West Bengal State University
Barasat, North 24 Parganas
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Syllabus for the M.Sc in Biochemistry

For Theory

- **14 weeks a semester; 1 credit = 14 lectures; 1 lecture = 1 hr class; Total theory teaching hours each day = 3 hrs = 3 lectures; 15 lectures a week; 210 lectures per semester**

For Practicals

- **1 credit = 28 one-hr classes; 224 classes per semester required; thus for practicals 15 weeks per semester is required**

	Semester	Credits	No. of classes	Total credits
Theory	1st	15	210	
	2nd	15	210	50
	3rd	15	210	
	4th	5	70	
Seminars	1 in each	4	4 seminars/term papers	4
Practicals	1st	8	224	
	2nd	8	224	36
	3rd	8	224	
	4th	12	336	
Aggregated				90

Courses offered (red courses are offered as common core courses for all the bioscience students)

Course No.	Title	Content	Credit	Text books	Coordinating Teachers	Who can take it
Theories		**1st Semester**				
220101	**Basic Maths, Stats and Computers for Biologists**	I. Basic maths (0.5) II. Biostatistics (2) III. Database use, analyses & simple programming (1.5)	4	Das and Mukhejee I. Das and DasGupta II. Goon, Gupta and DasGupta. III Lesk IV.	SJB (C) RB (Stats) PG (Maths) Dr. Somalee Basu (Bioinformatics)	Compulsory for all bioscience students
220102	**Biochemistry and Biophysics-I**	I. Biomolecular Structures and Interactions II. Enzyme and Reaction Kinetics	2	-Lehninger -Stryer Voet & Voet Van Holde Kensal E Creighton 2nd ed Gesteland, Cech and Atkins	SC (C), DM, Dr. Shantanu Dutta, Dr. Debkumar Mitra,	Compulsory for all bioscience students
220103	**Fundamentals of Molecular Biology & Microbiology**	I. Molecular Biology (3) : Fundamental Processes eg. Replication, Recombination, Repair, Transcription, mRNA processing, Genetic Code and Translation, Regulation of Gene Expression, Operon Concepts, Gene Expression in Eukaryotes. II. Microbiology (1): Development of Microbiology, Methods of Studying MOs, Organisation and structures of Microbes, Bacterial Growth and reproduction, I. Isolation, Identification and selection of microbial strains II. Optimal nutritional requirements Strain improvement III. Maintenance and preservation of microbial cultures	4	Molecular Biology of the Gene by Watson et al,; Genes IX by Lewin, Genome by Brown TA, Weaver Molecular Biology, Foster Prescott et al	BD (C), ZH, KR, PG, AS, TSG (Micro)	Compulsory for all bioscience students
220104	**Cell Biology and Fundamentals of immunology**	Cell Biology I. Cellular Organisation, Structures and Functions of the Cellular Organelles. II. Cell division and Cell Cycle III Cell Signalling and Communications IV Fundamentals of Immunology: Cell Mediated Immunity, Humoral Immunity, Effector Mechanisms, Infection & Immunity	3	Molecular Cell Biology By Lodish et al., Alberts et al.	CP (C), DPM, , SB, AM, SS, Dr. Shantanu Dutta	Compulsory for all bioscience students
220106	**Lab Course**	See Below	8	See Below		
		Total for each student	*23*			

Course No.	Title	Content	Credit	Basic text	Coordinating teachers	Who can take it
Theories		**2nd Semester**				
220201	**Evolution and Genetics -**	I. Evolution (1.5) II. Classical Genetics-Mendelian, Drosophila, Plants, Human, (1) III. Molecular Genetics : Bacterial Genetics (0.5)	3	I.Futuyama II.Hexter & Yost II. Stent et al. Strickberger Klug and Cummings	SJB (C), BD, Dr. Somnath Mukherji/Dr Ridhhi Majumder	Compulsory for all bioscience students
220202	**Biochemistry and Biophysics-II**	I. Molecular Biophysics and Instrumentation: II Bioenergetics and metabolism	2	Biochemistry by Lehninger A or Stryer L Voet & Voet Van Holde Kensal E, Freifelder David Cantor and Schimmel	DM (C), ,SC, Dr. Sumita Bannerjee , Dr. Pradip K. Sengupta	Compulsory for all bioscience students
0203	**Recombinant DNA Technology, Genomics and Proteomics**	I. Methods in Molecular Biology and Biotechnology II. Genomes: Structure, Diversity and Flux III. Proteomics IV Plant Biotechnology	4	Molecular Biology of the Gene by Watson et al,; Genes IX by Lewin, Genome by Brown TA Strachan and Reed Primrose and Twyman BM Turner Systems Biology-Uri Alon	BD (C) AM SC	Compulsory for Microbiology students
220204	**Ecology and Environmental Microbiology-II**	Environment, Habitat and Niche, Population, Community and Applied Ecology, Ecological Succession, Ecosystem, Conservation Biology Control of Pollution by microbes, Biopesticides and Bioreactors Microbial interaction: Plant-microbe and man-microbe interaction. Microbial Communities and Eco-systems	3	Brock Stanier.	TSG (C),	Compulsory for Microbiology students
220205	**Medical Microbiology**	I. Pathogenecity of Microorganisms II. Host Parasite interactions III. Diseases caused by bacteria, viruses and protozoa	3	Greenwood Prescott Jawetz	AM (C), TSG, NM, Dr. S. Joarder (WB Univ of Animal Fishery Science)	Compulsory for Microbiology students
220206	**Lab Course**	See Below	8			Compulsory for Microbiology students
		Total for each student	***23***			

