University of Lucknow

Master of Science in Biochemistry Programme

Course Structure:

Code	Nature		Credit
First Semester			
BCCC-101	Core	Biomolecules: Structure and Function	4
BCCC-102	Core	Biophysical Techniques	4
BCCC-103	Core	Enzymes & Intermediary Metabolism	4
BCCC-104	Core	Clinical Biochemistry and Physiology	4
BCCC-105	Core	Practical I: Biological Macromolecules, Enzymology I	4
BCVC-101	Val.	Protein Structure	4
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Second Semester			
BCCC-201	Core	Molecular Cell Biology	4
BCCC-202	Core	Bioenergetics and Microbial Biochemistry	4
BCCC-203	Core	Molecular Biology	4
BCCC-204	Core	Immunology	4
BCCC-205	Core	Biotechnology	4
BCCC-206	Core	Practical II: Cell Biology & Biophysical Techniques, Clinical Biochemistry & Immunology	4
BCVNC-201	Val (NC)	Bioethics and Biosafety	0
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Third Semester			
BCCC-301	Core	Plant Biochemistry	4
BCCC-302	Core	Practical III: Plant Biochemistry, Enzymology II, Biotechnology	4
BCEL-301	Elective/ MOOC	Bioinformatics, Genomics and Proteomics	4
BCEL-302	Elective	Techniques in Cell and Molecular Biology	
BCEL-303	Elective	Biostatistics and Computer Application	4
BCEL-304	Elective	Microbial Technology and Bioprocess Engineering	
BCIN-301	Core	Summer Internship	4
BCIER-301	Interdept.	Environmental Awareness	4
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Fourth Semester			
BCC-401	Core	Regulation of Gene Expression	4
BCEL-401	Elective	Advanced Enzyme Kinetics	4
BCEL-402	Elective	Metabolic Processes	
BCEL-403	Elective	Plant Tissue Culture and Molecular Markers	4
BCEL-404	Elective	Intellectual Property Rights	
BCMT-401	Core	Dissertation	8
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COURSE OUTLINE

BCCC-101: Biomolecules: Structure and Function

Course Objective:

1. Extend comprehensive knowledge about structure and properties of biomolecules (monomeric units) of the cell.
2. To teach the students how monomeric molecules of carbohydrate, amino acids, lipid and nucleotides form covalent linkages to form polymers.
3. How these polymers of biomolecules assemble with each other to form supramolecular assemblies having structural and functional role in cell.

Course Outcome: At the end of the course, a student should be able to

1. Know about structure and properties of biomolecules (monomeric units) of the cell.
2. Understand how monomeric molecules of carbohydrate, amino acids, lipid and nucleotides form covalent linkages to form polymers.
3. Understand how these polymers of biomolecules assemble with each other to form supramolecular assemblies having structural and functional role in cell.

Unit I

Carbohydrates: Classification and properties of simple carbohydrates, monosaccharides, disaccharides and polysaccharides. Structural polysaccharides: cellulose and chitin; storage polysaccharides: starch and glycogen; glycosaminoglycans; glycoconjugates: proteoglycans, glycoproteins and glycolipids

Unit II

Fatty Acids and Lipids: Structure, classification and properties of fatty acids, structure and functions of lipids: Triacylglycerides, phosphoglycerides, sphingolipids, cholesterol, steroids, eicosanoids, Lipoproteins

Unit III

Amino acids and proteins: Classification, chemical structure and general properties of amino acids. Standard and non-standard amino acids found in proteins. The peptide bond and its characteristics.

Unit IV

Sturcture and functions of DNA: Base pairing: Watson-crick, Hoogsteen and Wobble base pairs, The salient features of the Watson-Crick model of B-DNA, The structure and helical parameters of B-DNA, A-DNA, and Z-DNA. Melting temperature (T_m), Forces stabilizing the B-DNA.

Unit V

Structure and functions of RNA: Physicochemical properties of RNA, classification, structure and functions of different types of RNAs (hnRNA, mRNA, rRNA, tRNA, snRNA, snoRNA, antisense RNA telomerase RNA, gRNA,etc.). The clover leaf and L-shaped structures of tRNA.

Suggested Reading:

- Biochemistry by Voet B and Voet JG, Wiley Publishers, USA
- Biochemistry 5th Revised edition by Lubert Stryer, Jeremy M. Berg, John L. Tymoczko, Macmillan Publishers, USA
- D.L. Nelson and M.M. Cox Lehninger Principles of Biochemistry, Publisher: WH Freeman; *8th ed.* New York

BCCC-102: Biophysical Techniques

Program Objectives and Outcomes

- The course is designed to provide a broad exposure to basic techniques used in Modern Biology research.
- The goal is to impart basic conceptual understanding of principles of these techniques and emphasize biochemical utility of the same.
- Student is expected to have a clear understanding of all analytical techniques such that the barrier to implement the same is abated to a great extent.
- Students will learn to combine previously acquired knowledge of physics and chemistry to understand the biochemical processes in the cell.

UNIT I:

Electrochemistry: Ionization of water and its interaction with acids and bases, Buffers and buffering capacity. Determination of pH: theory and instrumentation.

Electrophoresis: Separation of biomolecules on electrophoretic gels: PAGE and agarose gels. Native PAGE, SDS-PAGE, Isoelectric focusing, 2D-PAGE,

UNIT II:

Centrifugation: Basic principle of sedimentation, centrifuge and their uses. Rotors. Preparative and analytical centrifugation and their application in Biochemistry.

Chromatography: Partition coefficient, Retention, Resolution, Capacity factor, theoretical plate, van Deemter curve, Gel filtration chromatography, Ion exchange chromatography, Affinity chromatography, Hydrophobic interaction chromatography, Paper chromatography, Thin layer chromatography, Fundamentals of high-performance chromatography.

Unit III:

Spectroscopic techniques: Basic concepts of molecular bonding and spectroscopy. Energy Levels. Theory of interaction of biomolecules with energy. Principle, instrumentation and applications of atomic absorption and emission spectroscopy.

Concepts and applications of UV-Visible and fluorescence spectrophotometry, EPR, XRD, NMR, MS.

Unit IV:

Optical methods for determination of molecular structure: Absorption of polarized light, optical rotatory dispersion, hypochromism, circular dichroism in relation to composition and structure of biomolecules.

UNIT V:

Biosensors: Basic techniques, enzyme electrode, organic salt electrode, immunoelectrodes, microbial biosensors.

Tracer techniques: Detection and measurement of isotopes and biological applications.

