- Extension and Enrichment Activity
- Hypothesis Based Own Experiment Design

Programme Outcomes:

Objectives of the M.Sc. Microbiology is to develop;

- Researchers of the highest quality in the field of Microbiology
- Entrepreneurs who can develop innovative products and solutions.
- Students who can identify new hypothesis and scientific problem through critical analysis.

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 Systematics	4	4	3Hrs	20	80	100
2	CPT-1.2	Microbial Biochemistry and Physiology	4	4	3Hrs	20	80	100
3	CPT-1.3	Microbial Diversity I: Bacteriology and Virology	4	4	3Hrs	20	80	100
4	SPT-1.4A	Environmental Microbiology	4	4	3Hrs	20	80	100
	SPT-1.4B	Microbial Ecology &Extremophiles	4	4	3Hrs	20	80	100
5	CPP-1.5	Practical based on CPT-1.1	4	2	3Hrs	10	40	50
6	CPP-1.6	Practical based on CPT-1.2	4	2	3Hrs	10	40	50
7	CPP-1.7	Practical based on CPT-1.3	4	2	3Hrs	10	40	50
8	SPP-1.8A	Practical based on SPT-1.4A	4	2	3Hrs	10	40	50
	SPP-1.8B	Practical based on SPT-1.4B	4	2	3Hrs	10	40	50
		Total	32	24		120	480	600

Note:

CPT: Core paper Theory **CPP:** Core paper Practical

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	Microbial Genetics	4	4	3Hrs	20	80	100
2	CPT-2.2	Microbial Diversity II: Mycology, Phycology, Protozoology and Parasitology	4	4	3Hrs	20	80	100
3	SPT-2.3A	Agricultural Microbiology & Plant Pathogen Interactions	4	4	3Hrs	20	80	100
	SPT-2.3B	Bioinformatics& Mathematical Biology	4	4	3Hrs	20	80	100
4	OEPT-2.4	*To be offered by other Departments of the faculty*	4	4	3Hrs	20	80	100
5	CPP-2.5	Practical based on CPT-2.1	4	2	3Hrs	10	40	50
6	CPP-2.6	Practical based on CPT-2.2	4	2	3Hrs	10	40	50
7	SPP-2.7A	Practical based on SPT-2.3A	4	2	3Hrs	10	40	50
	SPP-2.7B	Practical based on SPT-2.3B	4	2	3Hrs	10	40	50
8	OEPP-2.8	*To be offered by other Departments of the faculty*	4	2	3Hrs	10	40	50
		Total	32	24		120	480	600
	Compulsory Skill Based Value Added Certificate Programme- INTELLECTUAL PROPERTY AND PATENTING (Non-Credit).							

Note:

CPT: Core paper Theory **CPP:** Core paper Practical

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	Molecular Biology and Genetic Engineering	4	4	3Hrs	20	80	100
2	CPT-3.2	Immunology and Vaccine-technology	4	4	3Hrs	20	80	100
3	SPT-3.3A	Food Processing Microbiology	4	4	3Hrs	20	80	100
	SPT-3.3B	Biostatics and Microbial Systems Biology	4	4	3Hrs	20	80	100
4	OEPT-3.4	*To be offered by other Departments of the faculty*	4	4	3Hrs	20	80	100
5	CPP-3.5	Practical based on CPT-3.1	4	2	3Hrs	10	40	50
6	CPP-3.6	Practical based on CPT-3.2	4	2	3Hrs	10	40	50
7	SPP-3.7A	Practical based on SPT-3.3A	4	2	3Hrs	10	40	50
	SPP-3.7B	Practical based on SPT-3.3B	4	2	3Hrs	10	40	50
8	OEPP-3.8	*To be offered by other Departments of the faculty*	4	2	3Hrs	10	40	50
		Total	32	24		120	480	600
	Compulsory Skill Based Value Added Certificate Programme-CLINICAL RESEARCH (Non-Credit).							

Note:

CPT: Core paper Theory **CPP:** Core paper Practical

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 and Microbial Product Development	4	4	3Hrs	20	80	100
2	CPT-4.2	Research Methodology, Scientific Communication Skills and Bio Entrepreneurship	4	4	3Hrs	20	80	100
3	SPT-4.3A	Medical Microbiology and Molecular Diagnostics	4	4	3Hrs	20	80	100
	SPT-4.3B	Pharmaceutical Microbiology	4	4	3Hrs	20	80	100
4	CPPD-4.4	Project Dissertation	4	4	3Hrs	20	80	100
5	CPP-4.5	Practical based on CPT-4.1	4	2	3Hrs	10	40	50
6	CPP-4.6	Practical based on CPT-4.2	4	2	3Hrs	10	40	50
7	SPP-4.7A	Practical based on SPT-4.3A	4	2	3Hrs	10	40	50
	SPP-4.7B	Practical based on SPT-4.3B	4	2	3Hrs	10	40	50
8	CPPP-4.8	Practical's Based on Project	4	2	3Hrs	10	40	50
		Total	32	24		120	480	600

Note:

CPT: Core paper theory

CPP: Core paper practical

SPT: Special paper theory

SPP: Special paper practical

CPPD: Core paper project Dissertation

CPPP: Core paper project practical

The number of experiments for CPP/SPP papers may vary for each semester. A core set of common experiments will be retained for each CPP/SPP paper and up to 50% changes will be carried out in the number and nature of experiments. These changes will be carried out after evaluating recent research articles, availability of Lab kits / Consumables / Protocols and virtual demonstration tools at the beginning of each Semester.

I SEMESTER

CPT-1.1 MICROBIAL CELL BIOLOGY AND SYSTEMATICS

Course Objectives:

The objectives of this course are to sensitize the students on the:

- Scale of magnitude from cells to organelles.
- The understanding of various biological processes.
- Organization and classification systems in microbial world.
- Microbial diversity, morphology, physiology and taxonomy.

Student Learning Outcomes:

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

- Learn morphology and ultrastructure of prokaryotic and eukaryotic cells
- Identify major categories of microorganisms and analyze their classification, diversity, and ubiquity.
- Understand the biology of prokaryotic and eukaryotic cells

Unit I

Prokaryotic Cell

Structure and functions of cell wall, flagella, cilia, pili, fimbriae, periplasmic space, gas vesicles, chlorosomes, carboxyomes, magnetosomes and phycoblisomes. Capsule structure, composition and properties. Cell wall - chemical composition, characteristics and function (Gram positive & gram-negative bacteria: lipoproteins, lipopolysaccharides, matrix proteins); plasma membrane (fluid mosaic model), function of cell membrane; Mesosomes, cytoplasm, ribosomes, subunits and chemical composition; molecular chaperons, nucleoids, plasmids, cytoplasmic inclusions, endospores.

Unit II

Eukaryotic Cell

Structural organization of endoplasmic reticulum, Golgi apparatus, lysosomes, peroxisomes, ribosomes, cellular cytoskeleton, mitochondria, chloroplasts and their genetic organization, nuclear compartment: nucleus, nucleolus and chromosomes. Protein trafficking; Cell cycle and its regulation; cell division: mitosis, meiosis and cytokinesis. Study of cell cycle using FACS.

Unit III

Membrane Transport (Prokaryotes and Eukaryotes)

The composition and architecture of membranes, Membrane dynamics, Solute transport across membranes: Passive diffusion, active transport using P and F type ATPases, Ion mediated

transport, transport of ions across membranes (ion pumps), co-transport, symport, antiport, endocytosis and exocytosis. Biochemical shuttles across mitochondrial membranes, Liposomes.

Unit IV

Microbial Systematics

Definition of systematics, nomenclature rules, hierarchical organization. Classification systems- artificial and phylogenetic- dendrogram. Haeckel's three-kingdom classification, Whittaker's five kingdom approach, Three domain classification of Carl Woese. Major characteristics used in taxonomy- morphological, physiological, metabolic, genetic and molecular characteristics, comparison of proteins, nucleic acid hybridization, nucleic acid sequence comparison, DNA and RNA homology, G+C ratio, significance of rRNA in microbial taxonomy and Chemotaxonomy.

