Acharya Prafulla Chandra College

NAAC Accredited 'A' Grade College

Post Graduation Course in Microbiology

Syllabus

CBCS System

2019

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Post Graduate Course Content in Microbiology (CBCS system) – 2019

Semester	Type	Paper	Title of the Paper	Full Marks	Semester Total	Paper Credit	Semester Credit
1	Theory	MCBPCOR01T	Biomolecules and Enzymology	50	300	4	22
		MCBPCOR02T	Basic Microbiology and Microbial Diversity	50		4	
		MCBPCOR03T	Cell Biology	50		4	
		MCBPCOR04T	Bioenergetics and Metabolism	50		4	
	Practical	MCBPCOR05P	Biochemistry, Enzymology and General Microbiology	50		4	
	AECC	MCBPAEC01M	Environmental Science	50		2	
2	Theory	MCBPCOR06T	Biophysical Techniques	50	300	4	22
		MCBPCOR07T	Food, Industrial and Environmental Microbiology	50		4	
		MCBPCOR08T	Bioinformatics and Biostatistics	50		4	
	Practical	MCBPCOR09P	Bioinformatics and Biostatistics Applications	50		4	
		MCBPCOR10P	Microbial Ecology, Environmental Microbiology, and Industrial Microbiology	50		4	
	SEC	MCBPSEC01M	Diagnostic Microbiology OR Mendelian Genetics, Inheritance and Development	50		2	
3	Theory	MCBPCOR11T	Fundamentals of Molecular Biology	50	300	4	24
		MCBPCOR12T	Recombinant DNA Technology	50		4	
		MCBPCOR13T	Genetics	50		4	
	DSE 1	MCBPDSE01T	Applications of Microbial Technology OR Evolutionary Biology and Astrobiology	50		4	
	Practical	MCBPCOR14P	Molecular Biology, Recombinant DNA Technology and, Analytical and Biochemical Methods in Microbiology	50		4	
	GEC	MCBPGEC01T	Microbes in Sustainable Development OR Astrobiology	50		4	
4	Theory	MCBPCOR15T	Medical Microbiology and Pharmacology	50	300	4	24
		MCBPCOR16T	Immunology	50		4	
		MCBPCOR17T	Virology	50		4	
	Practical	MCBPCOR18T	Immunology and Virology, and Biophysical Techniques	50		4	
	DSE 2	MCBPDSE02T	Project and/or Review Work, Seminar Presentations and Grand Viva	100		8	
Total				**1200**		**92**	

Note: AECC – Ability Enhancement Compulsory Course, SEC – Skill Enhancement Course, DSE – Discipline Specific Elective Course, GEC – Generic Elective Course.

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Semester 1

Total Marks: 300

Total Credit Points: 22

Duration: July – December

Courses to be covered:

Core:

1. **Paper MCBPCOR01T** (Theory) – Marks: 50. Credit Points: 4.
   Biomolecules and Enzymology.
2. **Paper MCBPCOR02T** (Theory) – Marks: 50. Credit Points: 4.
   Basic Microbiology and Microbial Diversity.
3. **Paper MCBPCOR03T** (Theory) – Marks: 50. Credit Points: 4.
   Cell Biology.
4. **Paper MCBPCOR04T** (Theory) –Marks:50. Credit Points: 4.
   Bioenergetics and Metabolism.
5. **Paper MCBPCOR05P** (Practical) – Marks: 50. Credit Points: 4.
   Biochemistry and Enzymology and General Microbiology.

Ability Enhancement Compulsory Course (AECC):

1. **Paper MCBPAEC01M**– Marks: 50 (Theory). Credit Points: 2.
   Environmental Science.

Tentative date of examination: First week of January

Paper MCBPCOR01T (Theory)
Biomolecules and Enzymology

Marks: 50
Credits: 4

Course Content:

Unit I – Biomolecules

Carbohydrates: Families of monosaccharides. Stereoisomerism of monosaccharides, epimers. Mutarotation and anomers of glucose. Furanose and pyranose forms of glucose and fructose. Disaccharides. Concept of reducing and non-reducing sugars. Haworth projections of maltose, lactose, and sucrose. Polysaccharides: storage polysaccharides (starch and glycogen). Structural Polysaccharides (cellulose and chitin), Glycoproteins.
Amino Acids and Proteins: General structure and classification of Amino Acids. Chemical reactions and modifications. acid-base properties. Biphasic titration curve and isoelectric point. Reactions of carboxyl and amino groups. Formation of peptide bond. Determination of N-terminal amino acid (Edman's method) and C-terminal amino acid (hydrazinolysis). Structural organisation of proteins (primary, secondary, tertiary and quaternary). Covalent and Non-covalent interactions that stabilise the three-dimensional structures of proteins. Forces stabilising protein structure. Structure function relationship of proteins. Protein folding and chaperones. Unfolding of protein structure, effect of heat, pH and chemicals. Denaturation and renaturation of proteins. Diseases related to protein misfolding. Prions.
Lipids: Classification of lipids. Nomenclature and structure of saturated and unsaturated fatty acids. Δ and ω system. Essential fatty acids. Saponification number, Iodine number, Acetyl number of fats. Structure and biological importance of triglycerides, phospholipids, glycolipids and steroids (cholesterol); role in biological membranes. Lipoproteins.
Nucleic acids: Nucleosides and nucleotides. Structure of nucleotides. Nucleotides as sources of energy, component of coenzymes, second messengers. DNA structure – Watson-Crick model. A, B and Z forms of DNA. Supercoiled and relaxed DNA. Quadruplex DNA. Denaturation and renaturation of DNA, melting temperature, UV absorption and hyperchromic effect. Nucleosome structure and genome organisation. Structure of major types of RNA. DNA bending and supercoiling and their significance. Denaturation kinetics of DNA and Cot-curves. Folding of RNA into higher order structures.
Bonding in biomolecules: Importance of the non-covalent interactions. The *vander* Waals' interactions – London dispersion, dipole-dipole (Keesom) interactions and dipole-induced dipole (Debye) interactions and their relative strengths. Concept of polarisability. Brief concept of the Lennard-Jones potential.

Unit II – Enzymology

IUB classification. Definition of enzyme, active site, substrate, coenzyme, cofactor,prosthetic groupsand different kinds of enzyme inhibitors. Catalytic efficiency, activity, specific activity and turnover number. Techniques for purifying and characterising proteins and enzymes. Use of isotopes in enzyme kinetics mechanism analysis. Effects of pH, temperature, inhibitors and isotope labelled substrates on enzyme activity. Allosteric model of enzyme regulation. Substrate induced conformational change of enzyme. Catalytic mechanisms – lysozyme, serine proteases. Activation energy and transition state. Principles of enzyme kinetics. Michaelis-Menten equation. Significance of K_M and V_{max}. Determination of K_M and V_{max}. Lineweaver-Burk plot(double reciprocal plot), Eadie-Hofstee plot and Hanes-Woolf plot. Two substrate

kinetics, deviation from linear kinetics, rapid kinetics, association and dissociation constants. Single and double displacement reaction (Ping Pong, Bi-Bi reaction). Three substrate kinetics. Ligand binding studies. Reversible inhibition – competitive, un-competitive and non-competitive – and irreversible inhibition. Allosteric enzymes and feedback inhibition. Isozymes, Abzymes. Regulation of enzymes. Industrial application of several enzymes. Ribozyme.

Basic concept of chemical kinetics. Reaction rates, rate constants, rate laws and half-livesof zero, first and second order reactions. Temperature dependence of reaction rates – the Arrhenius equation. Order and molecularity of reactions.

Books:

1. Biochemistry by D Voet and J Voet.
2. Biochemistry by JM Berg, JL Tymoczko, GJ Gatto, Jr. and L Stryer.
3. Lehninger Principles of Biochemistry by DL Nelson and MM Cox.
4. Textbook of Biochemistry with Clinical Correlationsby TM Devlin.
5. Harper's Illustrated Biochemistry by VW Rodwell *et al.*
6. Physical Chemistry for the Life Sciences by P Atkins and J de Paula.
7. Proteins – Structures and Molecular Properties by TE Creighton.
8. Organic Chemistry, Volume 2 – Stereochemistry and the Chemistry of Natural Products by IL Finar.

Paper MCBPCOR02T (Theory)
Basic Microbiology and Microbial Diversity

Marks: 50
Credits: 4

Course Content:

Unit I – Microbial growth

Definition of growth and its mathematical expression, growth curve, measurement of growth: synchronous growth, continuous culture. Factors affecting growth (temperature, acidity, alkalinity, water availability and oxygen), maintenance of growth. Pure culture and culture characteristics.