Suggested Reading:

- Physical Chemistry for the Life Sciences (2nd Revised Edition). Atkins, de Paula. (2015).
- Biophysical Chemistry, Allen Cooper, (2011), Royal Society of Chemistry
- Principles of Physical Biochemistry, K. E. van Holde, C. Johnson, P. S. Ho. (2010) 3rd Edn., Prentice Hall

- C.R. Cantor and P.R. Schimmel (1982) Biophysical Chemistry (Part 1-3), 2nd Edn.
- Joachim Frank (2006) Three-Dimensional Electron Microscopy of Macromolecular Assemblies, Academic Press.
- Physical Chemistry: Principles and Applications in the Biological Sciences. Tinoco, Sauer, Wang, and Puglisi. (2013) Prentice Hall, Inc.

BCCC-103: Enzymes and Intermediary Metabolism

Objectives: Enzymes and intermediary metabolism form the fundamental basis of biochemistry. This course aims to acquaint the student with all these basics in general and metabolic pathways in particular.

Outcome: This course will enable a student to:

- Have a strong foundation to the understanding of enzymes and biological catalysis
- Have an integrated view of primary metabolic pathways

Unit I

Classification and nomenclature of enzymes, general properties of enzymes, techniques and use of enzyme assays, purification of enzymes and tests for homogeneity. Isozymes and multiple forms of enzymes. Factors (pH, temperature etc.) affecting the rate of enzyme catalysis and forces involved in enzyme-substrate complex formation.

Unit II

Michaelis-Menten initial rate equation based on equilibrium assumption, Briggs-Haldane steady-state approach, methods for the determination of K_m, V_{max} and K_{cat}, calculations based on Michaelis-Menten equation. Types of enzyme inhibitors and activators, qualitative analysis of data, derivation of equations for different types of enzyme inhibitors.

Unit III

Glycolysis and its regulation, homolactic and alcoholic fermentation, hexose-monophosphate pathway. Tricarboxylic acid cycle and its regulation. Anaplerotic reactions in metabolism, Krebs-Kornberg pathway.

Unit IV

Degradation and biosynthesis of saturated and unsaturated fatty acids. Biosynthesis of purine and pyrimidine nucleotides.

Unit V

Transamination, deamination, decarboxylation and urea cycle. Oxidative degradation of glucogenic and ketogenic amino acids.

Suggested Reading:

- Principles of Biochemistry- Lehninger, Nelson and Cox
- Biochemistry- Voet and Voet
- Enzymes- Dixon and Webb
- Enzymes-Palmer and Bonner

BCCC-104: Clinical Biochemistry and Physiology

Program Objectives and Outcomes

- The knowledge of various body fluids such as blood and urine, their detail composition and alterations under various pathological conditions is of paramount importance. Detailed Physiology of Nerve impulse transmission and muscle contraction is vital to our understanding of these important physiological processes.
- Mechanism of action of various hormones, their physiological roles and pathological disorders along with biochemical roles of vitamins and deficiency disease is important in the modern era.
- The knowledge of various communicable and non-communicable diseases along with lifestyle disorders with their modifiable and non-modifiable risk factors is very important to remain healthy and disease free.

Unit I

Blood: Function and composition: blood groups and Rh factor, plasma proteins and their alteration under pathological condition; mechanism of blood coagulation and clot lysis ; role of leucocytes in defense against pathogens. Urine composition: Alterations under pathological conditions, clinical significance of urine analysis.

Unit II

Nerve impulse transmission: Membrane potential, action potential, transmission of nerve impulse, synthesis, storage and release of neurotransmitters, venoms and nerve poisons.
Muscle contraction: Structural organization of skeletal muscle; skeletal muscle contraction; actin-myosin interactions; regulation of smooth and striated muscle contraction.

Unit III

Hormones: Mechanism of action, metabolic and physiologic role of hormones secreted by pituitary, thyroid, parathyroid, adrenals, pancreas and gonads, disorders due to over and under secretion. Vitamins: Biochemical and physiological roles of vitamins and their deficiency diseases.

Unit IV

Biochemical and clinical aspects of jaundice, atherosclerosis, cancer, diabetes mellitus, Symptoms, diagnosis, treatment and management of Cholera and Dengue.

Unit V

Corona virus pandemic: modes of spread and transmission, mechanism of infection, treatments, vaccination strategies and preventive measures.
Energy metabolism and nutrition: Balanced diet, nutritional aspects of fats, proteins and carbohydrates, protein calorie malnutrition, evaluation of protein quality; starvation and obesity; macrominerals and trace minerals.

Suggested Reading:

- Clinical Biochemistry:Metabolic and Clinical Aspects William J. Marshall , Márta Lapsley et al. Elsevier Health Sciences, 2008
- Textbook of Biochemistry with Clinical Correlation. Thomas M. Devlin. Wiley, 2019
- Bioquimica Clinica. Allan Gaw. Elsevier - Health Sciences Division, 2000
- A Text Book of Biochemistry by West & Todd. Oxford University press.
- Harpers Biochemistry-A Lange Medical edition.

BCVC-101: Protein Structure

Course outcome and objectives:

To have a knowledge base in the structure of proteins.To understand the detailed three dimensional structure of proteins, and the dynamics of their folding and unfolding.To appreciate the relationship between the structure and function of proteins in biological systems.

Unit I

Proteins as the executive molecule in the biological systems, Functional diversity of proteins.
The peptide bond and its properties. Flexibility of polypeptide chains, Ramachandran plot
Hierarchy of three-dimensional structure of proteins
Primary structure of proteins:Identification of the N- and C-terminal residues, Determination of primary structure of proteins, assignment of disulfide bonds

Unit II

Secondary structure of proteins:α-helices, β-sheets, β-turns, other helical structures.
Tertiary structure of proteins: General structure of globular proteins. Supersecondary structural motifs and domains

Unit III

Quaternary structure of proteins: Symmetry in protein structure, Determination of quaternary structure of proteins: Electron microscopy, succinylation
Protein denaturation, Melting temperature (T_m), Effect of salts on protein structure, Hofmeister series, Salting-in and Salting out, Chaotropic agents

Unit IV

Protein folding:Introduction, thermodynamic and kinetic considerations, the concept of local and global energy minima, Early protein folding experiments on RNase A, Renaturation of post-synthetically modified proteins (insulin), Folding pathways, Levinthal paradox and folding funnels, The multistage process of protein folding, Folding pathway of bovine pancreatic trypsin inhibitor (BPTI)

Unit V

Folding Accessory Proteins:Proteins disulfide isomerase (PDI), Peptidyl prolyl *cis-trans*isomerese (PPl), Heat shock proteins, Molecular chaperones
Structure and physical properties of representative structural proteins:Keratin, Silk fibroin and Collagen

Suggested Reading:

- Biochemistry. By Voet D, Voet JG, Wiley Publishers, USA
- Lehninger Principles of Biochemistry. By Nelson DL and Cox MM, Freeman WH and Company
- Biochemistry. By Berg JM, StryerL, Tymoczko J and Gatto G, Macmillan Publishers, USA
- Biochemistry. By Mathews CK, van Holde KE, Appling DR, Anthony-Cahill SJ, Pearson Publishers, USA
- Introduction to Protein Structure. By Branden C and TroozeJ, Garland Publishing, New York
- ProteinFolding. By Creighton TE, WH Freeman, Oxford, UK

BCCC-201: Molecular Cell Biology

Course outcome and objectives: The course aims to an extensive coverage of molecular cell biology and shall enable the student to comprehend problems and latest research in the area. Layering a problem-oriented approach to learning will lead to independent learning of advanced cell biology concepts.