Course No.	Title	Content outline	Credit	Basic text	Coordinating teachers	Who can take it
Theories		**3rd Semester**				
220301	**Microbial Genetics**	I. Advanced Bacterial and Phage Genetics and their applications II. Yeast Genetics, Cloning in yeast by complementation, Expression of Foreign Protein in Yeast, Gene Knock out, Plasmid shuffle, One Hybrid, Two Hybrid System	3	Stent and Calender Prescott et al. Watson et. al., Klug and Cummings Miller et al. Strickberger	Biswadip Das, Partho Saha (?)	Compulsory for Microbiology students
220302	**Bioenergetics and Metabolism**	I. Microbial Metabolism: Bacterial Photosynthesis, Pathways of Glucose metabolism, Metabolism of energy reserved compounds. II. Bioenergetics III. Metabolism of sugars, amino acids, lipids, nucleotides and vitamins in advanced level.	3	Leninger. Stryer Voet and Voet Dolle Nelson and Cox.	Dr. Debkumar Mitra, Dr. Pijus Das	Compulsory for Microbiology students
220303	**Cancer Biology and Immunology**	I. Overview of Immune System II. Innate and Adaptive immunity. III. Antigen-Immunoglobulin, Generation of immune Diversity IV. Antigen presentation, Major Histo-compatibility Complex, T-Cell maturation etc. VII. Autoimmunity and immunodeficiency Syndromes etc. VIII. Classification, Causes and Pathophysiology of Cancer. IX. Cancer Cell Biology and Therapeutics X. Gene therapy	4	Kuby Wood and Hood Roitt Lodish et al., Alberts et al., Abbas	Chiranjib Pal, Riddhi Majumder	Compulsory for Microbiology students
220304	**Virology**	I. Classification and modes of Propagation of viruses II. Morphology, Ultra-structure of plant, animal and bacterial viruses III. Assay, Cell Culture, viral enzymes Nucleic Acids. IV. Biology, Genetics and infectious cycle of DNA and RNA viruses. V. Host-Virus interaction, infection, diseases and pathogenesis. VI. Oncoviruses and their roles in cancer. VII. Retroviruses and their role in AIDS and other human disease	3	Dimmock Flint Ptashney Maniatis Friefelder Brock	ARS	Compulsory for Microbiology students
220306	**Lab Course**	See Below	8	See Below		
	Total for each student		***21***			

Course No.	Title	Content outline	Credit		Coordinating teachers	Who can take it
Theories		**4th Semester**				
220401	**Developmental biology**	I. Concept of Development II. Gametogenesis, Fertilization, and early development III. Morphogenesis and organogenesis in model organism. IV. Progammed Cell Death, aging and senescence	2	Gilbert	Ridhhi Majumder	Compulsory for Microbiology students
220402	**Clinical Biochemistry**	I. To be added Later	2			
220403	**Project Work**	At least 8 weeks	8			
220404	**Review of Research Papers and Presentation**		3			
	Total for each student		***15***			

PRACTICALS

Course No.	Title	Content	Credit	Teachers	Who can take it
Practicals		**1ST Semester**			
Bio- P01	**Biostatistics and Computer Applications**	1. Introduction to computer – Basic Handling, Operating system, E-mailing, Internet Accessing, Literature-Searching through internet. 2. Fundamentals of Microsoft Office Softwares, Converting an office document into printable document format, 3. Familiarity with softwares handling statistical methods, plotting (Sigmaplot or anything else) and graphics programs (Adobe Photoshop). 3. Two Projects on Statistics such as (a) Normal, Poisson distribution of body heights of the students in a class (b) Determination of Mean, SD of number of bacterial colonies grown on Agar plates (c) Testing of Null Hypothesis, alternative hypothesis, Application of t-test on the determination of generation times of more than one group of bacteria/microorganisms.			Compulsory for all bioscience students
Bio- P02	**Biochemistry and Biophysics**	1. Prep. of Buffers and Solutions. 2. pH titration of amino acids 3. Experiments with Enzyme and kinetics. 3. Tests of Carbohydrades, Proteins and Lipids. 4. Quantitations of Ascorbiic Acid and Sugar 5. Analysis of Oils: Iodine number, saponification no. And acid number. 4. TLC	2		Compulsory for all bioscience students
Bio-P03	**Molecular Biology & microbiology**	Plasmid DNA isolation. Genomic DNA isolation from Blood. DNA gel electrophoresis. Restriction Enzyme digestion Operation of microscope, Asceptic Techniques, Staining Techniques, Cultivation: Culture Characterisation of microorganisms, Culture transfer techniques Microbial Growth, Growth Curve effect of pH and temperature.	2		Compulsory for all bioscience students
Bio-P04	**Cell Biology and Immunology**	Cell isolation and identification, viable cell counting Gel diffusion techniques for Antigen-antibody reaction. Dissection of primary and secondary Lymphoid or organs.	3		Compulsory for all bioscience students
Micro-P01	**General Microbiology**	3. Isolation of pure culture. 4. Isolation of different bacterial flora from soil. 5. Techniques for cultivation of Aenorobic bacteria. 6. Plaque Assay of Coliphage	2		Compulsory for all Microbiology students
	Seminar	One power point presentation from any topic relating any of the courses taught in this semester	1		
	Total for each student		***9***		

Course No.	Title	Content	Credit	Teachers	Who can take it
Practicals		**2nd Semester**			
Bio- P05	Evolution and Genetics	Drosophila genetics Microbial genetics: 1. UV-Survival Curve of *E. coli*. 2. Isolation of *ts* growth defective and auxotrophic mutants in *E. coli*.	2		Compulsory for all bioscience students
Bio-P06	Biochem / biophysical techniques	Fundamental Chromatographic techniques: Such as gel-filtration/ion-exchange chromatography. Protein Gel Electrophoresis Quantitative estimation of protein, carbohydrate & lipid	2		Compulsory for all bioscience students
Micro-P02	RDT, Genomics Proteomics	Cloning of exogenous piece of DNA in a vector Amplification of a given gene from plasmid or genomic DNA by PCR Preparation of total cDNA from cellular RNA and amplification of specific fragment by RT-PCR.	1		Compulsory for all Microbiology students
Micro-P03	Environmental Microbiology	Determination of MPN, BOD, COD and DO of Water Measurement of microbial activity of soil by soil respiration method Isolation of an antibiotic	1		Compulsory for all Microbiology students
Micro-P04	Medical Microbiology	Isolation of antibiotic resistant bacteria from soil	2		Compulsory for all Microbiology students
	Seminar	One power point presentation from any topic relating any of the courses taught in this semester	1		Compulsory for all Microbiology students
	Total for each student		***9***		

Course No.	Title	Content	Credit	Teachers	Who can take it
Practicals		**3rd Semester**			
Micro-P05	Microbial Genetics	Experiments on bacterial Conjugation and Transformation Isolation of *auxotropihic mutant in* Yeast *S. cerevisiae*.	1		Compulsory for all Microbiology students
Micro-P06	Industrial Microbiology		7		Compulsory for all Microbiology students
	Seminar	One power point presentation from any topic relating any of the courses taught in this semester	1		
		Total for each student	***9***		

Course No.	Title	Content	Credit	Teachers	Who can take it
Practicals		**4th Semester**			
Micro-P0	Dev Biol	Experiments involving pattern formation in Drosophila or any other model system.	2		Compulsory for all Microbiology students
Micro-P0	Biosafety and Bioethics		1		Compulsory for all Microbiology students
Bio- P0	Project works and dissertation	Small Projects involving experimental methodologies taught in the previous semester important and emerging areas of Microbiology/Biochemistry	9		Compulsory for all Microbiology students
	Seminar		1		
		Total for each student	***13***		

Detailed Content of Courses Proposed

Semester I

220101 Basic Mathematics, Biostatics and Computers for Biologists

Basic Mathematics

Elements of Algebra

Theory of Equations: Polynomials, Descartes's rule of signs, extraction of roots of quadratic, cubic and biquadratic equatons, Relation between roots and coefficients, Transformation. Simple problems only.

