

	M. Sc. Biochemistry			
Semester	I	II	III	IV
Core I (4 Credits)	Cell Biology and Genetics (PS01CBIC21)	Molecular Biology (PS02CBIC21)	Human Physiology (PS03CBIC21)	Animal Biotechnology (PS04CBIC21)
Core II (4 Credits)	Bioinstrumentation (PS01CBIC22)	Toxicology (PS02CBIC22)	Genetic Engineering (PS03CBIC22)	Nutritional and Clinical Biochemistry (PS04CBIC22)
Core III (4 Credits)	Cellular Metabolism (PS01CBIC23)	Fundamentals of Immunology (PS02CBIC23)	Enzymology (PS03CBIC23)	Lab I (PS04CBIC23) Practicals based on PS04CBIC21 and PS04CBIC22
Core IV (4 Credits)	Lab I (PS01CBIC24) Practicals based on PS01CBIC21 and PS01CBIC22	Lab I (PS02CBIC24) Practicals based on PS02CBIC21 and PS02CBIC22	Lab I (PS03CBIC24) Practicals based on PS03CBIC21 and PS03CBIC22	
Core V (Credits)	Lab II (PS01CBIC25) Practicals based on PS01CBIC23 and PS01EBIC2X	Lab II (PS02CBIC25) Practicals based on PS02CBIC23 and PS02EBIC2X	Lab II (PS03CBIC25) Practicals based on PS03CBIC23 and PS03EBIC2X	
Elective I (4 Credits)	Biochemistry of Horticultural commodities (PS01EBIC21)	Biostatistics (PS02EBIC21)	Advanced Immunology (PS03EBIC21)	Lab II (PS04EBIC21) Practicals based on PS04EBIC2X and PS04EBIC2X
Elective II (4credits)	Biomolecules and Bioenergetics (PS01EBIC22)	Medical Biochemistry (PS02EBIC22)	Bioinformatics (PS03EBIC22)	Dissertation (PS04EBIC22) (12 Credits)
Elective III (4 Credits)	Phytoresource Utilization and Conservation (PS01EBIC23)	Microtechniques (PS02EBIC23)	Omics and Computational Biology (PS03EBIC23)	Microbial Physiology (PS04EBIC23)
Elective IV (4 Credits)			Plant Biochemistry (PS03EBIC24)	Plant Biotechnology (PS04EBIC24)
Elective V (4 Credits)				IPR and Biosafety (PS04EBIC25)
Elective VI (4 Credits)				Pharmacognosy (PS04EBIC26)
Elective VII (4 Credits)				Endocrinology (PS04EBIC27)

PS01CBIC21: Cell Biology and Genetics

Unit I

An overview of Cells and Cell Research; Structure and Organization of pro-and eukaryotic cells. Cell membranes: molecular organization, Cell permeability - transport across membranes: facilitated diffusion, active transport and receptor mediated endocytosis. Nucleus – Structure of the nuclear envelope, organization and regulation of nuclear pore complex. Transport across nuclear membrane, internal organization of the nucleus and nucleolus, the nucleus during mitosis.

Unit II

Chloroplast and Mitochondria: structural organization in relation to function, genome, transport of metabolites across the membranes, import and export of proteins through membrane compartments and biogenesis – Envelope, stroma and thylakoids; Molecular organization of thylakoids. Endomembrane system: endomembrane concept, membrane flow, Structural organization of ER and Golgi, targeting of proteins to ER, , insertion of proteins into ER membrane, Protein folding and exporting of proteins and lipids from ER to golgi protein sorting and export from golgi to different cellular compartments, mechanism of vesicle transport and vesicle fusion.

Unit III

Cytoskeletal elements– composition and organization of microtubules, microfilaments and intermediate filaments. Role in cell division, wall formation and transport. Cell Cycle – Phases of Cell Cycle, functional importance of each phase, Molecular events during cell cycle, Check points, Cyclins and protein kinases, MPF (maturation promoting factor), Regulation of cell cycle. Apoptotic pathway and cell death

Unit IV

Fundamentals of genetics: Mendelian analysis- Mendels laws of inheritance; Quantitative inheritance. Multiple alleles and physical basis of heredity. Linkage and tetrad analysis: Linkage and crossing over in higher organisms; tetrad analysis; mitotic recombination and gene conversion in haploid organisms. Molecular mechanisms of recombination.

Reference Books:

Cell and Molecular Biology: Concepts and Experiments (1996) Gerald Karp, John Wiley & Sons, Inc.,USA.

Cell and Molecular Biology (1987), 8th Edn. De Robertis, E. D. P. and De Robertis, E.

The Cell – A Molecular Approach (Third Edition) (2004) Geoffrey M. Cooper and Robert

Molecular Cell Biology 3rd edn, (1995) Lodish, Baltimore, Berk, Lawrence, et al, Scientific American Books, N.Y.

Cell Biology: A Laboratory Handbook- Third Edition. Volumes 1 – 4 (2006), Edited by Julio E. Celis, Elsevier Academic Press, U. K.

David. E. Sadava. 1993. Cell Biology. Jones and Bartlett Publishers, Boston.

Genetics: P K Gupta

Genetics: Suzuki et al

PS01CBIC22: Bioinstrumentation

Unit I

Visualization techniques:

Principle of working and applications of bright field microscopy, phase contrast microscopy, fluorescence microscopy, confocal microscopy, scanning and transmission electron microscopy, scanning tunneling microscopy, atomic force microscopy. Principle and applications of cytophotometry and flow cytometry.

Unit II

Separation techniques:

Basic principle and application of Differential, density and ultracentrifugation

Principle and applications of Native-PAGE, SDS-PAGE, Agarose and 2D gel electrophoresis. Capillary electrophoresis and its applications.

Principle, methodology and applications of gel – filtration, ion –exchange and affinity chromatography; Thin layer and High Performance Thin Layer Chromatography. Gas chromatography, High performance liquid chromatography and FPLC.

Unit III

Spectroscopy

Principle, instrumentation and applications of UV, Visible, IR (including FTIR and ATR), AAS, NMR, fluorescence and CD spectroscopy.

Unit IV

Principle and applications of tracer technique in biology:

Radioactive Isotopes and half-life of isotopes; Effect of radiation on biological system; autoradiography; cerenkov radiation; radiation dosimetry; ionization and scintillation based detection and quantification of radioactivity.

Biosensors: Principle, types and applications.

Principle of biophysical methods used for analysis of biopolymer structure: X ray diffraction and mass spectrometry.

Reference Books:

1. Instrumental method of chemical analysis: Sharma B K
2. Instrumental methods of analysis: D A Skoog
3. An introduction to practical Biochemistry: Plummer
4. Instrumentation: Chatwal and Anand
5. Modern experimental Biology: Boyer

PS01CBIC23: Cellular Metabolism

Unit I

Basic concept of metabolism, Concepts of energy transformation in metabolic reactions, Biological oxidations, free energy changes and redox potentials. The mitochondrial respiratory chain, order and organization of carriers, proton gradient, iron Sulphur proteins, cytochromes and their characterization. The Q cycle and the stoichiometry of proton extrusion. Respiratory controls and oxidative phosphorylation. Un-couplers and inhibitors of energy transfer. ATP- synthetase complex.

Glycolysis, citric acid cycle its function in energy generation and biosynthesis of energy rich bonds, coordinated regulation of glycolysis and citric acid cycle, pentose phosphate pathway and its regulation, Gluconeogenesis, interconversions of sugars, Biosynthesis of glycogen, starch and oligosaccharides. Regulation of blood glucose homeostasis. Hormonal regulation of carbohydrate metabolism.

Unit II

Metabolism of circulating lipids: Chylomicrons, LDL, VLDL and HDL. Free fatty acids.

Fatty acid oxidation: α , β , ω oxidation and lipid peroxidation. Fatty acid biosynthesis: Acetyl CoA carboxylase, Fatty acid synthase, desaturase and elongase. Lipid biosynthesis: Biosynthesis of triacylglycerol, phosphoglycerides, sphingolipids. Biosynthesis pathways for terpenes, steroids and prostaglandins. Ketone bodies – formation and degradation.

Unit III

Degradation of amino acid and their regulation, oxidative deamination, Urea cycle and its regulation. Linkage between urea cycle and citric acid cycle

Biosynthesis of amino acids and regulation.

Unit IV

Biosynthesis of purines and pyrimidines and regulation, Degradation of purines and pyrimidines, and regulation

Biosynthesis, Structure and regulation of ribonucleotide reductase, biosynthesis of ribonucleotides, deoxyribonucleotides and polynucleotides

Integration of metabolism

Reference Books:

Lehninger's Principles of Biochemistry : D. L. Nelson and M. M. Cox, Macmillan, Worth Pub. Inc., NY.

Biochemistry : Lubert Stryer WH Freeman & Co., NY.

Harper's Biochemistry : R. K. Murray and others. Appleton and Lange, Stanford.