Unit I

Membrane lipids: Physical properties of lipids and their interaction with water to form membranes. Concept of fluidity and factors causing variations in fluidity. Micelles and lipid bilayers. Lipids rafts. Membrane asymmetry Modification of lipids fluidity by membrane proteins. Arrangement of proteins within lipids bilayers. Hydropathy plots and prediction of membrane spanning domains.

Membrane transport: Channels, transporters and pumps. Active and passive transport. P-and F-type pumps and ABC transporters. Ion channels and electrical properties of membranes. Voltage and ligand gated channels

Unit II

Cytoskeleton: Actin microfilaments, microtubules and intermediate fiber assemblies. Actin and tubulin dynamics and roles of modifying /accessory proteins. Roles of microfilaments and microtubules in cellular structure and function. Control of assembly through signaling processes.

Unit III

Cell Signaling: General principles of signaling switches. Receptor characteristics. Identification and characteristics of receptor proteins, G-proteins and receptor tyrosine kinase mediated signaling Ca^{2+} flux and its interpretation in cytoplasm, role of Ca^{2+} binding proteins.

Unit IV

Intracellular vesicular trafficking: Import of proteins into ER and processing in the ER and Golgi. Mechanism of vesicle formation and fusion. Import of relevant nuclear coded proteins into chloroplasts and mitochondria.

Unit V

Cell Cycle and cancer: Overview and control. Cyclins, CDKs and Ubiquitin-proteasome dependent control of cell cycle. Checkpoints. Transition from normal to cancerous cell growth. Genetic instability and mutations as causative Agents. Oncogenes and retroviruses P_{53} and associated proteins as tumor suppressors

Apoptosis: The role of programmed cell death in maintaining the social order of cells and in tissue sculpting. Pathways and hallmarks of apoptosis. Role of caspases and Bcl2 family proteins.

Suggested reading:

- Molecular Biology of the Cell-Alberts *et al*
- Molecular Cell Biology-Lodish*et al*
- Cells-Lewin
- Becker's World of Cell-Hardin *et al*
- The Cell: A molecular Approach-Cooper and Hausmann

BCCC-202: Bioenergetics and Microbial Biochemistry

Objective:

Bioenergetics form the basis of life and provide a reason for the occurrence of biological reaction. Its study is essential for a good understanding of metabolism. Microbial Biochemistry extends the knowledge of pathways to the study of harmful and beneficial microorganisms, usually valid for higher animals.

Course outcomes:

The course will enable a student to:

- Understand the basis of life processes like metabolism and biological energy transduction.
- Participate in research and practice of microbiology after post graduation.

Unit I

Bioenergetics and Thermodynamics: Basic concept, ATP as the biochemical energy currency, Gibbs energy and its displacement from equilibrium, standard free energy of hydrolysis of ATP, High energy phosphate compounds and phosphate transfer potential, Redox potential, Electrochemical potential, Energy interconversions.

Energy transducing membranes and other transport systems: Membrane systems of mitochondria, chloroplasts, respiratory and photosynthetic bacteria, Hill reaction, Electron transport in purple photosynthetic bacteria, Microsomal electron transport, superoxides, bioluminescence.

Unit II

Electron transfer and intermediates in the mitochondrial respiratory chain and their organization. Q cycles and the stoichiometry of proton extrusion and uptake, P/O ratio. Reversed electron transfer, respiratory controls and oxidative phosphorylation, uncouplers and inhibitors, Hormonally induced uncoupling in brown fat mitochondria, Fractionation and reconstitution of respiratory chain complexes.

Unit III

Chemiosmotic theory, proton gradient generation, Mechanism of proton transport – Different theories related to oxidative phosphorylation,redox loop and proton pump mechanism, bacteriorhodopsin as proton pump, ionophores, ATP-synthase and its mechanism.

Unit IV

Types of microorganisms: General characteristics of main group of microorganisms, criteria used in the classification of microorganisms.

Nutrition and growth of microbial cells

Gram positive and Gram negative bacteria : Structure and function of peptidoglycan in Gram positive and Gram negative organisms, function of polymeric components in outer membrane, acidic polymers in Gram negative organisms, biosynthesis of bacterial cell wall.

Unit V

Special features of bacterial metabolism: Entner-Doudroff (ED) pathway, modified ED pathway methanogenesis, sulphur and iron utilizing bacteria.

Food spoilage, fermentation and food borne infection.

Biological nitrogen fixation: Overview, symbiotic nitrogen fixation, nitrogenase system, ammonia assimilation.
Role of microorganisms in nitrogen, carbon, sulfur and phosphorus cycles.

Suggested Reading:

- Biochemistry-Voet and Voet
- Biochemistry-Zubay
- Microbiolog-Pelczar, Chan and Krieg
- Microbiology-Black

BCCC-203: Molecular Biology

Course Objective:

1. To teach the dynamic properties of chromatin and its folding.
2. To teach topological properties of DNA, reassociation kinetic, transposable elements and genetic code
3. To provide students with a deep insight and mechanism of the various cellular processes such as DNA Replication, Transcription and Translation.

Course Outcome: At the end of the course, a student should be able to

1. To learn the dynamic properties of chromatin and its folding.
2. To learn topological properties of DNA, reassociation kinetic, transposable elements and genetic code
3. To understand the mechanism of the various cellular processes such as DNA Replication, Transcription and Translation.

Unit I

DNA topology: DNA supercoiling, linking number, twist and writhe.
Organization of DNA in chromosomes: The dynamic structure of chromatin. Structure of histone core. Histone association with DNA.
DNA melting and reassociation kinetics: Classes of DNA sequences, $C_o t$ curves. Analysis of DNA complexity
Transposable elements: Transposonsof bacteria - IS, composite transposons, Tn transposons of Drosophila: P and Copia, Transposons of maize: Ac, Ds, Spm (En), dSpn, Retrotransposons.