Unit II – Microbial Diversity

Microbial Systematics:General account of systematics. Classification and nomenclature. Classification systems – artificial or phonetic, natural and phylogenetic. Species concept – monophyletic, paraphyletic, polyphyletic. Molecular taxonomy. Molecular phylogeny. Molecular chronometers. Polyphasic taxonomy. Describing a new procaryotic species. Valid publication of names of bacterial taxa. Culture collection.
Chemical and Cellular evolution: Endosymbiotic origin of Eucaryotes.Evolution of eucaryotes from procaryotes and single cell to multicellular organism.

Unit III – Biodiversity

Introduction: Levels of biodiversity, alpha, beta and gamma diversity. Values and ethics of biodiversity. Global patterns of biodiversity. Hotspots of biodiversity and megadiversity country. Biogeographic zones in India. Factors influencing local and regional biodiversity. Biodiversity documentation. Perception on Bioresource. Legal binding of biological materials. Concept of Biopatents. Diversity of procaryotic and eucaryotic microbes.
Bacteria: General classification of bacteria with salient features of major bacterial phyla according to Bergey's Manual of Systematic Bacteriology.
Archaea:Systematics, occurrence, diversity, characteristic features and significance of different groups of Archaea.
Fungi:Modern trends of fungal classification and phylogeny. Growth, environmental conditions for growth; nutrition and life cycle patterns. Parasexuality and heterothallism.
Algae: Distribution and classification. Nutrition and culture. Reproduction and life cycles. Algal toxins. Algal bloom and its control. Economic importance of algae.
Protozoa: General account, structure, reproduction, life cycle of and diseases caused by*Plasmodium*, *Entamoeba*, *Leishmania*, *Wuchereria*, *Fasciola*, *Schistosoma*.Classification of protozoa.
Biodiversity and conservation: Threat to species diversity. Extinction vortex. Causes of extinction. Population viability analysis. Red Data Book. Approaches: Local, National and International. *Insitu* and *exsitu* conservation. Concept of protected area network. Selecting protected areas. Criteria for measuring conservation value of areas. Sanctuary, national park and biosphere reserves. Design and management of protected areas. Threats to wildlife conservation and wildlife trade. Tools for wildlife research. Wildlife threat. Use of Radio telemetry and remote sensing in wildlife research.

Paper MCBPCOR03T (Theory)
Cell Biology

Marks: 50
Credits: 4

Course Content:

Cell wall and membranes: Procaryotic-peptidoglycan wall, plant cell wall. Cell membrane – membrane structure, membrane constituents, phospholipids, glycolipids, cholesterol. Membrane proteins. Receptors and phospholipases. Phospholipid bilayer, structure asymmetry, fluid mosaic model of random diffusion of membrane components. Domains in membrane. Natural and artificial membranes. Methods to study the cell membrane. Fluorescence Resonance Energy Transfer (FRET), Fluorescence Recovery After Photobleaching (FRAP), Fluorescence Loss InPhotobleaching (FLIP), scanning colorimetry, chemiluminescence, freeze-etching, freeze-fracturing, hydrophobicity plot.
Complexities and compartmentalisation of eucaryotic cells: Cell Organelles: their structures and functions. Nucleus, other membrane bound organelles, *e.g.*, mitochondria and chloroplast, ribosomes, endoplasmic reticulum, Golgi bodies. Secretory vesicles. Protein trafficking, targeting, sorting and localisation of proteins and other macromolecules in peroxisomes and lysosomes. Cytoplasm.
Cytoskeleton: Microtubules and microfilaments, intermediate filaments, microtubule polymerisation dynamics, actin polymerisation dynamics, cell crawling, contractile structures, actomyosin complex, muscle contraction.
Other Granular bodies: Extracellular appendages, *e.g.*, flagella, cilia and extracellular matrix. Cell Function: Dynamic movements.
Cell cycle: Cyclins and CDKs as key cell cycle mediators, their roles and modes of activation and control. Special emphasis on mammalian cell cycle. CDK inhibitors. Cell cycle checkpoints, metaphase-anaphase transition. Generation of synchronous cell cultures. Cytoskeletal diseases. Antimitotic drugs, microtubule dependent drugs and actin targeted drugs. Loss of cell cycle control and cancer. Programmed cell death and apoptosis.
Cell junctions and cell-cell signalling: General characteristics, specificity, amplification, desensitisation or adaptation and integration. Non-receptor mediated cell signalling – gaseous messengers (NO and CO); receptor mediated, cell signalling – ligands (membrane diffusible, *e.g.*, steroid hormones and non-diffusible, *e.g.*, peptide hormones and other peptide or protein ligands) and receptors (intracellular, *e.g.*, steroid hormone receptors and cell surface); ion-channel-linked receptors – neurotransmitters; G protein coupled receptors – heterotrimeric G proteins and its effectors (second messengers like cAMP). Desensitisation process. Bacterial toxins as tools in study of receptor signalling. Calcium homoeostasis, calcium signalling. Signal transduction in the living cells.

Books:

1. The Cell A Molecular Approach by GM Cooper and RE Hausman.
2. Molecular Cell Biology by H Lodish*et al.*
3. Molecular Biology of The Cell by B Alberts*et al.*
4. Methods in Molecular Biology, Volume 296 – Cell Cycle Control Mechanisms and Protocolsby T Humphreyand G Brooks (ed.).
5. The Cell Cycle – Principles of Control by DO Morgan.

Paper MCBPCOR04T (Theory)
Bioenergetics and Metabolism

Marks: 50
Credits: 4

Course Content:

Unit I – Bioenergetics

Concept and Importance of Gibb's free energy in living systems. High energy compounds. Energy currency of the cell. Idea of redox potential. Coupled reactions.

Unit II– Metabolism (Amino acids and nucleotides)

Amino acids metabolism:Amino acids – Essential, non-essential, glucogenic, ketogenic and non-proteinogenic. Transamination and oxidative deamination. Central role of glutamic acid. Incorporation of ammonia into biomolecules through glutamate and glutamine. Removal of nitrogen waste from the body. Urea cycle and excretion of nitrogen. Nitrogen fixation by nitrogenase. Amino acid biosynthetic families.
Nucleotide Metabolism: Biosynthesis of purine and pyrimidine (*de novo* and salvage pathways). Degradation of purine and pyrimidine.

Unit III

Fatty acid metabolism:Transport of fatty acids into Mitochondria. β-oxidation of saturated odd and even chain fatty acids (reactions and energetics). Ketogenesis. Biosynthesis of fatty acids and cholesterol (outline only).

Unit IV
Carbohydrate metabolism:Basic differences in anaerobic and respiratory kinds of energy metabolism. Basic mechanism of ATP synthesis. Embden-Meyerhof pathway (glycolysis). Fate of pyruvate under aerobic and anaerobic conditions. TCA cycle, Electron Transport Chain (ETC), Chemiosmotic Hypothesis and Oxidative Phosphorylation. Inhibitors and Uncouplers. rTCA cycle. Pentose phosphate pathway and its significance. Gluconeogenesis, glycogenolysis and glycogen synthesis. Entner-Doudoroff pathway, phosphoketolase pathway. Glyoxylate cycle. Pasteur effect.Homolactic and heterolactic fermentations. Mixed acid, propionic acid, butyric acid and acetone-butanol fermentations. Substrate level phosphorylation in anaerobic energy metabolism. Metabolism of energy reserve compounds (polyglycans, poly- and β-hydroxybutyrate). Energy conservation in chemolithotrophic bacteria (*Nitrobacter*, *Nitrosomonas*, *Thiobacillus* including *Thiobacillus ferrooxidans*, methanogens, hydrogen oxidising bacteria).
Bacterial photosynthesis: Different types of photosynthetic bacteria, photopigments, paths of carbon and electron in bacterial photosynthesis. Bioluminescence.

Books:

1. Biochemistry by D Voet and J Voet.
2. Biochemistry by JM Berg, JL Tymoczko, GJ Gatto, Jr. and L Stryer.

3. Lehninger Principles of Biochemistry by DL Nelson and MM Cox.
4. Textbook of Biochemistry with Clinical Correlations by TM Devlin.
5. Harper's Illustrated Biochemistry by VW Rodwell *et al.*
6. Physical Chemistry for the Life Sciences by P Atkins and J de Paula.
7. Microbial Biochemistry by GN Cohen.

Paper MCBPCOR05P (Practical)

Biochemistry and Enzymology and General Microbiology

Marks: 50
Credits: 4

Course Content:

Group –A: Biochemistry and Enzymology

1. Properties of water.
2. Concept of pH and buffers, preparation of buffers and numerical problems to explain the concept.
3. Determination of the T_m of DNA under normal and denaturing conditions.
4. Determination of pI of an amino acid.
5. Study of enzyme kinetics – calculation of V_{max}, K_M, K_{cat} values.
6. Protein estimation – Lowry and Bradford assays.
7. Chemical analyses of biomolecules.

Books:

1. An Introduction to Practical Biochemistry by DT Plummer.
2. Biochemical Calculations by IH Segel.
3. Methods in Enzymology, Volume 182 – Guide to Protein Purification by MP Deutscher (ed.).
4. Methods in Enzymology, Volume 463 – Guide to Protein Purification, 2nd EditionbyRR Burgess and MPDeutscher (eds).