Text book of Biochemistry with clinical correlations by Delvin

PS01EBIC21: Biochemistry of Horticultural Commodities

Unit I

Introduction: common fruits, vegetables, flowers and their quality characteristics
Fundamental Nature of Perishable Products - Aspects of Deterioration
Biochemistry of development, maturation, ripening and senescence of fruits and vegetables;
Biochemistry of flower development and senescence

Unit II

Maturity indices and harvesting of fruits, vegetables and flowers
Metabolism of Harvested Products/Metabolic Control Mechanisms of Ripening and Senescence Processes
Programmed cell death during plant senescence

Unit III

Phytochemistry of fruits and vegetables
Carotenoids and colour in fruit and vegetables
Phenolic compounds and oxidative mechanisms in fruit and vegetables
Aroma biochemistry of fruits and vegetables
Gibberellins and fruit development
Phytochemistry of fruit and vegetables: an ecological overview

Unit IV

Biochemical analysis of major nutrient constituents
Postharvest Biology and Technology of fruits, vegetables and flowers
Postharvest handling and Physiology of fruits, vegetables, cut flowers and spices
Edible films and coatings for fruits and vegetables
Processing of horticultural commodities

References:

- Gopinadhan, P., Dennis, P. M., Avtar, K. H. and Susan, L. (2008) Postharvest Biology and Technology of fruits, vegetables and flowers.
- Tomas-Barberan, F. A. and Robins, R. J. (1997) Phytochemistry of fruits and vegetables.
- Salunkhe, D. K. and Kadam, S. S. (2005) Handbook of Fruit Science and Technology: Production, composition, Storage and Processing.
- Thompson, A. K. (1996) Postharvest Technology of Fruit and Vegetables
- Milda, E. E., Kerry, C. H. (2009) Edible films and coatings for food applications.
- Kenneth, V. T. (1980) Senescence in plants
- Heldt, H. 2005. Plant Biochemistry (3rd Edn.) Indian Reprint, Elsevier, New Delhi.
- Dey, P. M. & Harborne, J. B. (Eds.) 1997. Plant Biochemistry, Academic Press, London
- Doby, G.: Plant Biochemistry. Inter Science Publishers, New York
- Buchanan et al. 2004. Biochemistry & Molecular Biology of Plants.
- Taiz, L. and Zeiger, E. Plant Physiology, 4th Edition. Sinauer Associates, Inc.
- Hopkins, W. G., Introduction to Plant Physiology. 3rd Edition. John Wiley & Sons, New York.
- Salisbury, F. B. and Ross, C. W., Plant Physiology, 4th Edition. Wadsworth Publishing Company, California

- Lehninger, A. L., D. L. Nelson and M. M. Cox 2000: Principles of Biochemistry. CBS Publishers and Distributors, New Delhi.
- Briggs, W. R. (ed.) Plant hormones. Klywer Academic Publishers, Dordrecht.

PS01EBIC22: Biomolecules and Bioenergetics

Unit I

Carbohydrates and glycobiology : Monosaccharide - structure of aldoses and ketoses, ring structure of sugars, conformations of sugars, mutarotation, anomers, epimers and enantiomers, structure of biologically important sugar derivatives, oxidation of sugars. Formation of disaccharides, reducing and nonreducing disaccharides. Polysaccharides – homo- and heteropolysaccharides, structural and storage polysaccharides. Structure and role of proteoglycans, glycoproteins and glycolipids (gangliosides and lipopolysaccharides). Carbohydrates as informational molecules, working with carbohydrates, Industrial importance of carbohydrate.

Unit II

Amino acids: Structure and classification, physical, chemical and optical properties of amino acids, Classification of amino acids, Protein sequencing and alignment

Building blocks of lipids - fatty acids, glycerol, ceramide. Storage lipids - triacyl glycerol and waxes, Structural lipids in membranes – glycerophospholipids, galactolipids and sulpholipids, sphingolipids and sterols, structure, distribution and role of membrane lipids. Lipids as signals, cofactors and pigments

Nucleic acids: Structure of major species of RNA - mRNA, tRNA and rRNA.

Nucleic acid chemistry – UV absorption, effect of acid and alkali on DNA.

Unit III

Acid-Base Equilibrium & Henderson and Hassebach equation, Buffers and their importance, pKa of amino acid and their relevance, Importance of discontinuous buffer system used in SDS PAGE.

Common reaction mechanism in biological reaction: Peptide bond formation, oligonucleotide and oligosaccharide synthesis, disulphide bond, group-specific chemical modification for amino acid

Unit IV

Bioenergetics: The laws of thermodynamics, concept of entropy and free energy; ATP synthesis and hydrolysis, Biological oxidations—oxygenases, hydrolases, dehydrogenases, free energy changes and redox potentials, Gibbs energy,

The mitochondrial respiratory chain, order and organization of carriers, proton gradient, iron sulphur proteins, cytochromes and their characterization (Animals, Plants, and Bacteria), ATP- synthetase complex, Chemiosmotic theory of Energy Coupling, Inhibitors of ETC, Regulation of body temperature

References:

- Chemistry of Biomolecules by S. P. Bhutani, Ane Books Pvt. Ltd. CRC Press
- Lehninger's Principles of Biochemistry: D. L. Nelson and M. M. Cox, Macmillan, Worth Pub. Inc., NY.
- Biochemistry: Lubert Stryer WH Freeman & Co., NY.
- Harper's Biochemistry: R. K. Murray and others. Appleton and Lange, Stanford.
- Text book of Biochemistry with clinical correlations by Delvin.

PS01EBIC23: Phytoresource Utilization and Conservation

Unit - I

Plant Biodiversity : Concept, status in India, utilization and concerns.

Origin, evolution, botany, cultivation and uses of (i) Food, forage and fodder crops, (ii) fibre crops (iii) medicinal and aromatic plants, and (iv) vegetable oil – yielding crops

Plants as sources of drugs, pharmaceuticals and pharmaceutical aids.

Unit -II

Ethnomedicobotany: Basic approaches to study traditional knowledge on herbal medicine; Scope and potential applications.

Collection methods of ethnomedicobotanical data: Field methods and scrutiny of Herbarium specimens and folklore; verification of data; collection of materials for voucher specimen and for phytochemical screening; application of ethnomedicobotany.

Creating indigenous knowledge base of traditional medicines of plant origin.

Unit -III

Forest products:

Important timber yielding planting.

Timber types, identification diagnostic features, structure & quality

Important fire wood plants

Non Timber forest products bamboos, rattans, fibers pulp; gums, resins, tanins, lotex, fruits & tubers.

Innovations for meeting world food demands.

Plants used as avenue trees for shade, pollution control and aesthetics.

Unit –IV

Principles of conservation; extinctions; environmental status of plants based on International Union for Conservation of Nature.

Strategies for conservation – *in situ* conservation : International efforts and Indian initiatives; protected areas in India – sanctuaries, national parks, biosphere reserves, wetlands, mangroves and coral reefs for conservation of wild biodiversity.

Ex situ conservation : Principles and practices; botanical gardens, fields gene banks, seed banks, *in vitro* repositories, cryobanks; general account of the activities of Botanical Survey of India (BSI), National Bureau of Plant Genetic Resources (NBPGR), Indian Council of Agricultural Research (ICAR), Council of Scientific & Industrial Research (CSIR), and the Department of Biotechnology (DBT) for conservation, non-formal conservation efforts.

Reference Books :

- Anonymous. National Gene Bank: Indian Heritage on Plant Genetic Resources (Booklet). National Bureau of Plant Genetic Resources, New Delhi.
- Arora, R. K. and Nayar, E. R. Wild Relatives of Crop Plants in India. NBPGR Science Monograph.
- Baker, H. G. Plants and Civilization. C. A. Wadsworth, Belmont.
- Bole, P. V. and Vaghani, Y. Field Guide to Common Indian Trees. Oxford University Press, Mumbai.
- Chandel, K. P. S., Shukla, G. and Sharma, N. Biodiversity in Medicinal and Aromatic Plants in India : Conservation and Utilization. National Bureau of Plant Genetic Resources, New Delhi.

- Cristi, B. R. CRC Handbook of Plant Sciences and Agriculture. Vol. I. In-situ conservation. CRC Press, Boca Raton, Florida, USA
- Council of Scientific & Industrial Research. The Useful Plants of India. Publications and Information Directorate, CSIR, New Delhi.
- Plant Wealth of India. Special Issue of Proceedings India National Science Academy B – 63
- Rodgers, N. A. and Panwar, H. S. Planning a Wildlife Protected Area Network in India. Vol. 1. The Report Wildlife Institute of India, Dehradun.
- Sahni, K. C. The Book of India Trees, Oxford University Press, Mumbai.
- Sharma, O. P. Hill's Economic Botany. Tata McGraw Hill Co. Ltd., New Delhi.
- Swaminathan, M. S. and Kocchar, S. L. Plants and Society. Macmillan Publication Ltd., London.
- Thakur, R. S., Puri, H. S. and Husain, A Major Medicinal Plants of India. Central Institute of Medicinal and Aromatic Plants, CSIR, Lucknow. S.K. Jain: A Manual of Ethnobotany
- S.K. Jain: Glimpses of Indian Ethnobotany
- S.K.Jain, B.K. Sinha and R.C.Gupta: Notable plants in Ethnomedicine of India
- J.K. Maheswari: Dictionary of Indian Folk medicine and Ethnobotany
- S.K. Jain: Useful plants of India
- Wiley Chichester, CIBA Foundation Symposium 185: Ethnobotany and the search for new drugs

PS01CBIC24: Lab I (Practicals based on PS01CBIC21 and PS01CBIC22)

PS01CBIC25: Lab II (Practicals based on PS01CBIC23 and PS01EBIC2X)

Semester II

PS02CBIC21: Molecular Biology

Unit I: DNA structure

DNA structure: Chemistry of DNA, DNA structure, Different conformations of DNA (B, A and Z), Denaturation and Renaturation of DNA.