Unit II

DNA replication: Modes of DNA replication, components of cellular replisomes and their function (topoisomerase, helicase SSB proteins, primase, DNA polymerase ligase, etc.). Origin of replication in prokaryotes, Eukaryotic orgin of replication, Licensing factors and control of eukaryotic replication, Replication of telomeric DNA
Gene stability, DNA damage and DNA repair: DNA repair enzymes, photoreactivation; Nucleotide excision repair; mismatch correction; SOS repair

Unit III

Transcription in prokaryotes: Introduction, promoter architecture, structure of RNA polymerase, role of sigma factor in initiation of transcription, alternative sigma factors and their physiological functions, Termination of transcription, Antitermination in bacteriophage lambda.

Unit IV

Transcription in eukaryotes: Introduction, Transcription factors. Types of RNA polymerase and architecture of their promoters. Initiation of transcription by RNA polymerase I, II, and III. Elongation and termination of transcription; Enhancers and activators

Unit V

Genetic code: Universal genetic code; features of the genetic code, degeneracy of codons; Termination codons; wobble hypothesis; genetic code in mitochondria

Translation: Adaptor role of tRNA, amino acyl tRNA synthetase, A and P sites, initiation codon, formation of 70 S initiation complex, role of initiation factors, peptidyl transferase, translation and elongation factors, role of termination factors.

Suggested Reading:

- Molecular biology of the gene by Watson et. Al (5th edition), Pearson Publishers, USA
- Genes XII by Benjamin Lewin, Oxford University Press
- Biochemistry by Voet B and Voet JG, Wiley Publishers, USA
- Biochemistry 5th Revised edition by LubertStryer, Jeremy M. Berg, John L. Tymoczko, Macmillan Publishers, USA
- D.L. Nelson and M.M. Cox Lehninger Principles of Biochemistry, Publisher: WH Freeman; *8th ed.*NewYork

BCCC-204: Immunology

Course objectives and outcomes:

- To provide a basic knowledge and to appreciate the components of the human immune response that work together to protect the host.
- To understand the concept of immune-based diseases as either a deficiency of components or excess activity as hypersensitivity.
- To gain an insight into the mechanisms that lead to beneficial immune responses, immune disorders, and immunedeficiencies.
- The basic overview of Immunology strengthens their foundations for a career in Biochemistry.

Unit I: Introduction to Immunology

Innate and Acquired Immune system. Cells, Tissues and Organs of Immune System. Antigen and Antibody. Inflammatory Mediators. Cell Surface Receptors.

Unit II: Host Pathogen Interaction and Intervention Mechanisms I

Antigen processing, presentation and recognition. Mechanisms involving cell mediated and humoral immune response. Mucosal immune system. Complement system and associated deficiencies. Hypersensitivity reactions.

Unit III: Host Pathogen Interaction and Intervention Mechanisms II

Aspects of Microbial Pathogenesis and Host Defense Mechanisms.
Mechanisms of Immunological Tolerance.
Immunodeficiency diseases – primary and secondary.
Autoimmunity and autoimmune disorders.

Unit IV: Host Pathogen Interaction and Intervention Mechanisms III

Basic Transplantation Strategies and Graft Rejection Mechanisms.

Mechanisms of Tumor Formation and Evasion Strategies of Host.

Vaccination Approaches.

Unit V: Immunology Techniques and Methodologies

Strategies of Antigen and Antibody Purification.

Immunoblotting, Agglutination, Precipitation Reactions, Complement Fixation Assays, Fluorescence, Dyes, ELISA, RIA, Microscopy. Concept and Applications of Flow Cytometry.

Suggested Reading:

- Essential Immunology (2005) Roitt I.M. and Delves P.J.
- Essential Immunology (2011) Delves P J., Martin S. J., Burton D R, Roitt I.M.
- Immunology (2001) Roitt I, Bostoff J. & Male D.6th edition
- Immunology (2006) Luttmann M, Bratke K., Kupper M., &Myrtek D
- Immunology (2007) Goldsby R.A,, Kindt T.J., Osbrne B.A and Kuby J.

BCCC-205: Biotechnology

Course Objectives: This course enables the students to:

- Introduce knowledge on basic concepts of recombinant DNA techniques
- Exemplify different types of screening methods for recombinants and their applications
- Implement, organize and design different vectors for gene cloning and expression
- Generating contextual and conditional knowledge of gene function for various applications

Course Outcomes: After the completion of this course, students will be able to:

- Apply the principles of recombinant DNA techniques
- Analyze the experimental data to select a suitable recombinant for a particular application
- Evaluate selectivity and specificity of vectors for cloning genes and their expressions
- Examine gene function, gene modulation and their effects on improvement of crops and animals.

Unit I

DNA Modification and restriction: DNA methylation, restriction endonucleases, Class I, II and III, nomenclature, general properties, mode of action.

Chimeric DNA construction: Restriction enzymes, homopolymer tailing, synthetic linkers and adaptors.

Unit II

Overview of blotting technique: Methods of labeling of probe, Sothern, Northern, Western etc.

Methods of selection and screening of recombinants: Genetic/nutritional/ phenotypic, immuno-chemical, cross nucleic acid hybridization, HART/HAT, PCR.

DNA libraries: Genomic and cDNA libraries, cDNA synthesis and cloning,

Unit III

Plasmid cloning vectors: Plasmid types, properties of typical plasmid cloning vector.

Phage as a cloning vector: Lambda phage based vectors, M 13 phage based vectors, combination vectors e. g., cosmids and phagemids.

Unit IV

Cloning in yeast: Basic principles of development of yeast vectors, YEP, YRP, YCP, YIP.

Cloning in plants: Various methods for gene transfer in plants: Agrobacterium tumefaciens based, Ti-plasmid, T-DNA structure and transfer mechanism, binary vectors, Bioilistics, Electroporation, in planta transformation, selection marker and reporter genes, ,

Cloning in animal cells: SV 40 based vectors, retroviral based vectors

Unit V

Recombinant DNA technology: Applications in agriculture, medicine and industry.

Suggested Reading:

- Primorose- Principles of Gene Manupulation, Wiley.
- Glick & Pasternak, Molecular Biotechnology: Principles & Application of Recombinant DNA.
- Watson, Recombinant DNA., Scientific American Books
- Kreuzer & Massey, Recombinant DNA & Biotechnology Molecular Cell Biology., Freeman and Co.,
- Rastogi and Pathak. Genetic Engineering, Oxford University Press.

BCVNC-201: Biosafety and Bioethics

Course Objectives and Outcomes:

- To provide basic knowledge on biosafety and bioethics and their implications in biological research.
- To become familiar with India's biosafety and bioethics policies.
- To learn biosafety and risk assessment of products derived from biotechnology and regulation of such products.
- To become familiar with ethical issues in biological research. This course will focus on consequences of biomedical research technologies such as cloning of whole organisms, genetic modifications, DNA testing.