Matrix Theory: Matrix Operations, Symmetric and skew –symmetric matrices, orthogonal matrix, Determinants, Application to solution of system of equations, Cramer's rule, Eigen values and eigen vectors, Diagonalization of matrices, Quadratic form.

Set Theory: Sets and set operations, Relations, Functions, Injective, surjective and bijective functions, inverse of a function, composition of functions, Cardinality of a set, Cardinality theorem, Cartesian product of sets.

Elements of Calculus:

Differential Calculus: Integers, Real numbers-simple properties, complex numbers –simple properties, functions and their graphs and their interpretations, Study of the functions: xn, ex, *a*x, log x, sin x, cos x, tan x, sinh x, cosh x, tanh x, Boundedness, monotonicity and periodicity of functions, continuity and differentiability of functions, Higher order derivatives, Leibnitz's theorem, Physical, geometric and functional interpretations of derivative, maxima and minima, series expansions of functions.

Integral Calculus: Indefinite integral, Properties of Definite integral, Improper integral, Gamma and Beta functions, Reduction formulas only for ∫sinnx dx, ∫cosnx dx and ∫tannx dx. Evaluation of area – simple problems. Fourier Analysis.

Differential Equations: Definitions of ordinary and partial differential equations, Evolution of differential equations from biological processes, Methods of solving ordinary equations- separation of variables, exact, homogeneous equations, First order linear equations, equations of first order but not of first degree –simple equations only, Clairaut's equation for singular solution, Linear equations of second and higher orders with constant coefficients, Systems of equations – simple examples.

Biostatistics

Biostatistics and Biometry

Elements of Probability theory: Random experiment, sample space, events, Laplace's definition, Theorems of Total and Compound Probability, Bayes's theorem, Independence of events, Random variable, Probability function, Distribution function, Mathematical Expectation, Moment generating function,

Theoretical distributions- Binomial, Poisson, normal, uniform, exponential, and hypergeometric.

Elements of Statistics: Population, Sample, Methods of sampling, Sampling distributions, Measures of central tendency, dispersion, Moments Skewness and Kurtosis. Correlation and regression, Curve-fitting – linear, quadratic and exponential, Least-square method.

Biometry: Hypothesis testing, Parametric and nonparametric tests, z, t and $\chi 2$-tests.

Computer Application in Biology: Information and Data. Hardware: CPU, Primary and Secondary storage, I/O devices, Bus structure Software: Systems & Application. Generation of Computers: Super, Mainframe, Mini & Personal Computer. Programming Languages: Machine
Language, Assembly Language, High Level Language. Problem solving: Flow charts, Decision tables & Pseudo codes.

Basic Computer Organization: Arithmetic and Logic Unit, Control Unit, CPU Registers, Instruction Registers, Program Counter, Stack Pointer, System Bus. Instruction: Machine instruction and Assembly Language. Operation Code and Operand, Instruction types, Addressing modes, Instruction Cycle. Stack organization. Memory: Types of Memory, RAM, ROM, EPROM, DRAM, SRAM, Associative memory.

Introduction to Data Structures: Arrays, Linked Lists, Stacks, Queues, Trees, Graphs, Searching and Sorting.

Operating Systems: What is OS? Multiprogramming OS. Concepts of processes, Files, Shell, System Calls. Structures: Monolithic, Layered, Virtual, Client Server and Distributed Model.

Internet Technologies: Intranet and Internet; Servers and Clients; Ports; Domain Name Server (DNS); Accounts, Internet Service Providers; Connections : Dial up, ISDN, ADSN; Cable, Modem; Email : Account, Sending, Receiving, Mailing List, IRC, Voice and Video Conferencing, WWW,Browsers

220102 Biophysics and Biochemistry -I

Biophysics

Elementary Quantum Mechanics: with special reference to macromolecular structure and Dynamics, Concept of electromagnetic radiations, Idea of wave particle duality, de Broglie hypothesis, Heisenberg's Uncertainty Principle, Schrodinger equation (time independent), elementary concepts of operator, Eigenfunction and Eigenvalues, Schrodinger's equation, for hydrogen atom, separation of radial and angular parts, concept of orbitals and shapes of s, p, d orbitals.

Thermodynamics: Extensive and Intensive Variables, Mathematical Description of Thermodynamic System with two or more variables, Exact and Partial differential, First, Second and Third Law of Thermodynamics, isothermal process, Entropy, enthalpy, reversible and irreversible process, free energy and chemical potential, Gibb's free energy, osmotic pressure, Nernst Potential, Donnan Equilibrium, methods for determining free energy changes, coupled reaction, kinetics of reaction, principles, elementary and multi-step reactions, activation energy, Molar refraction and polarization, dipole moment, potentiometric determination of pKs of amino acidsDebye-Huckel Theory, Hydradtion and Solvation number.

Stereochemistry : Chirality, elements of symmetry, Plane of symmetry, center of symmetry and axis of symmetry, optical isomerism, enatiomerism and diastereomerism, D/L,R/S,E/Z,syn/anti, cis/trans, meso/dl, threo/erythro, nomenclature, conformational nomenclature, eclipsed/staggered, gauche/anti, dihedral angle, energy barrier of rotation, relative stability of conformers on the basis of steric effect, dipole- dipole interactions, H- bonding, conformational analysis of ethane, n-butane,stereochemistry of cyclohexane- chair and boat conformations, conformational analysis of cyclohexane.

Elementary Optics and Microscopy: Dispersion by a prism, dispersive power, Laser-Stimulated absorption, spontaneous emission, stimulated emission, characteristics and uses of laser. Interference of light- Diffraction of light, grating element Polarization, polarization of transverse wave, - plane of polarization, unpolarized, linearly polarized, circularly polarized, elliptically polarized, polarization of reflection, Polaroid, Nicol's prism (as polarizer and analyser), optical activity.
Microscope (compound)- Basic components, ray-diagram, magnifying power, resolving power; Stereo-microscope – stereo images; Optical microscope- Bright field, Dark field, Phase contrast, Fluorescence, Confocal laser scanning; Electron Microscope- Dicroism, Transmission (TEM), Scanning (SEM), Reflection (REM), Scanning Transmission(STEM),;Scanning Probe Microscope;
Atomic force, FACS Analysis.