CPT-1.2 MICROBIAL BIOCHEMISTRY AND PHYSIOLOGY

Course Objectives:

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

- Different biomolecules involved in the living system.
- Biochemical processes and different metabolic pathways involved in biological system.
- Enzymes and its importance in biochemical reactions.
- Analytical techniques involved in analyzing the biochemical entities

Student Learning Outcomes:

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

- General properties, structure, classification, function and metabolism of biomolecules.
- The concept of bioenergetics and electron transport chain.
- Nomenclature, classification, chemical nature and properties of enzymes.
- Principles and applications of analytical techniques

Unit I

Biomolecules

Carbohydrates – General properties, structure, classification, functions and Examples of Metabolism. Lipids - Classification, structure, properties, functions and Examples of Metabolism. Proteins– Structure (Primary, secondary, tertiary and Quaternary structure), Peptide synthesis: chemical and Merrifield synthesis. Nucleic acids – structure, a historical

perspective leading up to the proposition of DNA double helical structure; difference in RNA and DNA structure and their importance in evolution of DNA as the genetic material.

Unit II

Bioenergetics and Electron Transport Chain:

Laws of thermodynamics, Concept of free energy, standard free energy to enthalpy, entropy and equilibrium constant, determination of ΔG for a reaction. Relationship between equilibrium constant and standard free energy change, biological standard state & standard free energy change in coupled reactions. ATP as universal currency of free energy, Redox potentials. Oxidative phosphorylation: Electron transport and its Carriers-Complex I, II, III, IV, Determination of P: O ratio, ATP synthesis by F1-Fo ATP synthase. Difference between energy anabolism in diverse groups of Microbes. Bacteriorhodopsin: Photo cycle and significance

Unit III

Enzymology

Introduction to enzymes; nomenclature and classification of enzymes; chemical nature and properties of enzymes, activation energy, factors affecting enzyme activities, active site, allosteric site, coenzymes and co factors. Types of enzyme specificity, Units of enzyme activity. Mechanism of enzyme action-lock and key model, induced fit hypothesis, substrate strain theory, Mechanism of enzyme catalysis - Acid-Base catalysis, Covalent catalysis, Chemical kinetics, Derivation of Michaelis-menton equation, K_m value and its significance, Lineweaver- Burk plot, Enzyme inhibition-reversible and irreversible. Regulation of enzyme activity. Allosteric enzymes. Isozymes.

Unit IV

Analytical Techniques:

Principles and applications of Chromatography (TLC, Column Chromatography, Ion exchange Chromatography, Affinity Chromatography, Gas Chromatography, HPLC). Electrophoresis: Agarose gel Electrophoresis and SDS-PAGE. Spectroscopy: UV/Visible spectroscopy, Fluorescence spectroscopy, Infrared spectroscopy, NMR, ESR, Radiography: Autoradiography. Protein purification methods, Mass spectroscopy, X-Ray diffraction.

CPT 1.3 MICROBIAL DIVERSITY I: BACTERIOLOGY AND VIROLOGY

Course Objectives

The objectives of this course are to introduce students to:

- Microbial diversity, morphology, physiology and nutrition;

- Methods for control of microbes and host-microbe interactions.
- Distribution of species throughout the world.
- Key threats and approaches to conserving biodiversity.

Student Learning Outcomes

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

- Identify major categories of bacteria and viruses and analyze their classification, diversity, and ubiquity.
- Demonstrate structural, physiological, genetic similarities and differences of the major categories of bacteria and viruses.
- Understand control measures for microbial growth.
- Evaluate interactions between microbes, hosts and environment.
- Understand the various analytical techniques used for study of bacteria and viruses.

Unit I

Characteristics and Salient Features of Major Groups of Bacteria

General characteristics, Occurrence, shape and arrangement of bacterial cells. Major types of bacterial classification- morphological, phenotypic, genotypic, Numerical, analogical based classification. Taxonomic groups of bacteria based on Bergey`s manual; General characteristics, classification, ultrastructure, reproduction and economic importance of Eubacteria, Actinomycetes, Cyanobacteria, Mycoplasma, Rickettsia, Chlamydia, Photosynthetic bacteria and bioluminescent bacteria.

Unit II

Analytical Bacteriology

Microscopy: components of microscopes. Basic principles and types of Bright field, Dark field, Phase contrast, Fluorescence microscopes, Confocal microscope and their applications. Electron Microscopy – Principle, working and applications of Transmission Electron microscope (TEM) and Scanning Electron Microscope (SEM). STEM, Atomic force microscope (AFM). Isolation and sampling techniques: General isolation and sampling techniques for microorganisms from different sources. Microbial culture media and its types: Microbial growth; growth curve, diauxic growth curve, Measurement of microbial growth-cell number by turbidity and biomass, influence of environmental factors on growth. Staining techniques: Principles, protocols and applications of staining techniques. Simple, differential and structural staining techniques. Sterilization: Detailed process of physical and chemical methods of sterilization. Nutrition: Nutritional requirements, nutritional types of

microorganisms, growth factors, Crabtree effect, uptake of nutrients by the microbial cell, Microbial Safety measures: Concept, safety measures in handling microbiological samples and microorganisms.

Unit III

General Virology

Brief outline on discovery of viruses, Distinctive properties of viruses; Biological properties of viruses – host range, transmission-vector, non-vector; Physical properties of viruses – morphology, structure. Biochemical characteristics – chemical composition of viruses, proteins, nucleic acids, envelope, enzymes, lipids, carbohydrates, multiplication of viruses. Morphology & ultrastructure- Capsids and their arrangements - types of envelopes and their composition, their types and structures, ICTV nomenclature and classification of viruses. Major characteristics of different virus families- Viroid's and prions, Animal and Plant Viruses, bacteriophages.

Unit IV

Analytical Virology

Isolation and cultivation of viruses in embryonated eggs, experimental animals, and cell cultures- Primary & secondary cell cultures and continues cell cultures. Assay of viruses – Principle, Procedure, merits and demerits. Physical assay- electron microscopy and biological assay- Plaque Assay, Serological assay- ELISA, RIA, Western blot.

SPT-1.4A ENVIRONMENTAL MICROBIOLOGY

Course Objectives:

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

- Basic principles and characteristics of biochemical technology in environmental studies.
- Sustainable role of microbes in Environment.
- Bioremediation and role of different microbes in mitigating global environmental issues.

Student Learning Outcomes

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

- Basic principles and characteristics of biochemical technologies for water and wastewater treatment.
- In situ and ex situ Bioremediation.

- Bio sorption and accumulation of heavy metals.
- Bioaccumulation, Bio magnification, Biodegradation, Biofilms, Biofuels, Bioplastics.
- Microbial interaction in soil, water and air

Unit I

Air Microbiology

Factors effecting Air spora; Important air borne pathogens and toxins. Techniques for trapping air borne microorganisms: Vertical cylinder, Rotarod sampler, Burkard sampler, Anderson sampler, Hirst's trap, filtration, electrostatic precipitation, thermal precipitation, gravitational settling, impingement; Air sanitation: Methods and application.

Unit II

Soil Microbiology

Characteristics and classification of soil. Interactions between microorganisms: Mutualism, commensalism, ammensalism synergism, parasitism, predation, competition. Rhizosphere, microflora and its beneficial activity. Biogeochemical cycle: Carbon, Hydrogen, Nitrogen, phosphorous, sulphur, iron and manganese cycle. Detrimental effects of diverted biogeochemical cycles. Biological nitrogen fixation in detail: Symbiotic, asymbiotic and associated nitrogen fixation. Structure, function and genetic regulation of nitrogenases. Viable, non-culturable microorganisms. soil microbiome, Geomicrobiology and its environmental application

Unit III

Aquatic Microbiology

Distribution of microorganisms in Fresh and Marine ecosystems (estuaries, mangroves, deep sea, hydrothermal vents, salt pans, coral reefs). Zonation of water ecosystem. Effect of aquatic microorganisms on ecosystem. Water pollution sources, Source tracking of aquatic pollutants, biological indicators of water pollution, Determination of sanitary quality of water, Waste water Microbiology-Primary, secondary, tertiary treatment and reclamation of waste water. Microbial assessment of potable water. Advances in potable water purification. Biofilms: types, mechanism and its significance.