Unit I

Introduction to Biosafety; Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals.

Unit II

Biosafety guidelines – Government of India; Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs.

Unit III

Risk Analysis; Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements including Cartagena Protocol.

Unit IV

Ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation.

Unit V

Bioethics in research – cloning and stem cell research, Human and animal experimentation, animal rights/welfare.

Suggested Reading:

- Biosafety and bioethics (2006) Rajmohan Joshi. Gyan Publishing House.
- Laboratory biosafety manual. (2004). World Health Organization. WHO press, 2004.
- Biological safety: principles and practices (2000) Diane O. Fleming, Debra Long Hunt. ASM Press.
- CRC handbook of laboratory safety. (2000) A. Keith Furr. CRC Press.
- Craig, W., Tepfer, M., Degrassi, G., &Ripandelli, D. (2008). An Overview of General divisions/csurv/geac/annex-5.pdf F. (2009). Problem Formulation in the Environmental Risk
- Assessment for Genetically Modified Plants. Transgenic Research, 19(3), 425-436. doi:10.1007/s11248-009-9321-9
- Features of Risk Assessments of Genetically Modified Crops. Euphytica
- International Union for the Protection of New Varieties of Plants. http://www.upov.int
- Karen F. Greif and Jon F. Merz, Current Controversies in the Biological Sciences - Case
- Studies of Policy Challenges from New Technologies, MIT Press
- Kuhse, H. (2010). Bioethics: an Anthology. Malden, MA: Blackwell.
- National Biodiversity Authority. http://www.nbaindia.org
- Recombinant DNA Safety Guidelines, 1990 Department of Biotechnology, Ministry of Science and Technology, Govt. of India. Retrieved from http://www.envfor.nic.in/

BCCC-301: Plant Biochemistry

Course objective and outcome: Students will be taught specific aspects of plant biochemistry that are not covered under general biochemistry. The course has been a specialty of the Department of Biochemistry and is designed to give the students comprehensive knowledge of molecular aspects of plant biology. Preparing a strong platform for a research career in the area.

Unit I

Secondary plant products: Biosynthesis of isoprenoids and phenylpropanoids. Alkaloid classification.

The Plant cell wall: Components, structure and integration, Biosynthesis of cell wall, Cell plate formation, Cell expansion, Details of cellulose synnthase and expansin action

Mineral nutrient acquisition: Mineral nutrient acquisition from rhizosphere, Mechanisms and strategies, phytochelatins and phytosiderophores

Unit II

Plant defense: Mechanism of plant defense against pathogens, Genetic basis of plant-pathogen interaction, R-Avr gene interaction and isolation of R genes, Hypersensitive response (HR), systemic acquired resistance (SAR) and induced systemic resistance (ISR)

Reactive oxygen and nitrogen species: Generation, scavenging and damage caused by reactive oxygen species (ROS) and reactive nitrogen species (RNS) in plant systems. Roles of ROS and RNS in signaling and plant development

Unit III

Photosynthesis: General Principles and structural background: Energetic principles, system architecture and chlorophyll biosynthesis. Elements of chloroplast-nucleus dialogue and the role of chlorophyll biosynthesis intermediates

Photosynthetic energy transduction: Electron transport, light energy conversion and its control of carbon fixation. Points of cross-talk between electron transport and carbon fixation pathway

Unit IV

Carbon fixation: carbon fixation/assimilation through C3 (Calvin cycle) and control of metabolite flux through the cycle. Details of rubisco structure, assembly catalysis and regulation. Other regulatory enzymes of Calvin cycle. Light regulation of Cavin cycle

Photorespiration: Photorespiration and carbon concentrating mechanisms (C4 metabolism and CAM). Role of metabolite transporters in regulating inter-organellar carbon flux.

Unit V

Molecular control of plant photomorphogenesis: Rationale of photoreceptor action and its role in regulating plant responses. Structure, diversity and function of phytochrome, cryptochrome and phototropins.

Photoreceptors: Molecular mechanism of action and signaling mechanism of plant photoreceptors

Suggested Reading:

- Biochemistry and Molecular Biology of Plants-Buchanan *et al*
- Plant Physiology and Biochemistry-Taiz and Zeiger
- Plant Biochemistry-Heldt
- Photosynthesis-Lawlor
- Molecular Life of Plants-Waaland *et al*

BCEL-301: Bioinformatics, Genomics and Proteomics

Course Objectives:

- To learn about this relatively newer branch bioinformatics, its definition, objectives and applications.
- To learn about databases and mining tools
- To learn about techniques used in genomics, genome sequencing, annotation.
- To understand about differences between prokaryotic and eukaryotic genomes as well as forward and reverse genetics.
- To impart knowledge about the advances in structural and functional genomics. To understand the use of proteomics techniques

Course Outcomes: At the end of the course, a student should be able to

- Access various global bioinformatics centres such as NCBI, EBI and GenomNet etc.
- Do pairwise and multiple sequence alignments using database mining tools
- Explain the detailed characteristics of prokaryotes and eukaryotes genome
- Apply structural and functional genomics approaches on newly sequenced genome for functional characterization of genes.

Unit I

Introduction to bioinformatics. Different types of data. Databases: nucleic acid database, protein database. Database mining tools for mining of nucleic acid, protein database and other databases.

Unit II

Accessing and retrieving sequence information from databases. Use of sequence alignment tools, BLAST.

Unit III

Introduction to genomics: Structural genomics; genome sequencing projects. Comparative genomics: organization of genome in prokaryotes, eukaryotes and organelles.

Unit IV

Overview of functional genomics: expression profiling, transcriptomics, DNA microarray.

Unit V

Introduction of Proteomics. Branches and applications of proteomics. Techniques of proteomics.

Suggested Reading:

- 3rd Edition, By S. B. Primrose and R. L. Twyman, Blackwell publishing
- Bioinformatics and Functional Genomics, 3rd Edition, By Jonathan Pevsner, Wiley-Blackwell
- Plant Biotechnology by B. D. Singh, Kalyani Publishers

BCEL-302: Techniques in Cell and Molecular Biology

Course Objectives and Outcomes:

The course aims to provide a general understanding of the techniques involved in cell and molecular biology and is designed to complement the courses focused more on theoretical aspects. This will enable students to comprehend problems and latest research in the area in a more meaningful manner.

Unit I

Molecular probes for analyzing cellular structure and function: Fluorescent Resonant Energy Transfer (FRET). Cell imaging, including fluorescence and confocal imaging of live cells. Fundamentals of pseudocolor image capture, image analysis and live imaging. Fluorescent protein tagging as a tool for determining molecular organization, intracellular localization and trafficking.