General properties of matter: Surface tension, Viscosity and Newtonian flow of liquids: Surface tension and surface energy, molecular theory, angle of contact, elevation and depression of liquid columns in a capillary tube, excess pressure in a spherical bubble or drop, Streamline and turbulent motion, Poiseuille's formula, critical velocity, Reynold's number, Stoke's law.

Biohysical Methods: Brownian movements, osmosis and diffusion in aqueous solutions; Centrifugation (Isopicnic and density gradient sedimentation); Hydrodynamic methods: Determination of the hydrodynamic radius; Relationship of retardation time and molecular weight of biological polymers.

Biochemistry

Acid, Bases, Buffers and life processes

Arrhenius's concepts, theory of solvent system, Bronsted and Lowry's concepts, relative strengths of acids, Lux- Flood concept, Lewis concept, Usanovich's concept, HSAB principle, ionization of water, ionic product of water pH, Concept of pH, buffer solutions in biological sytstems, polyprotic acids, acid base neutralization curves, solubility product principle, common ion effect and its applications in separation and identifications of common cations, solvent properties of water, ampholytes electrostatic and hydrophobic interaction.

Biomolecules

Amino acids, peptides and proteins: Structure of amino acids, Chemical reactions and modification, physical properties, sequencing, synthesis of peptides.Proteins: End group analysis, Sequencing, Purification, Protein structure: Hierarchy of structure, primary, secondary, tertiary and quaternary, torsion angle and Ramachandran plot, motifs and domains, Chemical nature of polypeptides, the polypeptide chain, amino acids and their side chains, covalent modifications of the polypeptide chains, forces that determine protein structure. Methods to determine macromolecular structures Forces stabilizing protein structure: H-bond, Electrostatic interaction, Hydrophobic interaction, Vander Waal's interaction Structure function relationship of proteins **:** fibrous proteins (keratins and collagen), globular protein, (oxygen transport proteins hemoglobin and myoglobin).

Nucleic acid: Types and basic structure (DNA, RNA), Principles of sequencing and oligonucleotide synthesis. Double helical structure of DNA(Watson-Crick model), Sugar puckering and base stacking; B-,A- and Z-DNA, other nonperiodic structures (DNA bending, Supercoiling) and their significance. Denaturation kinetics of DNA, Cot curves. Nucleic acid hybridization its application. Folding of RNA into higher order structures (mRNA, tRNA, rRNA in ribosome), modified nucleotides in tRNA and rRNA and their importance, Purification and separation of nucleic acids. Protein Folding and Stability

Lipids: Classification, Structure-function, role in biological membranes. Lipoproteins

Carbohydrates: Classification and reactions. Polysaccharides: Types, Structural features, determination of composition. Glycoproteins

Introduction to examples of Macromolecular assemblies :Membranes, Ribosomes, DNA/RNA polymerases, Sliceosomes, Exosomes, Proteasomes etc.

Enzymology: Definition of Enzyme, Active Site, Substrate, co-enzyme, cofactor, Enzyme substrate Complimentarity, K_m and V_{max}, Micheaelis-Menten plot, Lineweaver-Burke Plot, Eadie-Hofstee, Hanes Plot, Enzyme Inhibition (Competitive and non-Competitive, uncompetitive inhibition, mixed, partial), Enzyme Kinetics, two and three substrate kinetics, deviation from linear kinetics, Ligand Binding sites, Hill Equation, Types of kinetics (acid-base, covalent, electrostatic, metal ion activated) Use of isotopes in enzyme kinetics mechanism analysis, Effect of temperature and pH on enzyme activity, Allosteric Regulation of Enzymes, Active site determination studies, Protease family of Enzymes.

Bioenergetics and Metabolism

Principles of Bioenergetics, ATP Cycle, Concept of metabolism, Nutritional importance, digestion, absorption, transport, mechanism of activation of digestive enzymes.

Carbohydrate Metabolism: Carbohydrates Digestion, Absorption, Intestinal transport. Intra Cellular metabolism of glucose – Glycolysis, HMP Shunt, Citric acid cycle; Glycogenolysis, Glycogen synthesis, metabolism of sugar other than glucose. Regulation of blood glucose level. Gluconeogenesis, biosynthesis of disaccharides, glycoproteins, Glyoxalate cycle, Metabolic regulation.

Amino acid Metabolism: Dynamic Equilibrium of body protein, Nutritional and Metabolic importance of amino acids, General catabolism of amino acids, Metabolism of a few individual amino acids, one carbon fragment metabolism amino acid as biosynthetic precursors. Urea, Metabolic diseases.

Lipid metabolism: Biosynthesis and catabolism of simple and complex lipids. Metabolic regulation. Lipoproteins, lipid storage and transport. Cholesterol metabolism and regulation. Abnormal metabolism of lipids.

Nucleotides metabolism: Biosynthesis degradation of purines and Pyrimidines and their nucleotides, their interconversion & regulation. Salvage pathways. Regulation of biosynthesis of deoxyribonucleotides from ribonucleotides, abnormal metabolism of purines and pyrimidines .

Nitrogen metabolism: Nitrate and ammonium assimilation; amino acid biosynthesis.

Photosynthesis; Light harvesting complexes; mechanisms of electron transport; photoprotective mechanisms; CO_2 fixation-C_3, C_4 and CAM pathways, photorespiratory pathway.

220103 Cell Biology and Immunology;

Cell Biology

Cell as basic unit of life, Cell Theory, Precellular Evolution of Cell, Evolution of Eukaryotes from Prokaryotes & single cell to multicellular organism, Common Structural Features of Living Cells, Prokaryotic and Eukaryotic Cells: Their chracteristics and differences, Structure of Model Procaryotic Cell.

Cell wall and membranes: Prokaryotic-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, Modern methods to study the cell membrane, FRAP, Scanning colorimetry,Chemilumiscence, Freeze-etching, Freeze-fracturing, Hydrophobicity plot,

Complexities and compartmentalization of Eukaryotic Cells: Cell Organelles: their structures and functions, nucleus, other membrane bound organelles eg. Mitochondria and chloroplast, Ribosomes, Endoplsmic reticulum, golgi bodies and secretory vesicles, trafficking, targetting, sorting and localization of proteins and other macromolecules Perxisomes and Lysosomes; Cytoplasm.

Cytoskeleton: Microtubules and microfilaments, intermediate filaments, microtubule polymerization dynamics, actin polymerization dynamics, cell crawling, contractile structures, actomyosin complex, muscle contraction.

Other Granular bodies: Extracellular appendages eg. flagella, cillia and extracellular matrix. Cell Function: Dynamic movements, and signal transduction in the living cells.