DNA topology: Supercoiling, Biology of Supercoiled DNA, DNA topoisomerases and their mechanism of action.

DNA- protein interactions: General features, Sequence specific DNA binding protein motifs, ss DNA binding proteins.

Unit II: Organization of genome and its replication

Organization of DNA into chromosomes: Packaging of DNA and organization of chromosome in bacterial cells; Packaging of DNA in eukaryotic nucleosome and chromatin condensation, assembly of nucleosomes upon replication, chromatin modification.

DNA replication: Mechanism of DNA polymerase catalyzed synthesis of DNA, Types of DNA polymerases in bacteria, Initiation of DNA replication and its regulation in prokaryotes, assembly of replisome and progress of replication fork, termination of replication. DNA replication in eukaryotes and archaea. Inhibitors of DNA replication.

Unit III: Gene expression in prokaryotes and eukaryotes

Transcription: RNA polymerases, features of prokaryotic and eukaryotic promoters, assembly of transcription initiation complex in prokaryotes and eukaryotes, and its regulation; synthesis and processing of prokaryotic and eukaryotic transcripts.

Translation: structure and role of t-RNA in protein synthesis, ribosome structure, basic features of genetic code and its deciphering, translation (initiation, elongation and termination in detail in prokaryotes as well as eukaryotes).

Unit IV: Regulation of gene expression

Regulation of gene expression in prokaryotes: Operon concept, positive and negative regulation. Examples of lac, ara, and trp operon regulation; global regulatory responses.

Regulation of gene expression in eukaryotes: Transcriptional, translational and processing level control mechanisms.

References Books:

Genes X: Lewin

Molecular Biology of the Gene: Watson et al

Molecular Genetic of Bacteria: Snyder and Champness

Molecular Biology, 4th Edition: Burton E Tropp

Principles of Genetics: Snustad and Simmons

PS02CBIC22: Toxicology

Unit-1

Definition and scope of toxicology: Eco-toxicology and its environmental significance. Toxic effects : Basic for general classification & nature. Dose-Response relationship: Synergism and Antagonism, Determination of ED50 & LD50. Acute and Chronic exposures. Factors influencing Toxicity. Pharmacodynamics & Chemodynamics, dose conversion between animals and human
Diagnosis of toxic changes in liver and kidneys : Metabolism of drugs: paracetamol and aspirin with their toxic effects on tissues.

Unit-2

Xenobiotics Metabolism: Absorption & distribution. Phase I reactions. Oxidation, Reduction, Hydrolysis and Hydration. Phase II reaction/Conjugation : Methylation, Glutathione and amino acid conjugation. Detoxification.
Biochemical basis of toxicity : Metabolism of Toxicity : Disturbances of Excitable membrane function. Altered calcium Homeostasis. Covalent binding of cellular macromolecules & Genotoxicity. Tissue specificity of Toxicity.
Toxicity testing : Test protocol, Genetic toxicity testing & Mutagenesis assays : In vitro Test systems – Bacterial Mutation Test, Ames Test, Fluctuation Tests, *In vivo* Mammalian Mutation tests –DNA repair assays, Chromosome damage test, Evaluation of Apoptosis and necrosis

Unit-3

Pesticide toxicity : Insecticides : Organochlorines, Anti cholinesterases – Organophosphates and Carbamates, Fungicides. Herbicides, Environmental consequences of pesticide toxicity. Biopesticides.
Food Toxicity : Role of diet in cardio-vascular disease and cancer. Toxicology of food additives.

Unit-4

Metal Toxicity : Toxicology of Arsenic, mercury, lead and cadmium. Environmental factors, affecting metal toxicity effect of light, temperature & pH.
Air pollution : Common air Pollutant & their sources. Air pollution & ozone. Air pollution due to chlorofluorocarbons (CFCS) and asbestos.

References:

1. Klaassen, C. D (8th Eds.). (2013). *Casarett and Doull's toxicology: the basic science of poisons* . New York: McGraw-Hill.
2. John A. Timbrell (4th Edn) (2008) Principles of biochemical toxicology. Taylor & Francis Ltd, London,.
3. Smart, R. C., & Hodgson, E. (4th Eds.). (2013). Molecular and biochemical toxicology. John Wiley & Sons.
4. Relevant review articles / research papers / handouts of latest development in the subject.

PS02CBIC23: Fundamentals of Immunology

Unit I

Introduction to immune system: mechanisms of barrier to entry of microbes / pathogens; Cells and organs of the immune system involved in innate and adaptive immunity: cells of the immune system, primary and secondary lymphoid organs, Hematopoiesis and its regulation

Innate immunity: receptors of the innate immunity (TLR and sensing of PAMPs, CLR, RLR and CLR); Inflammatory responses

Antigens: antigenicity, and immunogenicity. B and T cell epitopes

Unit II

Antibody: Structure of immunoglobulin; classes of immunoglobulins, Signal transduction pathways emanating from the BCR,

The Organization and Expression of Lymphocyte Receptor Genes: Hozumi and Tonegawa's Experiment, Multigene organization of Ig Gene, Mechanism of VDJ recombination, B cell receptor expression, allelic exclusion, B cell isotype switching and somatic hypermutation; expression of membrane bound and soluble immunoglobulin; T cell receptor genes and expression

Complement system: Overview of classical, alternative and lectin complement pathways, functions of complement, regulation of complement, complement deficiencies, microbial complement evasion strategies

Unit III

The Major Histocompatibility Complex and Antigen Presentation: The structure and function of MHC molecules, general organization and inheritance of MHC, self – MHC restriction, endogenous and exogenous pathway of antigen processing and presentation; cross presentation of exogenous antigen, presentation of non peptide antigens

Cytokines: properties, receptors, associated diseases, therapeutic applications, cytokine signaling pathways: JAK-STAT and FAS-FASL signaling pathways

Unit IV

Basics of Antigen-antibody interactions: Agglutination, precipitation, RIA and ELISA

Cell and antibody mediated effector response: Antibody mediated effector response (Neutralization, opsonization/ phagocytosis, complement fixation, ADCC); Cell mediated effector response (Generation of effector CTL's, Granzyme and Perforin Mediated Cytolysis, Fas-FasL Mediated Cytolysis, NK cell mediated cytotoxicity)

Immunity to infection: Immunity to viruses, Immunity to bacteria and fungi, Immunity to parasites (protozoa and worms).

References

1. Owen, J. A., Punt, J., & Stranford, S. A. (2013). *Kuby immunology* (7th Edn). New York: WH Freeman.
2. Murphy, K., & Weaver, C. (2016). *Janeway's immunobiology* (9th Edn) Garland Science.
3. Male, D., Brostoff, J., Roth, D., & Roitt, I. (2012). *Immunology* (8th Edn) *With STUDENT CONSULT Online Access*. Elsevier Health Sciences.

4. Abbas, A. K., Lichtman, A. H., & Pillai, S. (2014). *Cellular and molecular immunology* (6th Edn) Elsevier Health Sciences.
5. Relevant review articles / research papers / handouts of latest development in the subject.

PS02EBIC21: Biostatistics

Unit - I

Definition of Biostatistics

Data Collection:

Types of Biological Data:

Qualitative (Categorical) Data: Nominal and Ordinal Data

Quantitative (Numerical) Data: Discrete and Continuous Data

Methods of Collecting Data:

Survey Method: Concept of a statistical population and sample from a population; Methods of drawing sample from the population, Simple Random Sampling (SRS), Stratified Random Sampling, Cluster Sampling; Experimental Method

Presentation:

Construction of frequency distribution (Simple or Discrete and Grouped): Rules for constructing Grouped frequency distribution

Diagrammatic Presentation: Bar Diagram (Chart), Simple, Sub – divided (Component), Percentage, Multiple, Pie Chart

Graphical Presentation: Line Graph, Histogram (For uniform class width only), Frequency Polygon, Frequency Curve, Ogives or Cumulative Frequency Curves

Descriptive Statistics:

Measures of Central Tendency (Averages): Mean or Arithmetic Mean, Median, Mode, Partition Values (For Raw and Grouped Data), Quartiles, Deciles, Percentile, Partition values using graphs (Ogives).

Measures of Dispersion (Variation): Range, Quartile Deviation (Q.D), Inter Quartile Range (IQR), Standard Deviation (SD) and Variance, Coefficient of Variation (C.V), Box – and – Whisker Plot.

Measures of Skewness and Kurtosis: Karl – Pearson’s Coeff. of Skewness, Bowley’s Coeff. Of Skewness, Kurtosis (Definition Only).