Unit II

Study of membrane dynamics and composition: Fluorescence recovery after photobleaching (FRAP) and other tools for measuring membrane fluidity. Detergents, Solubilization and reconstitution of membrane-protein systems. Use of patch clamping to study ion channel activity.

Unit-III

Examining molecular interactions: Study of protein-protein, protein-ligand interactions based techniques. Pulldown assays, Western and Southwestern hybridization techniques. CHIP assays, FRET and related techniques.

Unit-IV

Nucleic acid and gene expression analysis: Pulsed Field Gel Electrophoresis, Nucleic acid blotting and hybridization techniques. Quantitative Real-time PCR in gene expression analysis. Microarrays: Classes and applications in gene expression analysis. Fluorescence *in situ* hybridisation.

Unit-V

Next-Generation sequencing, analysis of protein-nucleic acid interactions through footprinting and EMSA.

Suggested Reading:

- Becker's World of Cell-Hardin *et al*
- Cells-Lewin
- Molecular Biology of the Cell-Alberts *et al*
- Molecular Cell Biology-Lodish *et al*
- The Cell: A molecular Approach-Cooper and Hausmann

BCEL-303: Biostatistics and Computer Applications

Course Objectives and Outcomes:

- Understanding of data and its analysis with the help of computers, Interpretation of data analysis.
- Understanding the basics of computers and computational data analysis which in-turn can be used for interpretation of data analysis.

Unit I

Handling and description of data: tabulation and graphical representation. Sampling techniques. Measure of central tendency: Mean, Median, Mode, Percentile, Decile and Quartiles.

Unit II

Measure of dispersion: Range, mean deviation, standard deviation, quartile deviation and coefficient of variation.

Unit III

Correlation and simple linear regression. Use of computer for statistical data analysis.

Unit- IV

Test of significance: types of errors, χ^2 (Chi-square test) and contingency table, t, f, and z tests, Overview of ANOVA.

Unit- V

Computer: Definition, historical evolution, types and generations, Hardwares and Softwares, Low-level and High-level languages. Introduction to MS Office: MS Word, MS Excel, MS Power point, Internet/Intranet and its applications.

Suggested Reading:

Research Methodology and Biostatistics: A comprehensive Guide for Health Care Professionals. By Sharma Suresh.

Biostatistics and Computer Applications by G.N. Rao, N. K. Tiwari

Biostatistics: Basic Concepts and Methodology for the Health Sciences. By Wayne W. Oaniel.

Fundamentals of Biostatistics by Khan and Khanum

BCEL-304: Microbial Technology and Bioprocess Engineering

Course outcome

The objectives of this course are to introduce the students to the field of microbial technology with special emphasis on isolation and improvement of strains, bioreactor design, functional aspects of upstream and downstream processes in fermentation industry.

Student learning outcomes: Aims to educate students about the fundamental concepts of bioprocess technology and its related applications, thus preparing them to meet the challenges of the new and emerging areas of biotechnology industry.

Unit-I

Microbial strains: Isolation, maintenance, improvement and preservation of industrial strains. Principles of sterilization of media and air.

Unit-II

Whole cell Immobilization: kinetics of immobilized systems. Fermentation media formulation: Criteria for media selection, its types and composition and inoculum development

Unit-III

Principles and Kinetic characteristics of Batch culture, Fed-batch culture and continuous culture
Industrial fermenter design and its analysis: Basic functions, body construction, maintenance of aseptic conditions, aeration and agitation, valves and steam traps
Instrumentation, control and monitoring

Unit-IV

Transport phenomena in bioprocesses: Fluid flow and mixing in bioreactors, Methods of heat transfer, mass transfer.

Unit-V

Downstream Processing and Product Recovery Separation of insoluble products - filtration, centrifugation, sedimentation, flocculation; Cell disruption; separation of soluble products:

liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration, final purification: drying; crystallization

Suggested Reading

- Stanbury, P. F., & Whitaker, A. (1997). Principles of fermentation technology. Oxford: Pergamon Press.
- Comprehensive Biotechnology-The Principles, Applications, Regulations of Biotechnology in Agriculture, Industry and Medicine. Vol II- The Principles of Biotechnology- Engineering considerations. Cooney CL, Humphrey AE. Editor in – chief: Murray Moo Young, Elsiever, 2004
- Biotechnology. Smith JE. Cambridge University Press, 3rded, 1996.
- Bioprocess Engineering Principles. Doran, Academic Press Ltd, 2005.

BCIER-301: Environmental Awareness

Course outcome and objective:

- There is urgent need to spread awareness about important environment related issue such as ever-increasing air pollution and its effect on animal, plant and human health. Furthermore, detailed knowledge of water pollution, its sources waste water management, control and remedial measures in the prevention of spread of various water borne diseases.
- Knowledge about environment problems such as Green house effect, global warming – causes, consequences and remedial measures is of paramount importance to save our planet.

Unit I:

Air Pollution: Basic Concept, Sources, Suspended Particulate Matter (SPM), Acid Rain, effect of air pollution on plants, animals, human beings and buildings, control of air pollution.

Unit II:

Water Pollution: Source, River water pollution, Waste Water Treatment, BOD, and Control of Water Pollution.

Unit III:

Soil Pollution: Sources, Soil Erosion, Preservative Measures, Bioremediation.

Unit IV:

Xenobiotic Transformation: Phase I and Phase II Reactions.

Unit V:

Greenhouse effect, Global Warming, Chlorofluorocarbons (CFC's), Ozone depletion.

Suggested Reading:

- Environmental Biochemistry. NeelimaRajvaidya, Dilip Kumar Markandey. APH Publishing, 2005.
- Biochemical Ecotoxicology: Principles and Methods. Francois Gagne. Elsevier, 2014.
- Environmental Biochemistry. Erik Hamilton (Editor). Larsen and Keller Education (21 June 2017)

BCCC-401: Regulation of Gene Expression

Course outcome and objective:

To have a knowledge base in the structure and functions of the genes, and to demonstrate the concept and knowledge of different regulatory strategies in regulation of gene expression in prokaryotes and eukaryotes

Unit I

Basic concept and necessity of regulation of gene expression in prokaryotes and eukaryotes. Principle levels at which regulation is exercised.