Cell cycle: mitosis meiosis and cytokinesis, animal and yeast cell division, cdc mutants, cell cycle control, cell cycle checkpoint, metaphase-anaphase transition, antimitotic drugs, cytoskeletol diseases, microtubule dependent drugs and actin targeted drugs. Loss of cell cycle control and cancer, programmed cell death and apopotosis;

Cell junctions and cell-cell signaling: General characteristics, specificity, amplification, desensitization or adaptation and integration; non-receptor mediated cell signaling - gaseous messengers (NO and CO); receptor mediated, cell signaling – ligands (membrane diffusible, eg. 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); desensitization process, bacterial toxins as tools in study of receptor signaling; calcium homeostasis - calcium signaling.

Immunology

Introduction to Immunology: History & philosophy of Immunology, Specific & Non specific Immune system : Innate & acquired, Cells & Organs of Immune system.

Cell Mediated Immunity: Concept of Antigens : APC, APC structure & Classification; MHC , MHC Structure & Gene Complex, Antigen Presentation, T cell Structure, T cell Receptor & Molecule, APC-T cell Interaction, Co-stimulation, Development of T cell in Thymus; Positive & Negative Selection, Generation of Th1/Th2 responses, Mechanism of prevention & terminating T cell responses, Cytokines & Chemokines in maturation of T cells

Humoral Immunity: B cell Structure, B cell Receptor & Molecule B Cell development, Maturation of B cell & expression of Immunoglobin Genes, B cell antigen Presentation, B Cell- T cell Interaction, Cytokines & Chemokines in maturation of B cells.

Effector Mechanisms: Effector mechanisms in Cell Mediated & Humoral Immunity, Effector Mechanism of IgE-initiated immune responses, Cytokines, The Complement Pathway.

Infection & Immunity: Basic Concepts on Immunity against Infectious disease- Virus, bacteria, Fungi, Protozoan parasite, helminthic Parasite, Hypersensivity, Basic concepts of Vaccination and Immunotherapy.

220104 Fundamentals of Molecular Biology and Microbiology

Molecular Biology: Emegence of Molecular Biology as a new discipline, Demonstration of DNA as genetic material, Fundamentals of Molecular Processes, Adapter Hypothesis, Central Dogma

Fundamental Processes

Propagation and Maintenance of Genome

Genome Organization in prokaryote and Eukaryotes: Bacterial Nucleoid Structure, Chromosome Structure and Organization,Histones and non-histone proteins, Nucleosome Structure, and organization.

DNA replication in Prokaryotic and Eukaryotic Cells, Enzymology and general features, Detailed mechanisms of intiation, elongation and termination, experiments underlying each steps and role of individual factors, regulation and control of replication, Problem of linear DNA replication, Telomerases.

Recombination at the molecular Level: Homologous recombination, Rec A and BCD 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

Mechanism of Transcription: Prokaryotic Transcription: Promoters, Sigma Factors, Initiation, Elongation, Rho-dependent and independent termination, Eukaryotic Transcription: Eukaryotic Promoter, Enhancers: General Transcription factors, Activators, mediators. Transcription Termination.

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 II introns, Tetrahymena self splicing introns, Ribozyme, mRNA editing, folding, export.

Protein Synthesis and translation: Ribosome function, Genetic code, tRNA and Wobble hypothesis, Fidelity and control of translation, mRNA degradation, Protein Sorting and targeting to ER.

Regulation of prokaryotic and eukaryotic genes: Concept of regulation at different layers, negetive vs. positive regulations; regulations in prokaryotes, concepts of operons and regulatory molecules eg. inducers, repressors etc., model operons eg. lac and trp operons, lytic/lysogenic switches in bacteriophage lanbda, Positive regulation in eukaryotic cells at transcriptional and post-transcriptional levels, basic and accessory transcription factors, enhancers and alternative splicing and polyadenylation; NPCs are another control point of gene regulation, regulation of gene expression after export eg. at the levels of mRNA localization, translation and decay, Regulation of gene expression by micro RNAs, RNA interference, Doing reverse genetics with RNAi. Concept of quality control of gene expresssion and coupling of different steps of gene expression.

Epigenetics: Chromosomal remodelling and regulation of gene expression by modification of DNAs, Fundamentals of Genomics and system biology with very basic concepts of genome analysis

Microbiology

Introduction: Brief history and development of Microbiology as a separate discipline

Methods in Microbiology: Methods of studying microorganisms

Microbial Organisation: Structure and Organisation of microbes

Microbial growth: definition of growth and its mathematical expression, growth curve, mesurement of growth: synchronous growth, continuous culture. Factors affecting growth (temperature, acidity, alkalinity, water availability and oxygen), maintenance of growth, pure culture and culture characteristics.

Microbial Metabolism: Elementary Microbial nutrition, mode of uptake of nutrients.

Control of Microorganisms: Physical and chemical agents to kill microorganism, brief history of antibiotics and chemotherapeutic agents.

Microorganisms of various habitats: Air, water, soil and extremophiles, beneficial and harmful microbes.

220105 Lab Course

Semester II

220201: Evolution and Genetics

Evolution: Historical backgrounds (till 1859) and early Darwinian theory of evolution (1859-1900), Modernization of Darwinian concepts: Understanding of nature of inheritance from Mendel-Population genetics approach : H-W theorem, Defining Evolution, Natural Selection, Nature and impacts of Natural selections, Genetic Drift, Gene Flow and Mutation Rates on H-W populations. Sources of Variations, Concept of Species, Speciation –introduction to Allopatric, Parapatric and Sympatric models, Outline of the history and geography of evolution, Introduction to Molecular Evolution, Evolution of modern humans: an outline of latest information and ideas, Debated aspects of modern evolutionary theories (introductions only): Creationists' claims, Concept of Progress, Neutral Selection, Punctuated Equilibrium, Group Selection, Critics to Adaptationist Program, Sociobiology Debate.

Suggested Readings

Text Book

Evolutionary Biology (2nd or 3rd Edition) by Futuyama, D
Evolution (Edition) Strickberger, M.,
Evolution (Edition) Ridley, M.

Microbial Genetics: Introduction to genetics: Genes as the units of heredity, Mendelism, Allele, multiple alleles, pseudoallele, Genes are located on the chromosomes, A parallelism between the Mendelism and the behavior of chromosomes in Meoisis - chromosomal theory of inheritence, Linkage, complementation and recombination, Extensions of Mendelian principles: Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy.

Genetic system provided by *E. coli* and its bacteriophages: Advantage of using microorganism as model genetic system, Spontaneous origin of mutation, Lederberg's and Luria-Delbruck's experiments, Mechanism of origin of spontaneous and induced mutations, Forward reverse and suppressor mutations. Bacterial transformations: Griffith's and Avery's experiments; bacterial conjugation, sexes in bacteria, F Factor, plasmids and episomes, Genetics of Transposable elements, Insertion of phage chromosomes in *E. coli*, Phage Mu is transposable elements, Transduction via phages.