Group – B: General Microbiology

1. Biological safety cabinets and Centers for Disease Control and Prevention (CDC) and National Institutes of Health (NIH) biosafety levels.
2. Glassware – preparation and sterilisation techniques (wet heat, dry heat).
3. Preparation of culture media – synthetic, complex, selective, differential.
4. Preparation of slants.
5. Techniques for isolation of pure cultures: Isolation of discrete colonies from a mixed culture and isolation of pure cultures by (i) spread plate, (ii) pour plate and (iii) streak plate method.
6. Types of dyes and their preparation. Staining techniques – (i) simple, (ii) Gram, (iii) capsule, (iv) negative, (v) endospore, (vi) flagella and (vii) nuclear.
7. Demonstration of bacterial growth under aerobic, microaerophilic and anaerobic conditions.
8. Construction of the growth curve of bacteria under varying growth conditions and identification of the tolerance zones.
9. Control of microorganisms – theory and practice of sterilisation techniques (heat, filter and radiation).
10. Control of microorganisms – chemical methods.
11. Nutritional requirements of microbes – autotrophic, heterotrophic. Demonstration of nutritional requirements of bacteria by employing appropriate culture techniques.
12. Morphological, nutritional and culture characteristics of bacteria.
13. Observation and imaging of microbes through phase contrast microscopes.
14. Techniques for cultivation of anaerobic bacteria.
15. Identification of common algae from different classes, their slide preparation, observation and imaging.
16. Isolation and identification of algae from soil sample.
17. Identification of phytoplankton from water sample.
18. Enrichment and isolation of selective bacterial types – (i) nitrogen-fixing bacteria, (ii) cellulose degrading bacteria.

Books:

1. Difco™ & BBL™ Manualby MJ Zimbro*et al.* (eds.).
2. Handbook of Microbiological Media by RM Atlas.
3. Microbiology – A Laboratory Manual by JG Capuccino and N Sherman.
4. Laboratory Exercises in Microbiology by JP Harley and LM Prescott.
5. Laboratory Biosafety Guidelines of Health Canada.
6. Laboratory Biosafety Manual of the World Health Organisation.
7. BD Bionutrients™ Technical Manual by BD Biosciences.

Paper MCBPAEC01M (Ability Enhancement Compulsory Course, AECC)
Basic Environmental Science

Marks: 50
Credits: 2

Course Content:

What is environment? Types of environments. Climate system and its components – atmosphere (air), the hydrosphere (water), the cryosphere (ice and permafrost), the lithosphere (upper rocky layer) and the biosphere (living things).
Types of ecosystems - terrestrial (forest and grassland) and aquatic (marine and lake), natural and artificial. Ecosystems and their interplay with living organisms. Ecogeographical rules – Bergmann's rule, Hesse's rule, Allen's rule, Jordan's rule, Gloger's rule. Natural resources – air, water, soil. Biogeochemistry and the Gaia hypothesis. Environmental pollution and its effects on the living world. Environment and the climate change. Shelford's law of tolerance.
Shifting of the poles hypotheses and its effect on the environment. Features of the environment of the earth in the past and the ways in which it will help us to understand the future of the environment. Environmentalism, environmental legislations, economics and ethics. Environmental organisations, conferences and campaigns.

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Semester 2

Total Marks: 300

Total Credit Points: 22

Duration: January – June

Courses to be covered:

Core:

1. **Paper MCBPCOR06T** (Theory) – Marks: 50. Credit Points: 4
   Biophysical Techniques.
2. **Paper MCBPCOR07T** (Theory) – Marks: 50. Credit Points: 4.
   Food and Industrial Microbiology and Environmental Microbiology.
4. **Paper MCBPCOR08T** (Theory) –Marks: 50. Credit Points: 4.
   Bioinformatics and Biostatistics.
5. **Paper MCBPCOR09P** (Theory) – Marks: 50. Credit Points: 4.
   Bioinformatics and Biostatistics Applications.
6. **Paper MCBPCOR10P** (Practical) – Marks: 50. Credit Points: 4.
   Microbial Ecology and Environmental Microbiology and Industrial Microbiology.
   .

Skill Enhancement Course (SEC):

1. **Paper MCBPSEC01M** – Marks: 50. Credit Points: 2.
   Diagnostic Microbiology.
   or
   Mendelian Genetics, Inheritance and Development.

Tentative date of examination: First week of June

Paper MCBPCOR06T (Theory)
Biophysical Techniques

Marks: 50
Credits: 2

Course Content:

Microscopy
Optical microscopy: The nature of light – its particle and wave character. Applications of optical microscopes. Concepts of numerical aperture (NA), resolution, contrast and magnification. Spherical and chromatic aberrations of optical systems. Mathematical expression for the limit of resolution in terms of Rayleigh criteria. Empty magnification and limitations of optical microscopes. Phase contrast, ultraviolet and interference contrast microscopes. Fluorescence microscopy, epifluorescence microscopy and confocal microscopy – their principles and biological applications.
Electron microscopy: Transmission electron microscopy (TEM) and scanning electron microscopy (SEM). Sample preparation for EM. Advantages of electron microscope over optical microscope. Electrostatics and magnetostatics electron microscopes. The characteristics and uses of lasers. Relation between the applied voltage and wavelength of electrons.
Techniques of imaging with microscopes: Concepts of the point spread function and image deconvolution.

Diffusion
Diffusion in fluids. Fick's laws – statement and explanation. Facilitated diffusion, *e.g.*, gas exchanges in lungs and regulating principle relating to partial pressure of oxygen and carbon dioxide.

Osmosis
Definition of osmosis and contrast with diffusion. Tonicity and isotonic solutions. Effect of tonicity on red blood cell nutrition. Osmotic pressure. Gibbs - Donnan effect.

Centrifugation
Theory of centrifugation and ultracentrifuges. Concept of Relative Centrifugal Force (RCF) and its relationship with revolutions per minute (rpm). concept of the Svedberg unit (S). Sedimentation rate, sedimentation coefficient. Isopycnic (equilibrium) sedimentation. Analytical and preparative ultracentrifuges and their uses.

Spectrophotometry
The electromagnetic spectrum. Introduction to concepts of absorption spectra. Absorption of light, transmittance, absorbance and optical density. Lambert-Beer's law and its limitations. Concept of extinction coefficient and molar extinction coefficient. Study of the absorption spectra of proteins and nucleic Acids. Analyses of proteins and nucleic acids using UV and visible spectroscopy. Construction and working of a double beam spectrophotometer. Fluorescence spectroscopy. Concepts of excitation and emission spectra. Construction and working of a fluorescence spectrophotometer.
Raman spectroscopy, circular dichroism (CD), optical-rotatory dispersion (ORD) and their applications in the study of macromolecules. Applications of Fourier transform spectroscopy.

Nuclear magnetic resonance; principles behind splitting, spin-spin interaction, spin-lattice interactions, Concept of COrrelationSpectroscopy (COSY) and Nuclear OverhauserEffect Spectroscopy (NOESY), nuclear quadruple effects, spectral interpretations.
Electron Spin Resonance (ESR), zero field splitting.

Photobiology
Idea of fluorescence and phosphorescence. Jablonski diagram of the electronic states of a molecule. Quantum yield and fluorescence lifetime. Chemiluminescence and chemifluorescence. Fluorescence quenching.

Radioactivity
Radiolabelling techniques. Properties of different radiochemicals used in biology. Autoradiography, Geiger-Müller counters and liquid scintillation counters.

Chromatography
Thin Layer Chromatography (TLC), liquid and Gas Chromatography – High Performance Liquid Chromatography or High Pressure Liquid Chromatography (HPLC), Fast Protein Liquid Chromatography (FPLC), Gas Chromatography or Gas-Liquid Chromatography (GC or GLC), column chromatography for enzyme protein analyses – gel filtration chromatography, ion-exchange chromatography and affinity chromatography, reversed phase chromatography. Partition co-efficient. Column packing and fraction collection.

Electrophoresis
Principle and applications of native polyacrylamide gel electrophoresis, SDS polyacrylamide gel electrophoresis. Application of PAGE in checking activities and in determining subunits and molecular weight of proteins. Agarose gel electrophoresis.

Proteomics
Proteome, nature of proteome, overview of the tools to study proteome, two-dimensional gel electrophoresis (2D-PAGE), Mass Spectrometry (MALDI/MALDI-TOF), Interpretation of Mass Spectra, MS/MS of peptide, Mass spectrometry search engines: Mascot, structural proteomics. Metabolomics (in brief). Concept of X-Ray crystallography.