Unit IV

Role of Microbes in Mitigating Global Environmental Issues

Treatment of solid and liquid industrial wastes, Microbial degradation of pesticides, Xenobiotics, degradation of lignin, cellulose, pectin, metals. Bioremediation: Types, methods with examples and its applications. Microbes in metal extraction, mineral leaching and mining,

microbes in petroleum product formation and recovery (MEOR). Global Environmental Problems: Global Warming, Acid rain, Ozone depletion. Role of microbiology in achieving sustainable environment.

SPT-1.4B MICROBIAL ECOLOGY AND EXTREMOPHILES

Course Objectives:

The objectives of this course are to introduce students to:

- Interaction of organisms with each other and their Adaptation to environmental condition;
- Physiological aspects in organisms which effect the ecological interactions.
- Microorganisms found in extreme environmental conditions and their adaptions for survival.
- Experimentations on microorganism in space

Student Learning Outcomes:

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

- Understand major living and non-living components of regional and global environment, and their ecological interaction;
- Evaluate the physiology behind the interaction between the species
- Understand the importance and adaptation mechanism of extremophiles
- Explore the emerging theories of Exomicrobiology

Unit I

Concept of Microbial Ecology

Introduction to Microbial Ecology: Overview, History and applications, Ecological Factors, Population and Community Ecological factors, Laws of limiting Factors-Liebig's law of minimum, Shelford's law of tolerance. Structure and composition of atmosphere, hydrosphere, lithosphere and biosphere, Levels of organization- species, population characteristics, species interactions. Analytical techniques in microbial ecology. Microbial functions in ecosystem and Global cycles. Biodiversity and conservation: hotspots, causes of depletion, conservation methods and endangered species.

Unit II

Quantitative Ecology:

Microbial diversity, Operational taxonomic unit (OTU), Diversity indices (Shannon, Simpson), Alpha and beta diversity, Richness and evenness, Samples and samplings, Concept of

culturability, Determination of total and viable microbial number, Molecular analysis of function and diversity of microbial community, Metagenomics and microbiomics.

Unit III

Extremophiles:

Introduction to extremophiles, Isolation, classification and properties of extremophiles (Thermophiles, hyperthermophiles, Psychrophiles, Halophiles, Acidophiles, Methanogens, etc.). Adaptation mechanisms of extremophiles, biological applications of extremophiles, Genome analysis from extremophiles - Protein stability in hyper - extremophiles. Hyper-extremophiles and their novel metabolic machinery and biomolecules- unique applications.

Unit IV

Introduction to Exomicrobiology:

Introduction to Exomicrobiology. Life detection methods - Evidence of metabolism -Evidence of photosynthesis (autotrophic and heterotrophic) - ATP production – Phosphate uptake and Sulphur uptake. Monitoring of astronauts' microbial flora: Alterations in the load of medically important microorganisms, ESA STONE experiment. Aims and objectives of Astro microbiology research.

II SEMESTER

CPP 2.1 MICROBIAL GENETICS

Course Objectives:

The objectives of this course are to introduce students to:

- Basics of genetics and classical genetics covering prokaryotic and eukaryotic domains.
- Classical concepts of Mendelian genetics
- Concepts of population genetics, quantitative genetics encompassing complex traits, clinical genetics
- Genetics of evolution.

Student Learning Outcomes:

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

- Describe fundamental molecular principles of genetics;
- Understand relationship between phenotype and genotype in human genetic traits;
- Evaluate the basics of genetic mapping;
- Understand regulation of gene expression

Unit I

Principle of Genetics

Lamarck's and Mendel's Experiments and Principles of inheritance. Gene interaction, Genetic linkage and gene mapping, Tetrad analysis, Sex chromosomes and sex determination. General features of Genetic code, Universal genetic codes, degeneracy of codons, Wobble hypothesis. DNA as genetic material, Experiments of Griffith; Avery, McCleod; Mc Carthy and Harshey Chase. RNA as genetic material- Experiment of Fraenkel and Singer. Structure of nucleic acids- DNA structure and types, RNA types and structure, Extrachromosomal genetic elements – Plasmids and transposons, Ribozymes.

Unit II

Replication, Transcription and Translation

DNA Replication: Meselson and Stahl Experiment. DNA Replication in prokaryotes and eukaryotes. Transcription: Basic mechanism in prokaryotes and eukaryotes Regulation of transcription including transcription factors. Mechanism of protein synthesis, Post transcriptional modifications – nuclear splicing, rRNA and tRNA processing, Translation in prokaryotes and eukaryotes, post-translational modification.

Unit III

Mutations

Introduction and Types of Gene Mutations-Base substitution (Transition and transversion), Frame shift mutation, insertion, deletion, missense, nonsense, reverse, suppressor and lethal mutations). Pleiotropy- definition and examples. Mutagens – Physical (ionizing and non-ionizing radiations), chemical (Base analogs, Alkylating agents, Acridine dyes, Deaminating agents, Hydroxylating agents, Tobacco carcinogens) and biological (Bacteria, transposons, Oncogenic Viruses). DNA repair mechanisms- nucleotide excision repair, base excision repair, mismatch repair, recombination repair, double strand break repair, transcriptional coupled repair.

Unit IV

Genetic Transfer in Bacteria:

Transformation, Transduction, and Conjugation, Transposable elements: Transposable elements in prokaryotes – IS, Transposons, Mechanism of Transposition in Prokaryotes, Transposable elements in eukaryote, Retro-transposons and Retroposons. composite transposons, replicative and non-replicative transposons, Mu transposition, Controlling elements in TnA and Tn 10 transposition. SINES and LINES, retrotransposons.

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

Course Objectives:

The objectives of this course are to introduce students to:

- Diversity of higher microorganisms
- Morphology, physiology and nutrition of the above group of members.
- Economic importance of the above group of members.

Student Learning Outcomes:

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

- Identify major categories of microorganisms and analyze their classification, diversity, and ubiquity;
- Demonstrate structural, physiological, genetic similarities and differences of the major categories of microorganisms;

Evaluate the importance of these microbes in various industries.

Unit I

Mycology

History and development of Mycology, General characteristics, distribution and Ultrastructure of fungal cells, Nutrition in Fungi, Reproduction of Fungi-vegetative, asexual and sexual, Fungal spore and Fruiting bodies. Interaction between fungi and other organisms.

Major Fungal classification methods: general characteristics, structure and life cycle of Oomycetes, Zygomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes.

Unit II

Phycology

History and scope of Phycology; General characters, distribution and classificationof algae. Reproduction in Algae. Morphology and ultrastructure of Cyanophycean cell. Differences between micro and macro algae. Symbiotic algae: Lichens, coral reef and sea sponges. Economic importance of Algae- role of Algae in environment, Agriculture, industry and food.

Unit III

Protozoology

Salient features of Protozoa, Classification, Reproduction: Asexual method – binary fission and multiple fission Gamogony, Scizogony, Sporogony, Plasmotomy. Sexual method- Sexual Fusion, Autogamy, Paedogamy, Hologamy, Merogamy, Isogamy, Anisogamy, conjugation, Automixis, Parthenogenesis, Plasmogamy. Feeding in Protozoa and Economic importance of protozoa. Polymorphism in protozoa.

Unit IV

Parasitology

General Characters, systematics and pathogenicity: Flagellates: *Giardia intestinalis, Balantidium coli, Isospora belli, Trypanosomes, Leishmania, Toxoplasma gondii.*

Trematodes: *Fasciolla hepatica, Fasciolopsis buski, Paragonimus westermani,* Schistosomes, *Taeniasolium, Dipylidiumcaninum, Diphyllobothrium spp. Echinococcus spp.* Nematodes: *Ascaris lumbricoids, Trichinella spiralis*. Hook worms, *Wuchereria bancrofti, Dracunculus medinensis. Plasmodium* - Apicomplexan parasites, biology and phylogeny.

SPT-2.3A AGRICULTURAL MICROBIOLOGY AND PLANT PATHOGEN INTERACTIONS

Course Objectives:

The objectives of this course are to introduce students to:

- The principles, practices and application of agricultural microbiology,
- The effect of biocontrol agents, epidemiology of infectious disease
- The methods for control of microbial diseases
- The mechanism of plant-pathogen interactions

Student Learning Outcomes:

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

- Fundamental knowledge in agricultural microbiology
- Applications and their interaction with pathogens
- Importance of Biofertilizers and bio pesticides

Unit I

Microbes in Agriculture

Historical development, scope and concept of agricultural microbiology. Soil: Composition of soil and soil profile, physical, chemical and biological properties of soil. Distribution of microorganisms in soil, their importance in maintaining soil fertility, factors affecting soil microflora. Plant microbe Interactions: Rhizosphere, Rhizoplane, PGPR, PGPF, PGPA, Endophytes, Phyllosphere, Spermosphere and mycorrhizal association. Phosphate solubilizing microbes and microbiome for sustainable agriculture.