Elementary Yeast Genetics: Yeast is *E. coli* of eukaryotic cells, Strains, Growth, life cycles and Genomes of yeasts, genetic nomenclature, chromosomal and extrachromosomal inheritence, Tetrad analysis and transformation in yeasts, Different types of Yeast Vectors, Genetic mapping techniques, Techniques of genetic analyses, Mating and complementation, Random spores, Manipulating genomes in vitro, cloning by complementation, in vitro mutagenesis, one step and two step gene replacements, gene disruption, plasmid shuffle, Recovering mutant alleles, Heterozygosity and dominant negative mutations, Suppressors and epistatic relationships.

Drosophila Genetics: Linkage in Drosophila, Sex linkage, Sex limited and Sex influenced characters.

Gene mapping methods: Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids,

Human Genetics: Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.

Plant Genetics: development of mapping population in plants.

Suggested Readings

Molecular Genetics, Edition (2007) by Gunther Stent and Richard Calender
Genetics (Edition) W. M. Strickberger
Essentials of Genetics (Edition) by William S. Klug , Michael R. Cummings
Genetics: Analysis and Principles (Edition) by Robert J. Brooker
Introduction to Genetic Analysis (Edition) by Anthony J.F. Griffiths, Susan R. Wessler, Richard C. Lewontin, and Sean B. Carroll

220202: Biochemistry and Biophysics - II

Molecular Biophysics and Instrumentation:

Molecular Spectroscopy – Fundamentals of Spectroscopy, Beer Lambert's law, Electromagnetic Spectrum, Application of electromagnetism to biological system: Physical interactions of electromagnetic fields with biological systems; (b) biological effects of electromagnetic fields; (c) interaction mechanisms; (d) human exposure assessment; (e) experimental exposure systems; (f) medical application

UV-visible absorption spectroscopy, concept of chromophore, auxochrome, deviations of Beer's law, applications of UV-visible spectroscopy

Fluorescence Spectroscopy, Nuclear Magnetic Resonance spectroscopy: chemical shifts, coupling constants, ring currents, paramagnetic shifts, spin-spin and spin-lattice relaxation times.

Nuclear Magnetic Resonance: Basic NMR techniques, Chemical shift , J-coupling, coupling constants, ring currents, paramagnetic shifts, spin-spin and spin-lattice relaxation times.

Electron Spin Resonance Spectroscopy, intensity of ESR signals, hyperfine, interactions, interaction with n Nuclei, Zero- Field splitting and Kramer's degeneracy, ESR spectrometer, applications of ESR

Infrared Spectroscopy, use of Infrared spectrum, IR spectrometer, analysis and interpretation of IR data, Infrared spectrometer (FT-IR)

Mass Spectrometry, Mass spectrometer, Mass spectrometry, determination of molecular weight, determination of molecular formulas, some fragmentation patterns, McLafferty rearrangement

Chromatography- Equipment used**,** Basic operation, the output: Chromatogram, different types of Chromatography, Gas Chromatography**,** Liquid Chromatography**,** Ion Exchange Chromatography**,** Affinity Chromatography**,** scale up**,** Preparative chromatography, HPLC.

Overview of protein crystallography: X-rays and detectors, Crystals and crystal growth, indexing of lattice planes, X-ray scattering by atoms and unit cells; review of Fourier transforms, Scattering by crystals, convolution theorem, Bragg's Law, Three dimensional crystallography including point groups, Bravais lattices, indexing of lattice planes, space groups, Crystallography and Symmetry: A geometric approach to understand the fundamental symmetry elements. Laue conditions, Ewald construction, Isomorphous replacement, The Patterson function, Difference electron density maps: 2Fo-Fc, Fo-Fc, omit maps, Anomalous scattering and MAD phasing, Molecular replacement, Refinement, model accuracy.

Radioactivity: Types of radiation, Properties of the radioactive decay, Half-life, Measurement of radioactivity, Autoradiography.

Bioenergetics and metabolism

Principles of Bioenergetics: Biological energy transformations and thermodynamics, Standard free energy change and equilibrium constant. Phosphoryl group transfer and ATP, ATP and other phosphorylated compounds and thioethers w.r.t their free energies of hydrolysis.
Free energy of ATP hydrolysis in context of cellular metabolism. ATP energized biological processes, High energy phosphate compounds as free energy sources in biological systems, Biological oxidation /reduction reactions.

Carbohydrate catabolism (glycolysis, TCA cycle, oxidative degradation of fatty acids and amino acids in animal tissue and the correlation between carbohydrate, amino acid and fatty acid
degradation),gluconeogenesis, Cori cycle, Glycogen metabolism
Aerobic respiration in mitochondria (electron transport, oxidative phosphorylation, regulation of ATP production); photosynthesis in chloroplast (Calvin cycle, C4 cycle, elementary idea of photosynthetic electron transport).

Metabolism of nitrogen compounds; protein turnover; flow of nitrogen into biosynthesis and catabolism of amino acids, central role of glutamine; metabolism of nucleotides (purines and pyrimidines); urea cycle and the excretion of nitrogen.

Oxidation of fatty acids, β oxidation; biosynthesis of fatty acids and cholesterol (outline); ketone bodies.

Integration of metabolism and metabolic regulation with reference to metabolic pool.

220203: Recombinant DNA Technology, Genomics and Proteomics

Recombinant DNA Technology
Isolation and purification of RNA , DNA (genomic and plasmid) and proteins, different 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 eukaryotic 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; in vitro mutagenesis and deletion techniques, gene knock out in bacterial and eukaryotic organisms; protein sequencing methods, detection of post-translation modification of proteins; DNA sequencing methods, strategies for genome sequencing; methods for analysis of gene expression at RNA and protein level, large scale expression analysis, such as micro array based techniques; isolation, separation and analysis of carbohydrate and lipid molecules; RFLP, RAPD and AFLP techniques.

Antibody generation, detection of molecules using ELISA, RIA, western blot, immunoprecipitation, floweytometry and immunofluorescence microscopy, detection of molecules in living cells, *in situ* localization by techniques such as FISH and GISH.

Genomics
Fundamentals of Genomics: The Content of the Genome, Different mapping methods, Variations amongst individual genome, RFLPs and SNPs, Nature of eukaryotic genomes, Repetitive and non-repetitive DNA sequences, Epigenetic and Transcriptional and Post-transcriptional control, Functional and Comparative Genomics, Conservations of exons and genome organizations, Genomes of Organelles and Endosymbiosis.