Books:

1. Spectroscopy for the Biological Sciences by GG Hammes.
2. Physical Principles of Electron Microscopy - TEM, SEM and AEM by RF Egerton.
3. Principles of Fluorescence Spectroscopy by JR Lakowicz.
4. Biophysical Chemistry, Volumes 1,2 & 3 by CR Cantor and PR Schimmel.
5. Physical Biochemistry by D Freifelder.
6. Biochemistry by D Voet and J Voet.
7. Principles and Techniques of Biochemistry and Molecular Biology by K Wilson and J Walker.
8. Protein Biochemistry and Proteomics by H Rehm.
9. A Text-book of Quantitative Inorganic Analysis, 3rd edition, 1961 by AI Vogel.
10. Molecular Cloning – A Laboratory Manual by J Sambrook and DW Russell.

Paper MCBPCOR07T (Theory)
Food Microbiology Industrial Microbiology and Environmental Microbiology

Marks: 50
Credits: 4

Course Content:

Unit I – Food Microbiology

Antibiotic fermentations – production of β lactams (penicillins), semi-synthetic penicillins and cephalosporins, amino-glycosides (streptomycin), macrolides (erythromycin), quinines.
Production of vitamins (A, riboflavin, B12), enzymes for pharmaceutical industries, vaccines, recombinant proteins (insulin, interleukins and interferons). Biotransformation – hormones.
Microbiology of food stuffs: Vegetables, fruits, milk and non-fermented products, fresh meats, poultry and non-dairy products.
Microbial spoilage of food materials. Food preservation – physical, chemical and biological methods.
Industrial bioethics and intellectual property rights (IPR) – very brief introduction.

Unit II – Industrial Microbiology

Fermentation – an overview. Various definitions of fermentation. Relationships between Putrefaction, Fermentation and Synthesis of biomolecules**.** Isolation, screening and selection of industrially important microorganisms, strain improvement for industrial purposes, use of recombinant DNA technology, cloning vectors, role and applications of genetic engineering in development of industrial strains
Bioreactors, design and components of basic fermentor and specialised fermentor for specific purposes – continuous, anaerobic, for gaseous nutrients, for treatment of wastes, trickle flow reactors, cyclone reactors, submerged types, tube reactors, packed bed reactors, lab scale to pilot to industrial – scale up process, online monitoring.
Bioprocessing – downstream processing of industrial fermentation processes, product purification and recovery, physico-chemical basis of bio-separation processes, techniques for purification of end products – chromatography, electrophoresis, distillation, crystallisation, filtration.
Economics of a fermentation process, determination of cost and its recovery, cost cutting strategies, cell and enzyme immobilisation, biological waste treatment, hygiene and safety in fermentation industries.
Microbes in food industry, fermented foods (breads, sauerkraut, pickles, tofu), dairy products from microbes (cheese, curd, yoghurt), microbes as food - single cell protein, mushrooms, probiotics. Alcoholic beverages – brief history of development of industrial process, production of beer (brewing) – media (raw materials used), process, maturation, carbonation. Types of beer (lager, pilsner, bock, ale, stout, porter). Whiskeys – types and production, Production of wine – media and raw material used, different types (sparkling wine, burned wine, cider, wine vinegar), vinegar.

Unit III – Environmental Microbiology

Extremophile: anaerobes, halophiles, acidophile, alkalophile, thermophile, barophile. Effect of heavy metal and xenobiotic substances on microbes; biological magnification of toxic substances. Microbial deterioration of paper, leather, wood, textile, stone and monument.

Aeromicrobiology: Microbes of indoor and outdoor environment, pathways, enumeration, Extramural and intramural, control, bioterrorism. Eutrophication,

Water microbiology: Microbes in marine and freshwater environment – Eutrophication – food chain, water borne pathogens – indicator organism – water purifications. Significance of microbes in water quality. Test for portability of water.

Microorganism and metal pollutants: biodegradation of TNT, PCB; Bioremediation: bioventing, biofiltration, bioaugmentation, problems and advantages.

Bioleaching: mineral extraction, oil recovery. Biodegradation and bioremediation, Landfills, Composting and Earthworm treatment. Biodegradation of Xenobiotic compounds. Organisms involved in degradation of chlorinated hydrocarbons, substituted simple aromatic compounds, polyaromatic hydrocarbons, pesticides and surfactants. Microbial treatment of oil pollution.

Waste Management: Biomass waste management of plant's residues: Lignocellulolytic microorganisms, enzymes and their biotechnological applications in: (i) biopulping, (ii) biobleaching, (iii) textiles, (iv) biofules, (v) animal feed production. Liquid waste management: Treatment of sewage (Primary, Secondary and Tertiary treatments), Treatment of Industrial effluents (distillery, textile, pulp and paper), methods to detect various pollutants (metals, sediments, toxin and organic matters); application of wastewater in land.

Solid waste management: Solid waste types, composting, landfill development, incineration methods, composting and sustainable agriculture, plastic degrading microorganisms as a tool for bioremediation, challenges in waste management, composting of biosolids and domestic solid waste.

Plant-microbe interactions: Endophytic organisms, Common plant pathogenic bacteria, virus and fungus. Plant diseases: symptoms, disease cycle and control measures – Bacterial diseases, Blight of rice, Citrus canker and wilt of potato. Viral diseases, Vein clearing disease, Tungro disease of rice, TMV and CMV. Fungal diseases, rust of wheat, smut of sugarcane, wilt of cotton, tikka leaf spot in groundnut.

Beneficial association between plant and microorganisms. Different symbiosis including rhizosphere and phyllosphere microorganisms and their effect.

Important roles of soil microbes: Role of microorganisms in the formation of soil – Role of microbes in soil fertility. Biogeochemical cycles – Carbon, Nitrogen, Phosphorous and Sulphur cycles.

Bioremediation of environmental pollutants: Petroleum Hydrocarbons and pesticides, use of biosensors for their detection. Microbes in oil and mineral recovery: Microbial enhanced oil recovery, Bioleaching of copper, gold and uranium, electronic waste management.

Paper MCBPCOR08T (Theory)
Bioinformatics and Biostatistics

Marks: 50
Credits: 4

Course Content:

Unit I – Bioinformatics

Basic concepts of computers
Basic structure of a computer. Different operating systems like MSDOS, Microsoft Windows, UNIX, various Linux distros and their use. File attributes in various operating systems. UNIX/Linux commands for working in the command prompt. Concept of hardware, software, firmware, liveware. Concept of Local Area Networking (LAN). Concepts of computer security and file protections. Introduction to a high-level computer programming language.

Overview of basic bioinformatics tools
Finding sequences by Name, Accession Number, Key wordsand phrases, or by association. Using National Center for Biotechnology Information (NCBI) Entrez Global Query Cross-Database Search System. MEDLINE® (Medical Literature Analysis and Retrieval System Online) and PubMed references. Searching worldwide nucleotide and protein sequence databases like GenBank, RCSB PDB and others. Protein structure databases. Database searching by similarity. Similarity *vs.* homology. BLAST (Basic Local Alignment Search Tool), FastA. Expert Protein Analysis System (ExPASy) and its uses. Sequence comparison and multiple sequence alignment (MSA). Sequence-function relationship. Conserved domain databases and search. Conserved DNA sequences – promoters, restriction sites, motifs. Protein motifs (domain). Pattern recognition tools. Restriction mapping tools. Protein localisation/function prediction.

PCR primer design
Primer design tools on the web. DNA sequencing and fragment assembly tools.

Introductory phylogenetic analysis
Overview and assumptions. From multiple alignment to phylogeny. Neighbour joining. Maximum Likelihood *vs.* Maximum Parsimony. Computer tools for Phylogenetic analyses.

***Insilico* protein secondary and tertiary structure prediction**
Structure types – Model based – Homology Modelling, *abinitio* structure prediction.Advantages and disadvantages of *abinitio* structure prediction. Steps of homology modelling. The necessary criteria to be considered. Structure build up using standalone servers or modeller-based servers or software. Validation of the predicted tertiary structure using software from various servers. Refinement of the predicted tertiary structure in terms of energy minimisation. Using RasMol, UCSF Chimera, PyMol, PyRx.

Basic concepts of molecular docking
What is molecular docking? Introduction to molecular docking using AutoDoc/AutoDoc Vina/UCSF Chimera and/or related software.

Elementary concepts of Molecular Dynamics Simulation (MDS)

Introduction to Molecular Dynamics Simulation using GROMACS/VMD/NAMD and/or similar software.

Unit II – Biostatistics

Concept of Probability. Population, variables, collection, tabulation and graphical representation of data. Frequency distribution, cumulative distribution function, box plot, measures of central tendency (mean, median, mode) and skewness.Variance (Var), Standard Deviation (σ) and Coefficient of Variation (CV). Concept of Quartiles, Deciles and Percentiles. The Null Hypothesis. Binomial, Poisson and Gaussian (Normal) distribution. Standard error. Confidence limits. Additive and multiplicative laws of probability. Concept of correlation. Regression and line fitting through graph points, method of least squares and its use to draw best fit experimental graphs. χ^2 tests, goodness of fit, Student's *t*-test. Random number generation – testing and use. Systematic and random sampling, sampling error. Probability density and cumulative distribution function. Analysis of Variance (ANOVA) – 1-way and 2-way. Criteria of reliability, precision, accuracy, sensitivity, specificity. Concept of significant figures. Usage of software like Microsoft® Excel, Origin®, in relation to statistics.