Unit - II

Probability and Probability Distributions:

Elements of Probability theory: Concept, Classical definition of Probability, Laws of Probabilities (Statements Only), Conditional Probability, Examples

Probability Distributions: Binomial Distribution. Definition, Conditions for applicability of Binomial Distribution, Examples applicable in the field of Biosciences; **Normal**

Distribution, Definition (Normal and Standard Normal Distribution), Properties of Normal Distribution, Examples applicable in the field of Biosciences

Unit - III

Correlation and Regression Analysis:

Correlation: Meaning, Types of Correlation, Positive, Negative, Non – Sense or Spurious, Methods of studying correlation, Scatter Plot (diagram) method, Karl-Pearson’s Correlation Coefficient (Product Moment) Method; Properties of Correlation Coefficient

Coefficient of determination and its meaning: Spearman's Rank Correlation Coefficient;
Properties of Rank Correlation Coefficient
Regression: Meaning, Properties of Regression Coefficients, Applications in the field of
Biosciences
Testing Of Hypothesis: Contingency tables, Goodness of Fit

Unit - IV

Large Sample Test: Z - test for (Single) population proportion; Z - test for difference between two population proportions; Z - test for (Single) population mean; Z - test for difference between two population means

Small Sample Test: t – test for (Single) Population Mean, t – test for difference between two population means (Unpaired t-test), t – test for difference between two population means (Paired t-test)

Analysis Of Variance (ANOVA) : One – Way Classification , Two – Way Classification

References:

- Fundamentals of statistics by S.C. Gupta
- Principles of Biostatistics by Marcello Pagano and Kimberlee Gaurea
- Biostatistics : A Foundation For Analysis in the Health Sciences by Daniel, Wayne(Seventh Edition), Wiley India Pub.

PS02EBIC22 - Medical Biochemistry

Unit 1

Principles of Diagnostic Enzymology: Serum Enzyme in heart disease, Liver disease, GI tract disease, muscle disease, bone diseases and in Malignancy, clinical importance of Isoenzyme (creatinine kinase and lactate dehydrogenase, Alkaline phosphatase)

Disorders of mineral metabolism: Hypercalcaemia, hypocalcaemia, normocalcaemia, hypophosphataemia and hyperphosphataemia.

Vitamin : Dietary sources, biochemical functions and specific deficiency diseases

Unit 2

Organ function tests: Liver function tests - Bile pigment metabolism - Jaundice and its type; Blood coagulation disorder- Haemoglobinopathies, sickle cell anaemia.

Functions of Kidney, Urine formation and renal function tests disease of kidney - Renal Calculi, Theory of formation and analysis, chronic renal failure;

Gastric Analysis - Composition of gastric juice, concepts of free and bound acid, Fractional Test Meal;

Pancreatic function tests; Thyroid function tests; Cardiac function test

Unit 3

Lifestyle Diseases:

Cardiovascular Problems- Systemic Hypertension and Arteriosclerosis, Stroke,

Neurological Disorders - Epilepsy, Sleep Disorders, Alzheimer's Disease, Parkinson Disease, Huntington's disease,

Cancer biology- Mechanism of carcinogenesis, tumor suppressor genes and oncogene, Cancer markers

Unit 4

Infectious disease:

Relation between normal microbiota and host, opportunistic microorganisms, Spread of infectious diseases, Respiratory tract infection- Tuberculosis; Gastro intestinal tract infection: Food poisoning

Biochemistry of AIDS

Reference Book

- Textbook of Medical Biochemistry; (Eight Edition), By Dr (Brig) MN Chatterjea, Rana Shinde; JAYPEE BROTHERS MEDICAL PUBLISHERS (P) LTD
- Clinical Biochemistry- Metabolic and Clinical aspects By---William J. Marshall & Stephen K. Angert.
- Biochemistry with clinical correlation--- By Thomas Devli
- Text book of Medical Physiology --- By Guyton.
- Textbook of Biochemistry for Medical Students: D.M. Vasudevan and Sreekumari, S, 6th Edition, 2010, Jaypee Brothers Medical Publishers, New Delhi.
- Tietz Textbook of Clinical Chemistry, Third Edition. Carl A. Burtis and Edward R. Ashwood, eds.
- Harper's Illustrated Biochemistry- R.K.Murray, D.K.Grannes and V.W.Rodwell, McGraw Hill

PS02EBIC23: Microtechniques

Unit I

Light microscopy

Properties of lenses, Optical corrections, Properties and types of objectives, Oculars and Illumination.

Light microscopes: Bright field, dark field, fluorescence, phase contrast, polarizing, differential interference contrast.

Micrometry and photomicrography

Unit II

Basic components of electron microscopes. Thermionic and field emission guns. Types of electron microscopes: TEM, SEM, STEM, ESEM and HVEM

Unit III

Maceration, squash and clearing techniques. Sample preparation for light microscopy.

Classification of fixatives, formulas', (Plant and animal samples).

Sample preparation for light microscopy: Fixation, dehydration and infiltration procedures.

Embedding media for light microscopy. Stains and staining procedures- negative and positive staining procedures. Microtomes: Rotary, sliding, cryostat. Histochemical localization of

metabolites for light microscopy: Starch, proteins, lipids, total carbohydrates, lignins,

polyphenols, nucleic acid, histones, cutin, suberin and waxes. Localization of enzymes:

Peroxidase, acid phosphatase and succinic dehydrogenase.

Unit IV

Freeze etching and freeze fracturing.

Sample preparation for Electron microscope: Fixatives, double fixation, dehydration and infiltration procedures, embedding media for electron microscopy. Fixation and embedding of particulate samples like bacteria, virus etc. ultra-microtome and freezing ultramicrotome-semi thin sectioning, ultrathin sectioning, grids, formavar coating, Staining for electron microscopy.

Ultrastructural cytochemistry: Tannin, protein, cell wall polysaccharide, lignin and membrane.

Enzymes: Peroxidase and phosphatase.

Immunocytochemistry.

References:

- Microscopy and Microtechnique: R Marimuthu MJP Publisher, Chennai
- The study of plant structure: Principles and selected methods- T. P. O' Brien and M E McCully.
- Plant Microtechnique- Johansen, DA, McGraw Hill Book Co., New York.
- Botanical Microtechnique and Cytochemistry; Graeme P. Berlyn and Jerome P Micksche.

PS02CBIC24: Lab I (Practicals based on PS02CBIC21 and PS02CBIC22)

PS02CBIC25: Lab II (Practicals based on PS02CBIC23 and PS02EBIC2X)

Semester III

PS03CBIC21: Human physiology

Unit I

Homeostasis and the organization of body fluids, Control of Homeostasis, Positive and negative Feedback systems, Homeostatic Imbalances.

An overview of human circulatory system. Anatomy of heart, cardiac cycle, cardiac output, blood pressure and regulation, ECG. The arterial system, venous system, the microcirculation and mechanics of capillary fluid exchange. Control of blood flow to the tissues. Portal circulations. Arterial pressure and its regulation. Blood-components and functional significance. Blood buffer systems, Blood coagulation and factors involved in coagulation. Laboratory tests to measure coagulation and thrombolysis. Hemopoiesis and blood groups, Disorders of circulatory system: coagulation disorders, hypertension, thalassaemias and anemias.

Unit II

Digestive system – Composition, functions and regulation of saliva, gastric, pancreatic intestinal and bile secretions – digestion and absorption of carbohydrates, lipids, proteins nucleic acids, minerals and vitamins.

The Muscular System – Types of muscles and their functions. Physiology of muscle contraction in striated and non-striated muscle.

Unit III

Excretory system – structure of nephron formulation of urine, glomerular filtration, GFR, tubular reabsorption of glucose. renal and pulmonary control of blood pH, renal clearance.

Unit IV

Nervous System- Structure of neuron, function and organization of nervous system, Blood-brain barrier, Neurotransmitters, Nerve impulse transmission.

Reproductive physiology – secretion and function of reproductive hormones, pregnancy and lactation. Hormonal disturbances.

Reference Books:

- Text book of Medical Physiology by A. C. Guyton and J. E. Harcourt.
- Text book of Medical Physiology by Ganong.
- Principles of anatomy and physiology by Gerard Tortora and Bryan Derrickson, 12th edition

PS03CBIC22: Genetic Engineering

Unit-I

Concept and importance of Genetic Engineering; General strategies and Steps involved in gene cloning: Extraction and purification of DNA and RNA from bacteria, virus, plant and animal cells; physical and enzymatic methods for cutting DNA; DNA ligase and other enzymes involved in gene cloning; Construction genomic and cDNA libraries; Introduction of DNA into host cells; screening and selection methods for recombinant clones.

Unit-II

Cloning vectors- Basic properties and cloning strategies for vectors derived from Plasmids, λ -bacteriophages, M-13 phage, Cosmids, Fosmids, Phagemids, Phasmids, YAC, BAC, HAC/MAC and viral vectors for Plant and animal cells.

Salient features of expression vectors for heterologous expression in E. coli, Yeast, Insect and Mammalian system, factors influencing heterologous gene expression.

Unit-III

DNA sequencing and sequence assembly: Maxam-Gilbert's and Sanger's methods, Shot gun sequencing, Next generation sequencing strategies for large genomes. DNA mapping and DNA fingerprinting: Physical and molecular mapping, Hybridization and PCR based methods of fingerprinting. Site directed mutagenesis: Methods and applications.