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. Duplication, crossing over and other kinds of Rearrangements, Pseudogenes, Tandem Repeats of different clusters, Satellite DNA sequences.

The Interrupted Gene: Interrupted Gene consists of Exons and introns, Organizations of interrupted genes, Nature of Exon and intron sequences, Wide distribution of intron and exon sequences, Some DNA sequences code for more than one proteins, Evolution of interrupted genes, Members of a gene family have a common organization.

Regulation of gene expression by micro RNAs: RNA interference, Doing reverse genetics with RNAi. Concept of quality control of gene expresssion and coupling of different steps of gene expression.

Controlling Chromosome Structures and Epigenetics: Organizations of Viral, Prokaryotic and Eukaryotic Chromosomes, Loops and Domains, Banding Patterns of Chromosomes, Polytene and Lampbrush Chromosomes, Features and functions of Centrometers and Telomeres, Chromosomal remodelling and regulation of gene expression by modification of histones and chromatins, Epigenetic Effects are inherited, Nucleation and Other features of heterochromatin, Prions

Systems Biology - Graphs and networks in Systems Biology – Phylogeny Understanding Dymamics and Function of Cellular Networks Example problems - SBML (System biology markup language)- Gepasy - Cell Designer Oscillations in Biology . Comparing delayed negative feedback oscillators to those with interlinked positive and negative feedback- changing the amplitude and frequency of oscillations demonstration using circadian oscillator.

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.

Proteomics

Proteomics & the New Biology

Proteomics & the New Biology: Introduction to the the Proteomics

Overview of Analytical Proteomics: Analytical Protein and Peptide Separations, Protein Digestion Techniques, Mass Spectrometers for Protein and Peptide Analysis, MALDI-TOF, ESI; 2-D Gel electrophoresis,, Protein Identification by Peptide Mass Fingerprinting, Protein Sequence Analysis by Tandem Mass Spectrometry, Protein Identification with Tandem Mass Spectrometry Data DIGE, PF-2D, SELDI-TOF. Softwares for analysis of proteomic data, Mining Proteomes: Mining Specific Features of Tandem MS Data

Protein Expression Profiling: Identifying Protein-Protein Interactions and Protein Complexes, Mapping Protein Modifications, New Directions in Proteomics, Protein Chips and Array, The Application of Mass Spectrometry to Membrane Proteins

Proteomics and Human DiseaseReferences

Aebersold and Mann Nature 422: 198-207, 2003

Taylor et al Nature Biotech. 21: 281-286, 2003

Kakhniashvili et al Mol. Cell Prot. 3:501-509, 2004

Low et al. Proteom. 2:1229-1239, 2002

Olsen et al. Mol. Cell Prot. 3:608-614, 2004

Anderson et al Mol. Cell Prot. 3:311-326, 2004

Krokhen et al Mol. Cell Prot. 2: 346-356, 2003
Baldwin Mol. Cell Prot. 3:1-9, 2004

Peng and Gygi J. Mass Spec. 36:1083-1091, 2001
Medzihradszky et al Mol Cell Prot. 3:429-440, 2004

Durr et al Nature Biotech 22:985-992, 2004

Hansen et al Anal. Chem. 73:1676-1683, 2001

Washburn et al Nature Biotech. 19:242-247, 2001

Han et al Nature Biotech 19:946-951, 2001

Blagoev et al Nature Biotech 21:315-318, 2003

Peng et al Nature Biotech 21:921-926, 2003
Mann and Jensen Nature Biotech 21:255-261, 2003

Candas et al Mol. Cell Prot. 2:19-28, 2003

Coleman et al Proteom. 3:2101-2107, 2003

Luche et al Proteom. 3:249-253, 2003
Wu and Yates Nature Biotech. 21:262-267, 2003

220204 Ecology and Environmental Microbiology-II

Ecology

Environment: Physical environment; biotic environment; biotic and abiotic interactions.

Habitat and niche: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.

Population ecology: Characteristics of a population; population growth curves; population regulation; life history strategies (*r* and *K* selection); concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations.

Species interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.

Community ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.
Ecological succession: Types; mechanisms; changes involved in succession; concept of climax.

Ecosystem: Structure and function; energy flow and mineral cycling (CNP); primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine).

Biogeography: Major terrestrial biomes; theory of island biogeography; biogeographical zones of India.

Applied ecology: Environmental pollution; global environmental change; biodiversity-status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches.

Conservation biology: Principles of conservation, major approaches to management, Indian case studies on conservation/management strategy (Project Tiger, Biosphere reserves).

Environmental Microbiology - II

Environmental Microbiology

Microbial Communities and Eco-systems

Distribution of microorganisms in the aquatic environment- Microbiology of fresh water, marine, esturine, lacustrine. Lotic and lentic systems

Ocean Microbiology: Limnological and oceanographic conditions w.r.t MO's

Microbiology of Drinking water, purification and sources of pollution, Biomonitoring of harmful MOs in water, Wastewater recycling (types of filters)

Microbial Biofilms of Different Habitats

Control of Pollution by microbes

Biopesticides and Bioreactors

Microbial interaction: Plant-microbe and man-microbe interaction.

220204 Medical Microbiology

Pathogenisity of micro organism: Host parasite relationship, Pathogenesis of viral diseases, bacterial pathogenesis. Toxigenisity, Host defence against microbial invasion, microbial mechanism for escaping host defences.

Antimicrobial chemotherapy: Development of chemotherapy, Determining the level of anti microbial activity, Anti microbial/ bacterial drugs, Drug Resistance, Anti viral, fungal, protozoan drugs.

Human diseases caused by bacteria: *Staphylococcus*, *Streptococcus*, *Pneumococcus*, *Neisseria, Corynebacterium, Bacillus, Clostridium, Shigella, Salmonella, E.coli, Vibrio, Mycobacterium.*
Meningitis, Tuberculosis, Diptheria, Leprosy, Cystic fibrosis, Typhoid, Enteritis, Gastritis (*Helicobacter pylorae*), Cholera, Pneumonia.

Human diseases caused by viruses and prions

Human diseases caused by fungi and protists

Biology of obligate parasites: *Rickettsia, Chlymadia, Trypanosomes, Spirochetes*

Microbial production of therapeutic agents:

Structural variations in bacteria: Uncommon bacterial genera- Rickettsia, Chlamyda, Mycoplasma etc.