Books:

1. Biometry - The Principles and Practice of Statistics in Biological Research by RR Sokal and FJ Rohlf.
2. Fundamentals of Biostatistics by B Rosner.

Paper MCBPCOR09P (Practical)
Bioinformatics and Biostatistics Applications

Marks: 50
Credits: 4

Course Content:

Group – A: Bioinformatics

Unit I – Basic concept of computers

1. Demonstration of the basic hardware structure of a computer.
2. Operating systems of a computer – MSDOS, Microsoft Windows, UNIX, various Linux distros.
3. Computer security and file protection.
4. Overview of a high-level computer programming language.

Unit II – Uses of basic bioinformatics tools

1. Searching of scientific literature using Medline and PubMed.
2. Various DNA and protein sequence databases on the world wide web.
3. Finding and retrieval of DNA and protein sequences by name, accession number, key words and phrase from the various databases, *e.g.*, GenBank, GeneDB, WormBase ParaSite, UniProt, TrEMBL.
4. Alignment of sequences using BLAST, Clustal Omega and similar tools.
5. Finding protein structures form RCSB PDB and visualising them.
6. Sequence assembly and sequence analyses. Uses of ExPASy. Protein localisation/function prediction.

Unit III – PCR primer design

PCR primer designing using online and offline tools.

Unit IV – Introductory phylogenetic analysis

Construction of phylogenetic trees.

Unit V – *Insilico* protein secondary and tertiary structure prediction

1. Homology modelling of a protein structure.
2. *Ab initio* protein structure prediction.
3. Validation and refinement of predicted protein structures using software from various servers.
4. Use of RasMol, PyMol, PyRx, UCSF chimera.

Unit VI – Basic Molecular Docking

Idea of molecular docking using various software packages.

Unit VII – Introduction to Molecular Dynamics Simulation

Overview Molecular Dynamics Simulation using GROMACS/VMD/NAMD/other related software.

Group – B: Biostatistics

1. Representation by frequency distribution and analysis of real life data collected by students.
2. Graphical and Diagrammatic Representation of data.
3. Computation of Arithmetic Mean. Computation of Arithmetic Mean by change of origin and scale.
4. Computation of Median for ungrouped and grouped data and graphical location.
5. Computation of Mode for ungrouped and grouped data and graphical location.
6. Computation of central tendency for discrete and continuous data.
7. Computation of Quartiles, Deciles and Percentiles and their graphical location.
8. Computation of Variance, Standard Deviation (σ) and Coefficient of Variation (CV).
9. Determination of Standard Deviation and standard error in laboratory experiment data
10. Graphical representation of Standard Deviation and standard error
11. Computation of Mean by using the method of least squares.
12. Curve fitting through experimental graph points.
13. Test of goodness of fit – χ^2 tests and Student's *t*-test.
14. Determination of Confidence Interval by MPN test of water sample

Paper MCBPCOR10P (Practical)
Microbial Ecology Environmental Microbiology and Industrial Microbiology

Marks: 50
Credits: 4

Course content:

Group – A: Microbial Ecology Environmental Microbiology

1. Detection of pathogenic contamination (*E. coli*, *Salmonella*, *Pseudomonas*) in food and/or water sample.
2. Determination of phenol coefficient.
3. Microbiological quality of milk – phosphatase test.
4. Enumeration of bacteria present in a milk sample.
5. Determination of *Enterococci* in water.
6. Determination of (i) Biological Oxygen Demand (BOD), (ii) Chemical Oxygen Demand (COD) and (iii) Total Dissolved Solid (TDS) in water sample.
7. Most Probable Number (MPN) count of organisms.
8. Determination of microbial biomass carbon.
9. Determination of soil microbial activity by measuring CO_2 evolution.
10. Isolation and characterisation of microorganisms from soil.

Books:

1. Difco™ & BBL™ Manual by MJZimbro*et al.* (eds.).
2. Standard Methods for the Examination of Water and Wastewater by APHA.
3. A Text-book of Quantitative Inorganic Analysis, 3rd edition, 1961 by AI Vogel.

Group – B: Industrial Microbiology

1. Alcohol fermentation / Wine fermentation.
2. Baker's yeast production.
3. Isolation of organisms for diastase production.
4. Adaption of organisms for citric acid production.

Paper MCBPSEC01M (Skill Enhancement Course, SEC)
Diagnostic Microbiology

Marks: 50
Credits: 2

Course Content:

Understanding Infection:Host-parasite relationship.Pathogenesis of one common bacterial, one common parasitic and one common viral disease. Effect of the environment on emerging and re-emerging diseases.
Antimicrobials and Infection:Development of chemotherapy. Antibiotics – Definition, genera of antibiotics (overview), antibiotics *vs.* probiotics (to provide a concept and explain the necessity of the uses of probiotics and synbiotics). Multiple Drug Resistance (*e.g.*, MRSA) and its significance (mechanism notrequired), side effects of antibiotics. Drug trial phases. Strategies of prevention, diagnosis and treatment of infectious diseases with reference to any**two** currently relevant ailments.
Clinical Diagnosis: Collection, transport and processing of clinical samples. Laboratory methods for the examination and detection of bacterial, fungal, parasitic and viral infections from various blood, urine, stool, sputum, gastrointestinal, urogenital, cerebrospinal fluid (CSF), throat swab and other such specimens. Antibiotic susceptibility testing. Performance Standards for Antimicrobial Susceptibility Testing - CLSI guidelines.
Molecular Diagnostics:Enzyme-Linked Immunosorbent Assay (ELISA). Brief overview of the molecular diagnostic methods for detecting genetic diseases – RFLPs, SNP genotyping, genotyping by sequencing (detailed theory not required). Use of PCR in clinical diagnosis.

Book:
Bailey & Scott's Diagnostic Microbiologyby BA Forbes, DF Sahm and AS Weissfeld.

OR

Paper MCBPSEC01M (Skill Enhancement Course, SEC)
Mendelian Genetics, Inheritance and Development

Marks: 50
Credits: 2

Course Content:

Mendelian principles: Dominance, segregation, independent assortment, deviation from Mendelian inheritance.
Concept of gene: Allele, multiple alleles, pseudoalleles, complementation tests.
Extensions of Mendelian principles: Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, and sex-limited and sex-influenced characters.
Gene mapping methods: Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants.
Extra chromosomal inheritance: Inheritance of mitochondrial and chloroplast genes, maternal inheritance.
Development: Gametogenesis, fertilisation and early development. Life cycle of yeast.

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Semester 3

Total Marks: 300

Total Credit Points: 24

Duration: July – December

Courses to be covered:

Core:

1. **Paper MCBPCOR11T**(Theory) – Marks: 50. Credit Points: 4.
   Fundamentals of Molecular Biology.
2. **Paper MCBPCOR12T**(Theory) – Marks: 50. Credit Points: 4.
   Recombinant DNA Technology.
3. **Paper MCBPCOR13T** (Theory) – Marks: 50. Credit Points: 4.
   Genetics.
4. **Paper MCBPCOR14P** (Practical) –Marks: 50. Credit Points: 4.
   Molecular biology and Recombinant DNA Technology and Analytical and Biochemical Methods in Microbiology.
   .

Discipline Specific Elective Course 1 (DSE 1):

1. **Paper MCBPDSE01T**– Marks: 50. Credit Points: 4.
   Applications of Microbial Technology.
   or
   Evolutionary Biology and Astrobiology.

Generic Elective Course (GEC):

1. **Paper MCBPGEC01T**– Marks: 50. Credit Points: 4.
   Microbes in Sustainable Development.
   or
   Astrobiology.

Tentative date of examination: First week of January

Paper MCBPCOR11T (Theory)
Fundamentals of Molecular Biology

Marks: 50
Credits: 4

Course Content:

Demonstration of DNA as genetic material. Fundamentals of Molecular Processes, Adapter Hypothesis. Central Dogma Fundamental Processes. Propagation and Maintenance of Genome. Genome Organisation in procaryotes and Eucaryotes. Bacterial Nucleoid Structure. Chromosome Structure and Organisation. Histones and non-histone proteins. Nucleosome Structure and organisation. Nature of eucaryotic genomes. Repetitive and non-repetitive DNA sequences.

DNA replication in Eucaryotic Cells. Enzymology and general features. Detailed mechanisms of initiation,elongation and termination.Experiments underlying each steps and role of individual factors.Regulation and control of replication. Problem of linear DNA replication. Telomere and Telomerases.