Polymerase Chain Reaction: Principle and basic types of PCR; Reverse Transcription and Real Time PCRs.

Unit-IV

Applications of Genetic engineering in improvement of plants, animals and microbes; Gene editing and its applications; Metagenomics and Metabolic engineering; Gene therapy; Restriction and regulations for the release of GMOs; Biosafety and levels of Physical and Biological containment; The Indian Guidelines for release and use of GM organisms.

Reference Books

- Genome 3rd Edition – Brown
- Molecular Biotechnology – Glick
- Principles of Genetic Manipulation – Old and Primrose
- Applied Molecular Genetics – Roger Miesfeld
- Biotechnology – H. K. Das
- Recombinant DNA – Watson et. al.
- Molecular cloning – Sambrook and Russel
- From genes to clones – Ernst Whittaker

PS03CBIC23: Enzymology

Unit I

Introduction to enzymology and historical developments in enzymology

Enzyme Structure and classification.

Practical Enzymology: Enzyme Activity, assay, factors affecting enzyme activity, progress curve, rate enhancement, enzyme activators, coenzyme and cofactors,

Enzyme specificity

Enzyme purification: Objectives and strategy, separation techniques, test of purity, case study

Unit II

Enzyme Kinetics:

Chemical reaction kinetics and catalysis

Single substrate kinetics: Equilibrium and Steady state kinetics, significance of K_m , V_{max} & K_{cat} , enzyme efficiency

Multisubstrate kinetics: General rate equation, compulsory order, random order and ping-pong mechanisms and their primary and secondary plots.

Enzyme inhibition and its kinetics: Reversible and irreversible inhibition, competitive, non-competitive and uncompetitive, mixed, partial, substrate and allosteric inhibition.

Thermal kinetics: Effect of temperature on reaction rate, enzyme stability, Arrhenius equation and activation energy.

Unit III

Mechanism of Enzyme Action:

Enzyme mechanisms: Factors affecting catalytic efficiency, Mechanism of Lysozyme, Chymotrypsin, Carboxypeptidase, Restriction endonuclease, Aspartate transcarbamylase.

Allosteric enzymes and sigmoidal kinetics: Protein ligand binding, Co-operativity, MWC & KNF models,

Multienzyme enzyme complexes

Unit IV

Methods to study enzymes and its mechanisms

Enzyme engineering: Chemical modification of enzymes: methods of modification of primary structure, catalytic and allosteric properties, use of group specific reagents.

Enzymes in non conventional media, Enzymes as analytical reagents.

Isoenzymes and its physiological significance, Ribozymes and Abzymes

Reference Books:

- Fundamentals of Enzymology :Nicholes C. Price and Lewis Stevens, Oxford Univ. Press.
- Enzyme Structure and mechanism: Alan Fersht, Reading, USA.
- Understanding Enzymes: Trevor Palmer
- The chemical kinetics of enzyme action: K. J. Laidler and P. S. Bunting, Oxford University Press, London.
- Enzymes: M. Dixon, E. C. Webb, CJR Thorne and K. F. Tipton, Longmans, London.
- Proteins: Thomas Creighton
- Biochemistry: Lubert Stryer.

PS03EBIC21: Advanced Immunology

Unit I

Experimental systems and methods for diagnostics and therapy: Antibody generation (polyclonal, monoclonal, modification of monoclonal antibodies), Methods to Determine the Affinity (*Equilibrium dialysis, surface Plasmon resonance*), Microscopic visualization of cells and sub cellular structures (*Immunocytochemistry, Immunohistochemistry, Immunoelectron microscopy*), Immunofluorescence-Based Imaging Techniques of Antigen-Antibody Interactions (*Flow cytometry, Magnetic activated cell sorting, cell cycle analysis, assays of cell death*)

Antibody Engineering: Chimeric and hybrid monoclonal antibodies, Construction of monoclonal antibodies from Ig-gene libraries

Vaccines: Active and passive immunization, conjugate or multivalent vaccines, DNA vaccines, vaccines under development – malaria and cancer

Unit II

T cell Development: Early Thymocyte Development, Positive and Negative Selection, Lineage Commitment, Exit from the Thymus and Final Maturation, Other Mechanisms That Maintain Self-Tolerance, Apoptosis

B cell Development: The Site of Hematopoiesis, B-Cell Development in the Bone Marrow, The Development of B-1 and Marginal-Zone B Cells, Comparison of B- and T-Cell Development

T-Cell Activation, Differentiation, and Memory: T-Cell Activation and the Two Signal Hypothesis, T-Cell Differentiation, T-Cell Memory

B-Cell Activation, Differentiation, and Memory generation: T-Dependent B-Cell Responses, T-Independent B Cell Responses, Negative Regulation of B Cells

Unit III

Allergy, Hypersensitivity and Chronic inflammation: Allergy: A Type I Hypersensitivity Reaction, Antibody-Mediated (Type II) Hypersensitivity Reactions, Immune Complex-Mediated (Type III) Hypersensitivity, Delayed-Type (Type IV) Hypersensitivity (DTH), Chronic Inflammation

Transplantation immunology: Immunological principles of graft rejection, Role of T cells in graft rejection, Role of Blood Group and MHC Antigens in Graft Tolerance, Predictable clinical course of graft rejection, General and target specific immunosuppressive therapy, Circumstances favoring

Unit IV

Immunodeficiency disorders: Primary and secondary immunodeficiencies

Cancer and immune system: Terminology and Common types of cancer, Malignant transformation of cells, Tumor antigens, The Immune Response to Cancer, Cancer immunotherapy

Tolerance and autoimmunity: Establishment and maintenance of tolerance (*antigen sequestration, central tolerance, peripheral tolerance*), Autoimmunity (*Organ specific autoimmune disease, systemic autoimmune disease, intrinsic and extrinsic factors that can favor susceptibility to autoimmune disease, proposed mechanisms for induction of autoimmunity, treatment of autoimmune diseases*)

Basic Text and Reference Books:

- Owen, J. A., Punt, J., & Stranford, S. A. (2013). *Kuby immunology* (7thEdn). New York: WH Freeman.
- Murphy, K., & Weaver, C. (2016). *Janeway's immunobiology* (9thEdn) Garland Science.
- Male, D., Brostoff, J., Roth, D., & Roitt, I. (2012). *Immunology* (8thEdn) *With STUDENT CONSULT Online Access*. Elsevier Health Sciences.
- Abbas, A. K., Lichtman, A. H., & Pillai, S. (2014). *Cellular and molecular immunology* (6thEdn) Elsevier Health Sciences.
- Relevant review articles / research papers / handouts of latest development in the subject.

PS03EBIC22: Bioinformatics

Unit 1:

❖ Introduction to Bioinformatics:

- Overview, Internet and bioinformatics, Applications.
- Introduction and Bioinformatics Resources:
- Knowledge of various databases and bioinformatics tools available at these resources, the major content of the databases, Literature databases:
- Nucleic acid sequence databases: GenBank, EMBL, DDBJ
- Protein sequence databases: SWISS-PROT, TrEMBL, PIR, PDB, SCOP, CATH
- Genome Databases at NCBI, EBI, TIGR, SANGER
- Other Databases of Patterns/Motifs/System Biology (Gene and protein network database and resources)

❖ Sequence analysis:

- Various file formats for bio-molecular sequences: genbank, fasta, gcg, msf, nbrf-pir etc.
- Basic concepts of sequence similarity, identity and homology, Definitions of homologues, orthologues, paralogues, xenologues.
- Scoring matrices: basic concept of a scoring matrix, PAM and BLOSUM series.
- Sequence-based Database Searches: what are sequence-based database searches, BLAST and FASTA algorithms, various versions of basic BLAST and FASTA.
- Pairwise and Multiple sequence alignments: basic concepts of sequence alignment, Needleman & Wunsch, Smith & Waterman algorithms for pairwise alignments, Progressive and hierarchical algorithms for MSA.
- Use of pairwise alignments and Multiple sequence alignment for analysis of Nucleic acid and protein sequences and interpretation of results.

Unit 2:

❖ Gene prediction:

- Gene structure in Prokaryotes and Eukaryotes, Gene prediction methods: Neural Networks, Pattern Discrimination methods, Signal sites Predictions, Evaluation of Gene Prediction methods.

❖ Computational RNA Structure analysis:

- Secondary and tertiary structure of RNA. Various algorithms of RNA folding and their analysis. Energy minimization in RNA folding. RNA sequence alignment

based on secondary structure and its applications in functional genomics and phylogeny.

- ❖ Transcriptomics:
 - Complete transcript cataloguing and gene discovery sequencing based approach, Microarray based technologies and computation based technologies

Unit 3:

- ❖ Genomics:
 - Concepts and tools for genomics and comparative Genomics
 - Ancient conserved regions
 - Horizontal gene transfer
 - Functional classification of genes
 - Gene order (synteny) is conserved on chromosomes of related organisms.
 - Prediction of gene function based on a composite analysis.
 - Functional genomics.
 - Putting together all of the information into a genome database.
- ❖ Phylogenetic analysis:
 - Definition and description of phylogenetic trees and various types of trees, Molecular basis of evolution, Method of construction of Phylogenetic trees: Distance based method (UPGMA, NJ), Character Based Method (Maximum Parsimony and Maximum Likelihood method).