Unit II

Biofertilizers and Bio pesticides

Screening and selection of potential strains, large scale production of bacterial (Rhizobium, Azotobacter, Azospirillum), blue green algal and fungal fertilizers. Methods of application and evaluation of biofertilizers. Green manure, organic matter, compost & composting, vermi composting. Biopesticides -B. thuringiensis, Bacillus papillae, Trichoderma; Transgenic crop plants for crop protection and soil fertility. Importance of organic farming in maintaining soil fertility.

Unit III

Plant Pathology

Parasitism and Disease Development, Pathogenicity, Disease triangle, Disease cycle / Infection cycle. Epidemiology and control of Bacterial disease-fire blight of apple, potato scab, citrus

canker, lethal yellowing of coconut etc., Epidemiology and control of Fungal disease -powdery scab of potato, lite blight of potato, downy mildews of pearl millet, Fusarium wilt of tomato, blast disease of rice, stem rust of wheat, corn smuts etc. Epidemiology and control of Viral disease- TMV, Tomato spotted wilt (TSWV), Cucumber mosaic virus (CMV), Barley yellow dwarf, papaya ring spot, banana bunchy top etc.

Unit IV

Microbial Interactions

Interaction between microorganisms in soil (positive and negative interaction). Pathogens attack on host – Mechanical forces, Microbial enzymes and toxins, Defense Mechanisms of Plant: Disease Pre-existing structural and chemical defenses, Induced Structural and biochemical defenses. Elicitors and effectors of host defense responses, early and late events in plant disease Resistance, signaling in plant disease resistance, molecular mechanism of disease resistance, PR-Proteins in disease resistance.

SPP -2.3B BIOINFORMATICS& MATHEMATICAL BIOLOGY

Course Objectives:

The objectives of this course are to introduce students to:

- Theory and practical experience of the use of common computational tools for data analysis.
- Databases which facilitate investigation of molecular biology
- The *in silico* analytical tools for biological data analysis
- Mathematical concepts which aid biological research

Student Learning Outcomes:

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

- Basic theory of these computational tools;
- Working knowledge of these computational tools and methods;
- Specific contemporary biological questions using *Insilico* analysis.
- The methods used in the *Insilco* analysis

Unit I

Introduction to Bioinformatics

Introduction, scope and application of Bioinformatics, Biological databases: types of Databases-Nucleic Acid sequence databases- GenBank, EMBL DDBJ, Protein sequence databases-PIR-PSD, SwissProt, TrEMBL/GenPept, Database Searches-Text-based searching,

Simple and advanced forms, Database searching using BLAST and FASTA, Manipulation of displays, Entrez/SRS- query engines, Structure databases, viral databases, immunodatabases, genome databases and Gene expression databases

Unit II

Sequence Alignment

Sequence alignment- Introduction, principle and types of alignment, Matrices of alignment- DNA and Protein Matrices, Multiple sequence alignment, Structural alignment (DALI and SSAP), Genome annotation – identification of genes (promoter, ribosome binding sites, initiation codons, intron - exon boundaries in a gene, splice sites, termination codons) CpG Islands, repetitive elements, DNA barcoding, Phylogenetic analysis.

Unit III

Mathematical Biology:

Linear equations, functions: slopes-intercepts, forms of two-variable linear equations; constructing linear models in biological systems; quadratic equations (solving, graphing, features of, interpreting quadratic models etc.), introduction to polynomials, graphs of binomials and polynomials. Basics of vectors and introduction to matrices.

Unit IV

Mathematical Models in Biology:

Population dynamics; oscillations, circadian rhythms, developmental patterns, symmetry in biological systems, fractal geometries, size-limits & scaling in biology, modeling chemical reaction networks and metabolic networks.

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OEPT 2.4 THE EXCITING WORLD OF MICROBES

Course Objectives:

The objectives of this course are to introduce students to:

- Basics and history of microbiology
- Application of microbes used in various industry
- Role of microbes in the disease outbreaks and pathogenicity of the diseases

Student Learning Outcomes:

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

- History and importance of microbiology

- Different types of microbes involved in the food and agriculture
- Causes and prevention of diseases

Unit I

Introduction to Microbiology:

Microbes and origin of life History and scope of Microbiology as a modern science, Branches of Microbiology, Contribution of Scientists to the field of Microbiology - Antony Von Leewenhoek, Edward, Jenner, Lazzaro Spallanzani, Louis Pasteur, Joseph Lister, Robert Koch, Alexander Flemings and lwanovsky. Classification, isolation and identification of different groups of microbes. Major groups of microbes: General characteristics and economic importance of a) Bacteria b) Fungi c) Actinomycetes d) Cyanobacteria e) Mycoplasma`s f) Viruses.

Unit II

Microbiology of Food and Industry:

Primary sources of microorganisms in foods. Factors influencing microbial growth in foods - extrinsic and intrinsic. Principles of food preservation - preservation methods - irradiations-drying, heat processing, chilling and freezing, high pressure, modification of atmosphere and chemical preservatives. Nutritional value of fermented foods. SCP and its uses. Contamination, preservation and spoilage of fruits, vegetables, meat and poultry products. Industrially important microorganisms.

Unit III

Microbiology of Agriculture and Environment:

Distribution of soil microorganisms. Factors influencing the soil microflora- Role of microorganisms in soil fertility. Interactions among microorganisms, mutualisms, commensalism, competition, Ammensalism, parasitism, predation. Interactions between microbes and plants - Rhizosphere, Phyllosphere, mycorrhizae. Microbial interactions in Animals-Rumen microbiology - Microbial contribution to food digestion.

Unit IV

Microbiology of Health:

History and scope of Medical Microbiology, Concept of Disease, Disorder, Syndrome - Communicable Diseases – Microbial Infections and Diseases. Microbial Pathogenicity – factors responsible for Microbial pathogenicity. Distribution and occurrence of normal flora. Systematic study of important bacterial, fungal, viral and parasitic disease-causing agents.

III SEMESTER

CPT 3.1 MOLECULAR BIOLOGY AND GENETIC ENGINEERING

Course Objectives:

The objectives of this course are to introduce students to:

- Fundamental knowledge of genome structure of organism.
- Epigenetics, gene regulation, RNA transcription, protein synthesis, protein targeting and trafficking, and cell signaling.
- Various approaches to conducting genetic engineering and their applications in biological research as well as in industries.

Student Learning Outcomes

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

- Explain and summarize the scientific principles of molecular biology of DNA and RNA;
- Use specialized DNA/RNA isolation, manipulation, and cloning methods, individually and collaboratively that are typical of molecular biology laboratory investigations and communicate the results as written laboratory reports;
- Describe and explain the results of DNA and/or RNA experiments based on the scientific principles of nucleic acid structure.

Unit I

Genome Structure and Organization:

Definition and organization of viral, prokaryotic and eukaryotic genomes, genome organization in mitochondria and chloroplast, gene concept, Unit of function, Structure of chromatin, nucleosome, chromatin organization and remodeling, higher order organization- chromosome, centromere, telomere. Histones and their effect on structure and function of chromatin. Recombination: Homologous and site-specific recombination, models for homologous recombination- Holliday junction, NHEJ, Proteins involved in recombination- RecA, RuvA, B, C, Gene conversion. rII locus and complementation analysis, Gene function: one gene/one enzyme hypothesis.

Unit II

Genetic Engineering:

Impact of genetic engineering in modern society; general requirements for performing a genetic engineering experiment; restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt

end ligation; linkers; adaptors; homopolymeric tailing; labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes, hybridization techniques: northern, southern, south-western and far-western and colony hybridization, fluorescence in situ hybridization. determination of stringency conditions, Applications of nucleic acid hybridization.