Recombination at the molecular level. Homologous recombination, Rec A and RecBCD system. Chi-Sequence. Holliday junction and Ruv System. Site specific Recombination and Transposition.

DNA damage and Repair. Replication errors.Mutations and other kinds of damages. Enzymology, genetics and mechanisms of DNA Repair. Photoreactivation. Base and Nucleotide excision repair system. Mismatch Repair System, SOS Repair System.

Flow of genetic information and mechanism of transcription. Eucaryotic Transcription. Eucaryotic promoter, enhancers. General transcription factors, activators, mediators. Transcription termination. The Interrupted Gene – exons and introns, Organisations of interrupted genes. Nature of exon and intron sequences. Wide distribution of intron and exon sequences. Evolution of interrupted genes. Members of a gene family have a common organisation. Conservations of exons and genome organisations.

RNA processing, capping and polyadenylation. mRNA splicing, *cis*- and *trans*- splicing. Chemistry of splicing, spliceosome and SR proteins. Alternative splicing and exon shuffling. Splicing of group I and group II introns. Tetrahymena self-splicing introns. Ribozyme, mRNA editing, folding, export. Epigenetic and transcriptional and post-transcriptional control. Concept of quality control of gene expression and coupling of different steps of gene expression.

Translation and protein synthesis. Ribosome structure and function. Genetic code. tRNA and Wobble hypothesis. Fidelity and control of translation. mRNA degradation. Protein splicing.

Regulation of procaryotic and eucaryotic genes. Concept of regulation at different layers, negative *vs.* positive regulations. Positive regulation in eucaryotic cells at transcriptional and post-transcriptional levels.Basic and accessory transcription factors, enhancers and alternative splicing, and polyadenylation. Nuclear Pore Complexes (NPCs) and another control point of gene regulation. Regulation of gene expression after export, *e.g.*, at the levels of mRNA localisation, translation and decay. RNA induced interference (RNA*i*).

Duplication, crossing over and other kinds of rearrangements. Pseudogenes. Tandem Repeats of different clusters.

Fundamentals of genomics and systems biology with basic concepts of genome analysis.

Books:

1. Molecular Biology by D Freifelder.
2. Genes by B Lewin.

3. Molecular Biology of the Gene by JD Watson*et al.*
4. Molecular Biology by RF Weaver.
5. Molecular Biology of the Cell by B Alberts *et al.*
6. Molecular Cloning – A Laboratory Manual by J Sambrook and DW Russell.

Paper MCBPCOR12T (Theory)
Recombinant DNA Technology

Marks: 50
Credits: 4

Course Content:

Isolation and purification of RNA, DNA (genomic and plasmid) and proteins. Different DNA separation methods. Analysis of RNA, DNA and proteins by one- and two-dimensional gel electrophoresis, isoelectric focusing gels. Molecular cloning of DNA or RNA fragments in bacterial and eucaryotic systems. Expression of recombinant proteins using bacterial, animal and plant vectors. Isolation of specific nucleic acid sequences. Generation of genomic and cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors. *Invitro* mutagenesis and deletion techniques. Protein sequencing methods, detection of post-translation modification of proteins. DNA sequencing methods – Maxam-Gilbert (overview), Sanger's Method and High Throughput methods. Methods for analysis of gene expression at RNA and protein level. Nucleic acid hybridisation and its applications. Northern, Southern and Western blotting. Large scale expression analysis, such as micro array-based techniques. RFLP, RAPD and AFLP techniques.

Genome Sequences, Gene Numbers, Clusters and Repeats: Gene Numbers in Bacteria and Eukaryotes, Fundamentals of Human genome. Distribution of genes and other sequences. Essential genes. Patterns of expression of genes in the genome. Gene clusters and their origin. Sequence divergence is the basis for the evolutionary clock. Satellite DNA sequences.

Fundamentals of Genomics. The Content of the Genome. Different mapping methods. Variations amongst individual genome, RFLPs and SNPs. Functional and Comparative Genomics.

Genome projects. Creating the sequence map of a genome. Making sense of DNA sequence. DNA sequence variation and SNP. Application of SNP-technology-mapping genes underlying monogenic and multigenic disorder. Comparative genomics, transcriptomics and functional genomics. Gross chromosome abnormalities and cytogenetics.

Yeast Two Hybrid assays.

Books:

1. Principles of Gene Manipulation and Genomics by SB Primrose and RM Twyman.
2. Gene Cloning and DNA Analysis – An Introduction by TA Brown.
3. Protein Purification Handbook by Amersham Pharmacia Biotech.
4. Restriction Endonucleases Overview by New England Biolabs.
5. Enzymology Primer for Recombinant DNA Technology by H-M Eun.
6. Molecular Cloning – A Laboratory Manual by J Sambrook and DW Russell.

Paper MCBPCOR13T (Theory)
Genetics

Marks: 50
Credits: 4

Course Content:

Bacterial and Viral Genetics: The genetic organisation of bacteria and viruses. Mutation and its different types. Mutagens and mutagenesis. Bacterial Mutants, Bacterial Transformation, Conjugation – Plasmids. Hfr Cells. Time-of-entry mapping. F'plasmids. Transduction. Bacteriophage genetics – Plaque formation and phage mutants. Genetic recombination in virulent bacteriophages. Fine structure of the rIIgene in bacteriophage T4. Genetic recombination in temperate bacteriophages – Lysogeny. Generalised and specialised transducing phages and the mechanism of gene transduction. Transposable elements – Transposons in genetic analysis.

Yeast Genetics:History of yeast and yeast in history. What are yeasts? Yeast as a model eucaryote. Yeast strains. Growth and life cycles - the vegetative cell cycle. Mating and homothally. Sporulation and meiosis. The yeast genome - Sequencing project overview. Overview of clustered duplications in the *Saccharomycescerevisiae* genome. Example of the genetic and physical map of chromosome III. Genetic nomenclature. Chromosomal genes. Mitochondrial genes. Non-mendelian determinants. Genetic analyses – Overviews with examples. Mutagenesis and genetic screens. Tetrad analysis. Dominance and complementation tests. Complementation and its complications. Complementation groups as genes. Intragenic complementation as an indication of multiple domains. Non-mendelian inheritance. Suppression, transformation – Yeast vector and DNA fragments. Synthetic oligonucleotides. Homologous recombination and integrative transformation. Cloning in yeast by complementation. Expression of foreign proteins in yeast. Gene knock out. Plasmid shuffle.

Controlling Chromosome Structures and Epigenetics: Organisations of viral, procaryotic and eucaryotic chromosomes. Loops and domains. Banding patterns of chromosomes. Polytene and lamp brush chromosomes. Features and functions of centromeres and telomeres. Chromosomal remodelling and regulation of gene expression by modification of histones and chromatins.Ways epigenetic effects are inherited. Nucleation and other features of heterochromatin. Genomes of Organelles and Endosymbiosis.

Books:

1. Principles of Genetics by DP Snustad and MJ Simmons.
2. Microbial Genetics by D Freifelder.
3. Genetics – From Genes to Genomes by LH Hartwell *et al.*
4. Molecular Genetics of Bacteria by L Snyder and W Champness.
5. Molecular Genetics of Bacteria by JW Dale and SF Park.

Paper MCBPCOR14P (Practical)
Molecular Biology and Recombinant DNA Technology & Analytical and Biochemical Methods in Microbiology

Marks: 50
Credits: 4

Course Content:

Group A – Molecular Biology and Recombinant DNA Technology

1. Detailed concepts about laboratory habits and precautions needed for working with DNA, RNA and Protein samples.
2. Radiological safety guidelines.
3. Isolation of (i) genomic DNA and (ii) plasmid DNA from bacterial cells.
4. Purification of DNA from agarose gels.
5. Analysis of the concentration and purity of DNA by (i) spectrophotometry and (ii) agarose gel electrophoresis.
6. Southern Blotting.
7. Amplification of a stretch of DNA by Polymerase Chain Reaction.
8. Restriction enzyme digestion and ligation of DNA.
9. Chemical transformation of plasmid DNA.
10. Expression and partial purification of recombinant proteins from bacterial cells.
11. Estimation of concentration of proteins using UV absorption, Lowry and Bradford methods.
12. Analysis of proteins by Polyacrylamide Gel Electrophoresis (PAGE). Staining of polyacrylamide gels – (i) Coomassie stain and (ii) Silver stain.
13. Demonstration of the technique of DNA sequencing by Sanger's dideoxy method.

Book:

1. Molecular Cloning – A Laboratory Manual by J Sambrook and DW Russell.
2. Current Protocols in Molecular Biology by FM Ausubel *et al.* (eds.).
3. Methods in Molecular Biology, Volume 112 – 2-D Proteome Analysis Protocols by AJ Link (ed.).
4. Methods in Enzymology, Volume 182 – Guide to Protein Purification by MP Deutscher (ed.).
5. Methods in Enzymology, Volume 463 – Guide to Protein Purification, 2nd EditionbyRR Burgess and MPDeutscher (eds).