Unit 4:

- ❖ Proteomics and Protein Computational Biology:
 - Tools for proteomics: Acquisition of protein structure information, databases and applications.
 - Structural classification of proteins, Protein structure analysis structure alignment and comparison,
 - Secondary structure and evaluation: algorithms of Chou Fasman, GOR methods.
 - Tertiary Structure: basic principles and protocols, Methods to study 3D structure. prediction of specialized structures.
 - Active site prediction, Protein folding, Protein modeling and drug design
- ❖ Protein structure comparison and classification:
 - Classes, folds, motif, domain; the concepts in 3D structure comparison, purpose of structure comparison, algorithms such as FSSP, VAST and DALI. Principles of protein folding and methods to study protein folding.

Basic Text & Reference Books:

- Bioinformatics: A Beginners Guide, Clavarie and Notredame
- Bioinformatics: David Mount
- Bioinformatics: Rastogi
- Introduction to Bioinformatics: Arthur M. Lesk
- Bioinformatics: Principles and applications, Ghosh and Mallick
- Bioinformatics: Genes, Proteins and Computer, C A Orengo
- Protein Structure Prediction: Methods and Protocols, Webster, David (Southern Cross Molecular Ltd., Bath, UK)

PS03EBIC23: Omics and Computational Biology

Unit I Genomics and methods in genomics

Introduction to the proteome and the genome, codon bias, gene expression, Genome size-C value paradox, DNA sequencing: Maxam- Gilbert, Sanger, Pyrosequencing, automated DNA sequencing. Other features of nucleic acid sequencing. Analysis and Annotation-ORF Exon-intron boundaries, DNA Microarray technology: The generation of cDNA expression libraries, their robotic arraying, Complex hybridization on DNA chips.

Transcriptomics: Comparative transcriptomics, Differential gene expression; Genotyping/SNP detection; Detection technology; Computational analysis of microarray data.

Unit II Proteomics and methods in proteomics

Relationship between protein structure and function, Identification and analysis of proteins by 2D analysis; Spot visualization and picking; Tryptic digestion of protein and peptide fingerprinting; Common ionization methods for peptide/protein analysis; Introduction to Mass spectrometers; MALDI-TOF and LCMS analyses

Protein-protein interactions: Solid phase ELISA, pull-down assay (using GST-tagged protein), far western analysis, surface plasmon resonance technique, Yeast two hybrid system, Phage display; Protein interaction maps.

Protein arrays-definition, applications- diagnostics, expression profiling. Uses of automated technologies to generate protein arrays and chips.

Unit III Introduction to computational biology basics and biological databases

Computers in biology, Overview of biological databases, nucleic acid & protein databases, primary, secondary, functional, composite, structural classification database, Sequence formats & storage **Pairwise and multiple sequence alignments:** Local alignment, Global alignment, Scoring matrices - PAM, BLOSUM, Gaps and penalties, Dot plots. Dynamic programming approach: Needleman and Wunsch Algorithm, Smith and Waterman Algorithm, Hidden Markov Model: Viterbi Algorithm. Heuristic approach: BLAST, FASTA. Building Profiles, Profile based functional identification.

Unit IV Genome analysis

Polymorphisms in DNA sequence, Introduction to Next Generation Sequencing technologies, Whole Genome Assembly and challenges, Sequencing and analysis of large genomes, Gene prediction, Functional annotation, Comparative genomics, Probabilistic functional gene networks, Human genome project. **Structure visualization:** Retrieving and drawing structures, Macromolecule viewing platforms, Structure validation and correction, Structure optimization, Analysis of ligand-protein interactions; Tools such as PyMol or VMD.

References:

- Discovering Genomics, Proteomics and Bioinformatics, A,M, Campbell, C,S,H, Press,
- (2003).
- Essential of Genomics and Bioinformatics C,W, Sensen, Wiley (2003).
- Hand book of Comparative Genomics: Principle and Methodology by Cecilia Saccone,
- GrazianoPesole, Wiley-LISS publication (2003).
- Proteomics: From protein sequencing to function by S.R. Pennington and M.J. Dunn, Private Ltd (2001).
- Introduction to Proteomics by Daniel C, Liebler, Humana Press.
- Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
- Bourne, P. E., &Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss.
- Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press.
- Campbell, M &Heyer, L. J. (2006), Discovering Genomics, Proteomics and Bioinformatics, Pearson Education.

PS03EBIC24: Plant Biochemistry

UNIT I

Structure and biochemical aspects of specialized plant cell organelles – cell plate, primary and secondary cell walls, plasmodesmata, importance of vacuoles, Vacuole and tonoplast membrane, cell wall, plastids and peroxisomes, Characteristics of meristematic Cells.

Water relations of plants: transpiration, guttation, Water balance and Stress Physiology. Osmoprotectants

UNIT II

Photosynthesis - Light and pigments; Light dependent reactions of

Photosynthesis; Carbon metabolism – The Photosynthetic Carbon Reduction (PCR) cycle; Activation and regulation of the PCR cycle, The C4 syndrome, Crustacean Acid Metabolism (CAM), Regulation of C4 photosynthesis and CAM; Translocation and distribution of photo assimilates, Photorespiration, Factors affecting the rate of photosynthesis.

Synthesis and storage of polysaccharide: Starch, sucrose. Fructans and cellulose synthesis as photoassimilates produced by photosynthesis.

UNIT III

Nitrogen metabolism:

Biological Nitrogen fixation by free living and in symbiotic association, structure and function of enzyme Nitrogenase. Nitrate assimilation: Nitrate and Nitrite reductase. Primary and secondary ammonia assimilation in plants; ammonia assimilation by Glutamine synthetase-glutamine oxoglutarate amino transferase (GS-GOGAT) pathway.

Sulfate assimilation and synthesis of sulfur containing substance in plant

Plant Hormones - Growth regulating substances and their mode of action. Role of auxins, gibberellic acid, abscisic acid, cytokinins and brassinosteroids (synthesis and their role)

UNIT IV

Secondary metabolism - Special features, formation and functions of phenolic acids, tannins, lignins, flavonoid pigments, surface waxes, cutin and suberin – the plant protective waxes, terpenes.

Defence system in plants against biotic stresses- roles of phytoanticipins, NADPH oxidase, defense proteins, NO, phenolic compounds, jasmonic acid, ethylene and phytoalexins. Hypersensitive Reaction and Systemic Acquired Resistance (SAR); Induce Systemic Resistance (ISR); Resistance to virus by gene silencing. Genetic basis of pathogen resistance Pathogenesis Related (PR) Proteins.

Reference Books:

Plant Biochemistry by Hans- Walter Heldt; Elsevier Publication

Plant Physiology by Lincoln Taiz and Eduardo Zeiger; Sinauer Associates Inc Publishers

Introduction to Plant Physiology by William G. Hopkins and Norman P. A. Huner; Wiley

Semester IV

PS04CBIC21: Animal Biotechnology

Unit I:

Introduction to animal tissue culture (Historical background, Advantages of tissue culture, limitations, major differences in vitro, types of tissue culture)

Biology of cultured cells (Brief description on cell adhesion, cell proliferation, energy metabolism and origin of cultured cells)

General out-line of cell types (epithelial tissue, connective tissue, muscular tissue and nervous tissue)

Equipments and materials for animal cell culture technology (Inverted microscope, Laminar flow-hood, humid CO₂ incubator, centrifuges, refrigerators and other miscellaneous equipments) **Aseptic Techniques** (Objectives of aseptic techniques, elements of aseptic environment, sterile handling)

Sterilization (Different types - dry heat (hot air oven), wet heat (autoclaving), various chemical agents used in sterilization, irradiation techniques (UV and Gamma Ray)

Unit II

Defined media and supplements(Physicochemical properties, Balanced salt solutions, serum, selection of medium and serum)

Serum – Free Media (Disadvantages of serum, advantages of Serum -free media, Preparation of serum free media, Animal protein free media)

Primary culture (Initiation of primary cell culture, isolation of tissue, types of primary culture, , mechanical and enzymatic disaggregation)

Sub culture and cell lines (Subculture and propagation, routine maintenance, subculture of monolayer and suspension cultures)

Monitoring for contamination – Visible microbial contamination, Mycoplasma, Viral contamination, Eradication of contamination.

Unit III

Cell cloning and selection (Feeder layer, suspension cloning, separation of clones)

Cell separation (Centrifugation, Antibody based techniques, FACS)

Cell differentiation (Stem cell plasticity, markers of differentiation, induction of differentiation, differentiation and malignancy)

Transformation and Immortalization (Immortalization with viral genes, Immortalization of human fibroblasts, telomerase induced immortalization, Aberrant growth control, Tumorigenicity)

Characterization (Need for characterization, characterization based on cell morphology, DNA and RNA content, enzyme activity and antigenic markers)

Unit IV

Culture of specialized cells(Mammary epithelium, liver, epidermal keratinocytes, adipose tissue, muscle, glial cells, human astrocytes, lymphocytes, testis and ovary)

Stem cells, germ cells and aminocytes(Culture of embryonic stem cells, culture of

aminocytes, applications of stem cells)

Embryo technology (Embryo sexing, embryo splitting)

Assisted reproductive techniques (IVF, ISCI, ZIFT, GIFT)

Scale-up and automation (Scale – up in suspension and monolayer culture)

Three-Dimensional Cultures (Histotypic and organotypic cultures, tissue equivalents)

Basic Text and Reference Books:

1. Freshney, R. I. (2015). *Culture of animal cells: a manual of basic technique and specialized applications* (6thEdn) John Wiley & Sons.
2. Masters, J. R. (2000). *Animal cell culture: a practical approach* (3rdEdn) Oxford University Press
3. Butler, M., 2004. *Animal cell culture and technology*. Taylor & Francis.
4. Clynes, M. (Ed.). (2012). *Animal cell culture techniques*. Springer Science & Business Media.
5. Davis, J. M. (Ed.). (2011). *Animal cell culture: essential methods*. John Wiley & Sons.