Unit III

Vectors:

Plasmid vectors Use of natural plasmids as vectors, artificial plasmid vectors, pBR322, pUC 19, Ti & Ri as vectors, plasmid vectors. Bacteriophage, Insertion vectors, replacement vectors, cosmid vectors, phagemid vectors, shuttle vectors, expression vectors, M13 based vectors. YAC, BAC, Baculovirus and Pichia vectors system, yeast vectors. RFLP and RAPD. Isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; cDNA & Genome libraries – construction and screening, chromosome walking.

Unit IV

rDNA Technology:

Insertion of foreign DNA into host cells; Gene transformation techniques- Direct Method-Indirect methods, Screening of recombinant, Applications of rDNA technology. PCR – principles, primer design, types and applications. DNA fingerprinting, sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; construction of microarrays – genomic arrays, cDNA arrays and oligo arrays; study of protein-DNA interactions: electrophoretic mobility shift assay; DNase foot printing; methyl interference assay, chromatin immunoprecipitation

CPT 3.2 IMMUNOLOGY AND VACCINE-TECHNOLOGY

Course Objectives:

The objectives of this course are to introduce students to:

- Structural features of components of immune system as well as their function.
- Development of immune system and mechanisms by which our body elicits immune response.
- The concept of immune response that develops against bacterial, viral or parasitic infection, and prove it by designing new experiments.

Student Learning Outcomes:

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

- Evaluate usefulness of immunology in different pharmaceutical companies;
- Identify proper research lab working in area of their own interests;
- Apply their knowledge and design immunological experiments

Unit I

Immune System and Immune Response

History and scope of immunology: Innate and acquired immunity, structure and functions of immune Cells-T cells, B cells, Macrophages, NK cells and dendritic cells, Eosinophils, Neutrophils, Mast cells. Organs of immune System-Primary and secondary lymphoid organs. Immunoglobulins - basic structure, classes & subclasses of immunoglobulins, Antigen: Types-properties and functions, Primary and secondary immune response, Clonal selection theory.

Unit II

Hypersensitivity Reactions:

Allergy, Hypersensitivity reactions -types (I, II, III, and IV), symptoms, immunodiagnostic. Lymphokines and cytokines: Interleukins and Interferons - Production, biological functions and assay methods. Immunological tolerance.

Unit III

Immunological Techniques:

Agglutination, precipitation, immune-fluorescence, immuno electrophoresis, immunoblotting, ELISA, RIA, Flow cytometry. Production and purification of antibodies, determination of antibody titre by RID and EID, production of hybridoma. T-cell cloning: Mechanism of antigen recognition T and B -lymphocytes, Importance of antigen and MHC class II molecules in T-cell cloning. Antigen specific and alloreactive T-cell cloning -immunologically relevant antigens and T cell subtypes. Processes of vaccine development and clinical trials.

Unit IV

Vaccines and Immunization:

Vaccines- Principles and types, conventional, peptide vaccines, subunit, DNA vaccines. Toxoids, antisera, edible vaccines, plantibodies, ISCOMs, recombinant antibodies, Immune stimulatory complexes. Common immunization programs-BCG, small pox, PT, polio, measles, Hepatitis B.

SPT 3.3A FOOD PROCESS MICROBIOLOGY

Course Objectives:

The objectives of this course are to introduce students to:

- Basic principles of food science and technology
- Growing and dynamic needs of food and beverage industries
- The standard practices used in the food industry

Student Learning Outcomes:

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

- Demonstrate a level of comprehension of concepts of food science;
- Critically evaluate and solve issues or problems pertaining to food science
- Understand the important laws and practices involved in food industry

Unit I

Introduction

Introduction of food microbiology and its relevance to everyday life. Food and its constituents-carbohydrates, proteins, lipids, vitamins, minerals, water (different forms of water present in foods and their effect on quality and preservation of foods), minor constituents affecting texture, color, taste, odor; Food microbiology, Food biochemistry, Food additives, General food composition and effect of food constituents on food quality. extrinsic and intrinsic factors influencing microbial growth

Unit II

Food Processing and Preservation

Introduction to food processing of various foods including dairy, bakery, brewing, fruit and vegetable products, plantation products; gut microbiome, pro and prebiotics and nutraceutical. Membrane technology: Introduction to pressure activated membrane processes: microfiltration, UF, NF and RO and their industrial application. High Pressure processing: Concept and its application in food processing. Principles of food preservation by: Dehydration, Thermal treatments like pasteurization, sterilization, canning, retorting etc. Low temperature i.e. chilling and freezing, Chemical preservation/ bio-preservation, Traditional methods like salting/ syruping, pickling, fermentation etc. Non thermal processes like MAP, irradiation, high pressure processing etc. Hurdle technology.

Unit III

Food Analysis

Introduction to Food Analysis, Types of Samples Analyzed, Choice and Validity of method, Official methods, Sampling and Preparation of samples, Moisture and Total Solids Analysis, Ash analysis: Dry and wet ashing. Fat Analysis: Solvent extraction. Protein analysis and Carbohydrate analysis, Vitamin Analysis, Standards of identity, purity and methodology for analysis of: a) Cereals, legumes, oil seeds and their products; b) Fruits, vegetables, tubers and their products; c) Tea, coffee, cocoa, chocolate, spices, condiments; d) Milk and milk products; e) Meat, fish and poultry products; f) Miscellaneous foods e.g., fermented products.

Unit IV

Food Safety Law

Relevance of microbial standards for food safety. Food Agricultural Organization (FAO), World Health Organization (WHO), The International Children's Emergency Fund (UNICEF), Codex Alimentarius, The International Commission on Microbiological Specifications for Foods (ICMSF), The Food and Drug Administration (FDA), United States Department of Agriculture (USDA). FSSAI, FPO, MPO, CSO, Agmark standard, BIS, National and international Food testing laborites.

SPP 3.3B BIOSTATICS AND MICROBIAL SYSTEMS BIOLOGY

Course Objectives:

The objectives of this course are to introduce students to:

- Theory and practical experience of the use of common computational tools
- databases which facilitate investigation of molecular biology
- Evolution-related concepts. conceptual exposure of essential contents of mathematics

Student Learning Outcomes:

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

- Develop an understanding of basic theory of these computational tools;
- Gain working knowledge of these computational tools and methods;
- Appreciate their relevance for investigating specific contemporary biological questions;
- Critically analyze and interpret results of their study.
- Gain broad understanding in mathematics;
- Recognize importance and value of mathematical thinking, training, and approach to problem solving, on a diverse variety of disciplines.

Unit I

(A) Introduction to Biostatistics:

Introduction, scope and application of Biostatics, Concepts of Primary and Secondary data. Methods of collection and editing of primary data and Secondary data. Designing a hypothesis and schedule. Measures of Central Tendency - Mean, Median, Mode, Geometric Mean and Harmonic Mean, Measures of dispersion: Range, Quartile Deviation, Mean Deviation and Standard Deviation. Descriptive Statistics -Central and Non-Central moments and their interrelationship. Sheppard's correction for moments. Skewness and kurtosis. Data graphics-Construction and labeling of graphs, histogram, piecharts, scatter plots, semilogarthimic plots

(B) Basics of testing hypothesis related to statistics

Null hypothesis, level of significance, power of test, P value, statistical estimation of confidence intervals. Level of significance: Parametric data- student's t-test (paired and unpaired), chi square test, Analysis of Variance (one-way and two-way), non-parametric dat)-Sign test, Wilcoxan's signed rank test, Wilcoxan rank sum test, Mann Whitney U test, Kruskal-Wall is test (one way ANOVA); Linear regression and correlation- Introduction, Pearsonn's and Spearmann's correlation and cor- relation co-efficient; Statistical software: SPSS, Epi Info, SAS.

Unit II

Genomics

Computational analysis, Databases, finding genes and regulatory regions; Tools for genome analysis- PCR, RFLP, DNA fingerprinting, RAPD, SNP detection, SSCP, FISH to identify chromosome landmarks; Human Genome Project- landmarks on chromosomes generated by various mapping methods, BAC libraries and shotgun libraries preparation, Physical map, Cytogenetic map, Contig map, Restriction map, UCSC browser. Introduction, Basic principles and design, cDNA and oligonucleotide arrays, DNA microarray, Instrumentation and structure; Designing a microarray experiment - The basic steps, Types of microarrays - expression arrays, protein arrays, Comparative Genomic Hybridization (CGH) arrays, Resequencing arrays; Different platforms (Affymetrix, Agilent etc.); Data Processing and Normalization. Next generation sequencing (NGS).