Group B– Analytical and Biochemical Methods in Microbiology

1. Assay of antibiotics by: (i) turbidimetry, (ii) serial dilution and (iii) agar diffusion.
2. Antibiotic sensitivity tests.
3. Isolation and count of microorganisms from rhizosphere/rhizoplane soil.
4. Isolation and count of microorganisms from phyllosphere/phylloplane.
5. Determination of biochemical activities of microorganism: (i) starch hydrolysis, (ii) nitrate reduction, (iii) production of urease, H_2S, catalase-peroxidise, oxidase, protease.
6. Detection of extra cellular protease and amylase.
7. Chemical estimation of vitamin.
8. Immobilisation of cells.
9. Chromatographic techniques.
10. Purification of enzymes.
11. Isolation of phospholipids from liver and their separation by Thin Layer Chromatography (TLC).
12. Determination of molecular weight of protein using gel filtration.

Books:

1. Performance Standards for Antimicrobial Disk Susceptibility Tests, M02-A10 by CLSI.
2. Performance Standards for Antimicrobial Susceptibility Testing, M100-S17 by CLSI.
3. Thin-Layer Chromatography by E Stahl.

Paper MCBPDSE01T (Discipline Specific Elective Course 1, DSE 1) Applications of Microbial Technology

Marks: 50
Credits: 4

Course Content:

Microbial Biotechnology: Scope and applications - horizons of Microbial Technology. Agriculture, Soil, Forest Microbiology.
Microbes: Living factories for macromolecules - Production of proteins in bacteria and yeast; recombinant and synthetic vaccines; microbial enzymes- application in starch processing, textile designing, detergents, cheese making, polysaccharides and polyesters. Immobilisation of cells and enzymes.
Microorganisms in fermentation and probiotics: Ethanol from feed stocks to fermentable sugars; from sugars to alcohols. Clostridial fermentation, lactic acid fermentation, acetic acid production and industrial production of various milk products. Production of probiotics.
Metabolites from microorganisms: Amino acids; antibiotics-antibacterial agents (β-lactams, tetracyclines, peptides, amino glycosides), antifungal agents, anti-tumour antibodies. Biotechnological potential of micro algae – food – fuel production –pharmaceutically valuable compounds of micro algae.Single-cell protein (SCP);mycoprotein.
Environmental Microbiology and Drug Discovery:Basics of environmental microbiology. Marine andaquatic microbiology.DNA microarray technology and its application in microbial biotechnology.
Nanobiotechnology: potential use in human health and environmental management
Biopesticides: Biological control of insects. Microbial insecticides – bacterial, fungal and viral. (*Bacillus thuringiensis, B. spaerinus, B. papilliae*and Baculoviruses). Recent advances in biological pest control.
Biofertilisers: Nitrogen fixing bacteria, mycorrhiza and phosphate solubilising bacteria. Genetically engineered organisms.
Bioremediation, Biosorption, Environmental clean-up by microbes: Application of microbial biotechnology in sewage and wastewater treatment, degradation of xenobiotics, mineral recovery, removal of heavy metals from aqueous effluents.Public concerns about the microbial biotechnology and economics of microbial biotechnology.Use of GMOs and Biotechnology tools for human development and sustainable environment. Bioremediation and bioaugmentation. Biosafety and biosecurity.
Microbes in composting: Farmyard manure;method of composting (aerobic, anaerobic); enrichment of compost with microbial inoculants. Super digested compost.Biogas production.
Vermiculture: Vermiculture process, Vermicomposting materials, Advantages of vermicompost.

OR

Paper MCBPDSE01T (Discipline Specific Elective Course 1, DSE 1) Evolutionary Biology and Astrobiology

Marks: 50
Credits: 4

Course content

Unit I – Evolutionary Biology

Emergence of evolutionary thoughts:Lamarckism, Darwinism. Concepts of variation, adaptation, struggle, fitness and natural selection. Mendelism. Spontaneity of mutations. The evolutionary synthesis.
Origin of life: Origin of basic biological molecules. Abiotic synthesis of organic monomers and polymers. Aspects of prebiotic environment and molecular evolution. Concepts of evolution. Theories of evolutions. Concepts of Oparin and Haldane. Experiment of Miller (1953). The first cell. Evolution of prokaryotes. Origin and evolution of economically important microbes. Origin of eukaryotic cells. Evolution of unicellular eukaryotes, anaerobic metabolism, photosynthesis and aerobic metabolism.Mechanisms of speciation. Biological classification (including 5 kingdom system of Whittaker and 6 kingdom system and 3 domain system of Woese*et al.*).
Evolutionary history:The evolutionary time scale – eras, periods and epoch. Major events in the evolutionary time scale. Origins of unicellular and multicellular organisms. Major groups of plants and animals. Stages in primate evolution including *Homo sapiens*. Concepts of neutral evolution, molecular divergence and molecular clocks; origin of new genes and proteins; gene duplication and divergence. Interactions between environment and biota, types of ecosystems. Concept of habitat and niche.
Population genetics: Populations, gene pool, gene frequency. Hardy-Weinberg law. Concepts and rate of change in gene frequency through natural selection, migration and random genetic drift. Adaptive radiation and modifications. Isolating mechanisms, speciation, allopatricity and sympatricity. Convergent evolution, sexual selection, co-evolution.

Unit II – Astrobiology

What is astrobiology? Why study astrobiology? Terminologies related to the study of astrobiology. Definition of life. Basic components of life. Origin of the universe. Origin and distribution of the chemical elements. Formation and evolution of stars and planets. The habitable zones and the pre-requisites of life. Prospects of life in our solar system. Extrasolar planets. Extraterrestrial intelligence. Planetary missions, space biology and planetary protection. Types of telescopes (X-Ray, UV, optical, IR, submillimetre and radio) and observing the universe through telescopes.

Book:
Astrobiology – A Very Short Introduction by DC Catling.

Paper MCBPGEC01T (Generic Elective Course, GEC)
Microbes in Sustainable Development

Marks: 50
Credits: 4

Course Content:

Unit I

Definition and concepts of sustainable development. Issues in Sustainable Development. Strategic Planning for Sustainable Development. Modern approach of bacterial classification. Microbes and its suitability in sustainable development. Brief account of bacterial cell structure, metabolic diversity, different niche occupancy.

Unit II

Microbial Growth characteristics, strategies of cell division, stressresponse. Genetic recombination in bacteria, transformation, conjugation,transduction. Signal transduction in bacteria.Regulation of signalling pathways.Bacterial and plant two-component systems.Bacterial chemotaxis andquorum sensing.

Unit III

Host-parasiteinteraction.Entryofdifferentpathogenslikebacteria andvirusesintoanimaland planthostcells.Pathogen-induced diseases in animals andplants. General idea on bacterial drugresistance. Concept of antisepsis, disinfection, sterilisation and chemotherapeutant.

Unit IV

Microbial fermentation (definition) and production of small and macromolecules.

Unit V

Microbes in environmental management – Bioremediation and phytoremediation.Biosensors. Microbes in healthcare.Antibiotics and drugdevelopment. Microbes in agriculture – crop improvement andprotection. Microbes in foodprocessing. Microbes in bio-hydrometallurgy and fuelindustry.

OR

Paper MCBPGEC01T (Generic Elective Course, GEC)
Astrobiology

Marks: 50
Credits: 4

Course Content:

What is astrobiology? Why study astrobiology? Terminologies related to the study of astrobiology. Definition of life. Basic components of life. Origin of the universe. Origin and distribution of the chemical elements. Formation and evolution of stars and planets. The habitable zones and the pre-requisites of life. Prospects of life in our solar system. Extrasolar planets. Extraterrestrial intelligence. Planetary missions, space biology and planetary protection. Types of telescopes (X-Ray, UV, optical, IR, submillimetre and radio) and techniques of observing and imaging the universe through telescopes and other optical instruments and software.

Book:
Astrobiology – A Very Short Introduction by DC Catling.

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Semester 4

Total Marks: 300
Total Credit Points: 24
Duration: January – June

Courses to be covered:

Core:

1. **Paper MCBPCOR15T** (Theory) – Marks: 50. Credit Points: 4.
   Medical Microbiology and Pharmacology.
2. **Paper MCBPCOR16T** (Theory) – Marks: 50. Credit Points: 4.
   Immunology.
3. **Paper MCBPCOR17T** (Theory) – Marks: 50. Credit Points: 4.
   Virology.
4. **Paper MCBPCOR18P** (Practical) –Marks: 50. Credit Points: 4.
   Immunology and Virology & Biophysical Techniques.

Discipline Specific Elective Course 2 (DSE 2):

1. **Paper MCBPCOR19T** – Marks:100 (30+40+30). Credit Points: 8(2+4+2).
   Project Work.
   and/or
   Review Work.