PS04CBIC22: Nutritional & Clinical Biochemistry

Unit I

Basic concept- composition of human body: Energy content of food. Measurements of energy expenditure. Energy requirements of man, woman and factor affecting energy requirements, Basal metabolic rate, factor affecting BMR.

Carbohydrates- Dietary requirements and sources of available and unavailable carbohydrates and action of dietary fibers.

Disorders of carbohydrate metabolism: Diabetes mellitus; Metabolic syndrome, Glucose tolerance test; Glycogen storage diseases

Unit II

Proteins: protein reserves of body. Nitrogen balance studies and factor affecting it. Protein quality and essential amino acids. Cereal proteins requirement at different stages of development

Disorder of AA metabolism-phenylalaninemia, homocystinuria and tyrosinemia.

Disorders of purine and pyrimidine metabolism.

Protein energy malnutrition (PEM)-Marasmus and Kwashiorkor disease.

Starvation –protein metabolism in prolonged fasting, high proteins, low caloric weight reducing diets.

Unit III

Lipids-major classes of dietary lipids. Properties and composition of plasma lipoproteins. Essential fatty acid and their physiological function.

Clinical inter-relationship of lipids, lipoproteins and apolipoproteins.

Tests for apolipoproteins, HDL, LDL, cholesterol and Triglyceride disorder.

Obesity-factor leading to obesity –environmental and genetic. Role of leptin in regulation of body mass.

Unit IV

Electrolytes and water balance

Food processing and loss of nutrients during processing and cooking.

Anti-nutrients-naturally occurring food born toxicants, Protease inhibitors, hepatotoxins allergens, toxins from mushroom, animal and sea foods

Reference Books:

Harper's Illustrated Biochemistry by Murray, Granner and Rodwell 27th edition McGraw Hill

Food and nutrition by Swaminathan

Nutritional biochemistry and metabolism by Linten .

Biochemistry with clinical correlation: Devlin.

PS04EBIC23: Microbial Physiology

Unit-I

Bacterial Cell Structure and its type, Bacterial Cell surfaces, Bacterial Cell wall structure function and synthesis, Membrane transport in bacteria-simple, group translocation, ABC transporters, Protein export in bacteria–Type 1,2,3,4, Protein export pathways.

Bacterial capsules structure and importance.

Bacterial organs for locomotion: Flagella: structure, synthesis, function and mechanism of locomotion, Swarming motility, Motility in spirochetes, Gliding motility, Twitching.

Chemotaxis: Molecular mechanism and physiological significance.

Two component signal transduction in prokaryotes

Unit-II

Bacterial differentiation: endospore formation, physiological and genetic aspects of sporulation, Sporulation inducing signals & events in sporulation

Bacterial cell division: molecular mechanisms involved in formation of Z-ring, Cell division machinery.

Yeast cell division: Growth and cell division coordination, Cell division events, molecular basis of cell cycle and control.

Microbial stress responses: Oxygen toxicity, pH, Heat shock, Osmotic pressure, Osmolarity regulation in *E.coli* (Omp system) Phosphate assimilation in *E.coli* (Pho system), Nitrogen fixation in *Klebsiella* & *Rhizobium* (Ntr system).

Metabolism in Autotrophs, Methylophiles and Photoautotrophs

Unit-III

Bioluminescence: process, biochemistry, genetics and significance.

Mechanism of action of antibiotics and mechanisms of drug resistance.

Bacteriocins: Structure, Classification and physiological significance of it.

Microbial reserve compounds: Types, Synthesis and Applications

Siderophores; structure, function and significance

Bacterial biofilms formation steps, dispersion and control strategies

Unit-IV

Quorum sensing process in gram positive and gram negative bacteria.

Microbial fuel cells: Energy generation principle and application.

Microbial production of Hydrogen.

Host Parasite interactions: Structures and functions involved in Host-parasite interactions, Bacterial damages to host upon infection. Structure and Mechanism of Endotoxin, Exotoxin and Exoenzymes formed by bacteria.

The prokaryotic “immune system”, CRISPR/Cas

References:

- Bacterial signalling, Kramar and Jung
- Microbial Physiology, Moat, Foster and Spector
- The Physiology and Biochemistry of prokaryotes, David White
- Bacterial physiology: A molecular approach, W. E. Sharoud

Topic related review articles

PS04EBIC24: Plant Biotechnology

Unit-I

Cell & tissue culture in plants; callus cultures; in-vitro morphogenesis organogenesis and embryogenesis; Artificial Seeds, Micro propagation (Clonal propagation); Haploidy; anther and ovule cultures, Embryo cultures; Protoplast isolation, culture and protoplast fusion and somatic hybridization, Cybrids, Somaclonal Variation; in-vitro mutation methods; Virus elimination, pathogen indexing; Cryopreservation.

Unit-II

Production of secondary metabolites; Sources of plant secondary metabolites; criteria for cell selection, factors affecting the culture of cells; different bioreactors and their use in secondary metabolite production; biochemical pathways for the production of different secondary metabolites; and biotransformation.

Unit-III

Principles and methods of genetic engineering, and its applications in Agriculture. Methods for genetic transformation and transgenic plants production through *Agrobacterium tumefaciens* and *A. rhizogenes*; Gene transfer methods in plants; PEG mediated, microinjection, particle bombardment, electroporation, Molecular markers and their importance in plant breeding, Marker Assisted Selection (MAS).

Unit-IV

Molecular plant pathology: Mechanisms of disease resistance in plants against pathogens; Signalling pathways and molecular events during pathogen – plant interaction. Biotechnology and intellectual property rights (IPR); Plant genetic resources GATT & TRIPS; Patent for higher plant genes and DNA sequence.

Basic Text and Reference books:

- Plant biotechnology - J Hammond, et. al., Springer Verlag.
- Plant cell and tissue culture for production of food ingredients – T J Fu, G Singh, et. al.
- Biotechnology in crop improvement – H S Chawla.

- Practical application of plant molecular biology – R J Henry, Chapman & Hall.
- Elements of biotechnology – P K Gupta.
- An introduction to plant tissue culture – M K Razdan.
- Plant propagation by tissue culture: The technology (Vols. 1 & 2) – Edwin George.
- Handbook of plant cell culture (Vols. 1 to 4) – Evans et. al., Macmillan.
- Plant tissue and cell culture – H E Street, Blackwell Scientific.
- Cell culture and somatic cell genetics of plants (Vols. 1 to 3) – A K Vasil, A. Press.
- Plant cell culture technology – M M Yeoman.
- Plant tissue culture and its biotechnological applications – W Bary, et. al., Springer Verlag.
- Principles of plant biotechnology: An introduction to genetic engineering in plants – S H Mantel, et. al. Advances in biochemical engineering / Biotechnology – Anderson, et. al.
- Applied and fundamental aspects of plant cell tissue and organ culture edited by Reinert & Bajaj Y P S, Springer Verlag.
- Plant cell and tissue culture - S Narayanswamy, Tata Mc Graw Hill Co.

PS04EBIC25: IPR and Biosafety

UNIT-I

Biotechnology and society: Biotechnology and social responsibility, public acceptance issues in biotechnology, issues of access, ownership, monopoly, traditional knowledge, biodiversity, benefit sharing, environmental sustainability, public vs private funding. Social and ethical issues in biotechnology. Principles of bioethics. Ethical conflicts in biotechnology- interference with nature, unequal distribution of risk and benefits of biotechnology, bioethics vs business ethics.

UNIT-II

Bio- safety: Definition of bio-safety, Biotechnology and bio-safety concerns at the level of individuals, institutions, society, region, country and world.

Bio-safety in laboratory institution: laboratory associated infection and other hazards, assessment of biological hazards and level of biosafety.

Bio safety regulation: handling of recombinant DNA products and process in industry and in institutions.

UNIT-III

IPR I: Introduction to IPR: Forms of IPR and Intellectual property protection. Concept of property with respect to intellectual creativity, Tangible and Intangible property.

WTO: agency controlling trade among nations, WTO with reference to biotechnological affairs, TRIPs. WIPO, EPO.

UNIT-IV

IPR II: Concept related to patents novelty, non-obviousness, utility, anticipation, prior art etc. Type of patents. Indian patent act and foreign patents.

Patentability, Patent application, Revocation of patent, Infringement and Litigation with case studies on patent, Commercialization and Licensing.