Regulation of gene expression in prokaryotes by substitution of σ factor, and by antitermination of transcription

The operon concept: Circuits of regulation of operons. The *lac* operon: repressor control and catabolite repression. The *trp* operon: repressor control and attenuation

Unit II

Maturation of 5' and 3' ends of eukaryotic mRNA: Capping, cleavage and polyadenylation. Function of the cap and the poly *A* tail of eukaryotic mRNA, and their roles in regulation of gene expression

mRNA splicing and regulation of eukaryotic gene expression: Exons and introns, classification and properties of introns. Autocatalytic splicing, splicing of Group II and Group I introns. Splicing of nuclear pre-mRNA introns. Alternative splicing, mechanism of alternative splicing and its regulation, Role of alternative splicing in sex determination of *Drposophila melanogaster*

Unit III

Activation of transcription factors: Types of transcription factors; mechanisms of activation of transcription factors; Regulation of many genes by a single transcription factor; Regulation of a single gene through different circuits; combinatorial principle of gene expression. Regulation of the *hsp* and *metallothionein* gene

Control of gene expression by DNA methylation, CpG islands

Unit IV

DNA-protein interaction: Physicochemical characteristics of DNA-protein interaction. DNA binding motifs: Homeodomain, Zinc fingers, *b/zip*, *b/HLH*, *b/HLH/zip* motifs

Experimental techniques for study of DNA-protein interactions: Gel retardation assay, DNase I footprinting, Modification protection assay, Modification interference assay

Unit V

Control of gene expression by histone modification: Histone acetylation, deacetylation and methylation. Enzymes associated with these modifications. Chromatin remodeling and chromatin remodeling complexes

Genomic regulatory domains: Introduction to regulation of expression of gene clusters; locus control region (LCR): structure and function LCR of mouse globin gene cluster; Insulators, structure and functions, the insulators of *hsp70* genes of *Drosophila melanogaster*; Genomic imprinting of *Igf-2* and *H-19* genes.

Suggested Reading:

- Lewin's Genes XII. By Krebs JE, Goldstein ES and Kilpatric ST, Jones & Bartlett Learning, Burlington, MA, USA

- Molecular Biology of the Gene. By Watson JD, Baker TA, Bell SP, Gann A, Levine M, Losick R, Pearson Publishers, USA
- Molecular Biology of the Cell. By Alberts B, Johnson A, Lewis J, Raff M, Roberts K and Walter P, Garland Science Inc., New York, USA
- Principles of Gene Manipulation: An Introduction to Genetic Engineering. By Old RW and Primrose SB, Blackwell Scientific Publication, Oxford-London-Edinburgh-Boston-Melbourne

BCEL-401: Advanced Enzyme Kinetics

Course Objectives and Outcome: At the end of the course, students will be able to understand advanced kinetics of enzymes especially those catalyzing bisubstrate reactions. They will learn classification, annotation and kinetics of bisubstrate reactions, its kinetics and properties of allosteric enzymes, various mechanisms of enzyme action by taking examples of some important enzymes catalysing two substrate reaction.

Unit I
Two substrate systems: kinetic mechanisms, Sequential and ping pong pathways, Cleland representation and nomenclature, forms of initial rate equations for random, ordered and ping-pong pathways and their primary and secondary plots.

Unit II
Regulation of Enzyme activity: feedback inhibition, allosteric concept, qualitative description of concerted and sequential models, negative cooperativity and half-site reactivity, Hill and Scatchard plots.

Unit III
Regulation of enzyme activity by covalent modification. Mechanisms of enzyme action: Proximity orientation effect, strain and distortion theory, Acid-base catalysis, covalent catalysis,

Unit IV
Techniques for studying the mechanism of enzyme action;chemical modification, site directed mutagenesis, general mechanistic principles.

Unit V
Physicochemical properties and mechanism of action of enzymes, alcohol dehydrogenase, chymotrypsin, lysozyme and hexokinase.

Suggested Reading:
- Enzymes by Dixon M, Webb EC, 2 ND Ed., Academic Press
- Enzymes by Palmer, Woodhead Publishing Ltd., UK
- Biochemistry by Voet B and Voet JG, Wiley Publishers, USA
- Biochemistry 5th Revised edition by LubertStryer, Jeremy M. Berg, John L.
- Tymoczko, Macmillan Publishers, USA
- D.L. Nelson and M.M. Cox Lehninger: Principles of Biochemistry, Publisher: WH
- Freeman; 8th ed. NewYork

BCEL-402: Metabolic Processes

Course Outcome: Students will be taught the metabolic pathways of carbohydrate, amino acid, lipid and coenzymes and their regulation. At the end of the they will be able to distinguish between different metabolic processes and their impact in metabolism of biomolecules.

Unit I

Control of carbohydrate metabolism, Regulation of glycolysis, Krebs' cycle, glycogen breakdown and glycogen synthesis.

Unit II

Biosynthesis of lipids: biosynthesis of triglycerides, glycerophospholipids, cerebrosides, ether lipids galactolipids and sulpholipids. Control of lipid metabolism.

Unit III

Biosynthesis of amino acids; biosynthesis of α-ketoglutarate, oxaloacetate, puruvate family amino acids and the controlof their synthesis.

Unit IV

Biosynthesis of amino acids; biosynthesis of ribose-5 phosphate, 3-phospoglycerate and phosphoenolpyruvate plus erythrose-4-phosphate family amino acids and the controlof their synthesis.

Unit V

Biosynthesis of coenzymes; Coenzyme A, NAD and NADP, FMN and FAD.

Suggested Reading:

- Geoffrey L. Zubey, Biochemistry, Fourth Edition: Wm. C. Brown Publishers, 1998
- Biochemistry by Robert Roskoski. W.B. Saunders, Philadelphia, ISBN 0-7216-5174-7
- D.L. Nelson and M.M. Cox Lehninger Principles of Biochemistry, Publisher: WH Freeman; 8th ed.NewYork.
- Biochemistry 5th Revised edition by Lubert Stryer, Jeremy M. Berg, John L. Tymoczko (ISBN: 8601300395166)

BCEL-403: Plant Tissue Culture and Molecular Markers

Course objectives and outcome: The course is designed to give the student an overview of plant tissue culture which will make her/him appreciate the different techniques involved in the process applications of plant tissue culture for the greater goal of crop improvement.

Unit I

History of Tissue Culture technique. Requirements for a plant tissue culture lab - Laminar air flow device. Sterilization procedure; autoclaving, ultraviolet sterilization, ultra-filtration and surface sterilization.

Unit II

Nutrient media for plant issue culture: Media for in vitro culture; Types of media – Solid, liquid and commercial prepacked media; Media composition – Macronutrients, micronutrients and growth regulators

Explants for Tissue Culture: Shoot tip, axillary buds, leaf discs, cotyledons, inflorescence and floral organs. Callus culture - initiation and maintenance of callus.

Unit III

Micropropagation - direct and indirect morphogenesis. Biochemical and molecular basis of differentiation in plant tissue culture. Somatic embryogenesis and synthetic seed production. Applications in crop improvement.