2. **Seminar Presentations:**

3. **Grand Viva:**

Tentative date of examination: First week of June

Paper MCBPCOR15T (Theory)
Medical Microbiology and Pharmacology

Marks: 50
Credits: 4

Course Content:

Pathogenicity of microorganisms: Host parasite relationship, pathogenesis of bacterial and viral diseases. Toxigenicity. Host defence against microbial invasion, microbial mechanism for escaping host defences.Effect of environment on emerging and re-emerging diseases.
Pharmacokinetics: Concept ofAbsorption, Distribution, Metabolism and Elimination (ADME) of drugs. Absorption and Bioavailability. Routes of drug administration – Oral, Parenteral (Intravenous, Subcutaneous, Intramuscular, Intra-arterial, Intrathecal), Pulmonary, Topical (Mucous membrane, Eye, Skin or transdermal), Rectal. Volume of distribution, drug half-life (terminal and steady state). Dosing rate and drug clearance.
Pharmacodynamics: Specificity of drug responses. Full, partial and inverse agonists, and competitive antagonists. Drug receptor interactions – Affinity, Efficacy and Potency. Concept of EC_{50}.
Antimicrobial chemotherapy: Development of chemotherapy. Antibiotics – definition, genera of antibiotics, assay of antibiotics, antibiotics *vs.* probiotics (to provide a concept and explain the uses of probiotics and synbiotics). Multiple Drug Resistance (MDR), its mechanisms and significance.Side effects of antibiotics. Drug trial phases. Modes of action of the important classes of antibiotics, antifungal, anti-protozoal and antiviral agents.Biochemical modes of action of antibiotics acting as inhibitors of ribosomal functions (*e.g.*, aminoglycosides, tetracyclines, puromycin, chloramphenicol, macrolides,*etc.*), inhibitors of nucleic acid metabolism (*e.g.*, actinomycin D, mitomycin C), inhibitors of cell wall bio synthesis (*e.g.*, penicillin, bacitracin *etc.*) and inhibitors of membrane function (*e.g.*, polyenes, tunicamycin, ionophores *etc.*). Antifungal agents (*e.g.*, clotrimazole, fluconazole, terbinafine, butenafine). Antiprotozoal agents.The Schedules G, H, X and J of the Drugs and Cosmetics Rules, 1945, Government of India.
Human diseases caused by bacteria: Diseases caused by the following organisms (**one** example each, its diagnosis and treatment) – *Staphylococcus*, *Streptococcus*, *Pneumococcus*, *Neisseria*, *Corynebacterium*, *Bacillus*, *Clostridium*, *Shigella*, *Salmonella*, *Escherichiacoli*, *Vibrio*, *Mycobacterium*. Aetiology, diagnosis and the treatment of the following diseases (any**five**) – Meningitis, Tuberculosis, Diphtheria, Leprosy, Cystic fibrosis, Typhoid, Enteritis, Gastritis (*Helicobacterpylori*), Cholera, Pneumonia.
Human diseases caused by fungi: Role of mycotoxins in human diseases.Any**two** fungal disease, their diagnosis and treatment.
Human diseases caused by viruses and prions: Any**three** viral diseases and any**one** prion disease – their diagnosis and treatment/management.
Bioterrorism and Bioweapons: Introduction to bioterrorism and bioweapons. The infectious agents used for these purposes and their epidemiology.
Pharmacognosy and the Future of Drug Development: Medicines form natural sources. Cheminformatics and target-to-ligand molecular docking studies in new drug discovery – basic concepts.

Books:

1. Goodman & Gilman's The Pharmacological Basis of Therapeutics by LL Brunton(ed.).
2. Pharmacognosy by WC Evans.
3. Antibiotic Essentials by BA Cunha.

Paper MCBPCOR16T (Theory)
Immunology

Marks: 50
Credits: 4

Course Content:

Overview of Immune System: General features of immune responses; Clonal selection hypothesis; cell, tissues and organs of immune system.
Innate, Adaptive and Humoral immunity: Anatomic barriers, Physiologic barriers, Phagocytic/endocytic barriers, inflammatory barriers. B lymphocytes, T lymphocytes, Antigen-Presenting Cells.
Antigen and Immunoglobulins: Overview of Antibody structure, Antigen-Antibody interactions, antibody heterogeneity and hybridoma technology. Generation of antibody diversity. Antigen presentation, Major Histocompatibility Complex, T-Cell maturation.
Cytokines: Properties of Cytokines; Cytokine Receptors; Cytokine Antagonists; Cytokine Secretion by TH1 and TH2 Subsets; Cytokine-Related Diseases; Therapeutic Uses of Cytokines and Their Receptors; Cytokines in Haematopoiesis.
Autoimmunity and immunodeficiency Syndromes: Antibody generation, detection of molecules using ELISA, RIA, western blot, immunoprecipitation, flowcytometry and immunofluorescence microscopy, detection of molecules in living cells, *insitu* localisation using techniques such as FISH and GISH.
Cancer:Incidence and aetiology of cancer.Genetics of cancer.Hallmarks of cancer, metastasis.Molecular and cellular events, such as regulation of gene expression, genome maintenance, cell growth and death, differentiation, cell-cell recognition, signalling, and homoeostasis.

Books:

1. Kuby Immunology by JA Owen, J Punt and SA Stranford.
2. Roitt's Essential Immunology by IM Roitt and PJ Delves.

Paper MCBPCOR17T (Theory)
Virology

Marks: 50
Credits: 4

Course Content:

Lytic and lysogenic cycles of bacteriophage λ – marvels of transcriptional control.Site-specific recombination in λ (generalised and specialised transduction).Problems in replication of the ends of linear DNA and how viruses circumvent the problem, with examples of T4 (terminal redundancy and circular permutation), λ (rolling circle model of replication, concatemers, site-specific cleavage), adenovirus and retrovirus.Viruses as vectors for recombinant DNA technology – M13, baculovirus. oncogenic viruses.Oncolysis - VSV.
Structure of Herpes virus, adeno virus, hepatitis virus, Rhabdoviridae, Simian vacuolating Virus 40 (SV40), orthomyxo virus, paramyxo virus, rotavirus, oncogenic viruses, H5N1 and H1N1 influenza viruses, RNA viruses like polio, Vesicular Stomatitis Virus (VSV), retroviruses. Life cycle of M13, Qβ, T7, ΦX174, T4, baculovirus, adenovirus, retrovirus, cellular transformation. Viroids. Molecular biology of genetic shift and drift in influenza virus. Cellular tropism of HIV. Plant viruses like Tobacco Mosaic Virus (TMV). Response to viral infection – slow and persistent infections, interferons.

Books:

1. Molecular Biology by D Freifelder.
2. Microbial Genetics by D Freifelder.
3. Fields Virology by DM Knipe and PM Howley.

Paper MCBPCOR18P (Practical)
Immunology and Virology and Biophysical Techniques

Marks: 50

Course Content:

Group A – Immunology and Virology

Unit I – Immunology

1. Immunoelectrophoresis.
2. Precipitin curve.
3. Enzyme Linked Immunosorbent Assay (ELISA).
4. Purification of Immunoglobulin G using affinity chromatography.
5. Western blotting.

Unit II – Virology

1. Assay of Bacteriophages.
2. Induction pattern of temperature sensitive lysogens.
3. Purification of Bacteriophages.
4. Transduction.

Group B – Biophysical Techniques

1. Verification of the Beer-Lambert-Bouguer law.
2. Construction of the absorption spectrum of any biologically relevant chromogenic substance.
3. Solvent extraction of phytochemicals from plant parts and concentrating the extract by vacuum distillation.
4. Study of the phytochemical extracts by chemical, chromatographic and/or spectrophotometric analyses.
5. Fitting bacterial growth curves into accepted mathematical models.
6. Standardisation of autoclaves.
7. Methods of imaging biologically relevant samples.

Paper MCBPDSE02T (Discipline Specific Elective 2, DSE 2)
Project Work and/or Review Work

Marks: 30
Credits: 2

Course Content:

Students will be required to undergo an intensive project of about two months to acquire hands on experience on various research and/or industrial techniques and learn to use various instruments used in research and/or industry.
Alternatively, they can also prepare a review of any relevant scientific topic or a demo project proposal for submission to a funding agency.
The students will be required to submit a one page abstract and a detailed writeup of their work electronically and/or physically.The work will be assessed by the respective instructors of the students and through a seminar presentation at the end of the work.

Seminar Presentations

Marks: 40
Credits: 4

Course Content:

Students will be required to participate in journal clubs and/or seminar presentations from time to time, either individually, or in groups of four or five, where they will be encouraged to review recent and relevant scientific research and/or review and present their work.
Students will also have to present seminars on popular topics to general audiences.

Grand Viva

Marks: 30
Credits: 2

Course Content:

Students will be assessed by a group of examiners through a viva voce examination which shall cover the entire syllabus covered during the four semesters.