Unit III

Proteomics

Overview of protein structure-primary, secondary, tertiary and quaternary structure, Relationship between protein structure and function; Outline of a typical proteomics experiment, Identification and analysis of proteins by 2D analysis, Spot visualization and picking; Tryptic digestion of protein and peptide fingerprinting, Mass spectrometry : ion source (MALDI, spray sources), analyzer (ToF, quadrupole, quadruple ion trap) and detector; Post translational Modifications: Quantitative proteomics, clinical proteomics and disease biomarkers, mass spectral tissue imaging and profiling; Protein-protein interactions: Surfaceomes and Secretomes, Solid phase ELISA, pull-down assays (using GST-tagged protein) tandem affinity purification, far western analysis, by surface plasmon resonance technique; Yeast two hybrid system, Phage display, Protein interaction maps, Protein arrays-definition; applications- diagnostics, expression profiling.

Unit IV

Metabolomics

Introduction and overview of metabolites, sample collection and processing, Non tracer and tracer (radio labelled)-based techniques in metabolomics (HPLC, NMR, LC-MS and GC-MS); Metabolome data processing derived by various techniques, analysis of databases (Metabolite, Meta Cyc, MMCD etc), Analysis tools, Metabolic pathways and network analysis; Metabolic flux analysis (TCA, Amino acids, fatty acids, intermediary metabolites), Stoichiometric metabolic flux analysis, 13C metabolic flux analysis (MFA), Metabolic control analysis (MCA); Applications of metabolomics; Integration of metabolomics data sets with other data (e.g. Transcriptomic, enzyme activity, etc.).

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OEPT 3.4: MICROBIOLOGY FOR HUMAN WELFARE

Course Objectives:

The objectives of this course are to introduce students to:

- Applications of microbial techniques for sustainable human welfare.

Student Learning Outcomes:

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

- application of industrially important organisms,

- fermentation technology, microbial fuels,
- bioremediation and biocontrol agents.

Unit I

Fundamental Principles of Applied Microbiology

Microbial Biodiversity and Sustainable development. Isolation of industrially important microorganisms, preservation and improvement of industrially useful microorganisms. Types of Fermentation and its advantages, Types of fermenters; Airlift, Fluidized bed reactor, Photobioreactors, Stirred tank and Packed bed bioreactors, Downstream processing Methods. GMO and their impact.

Unit II

Microbial Fuels

History of Biofuels-Global scenario of Biofuel production. Microbial macromolecules as biofuel feedstocks. Alternate sources of energy – methane, hydrogen and biogas production and their significance of commercial production of biofuels. Single cell proteins & single cell oil, MEOR.

Unit III

Production of Commercially Important Products from Microorganisms:

Industrial products from Microorganisms- Antibiotics: Penicillin and Streptomycin, Vaccines, Enzymes: Amylase and Protease, Vitamins, Monoclonal antibodies, Production of Alcoholic Beverages, Mushroom cultivation, Overview of biofertilizers and biopesticides.

Unit IV

Microbes in Bioremediation:

Bioremediation: Methods and applications. Biodegradable polymers from microorganisms. Biotransformation of Xenobiotics, Methods of Metal Recovery by Microorganisms, Microbial leaching - copper, gold, and Uranium.

IV SEMESTER

CPP 4.1 BIOPROCESS AND MICROBIAL PRODUCT DEVELOPMENT

Course Objectives:

The objectives of this course are to introduce students to:

- Fundamental concepts of bioprocess technology
- Related applications in the fermentation technology
- Commercially important microbial products and their production

Student Learning Outcomes

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

- Appreciate relevance of microorganisms from industrial context;
- Carry out stoichiometric calculations and specify models of their growth;
- Give an account of design and operations of various fermenters;
- Critically analyze any bioprocess from market point of view;
- Give an account of important microbial/enzymatic industrial processes in food and fuel industry.

Unit I

Introduction to Bioprocess Technology:

Basic principles in bioprocess technology; Media Formulation; Types of sterilization, thermal death kinetics of microorganism; Heat sterilization of liquid medium in batch and continuous mode; Air sterilization; Inoculum development; Bioprocess control and monitoring variables such as temperature, agitation, pressure, pH, Microbial processes-production, optimization, screening, strain improvement.

Unit II

Fermentation:

Concepts, components and factors affecting Fermentation Process, Design of Fermenters, Types of Fermenters – Airlift, Packed bed, Fluidized bed, Membrane, Bubble column, Types of Fermentation process- Batch Fermentation, Continuous Fermentation, Fed Batch Fermentation, Anaerobic Fermentation, Aerobic Fermentation, Surface Fermentations, Submerged Fermentations, Solid state Fermentation.

Unit III

Microbial Products:

Industrial production of Antibiotics: penicillin, Streptomycin, Tetracycline, Production of Vaccines, Production of Enzymes: Amylase, Protease, Lipases, Pectinases, and Cellulases.

Production of organic acids: Citric acid, Gluconic acid, Lactic acid, Biofuel: Ethanol, Methanol, Biodiesel, Biogas and Biorefinery. Fermented foods; food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; microbes and their use in pickling, producing colours and flavours, Single cell protein, Probiotics and Prebiotics, production and applications in food preservation, Alcoholic beverages and other products; process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products.

Unit IV

Downstream Processing:

Downstream processing: Separation of insoluble products – separation of cells and foam; filtration (plate filters, rotary vacuum filter), centrifugation (continuous, basket and bowl centrifuge, sedimentation, flocculation; cell disruption (mechanical and non-mechanical methods); separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis; final purification: drying (spray, drum, freeze driers); crystallization; storage and packaging, Quality Control and Quality Assurance.

CPT 4.2 RESEARCH METHODOLOGY, SCIENTIFIC COMMUNICATION SKILLS AND BIO ENTREPRENEURSHIP

Course Objectives:

The objectives of this course are to introduce students to:

- Background on history of science, emphasizing methodologies used to do research.
- Use framework of these methodologies for understanding effective lab practices
- scientific communication and appreciate scientific ethics

Student Learning Outcomes

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

- Understand history and methodologies of scientific research, applying these to recent published papers;
- Practice scientific reading, writing and presentations;
- Appreciate scientific ethics through case studies
- Adapt communication practices in the scientific discussion

Unit I

Research Writing:

Empirical science; scientific method; manipulative experiments and controls; deductive and inductive reasoning; descriptive science; reductionist vs holistic biology; research methods vs methodology; types of research, data collection and analysis; research ethics and IPR; preparation of a research; choosing a mentor; lab and research question; research problem; literature review; hypothesis, gaps in research; research reports; publication of research

Unit II

Scientific Communication:

Technical writing skills - types of reports; layout of a formal report; scientific writing skills - importance of communicating science; problems while writing a scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers - peer review process and problems, recent developments such as open access and nonblind review; plagiarism; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.

Unit III

Innovation and Entrepreneurship in Bio-business:

Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (e.g. pharmaceuticals vs. Industrial biotech), Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities, Alternatives faced by emerging bio-firms and the relevant tools for strategic decision, Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies.

Unit IV

Bio Markets and Technology Management:

Negotiating the road from lab to the market (strategies and processes of negotiation with financiers, government and regulatory authorities), Pricing strategy, Challenges in marketing in bio business (market conditions & segments; developing distribution channels, the nature, analysis and management of customer needs), Basic contract principles, different types of

agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills.

SPT 4.3A MEDICAL MICROBIOLOGY AND MOLECULAR DIAGNOSTICS

Course Objectives:

The objectives of this course are to introduce students to:

- Recent advances in medical microbiology and various facets of medicine.
- Analysis of genetic diseases and Identification of individuals predisposed to disease ranging from common cold to cancer
- Various molecular techniques in medical diagnostics

Student Learning Outcomes

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

- Various facets of molecular procedures
- Basics of molecular techniques that could be employed in early diagnosis and prognosis of human diseases
- Epidemiology and impact of various diseases

Unit I

Infectious Diseases

Epidemiology and Environmental Factors in Infectious diseases, Normal microflora of the Human body, Monoprophylaxis, Heath care associated infection, Emerging and re-emerging infections, Recognition of Bioterrorism, control strategies, WHO regulation and Guidelines. Overview of Microbial diseases: Bacterial diseases- Pneumonia, Tuberculosis, Diphtheria, Tetanus, Fungal Diseases– Aspergillosis, Candidiasis, Mucormyosis, Blastomycosis, Histoplasmosis, Sporotrichosis. Protozoan diseases - Malaria, Leishmaniasis, Amoebiasis and Giardiasis, Infection by Helminths-Ascariasis, Filariasis, Taeniasis, Echinococcosis and Schistosomiasis. Viral diseases- Influenza, Measles, Herpes, Rabies, Small pox, Polio, Chickenpox, Mumps, Viral Hepatitis, AIDS. Antimicrobial drugs classification and its mode of action.