Antimicrobial Agents and Chemotherapy: Antibiotics - Definition, genera of antibiotics, mode of action of antibiotics, assay of antibiotics, Antibiotics vs probiotics, Antibiotic resistance, MAR(its significance), Methods of action of antibiotics and antibacterial agents

Bioterrorism and Bioweapons: Introduction to Bioterrorism and Bioweapons, Pathogenic microorganisms used for these purpose and their properties, Infectious agents and their epidemiology.

Semester III

220301 Microbial Genetics

Bacterial Genetics

A Chemist's view of the bacterial cell: Characteristics of Bacterial Cells: A Typical Prokaryotic Cells-No nuclei, no well defined chromosomes and no compartmentalization.

E. coli is best understood organism at the molecular level, Bacterial DNA is Condensed into nucleoid body, Replication, Transcription and Translation occurs in the same compartment

Rapid Turnover of mRNA molecules allows speedy changes of gene expression pattern

Regulation of Protein function by feedback inhibition,Protein modification lead to the modulation in enzymatic activity, Bacterial Cell is finely and precisely tuned machine. (1 Class)

Genetic System Provided by *E.coli* and its Phages: Intrinsic advantage of using microorganisms for genetic research, Bacteria have genes that mutate spontaneously, Phages provide easy to study Chromosomes, Phages are parasite at the genetic level and form plaques, Phages also mutate, Phage Crosses. Mutations: Spontaneous Origin of mutation: Awesome Power of Replica Plating: Lederberg's Experiment, Mutations: Mechanism of origin of Spontaneous Mutations; Induced Mutations by mutagens, Forward, Reverse and Suppressor Mutations.

Bacterial Conjugation: Two sexes are found in bacteria Transformation: Griffith's, Avery-Mcleod and Hershey-Chase.

Transposable elements in E-coli, Plasmids, Genetic elements that invert, Insertion of the phage chromosomes into chromosomes of E.coli, Phage Mu is a transposable genetic element, Phages occasionally carry bacterial genes, Transduction via phages (1 Class).

Yeast Genetics: Yeast as a model organism, information on Yeast, Strains of *S. cerevisiae*, Growth and Life cycles of Yeast, Genomes of *S. cerevisiae*, and Genetic Nomenclature, Chromosomal and extrachromosomal inheritance.

Genetic Analyses: Tetrad Analysis, Transformation: Yeast Vectors and DNA fragments, Different type of Yeast Vectors, Genes important for genetic studies,Gene mapping, Techniques of Genetic Analysis, Replica Plating, Mating and Complementation, Random Spores.

Manipulating Genome in vitro with Plasmids: Cloning by complementation, In vitro mutagenesis,Two step genere-placement, Gene disruptions and one step replacement, Plasmid Shuffle, Recovering mutant alleles, Interactions of Genes: Heterozygosity and Dominant Negetive Mutations, Suppressors and Epistatic Relationships.

Analyses with Yeast Systems: Two-Hybrid Systems, Yeast Artificial Chromosomes (YACs) and Expression of heterologous Proteins in Yeasts.

220302 Bioenergetics and metabolism

Principles of Bioenergetics: Biological energy transformations and thermodynamics, Standard free energy change and equilibrium constant. Phosphoryl group transfer and ATP, ATP and other phosphorylated compounds and thioethers w.r.t their free energies of hydrolysis.
Free energy of ATP hydrolysis in context of cellular metabolism. ATP energized biological processes, High energy phosphate compounds as free energy sources in biological systems, Biological oxidation /reduction reactions.

Carbohydrate catabolism (glycolysis, TCA cycle, oxidative degradation of fatty acids and amino acids in animal tissue and the correlation between carbohydrate, amino acid and fatty acid
degradation),gluconeogenesis, Cori cycle, Glycogen metabolism
Aerobic respiration in mitochondria (electron transport, oxidative phosphorylation, regulation of ATP production); photosynthesis in chloroplast (Calvin cycle, C4 cycle, elementary idea of photosynthetic electron transport).

Metabolism of nitrogen compounds; protein turnover; flow of nitrogen into biosynthesis and catabolism of amino acids, central role of glutamine; metabolism of nucleotides (purines and pyrimidines); urea cycle and the excretion of nitrogen.

Oxidation of fatty acids, β oxidation; biosynthesis of fatty acids and cholesterol (outline); ketone bodies.

Integration of metabolism and metabolic regulation with reference to metabolic pool.

220303 Cancer Biology and Immunology

Immunology

Overview of the immune system, Cells and organs of the immune system, Antigens, Immunoglobulin: Structure and function, Organization and expression of immunoglobulin genes, antibody engineering, monoclonal antibodies, Toll like receptors, Antigen - Antibody interactions, Major histocompatibility complex, Antigen processing and presentation, T cell receptor, T cell maturation, activation and differentiation, B cell generation, activation and differentiation, Cytokines, The Complement system, Cell mediated effector responses, Leukocyte migration and inflammation, Hypersensitive reactions, Immune response to infectious diseases (bacterial- tuberculosis), (parasitic - malaria), (viral - HIV) infections, Vaccines, AIDS and other immunodeficiencies, Autoimmunity, Transplantation immunity.

Cancer Biology

Genetic rearrangements in progenitor cells, oncogenes, tumour suppressor genes, cancer and the cell cycle, virus induced cancer, metastasis, interaction of cancer cells with normal cells, apoptosis, telomerase and cancer, therapeutic interventions of uncontrolled cell growth, Tumour cells and the onset of cancer, Oncogenic mutations affecting cell proliferation, Mutations affecting genome stability.

220304 Virology

Lytic and lysogenic cycles of bacteriophage λ - marvels of transcriptional control; spite-specific recombination in lambda (generalized and specialized transduction); problems in replication of the ends of linear DNA and how viruses circumvent the problem with examples of T-4 (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, fd, TMV, Ti, Baculovirus, Adenovirus, Retrovirus; oncogenic viruses; oncolysis - VSV.

Semester IV

220401: Developmental Biology

Basic concepts of development: Potency, commitment, specification, induction, competence, d etermination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development.
Gametogenesis, fertilization and early development: Production of gametes, cell surface molecules in sperm-egg recognition in animals; embryo sac development and double fertilization in plants; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis, establishment of symmetry in plants; seed formation and germination.
Morphogenesis and organogenesis in animals: Cell aggregation and differentiation in *Dictyostelium*; axes and pattern formation in *Drosophila*, amphibia and chick; organogenesis – vulva formation in *Caenorhabditis elegans;* eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development-larval formation, metamorphosis; environmental regulation of normal development; sex determination.
Morphogenesis and organogenesis in plants: Organization of shoot and root apical meristem; shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in *Arabidopsis* and *Antirrhinum.*

Programmed cell death, aging and Scenesence

220403: Clinical Biochemistry

220403: Project Work, Research Presentation and Journal Club