Unit IV

Methods for production of haploids. Protoplast culture and regeneration of plants, isolation, merits and demerits. Somaclonal variations, isolation of somaclonal variants. Molecular basis of somaclonal variation. Applications in crop improvement.

Unit V

Molecular Markers: RFLP, RAPD, AFLP,microsatellites, STS, SCAR (sequencecharacterized amplified regions), SSCP (single strand conformational polymorphism) and SNPs, QTL, map based cloning, MAS (molecular marker assisted selection).

Suggested Reading:

- Hartmann, H.T., Kester, D.E., Davies, F.T. and Geneve, R.L. Hartmann & Kester's Plant Propagation: Principles and Practices, Pearson, 2010.
- Razdan, M. K. Introduction to Plant Tissue Culture. Oxford & IBH, 2005.
- Gamborg, O. and Gregory, P. (Eds.) Plant Cell, Tissue and Organ Culture: Fundamental Methods, Springer, 1995.
- Slater, A., Scott, N. and Fowler, M. Plant Biotechnology: The Genetic Manipulation of Plants, Oxford, 2008.
- B D Singh, Plant Biotechnology, Kalyani Publishers, New Delhi.

BCEL-404: Intellectual Property Rights

Course objective and outcome:

Detailed knowledge of various forms of intellectual property right such as patent, copyrights, geographical indications, industrial design, trade mark etc, filing of patent application, infringement of patent rights is very important for MSc. Students of life sciences as intellectual property rights and technological innovation have played an important role in improving the economy of Nations.

Unit I:

IPR:Definition, Basic Concepts, Types, Innovation, Invention, Importance in modern era.

Unit II:

Patents: Infringement of Patent Rights, Rights of Patent Owner, importance of patents in modern era.

Unit III:
Trademark and Copyright: definition, basic concepts, Infringement, Registration.

Unit IV:
Industrial design, Semiconductor Integrated circuits Layout design: Definition, basic concepts, Infringement, Registration.

Unit V:
Geographical Indications, plant variety protection act and trade secrets.

Suggested Reading:

- Indian Patent Law. Kalyan C Kankanala ; Arun K. Narasani ; Vinita Radhakrishnan.Oxford University Press, New Delhi.
- Fundamentals of Intellectual Property. Dr.KalyanC.Kankanala.Asia Law House
- Universal's Guide to Patents Law. Manish Arora.Universal Law Publishing House
- IPR, Biosafety and Bioethics, Deepa Goel &Shomini Parashar. Pearson Publication

BCIRA-401: Pandemics: Covid-19

Course Objectives and Outcomes:

- Covid-19 Pandemic hit the whole world very hard. The economy of virtually lots of developed as well as developing nations the world was crippled and people with little financial security were most susceptible and the worst hit.
- It is very important to have awareness about pandemics and Covid-19 in particular. Knowledge about Source, Mechanism of infection, worldwide status, Medication, Vaccine strategies will be imparted to students.
  This course has been designed to create awareness among students of different faculties about various aspects of Covid-19 pandemic so that they become aware about modes of transmission of the virus, how to boost immunity and how to protect against the viral infection.

Unit I
Introduction to virology: definition, structure, types and properties of viruses. Zoonotic viruses: definition, transmission, prevention and examples of few zoonotic viruses. Host virus interactions: mechanism of viral entry, incubation time, immune response towards virus

Unit II
Corona virus pandemic: difference between endemic, epidemic, pandemic and sporadic diseases, worldwide effect of COVID-19. Origin of corona virus pandemic, morphology of the virus. Causes of COVID-19: sources of spread, transmission

Unit III
Mechanism of infection: mechanism of entry of virus into the host, mechanism of replication, immunological response of the body. Health effects: symptoms, pulmonary embolism in COVID-19 patients

Unit IV

Medication: use and efficacy of hydroxychloroquine, remdesivir and other antiviral drugs, antibody therapy, plasma therapy. Vaccination: strategies employed by therapeutic companies, stages of clinical trials, human trials

Unit V

Preventive measures: meaning of quarantine and social distancing, steps to prevent the spread, preventive measures while travelling, Lockdown (commencement & different stages), division of country into 3 zones, guidelines to follow for future prevention, awareness among general public (including use of Aarogyasetu app)

Ways to boost immunity: foods that boost antiviral immunity, healthy lifestyle, exercising, managing stress (including importance of Yoga & Ayurveda), not relying on supplements

Suggested Reading:

- COVID-19: An editorial by leaders in infectious medicine, this article elegantly summarises what is known about the disease. Fauci, Anthony S., et al. 'Covid-19: navigating the unchartered.' New England Journal of Medicine, Vol. 382, No. 13, 26 February 2020 pp. 1268-69.
- Responding to COVID-19: Bill Gates writes a must-read opinion piece on the pandemic and the steps that need to be taken to combat it. Gates Bill 'Responding to Covid -19: A Once –in-a –Century Pandemic?' New England Journal of Medicine, Vol. 382, No. 18,2020 pp1677-79.
- Cheng, Vincent C.C., et.al. 'Severe Acute Respiratory Syndrome Coronavirus as an Agent of Emerging and Re-emerging Infection.' *Clinical Microbiology Reviews*, Vol. 20, No. 4, 2007, pp. 660-94.
- Zhang, Haibo, et.al. 'Angiotensin-Converting Enzyme 2 (ACE2) as a SARS-CoV-2 Receptor: Molecular Mechanisms and Potential Therapeutic Target.' *Intensive Care Medicine*, Vol. 46, No. 4,2020, pp. 586-90.
- Pharmacologic Treatments for COVID-19: This article provides an overview of pharmacotherapy being tested and used for COVID-19. Sanders, James, M., et. Al. 'Pharmacologic Treatments for Coronavirus Disease 2019 (COVID-19).' *JAMA*, Vol. 323, No. 18,2020, pp. 1824-36.
- Characteristics of SARS-CoV-2 and COVID-19 Ben Hu, Hua Guo, Peng Zhou & Zheng-Li Shi, *Nature Reviews Microbiology* (2020).
- Coronavirus Pathogenesis and the Emerging Pathogen Severe Acute Respiratory Syndrome Coronavirus, Susan R. Weiss, Sonia Navas-Martin, Microbiology and Molecular Biology Reviews.
- How Moderna's Vaccine Works, Jonathan Corum and Carl Zimmer, The New York Times.
- *COVID-19 and D-dimer, Drs. Morayma Reyes Gil, Aggie Lee, Nigel Key, Dan Sabath, Cindy Leissinger, Oksana Volod, Geoff Wool, Lisa Baumann Kreuziger, American Society of Haematology*