Unit II

Molecular Diagnostics

Direct and Indirect Methods for detection of various diseases, PCR, RT-PCR, qRTPCR, Loop mediated isothermal amplification (LAMP), FISH, DNA sequencing and genotyping, Next generation sequencing, Oligonucleotide-coupled fluorescent microsphere diagnostic assay,

Nucleic acid hybridization based methods of detection – Southern, Northern and Western, Microarrays based detection, multiplexing etc., Immunodiffusion – double and single immune diffusion, ELISA and its types, Radio immuno assay, chemiluminescent immunoassay, Lateral flow immunoassay strips, Dot blot immuno assay, Western blotting, immunofluorescence, flow cytometry assays, Immunoelectron microscopy, Thermography, Fluorescence imaging, hyperspectral techniques, Biosensors – nanomaterials based, affinity based biosensors – antibody based, nucleic acid based, Enzymatic electrochemical based biosensors, bacteriophage based biosensor. Drug therapies for microbial diseases.

Unit III

Molecular Therapeutics

Gene therapy; Intracellular barriers to gene delivery, Overview of inherited and acquired diseases for gene therapy, Retro and adeno virus mediated gene transfer; Liposome and nanoparticles mediated gene delivery; Cellular therapy; Recombinant therapy; Clinical applications of recombinant technology; Erythropoietin Recombinant human growth hormone, Recombinant coagulation factors; Immunotherapy and Immunostimulants, Types of recombinant vaccines and clinical applications; Gene silencing technology; Antisense therapy; siRNA; Tissue and organ transplantation; Transgenics and their uses; Cloning; Ethical issues.

Unit IV

Pandemic Biology

Major Emerging Infectious Disease of the 21st Century, Ecology and Evolutionary Biology for Infectious Disease, Vectors of Change: Climate and Shifts in Vector Behavior and Habitat, SAR, Measuring Outbreaks and Introduction to Complex System, Models of Infectious Disease and the Basic Reproduction Number, The Perfect Storm: Extreme Weather, Malnutrition, and Pathogen, Trophic Amplification in a More Variable World, Building New Ecologies: Case studies in Urbanization and Infectious Diseases, Habitat Destruction and Loss of Biodiversity, The Legacies of Colonialism: the Emergence of HIV, HIV and the Evolution of Virulence, Antimicrobial Resistance and Evolution-Proofing, Humanity's Changing Epidemiological Environments, Covid-19: Educated Pandemic Response.COVID-19 pandemic Mitigation approaches, Comparing COVID-19 with other pandemics, Covid 19, Therapeutics and vaccines, The Black Plague, Small Pox & Polio virus, Cholera, Spanish-1918 Flu.

SPT 4.3B PHARMACEUTICAL MICROBIOLOGY

Course Objectives:

The objectives of this course are to:

- To get overview knowledge of microbes in pharma in both positive and negative aspects.
- To be familiar in antibiotics and advanced drug delivery system.
- To know about drug formulation regarding to guidelines and regulations.

Student Learning 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.
- Discuss Microbial contamination/product spoilage and antimicrobial preservation of pharmaceutical formulations during production and in products.
- Demonstrate a knowledge and understanding of microbiological assays of growth promoting and growth inhibiting substances.
- Acquire a Knowledge of GMP, GLP and other practices.

Unit I

Antibiotics:

Antibiotics - Natural and synthetic - antifungal agents, antitumor substances. Peptide antibiotics, Chloramphenicol, Sulphonamides and Quinolone antimicrobial agents. Chemical disinfectants, antiseptics and preservatives- Basic aspects of the structure and functioning of the immune system- Laboratory evaluation of antimicrobial agents- Mechanism of action of antibiotics and synthetic anti-infective agents. Bacterial resistance to antibiotics- Clinical uses of antimicrobial drugs.

Unit II

Drug Delivery:

Molecular principles of drug targeting. Drug delivery system in gene therapy. Bacterial resistance to antibiotics. Mode of action of non-antibiotic antimicrobial agents. Delivery systems – formulations, targeted drug delivery, Sustained release drugs. Drug distribution in body, bio-availability and pharmacokinetic studies.

Unit III

Techniques in Pharmaceutical Industry:

Ecology of microbes as it affects the pharmaceutical industry- Microbial contamination and spoilage of pharmaceutical products – infection risk and contamination control - and their sterilization. Bioassay of antibacterial agents in liquid media and in agar media using standard guidelines (e.g. (NCCLS) / (CLSI)) - Factors affecting bioassay, Laboratory methods to assess activity of antimicrobial combinations (antagonism, synergism and additive effect). Methodologies for testing of anti-mycobacterial, antifungal, anti-parasitic and antiviral drugs (in vivo and in vitro infectivity models).

Unit IV

Regulatory Practices and Policies:

Government regulatory practices and policies, Regulatory aspects of quality control. Sterilization control and sterility testing- Chemical and biological indicators. Regulatory authorities for introduction of medicines in market – Role of Food and Drug Administration, FDA guidelines for drugs / biologicals, Validation (GMP, GLP, GCP, etc.). Clinical studies: Phase I, phase II, phase III and phase IV of clinical trials – Objectives, Conduct of trials, Outcome of trials.

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I SEMESTER

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III SEMESTER

CPT 3.1 MOLECULAR BIOLOGY AND GENETIC ENGINEERING

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IV SEMESTER

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SKILL BASED VALUE ADDED CERTIFICATE PROGRAMME (Non-Credit)

(Conducted in Association with Industry Partners)

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.

Duration: Duration: 40 hrs (4 Weeks@ 10 hours/week)

Unit I

Overview of Intellectual Property:

a) Introduction and the need for intellectual property right (IPR)
b) Kinds of Intellectual Property Rights:
    a. Patent
    b. Copyright
    c. Trade Mark
    d. Design
    e. Geographical Indication

f. Plant Varieties
g. Layout Design
h. Genetic Resources and Traditional Knowledge
i. Trade Secret

c) Major International Instruments concerning Intellectual Property Rights:
   a. Paris Convention, 1883,
   b. The Berne Convention, 1886,
   c. The Universal Copyright Convention, 1952,
   d. The WIPO Convention, 1967,
   e. The Patent Co-operation Treaty, 1970,
   f. 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
b) Fundamentals of claim drafting
c) Patent claim design
d) Drafting description, drawings, abstract
e) Filing patent applications: Prosecution and strategies
f) National/Regional Patent Laws of WIPO
g) WIPO Patent laws
h) Patent laws in India
i) United States patent law
j) 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.

EVALUATION PATTERN

Grades

Grades to be awarded (O, A+, A, B+, B, C, P, F) based on following aspects;

1. **Attendance-** minimum 75% attendance to be required for awarding certificates
2. **Continuous assessment**
   a. Assessment at the end of the week -02(Patent application preparation)
   b. Assessment at the end of the week-04 (Identification of non-patentable subject matter)
   c. Assessment at the end of the week-06 (Patent claims design)
   d. Assessment at the end of the week-08(Case studies on patents of India, USA, Europe and WIPO)

***All assessment to be based on submission of assignments.**

3. **Assignments review**: Marks for assignments: Max marks: 50
   a. Novelty + Innovation -10
   b. Plagiarism- 10
   c. Clarity of thought process & organization of the assignment-10

d. Quality of the references used -10

e. Writing style, language & bibliography-10

Grades to be awarded

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%)

***Average of 4 assignments for award of grades.**

SKILL BASED VALUE ADDED CERTIFICATE PROGRAMME (Non-Credit)

(Conducted in Association with Industry Partners)

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.