References:

1. Fleming, D.A., Hunt, D.L., (2000). Biotechnology and Safety Assessment (3rd Ed) Academic press. ISBN-1555811804, 9781555811808.
2. Thomas, J.A., Fuch, R.L. (1999). Biotechnology and safety assessment (3rd Ed). CRC press, Washington. ISBN: 1560327219, 9781560327219
3. Law and Strategy of biotechnological patents by Sibley. Butterworth publication. (2007) ISBN: 075069440, 9780750694445.
4. Intellectual property rights- Ganguli-Tat McGrawhill. (2001) ISBN-10: 0074638602,
5. Intellectual Property Right- Wattal- Oxford Publication House. (1997) ISBN: 0195905024.
6. Biotechnology - A comprehensive treatise (Vol. 12). Legal economic and ethical dimensions VCH. (2nd ed) ISBN-10 3527304320.
7. Encyclopedia of Bioethics 5 vol set, (2003) ISBN-10: 0028657748.
8. Thomas, J.A., Fuch, R.L. (2002). Biotechnology and safety Assessment (3rd Ed) Academic press.
9. B.D. Singh. Biotechnology expanding horizons.
10. H.K.Das. Text book of biotechnology 3rd edition.

PS04EBIC26: Pharmacognosy**Unit-I**

Plants as sources of drugs, pharmaceuticals and pharmaceutical aids.

Ethnomedicobotany: Basic approaches to study traditional knowledge on herbal medicine; Scope and potential applications.

Unit -II

Collection methods of ethnomedicobotanical data: Field methods and scrutiny of Herbarium specimens and folklore; verification of data; collection of materials for voucher specimen and for phytochemical screening; application of ethnomedicobotany.

Creating indigenous knowledge base of traditional medicines of plant origin.

Unit-III

Pharmacognosy of drugs derived from alkaloids, glycosides, volatile oils, lipids, gums, resins, tannins and saponins. Drugs of botanical origin: Structure, physical properties and chemistry of secondary metabolites: phenols, phenolic glycosides, saponins, steroids, alkaloids.

Unit-IV

Vitamins and hormones and natural antibiotics.

Biosynthesis of important secondary metabolites such as Glycosides, alkaloids, terpenes and phenols in plants.

Methods for screening natural sources for bioactive principles.

References Books:

Dennis, D. T., D. H. Turpin, D. D. Lefebvre and D. B. Layzell : Plant Metabolism. Addison Wesley Longman Ltd. England.

Doby, G. : Plant Biochemistry. Inter Science Publishers, New York

Dey, P. M. and J. B. Horborne: Plant Biochemistry. Academic Press, London.

Lehninger, A. L., D. L. Nelson and M. M. Cox 2000: Principles of Biochemistry. CBS Publishers and Distributors, New Delhi.

Sadasivam, S. and A. Manickam : Biochemical Methods. 2nd edition. New Age International (P) Ltd. New Delh.

Voet, D., J. G. Voet and C. W. Pratt : Fundamentals of Biochemistry. John Wiley & sons, Inc. New York.

Zubay, G. : Biochemistry. Vol. 1 – 3. Wm. C. Brown Publishers, Oxford, England

Chadwick, D.J. & Marsh, J.: Bioactive compounds from plants
Wiley Chichester, CIBA Foundation Symposium 185: Ethnobotany and the search for new drugs

J.B. Harborne: Phytochemical methods
J.C. Willis: Pharmacognosy
C.K. Kokate: Pharmacognosy
Trease, G.E and Evans, W.C.: Pharmacognosy

PS04EBIC27: Endocrinology

UNIT I

General Principles of Endocrine Physiology :

- endocrine, paracrine, and autocrine; Definition of hormone, target cell, and receptor.
- mechanisms of action of peptides, steroids, and thyroid hormones; hormone actions exerted via plasma membrane receptors with those mediated via intracellular receptors.
- the role of hormone-binding proteins.
- the feedback control mechanisms of hormone secretion.
- the effects of secretion, degradation, and excretion on plasma hormone concentrations - the basis of hormone measurements and their interpretation.

The Hypothalamus and Posterior Pituitary Gland :

- The physiologic and anatomic relationships between the hypothalamus and the anterior and the posterior pituitary.
- The appropriate hypothalamic releasing and inhibitory factors controlling the secretion of each of the anterior pituitary hormones.
- Differences between the routes of transport of hypothalamic neuropeptides to the posterior and anterior pituitary.
- The mechanisms that control the release of oxytocin and ADH (arginine vasopressin, AVP); the cellular mechanisms of oxytocin and AVP action.

UNIT II

Thyroid Gland:

- The steps and control factors of thyroid hormone biosynthesis, storage, and release; the distribution of iodine and the metabolic pathway involved in thyroid hormone synthesis.
- Explain the importance of thyroid hormone binding in blood for free and total thyroid hormone levels.
- The significance of the conversion of tetraiodothyronine (T₄) to triiodothyronine (T₃) and reverse T₃ (rT₃) in extrathyroidal tissues.
- Cellular effects of thyroid hormones; their effects on development and metabolism; the causes and consequences of excess and deficiency of thyroid hormones.

Parathyroid Gland and Ca²⁺ and PO₄⁻ Regulation

- The origin, target organs and cell types, and physiologic effects of parathyroid hormone.
- The functions of osteoblasts and osteoclasts in bone remodeling and the factors that regulate their activities.
- The regulation of parathyroid hormone secretion and the role of the calcium-sensing receptor.
- The sources of vitamin D and the biosynthetic pathway involved in modifying it to its biologically active form and cellular mechanisms of action of vitamin D.
- The negative feedback relationship between parathyroid hormone and the biologically active form of vitamin D.
- The causes and consequences of excess or deficiency of parathyroid hormone and of vitamin D.
- The regulation of calcitonin release and the cell of origin and target organs for calcitonin action.

UNIT III

Adrenal Gland :

- The functional anatomy and zones of the adrenal glands and the principal hormones secreted from each zone.
- The regulation of synthesis and release of the adrenal steroid hormones (glucocorticoids, mineralocorticoids, and androgens) and the consequences of abnormalities in their biosynthetic pathways.
- The cellular mechanism of action of adrenal cortical hormones and their major physiologic actions, particularly during injury and stress.
- The regulation of mineralocorticoid secretion and relate this to the regulation of sodium and potassium excretion.
- The causes and consequences of oversecretion and undersecretion of glucocorticoids, mineralocorticoids, and adrenal androgens.
- The chemical nature of catecholamines and their biosynthesis and metabolic fate.
- The biologic consequences of sympatho-adrenal medulla activation and identify the target organs or tissues for catecholamine effects along with the receptor types that mediate their actions.
- The interactions of adrenal medullary and cortical hormones in response to stress.
- Diseases caused by oversecretion of adrenal catecholamines.

Endocrine Pancreas :

- The principal hormones secreted from the endocrine pancreas, their cells of origin, and their chemical nature.
- Understand the nutrient, neural, and hormonal mechanisms that regulate pancreatic hormone release.
- Insulin and glucagon action and their major physiologic effects;; The disease states caused by oversecretion, undersecretion, or decreased sensitivity to insulin.

UNIT IV

Reproductive Endocrinology:

Male Reproductive System:

- The physiologic functions of the principal components of the male reproductive system.

- The endocrine regulation of testicular function by gonadotropin-releasing hormone, follicle-stimulating hormone, luteinizing hormone, testosterone, and inhibin.
- The cell of origin for testosterone, its biosynthesis, mechanism of transport within the blood, metabolism, and clearance. List other physiologically produced androgens.
- List of the target organs or cell types, the cellular mechanisms of action, and the physiologic effects of testosterone.
- Spermatogenesis and the role of different cell types in this process; the neural, vascular, and endocrine factors involved in the erection and ejaculation response.
- The causes and consequences of androgen oversecretion and undersecretion in prepubertal and postpubescent adult males.

Female Reproductive System:

- Oogenesis, its relationship to follicular maturation, and the roles of pituitary and ovarian factors in their regulation.
- Gonadotropin control of ovarian function.
- The target organs and principal physiologic actions of estrogen and progesterone and how they interact with each other.
- The cellular mechanisms of action for estrogen and progesterone.
- The menstrual cycle.
- The pathways of sperm and egg transport required for fertilization and for movement of the embryo to the uterus.
- The principal endocrine functions of the placenta, particularly in rescue of the corpus luteum and maintenance of pregnancy, and the fetal adrenal-placental interactions involved in estrogen production.
- The roles of oxytocin, relaxin, and prostaglandins in the initiation and maintenance of parturition.
- The hormonal regulation of mammary gland development during puberty, pregnancy, and lactation, and explain the mechanisms
- Control of milk production and secretion.
- The physiologic basis for the effects of steroid hormone contraceptive methods.
- The age-related changes in the female reproductive system, including the mechanisms responsible for these changes, throughout life from fetal development to senescence.

Basic Text and Reference Books:

1. Molina P.A. (2013). *Endocrine Physiology* (4thEdn). Mcgraw Hill Lange
2. Bolander, F(2004) **Molecular Endocrinology** Third Edition. Academic press. SanDiego.
3. Holt, E.H. and Peery, H., (2010) **Basic medical endocrinology**. Academic Press.
4. Gard, P. R. (2002). *Human endocrinology*. CRC Press.