Duration: Duration: 40 hrs (4 Weeks@ 10 hours/week)

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

EVALUATION PATTERN

Grades

Grades to be awarded (O, A+, A, B+, B, C, P, F) based on following aspects;

1. **Attendance**: minimum 75% attendance to be required for awarding certificates
2. **Continuous assessment:**

a. Assessment at the end of the week -02 (Protocol writing)
b. Assessment at the end of the week-04 (Informative content preparation)
c. Assessment at the end of the week-06 (Drawing a clinical trial design)
d. Assessment at the end of the week-08(Case narration on successful clinical trial)

***All assessment to be based on submission of assignments**

3. Assignments review: Marks for assignments: Max marks: 50

a. Novelty + Innovation- 10
b. Plagiarism - 10
c. Clarity of thought process & organization of the assignment-10
d. Quality of the references used -10
e. Writing style, language & bibliography-10

Grades to be awarded

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%)

***Average of 4 assignments for award of grades**

THEORY QUESTION PAPER PATTERN

Max. Marks = 80 **Time: 03 hours**

1. Answer in Brief (Answer any ten) **02 x 10 = 20**

a.
b.
c.
d.
e.
f.
g.
h.
i.
j.
k.
l.

2. Write short notes on the following (Answer any four) **04 x 06 = 24**

a.
b.
c.
d.
e.
f.

3. Essay type questions (Answer any three) **03 x 12 = 36**

a.
b.
c.
d.
e.

Note: Equal Weightage should be given to all the units while setting the question paper

PRACTICAL QUESTION PAPER PATTERN

Max. Marks = 40 **Time: 03 hours**

1. Major Experiment:	12 Marks
2. Minor Experiment:	06 Marks
3. Spotters (04):	12 Marks
4. Records:	03 marks
5. Case study:	02 marks
6. Viva –Voce:	05 marks

<table>
<tr><th colspan="3"><u>EVALUATION RUBRICS</u></th></tr>
<tr><th colspan="3">THEORY INTERNAL ASSESSMENT -- 20M</th></tr>
<tr><th colspan="3">1. Continuous Theory Internal Assessment C1+ C2+ MCQ (7+3)</th></tr>
<tr><td colspan="2">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%)</td><td>10</td></tr>
<tr><th colspan="3">2. Assignments (Microbiology Perspective)</th></tr>
<tr><td>• Latest developments in that field</td><td>1</td><td rowspan="3">3</td></tr>
<tr><td>• Sentence structure and flow</td><td>1</td></tr>
<tr><td>• Comparison between the recent technology developments</td><td>1</td></tr>
<tr><th colspan="3">3. Seminars (Journal Club)</th></tr>
<tr><td>• Concept communication</td><td>1</td><td rowspan="5">3</td></tr>
<tr><td>• PPT/Video visibility, clarity & organization</td><td>0.5</td></tr>
<tr><td>• References</td><td>0.5</td></tr>
<tr><td>• Time limit</td><td>0.5</td></tr>
<tr><td>• Confidence in answering queries</td><td>0.5</td></tr>
<tr><th colspan="3">4. Write Up on Innovative Product Production</th></tr>
<tr><td>• Concept understanding</td><td rowspan="3">1</td><td rowspan="8">4</td></tr>
<tr><td>• Technical/scientific supporting material</td></tr>
<tr><td>• Objectives</td></tr>
<tr><td>• Methodology: Experimental skills and/or mathematical skills/Analytical skills</td><td>1</td></tr>
<tr><td>• Innovation Quotient</td><td>1</td></tr>
<tr><td>• Reference</td><td rowspan="3">1</td></tr>
<tr><td>• Importance/Significance</td></tr>
<tr><td>• Grammar and Style</td></tr>
</table>

<table>
<tr><td colspan="3">PRACTICAL INTERNAL ASSESSMENT -- 10M</td></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>05</td></tr>
<tr><td colspan="3">Do Your Own Experiment</td></tr>
<tr><td>• Selection of the problem</td><td rowspan="3">02</td><td rowspan="7">05</td></tr>
<tr><td>• Hypothesis</td></tr>
<tr><td>• Relevant Content</td></tr>
<tr><td>• Demonstration</td><td rowspan="2">02</td></tr>
<tr><td>• Reporting</td></tr>
<tr><td>• References</td><td rowspan="2">01</td></tr>
<tr><td>• Grammar/Spelling</td></tr>
<tr><td colspan="3">THEORY (INTERNALS AND SEMESTER END EXAMS) 80M</td></tr>
<tr><td colspan="3">EVALUATION PATTERN: Answer in Brief: 2M×10Q = 20
Short Answers: 6M×4Q = 24
Essay Type: 12M×3Q = 36</td></tr>
<tr><td>Answer in Brief: 2M
• Clear definition/description</td><td>01</td><td rowspan="3">2M×10Q = 20</td></tr>
<tr><td>• Importance</td><td>0.5</td></tr>
<tr><td>• Significance</td><td>0.5</td></tr>
<tr><td>Short Answers: 6M
• Introduction</td><td>01</td><td rowspan="4">6M×4Q = 24</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>02</td></tr>
<tr><td>• Importance/Significance</td><td>01</td></tr>
<tr><td>Essay Type: 12M
• Introduction</td><td>02</td><td></td></tr>
</table>

<table>
<tr><td>• Description/classification/pathway/functions etc.</td><td>04</td><td colspan="2" rowspan="2">12M×3Q = 36</td></tr>
<tr><td>• Diagrams/ Flow charts/tables/charts/representation/general account</td><td>04</td></tr>
<tr><td>• Importance/Significance</td><td>02</td><td colspan="2"></td></tr>
<tr><td colspan="4">PRACTICALS (SEMESTER END EXAMS) 40M</td></tr>
<tr><td colspan="4">PRACTICALS Major (12) and Minor (08) Experiments- 20M</td></tr>
<tr><td></td><td>Major (12)</td><td>Minor (06)</td><td></td></tr>
<tr><td>• Understanding of the Objective</td><td>01</td><td rowspan="2">02</td><td rowspan="6">12+6</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>02</td></tr>
<tr><td>• Result</td><td>01</td><td>01</td></tr>
<tr><td>• Conclusion/Inference</td><td>01</td><td>01</td><td></td></tr>
<tr><td>SPOTTERS: 12M
• Correct Identification</td><td>01</td><td colspan="2" rowspan="3">03</td></tr>
<tr><td>• Description</td><td>01</td></tr>
<tr><td>• Significance/Importance</td><td>01</td></tr>
<tr><td>Record submission – 03m
• Content page</td><td></td><td colspan="2" rowspan="6">03</td></tr>
<tr><td>• Certificate</td><td></td></tr>
<tr><td>• Dates of experiments</td><td></td></tr>
<tr><td>• Content & legibility</td><td>01</td></tr>
<tr><td>• Diagrams /graphs</td><td>01</td></tr>
<tr><td>• Proper representation of results</td><td>01</td></tr>
<tr><td>Case Study- 02M</td><td></td><td colspan="2"></td></tr>
<tr><td>• Introduction of the of given case and significance</td><td>0.5</td><td colspan="2"></td></tr>
<tr><td>• Body of the content and comparison with known and unknown scenario</td><td>0.5</td><td colspan="2">2.0</td></tr>
</table>

• Relevance to the content	**0.5**	
• Conclusion, Reference and recent updated & Supportive materials	**0.5**	
• Market Perspective		
PRACTICAL VIVA: • Knowledge about the topic • Depth in understanding	**02**	**5.0**
• Comprehension	**01**	
• Clarity in answers • Relating case studies with practical's conducted	**02**	
GROUP PROJECT: 80 M		
• Project value • Project innovation and implementation of their ideas • Group coordination and involvement in the activities	**20**	**80**
• Plagiarism • Review of Literature • Introduction • Hypothesis • Gaps in Research	**20**	
• Materials and Methods • Results and Discussion • Summary and Conclusion	**30**	
• Scientific Knowledge produced • Societal Impact • References • Grammar/ Spelling	**10**	
PROJECT VIVA- 40M		
• Introduction - Significance of topic, • objectives	**10**	**40**
• Review - succinct explanation, current reviews • Methodology -selection of experiments	**10**	
• Results & Discussion- clear and lucid presentation, organization of data/ charts/ spectral data, highlight of key findings with suitable justification	**15**	
• Reference- Appropriate references	**05**	