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UNIVERSITY OF MYSORE

Estd. 1916

VishwavidyanilayaKaryasoudha
Crawford Hall, Mysuru- 570 005

No.AC2(S)/164/2021-22

Dated: 27-01-2022

Notification

Sub:- Revision of the Syllabus of Molecular Biology (PG) with effective from the Academic year 2021-22

Ref:-
1. Decision of Board of Studies in Molecular Biology (PG) meeting held on 24-11-2021.
2. Decision of the Faculty of Science & Technology Meeting held on 20-12-2021.
3. Decision of the Academic Council meeting held on 23-12-2021.

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The Board of studies in Molecular Biology (PG) which met on 24-11-2021 has recommended to revision of the Syllabus of M.Sc. Molecular Biology Programme with effective from the Academic year 2021-22.

The Faculty of Science & Technology and Academic Council at their meetings held on 20-12-2021 and 23-12-2021 respectively have also approved the above said proposal and it is hereby notified.

The syllabus is annexed herewith and the contents may be downloaded from the University Website i.e., www.uni-mysore.ac.in.

DRAFT APPROVED BY THE REGISTRAR

27/01

Deputy Registrar (Academic)
University of Mysore
Mysore-570 005

Deputy Registrar(Academic)

To:-

1. The Registrar (Evaluation), University of Mysore, Mysuru.
2. The Chairman, BOS/DOS, in Molecular Biology (PG), Manasagangothri, Mysore.
3. The Dean, Faculty of Science & Technology, DoS in Earth Science, MGM.
4. The Director, Distance Education Programme, Moulya Bhavan, Manasagangotri, Mysuru.
5. The Director, PMEB, Manasagangothri, Mysore.
6. Director, College Development Council , Manasagangothri, Mysore.
7. The Deputy Registrar/Assistant Registrar/Superintendent, Administrative Branch and Examination Branch, University of Mysore, Mysuru.
8. The PA to Vice-Chancellor/ Registrar/ Registrar (Evaluation), University of Mysore, Mysuru.
9. Office Copy.

Department of Studies in Molecular Biology
University of Mysore
Molecular Biology Syllabus

Preamble

The subject "Molecular Biology" is a unique multi-disciplinary post-graduate degree programme offered by the University of Mysore (UOM) in its Manasagangotri campus. The course was started during 2015-16 as a part of the centenary celebrations of the UOM. The Department of Studies (DOS) in Biochemistry provided the necessary infrastructure to run the M.Sc. in Molecular Biology programme in the initial five years. In 2020, the Molecular Biology department got its independent existence and moved to the new building. The main objective of the department is to expose the students to modern biology without neglecting classical biological sciences and to develop the skills to build their career in research, academics, and industries in the field of life sciences. The department also offers a Ph.D. program in Molecular Biology. Since it is an upcoming department, it has both challenges and opportunities to grow. However, five batches of students have already graduated from this department and have been placed in various biological organizations. The alumni members of DOS in Biochemistry have generously contributed books, instruments, and other necessary infrastructure to the department by realizing the importance of Molecular Biology which will assist the growth of the department.

Molecular Biology is the branch of Biology that deals with the structural, functional and fundamental organization of macromolecules and their role in transfer of genetic information from one generation to next generation. The course deals with the structural organization and functions of biomolecules which is essential to learn any of the biochemical aspects of life irrespective of the organism. The syllabus also covers classical and applied branches of biology such as enzymology, immunology, toxicology, cell biology, gene expression, genetic engineering, membrane biology, genomics, neurobiology, and many more. The human body has trillions of cells and each cell undergoes multiplication in a regulated way. Every cell has its own physiological role and the cell commits itself to death after a defined time. Therefore, it is essential to understand the underlying mechanism of cell division, its regulation, the role of biomolecules in cell division, and how a cell is driven to death. Most of the cells in every organism replicate in order to produce daughter cells. Students learn the mechanism of transcription of DNA to RNA followed by translation to proteins. Importantly, the regulation of critical events in transcription and translation in prokaryotes and eukaryotes and role of

individual protein factors are being studied. The syllabus equips students to have a strong background in basics of Molecular Biology and provides the necessary knowledge and critical thinking skills that are essential to take up various teaching, research, and industrial assignments.

Choice Based Credit System (2021)

The Choice Based Credit System (CBCS) comprises Hard Core, Soft Core subjects for Molecular Biology Students and Open Elective for students other than Molecular Biology. Following shall be the minimum and maximum subjects per semester:

The credit pattern is Lecture: Tutorial: Practical (L:T:P) Pattern.

Lecture: One hour session of theory class per week in a semester is 1 credit.

Tutorial and Practical: Two-hour session of tutorial or practical per week in a semester is 1 credit.

One semester period is 16 weeks of teaching and learning.

Duration of semester is 20 weeks that includes semester end examinations.

Credit Pattern:

Hard Core: 3 – 6 Credits

Soft Core: 2 – 4 Credits

Open elective: 4 Credits

Project Work: 6 Credits

Credit distribution:

Course type	**Credits**
Hard Core	Minimum Credits - 42 and Maximum Credits - 52
Soft Core	Minimum Credits – 16
Open Elective	Minimum Credits - 4

- A Candidate can enrol for a Minimum of 18 Credits per semester (First two Semester) and maximum of 24 Credits per semester inclusive of Open Elective earned from the other Department
- A Candidate has to earn a minimum of 76 Credits for successful completion of a Master's degree in Molecular Biology
- A minimum 76 Credits and additional 18 Credits (76 + 18 = 94 Credits) shall acquire an add-on Proficiency Diploma.

Continuous Assessment Pattern:

Continuous Assessment	Time Duration	Marks		Minimum 30% and an aggregate of 40% to declare pass
		Max	Min	
C1	1 week to 8 weeks	15	4.5	
C2	9 week to 16 weeks	15	4.5	
C3	Complete 16 weeks	70	21	

Credit Distribution

Hard Core 48 Credits distributed as 12 credits in a semester

Soft Core 36 Credits distributed as 8 - 12 credits in a semester

Open Elective 8 Credits distributed as 4 credits in a semester in II and IV semesters

I Semester: (6 + 3 + 3) (3 + 3 + 3 + 3) (0) = (24 + 0 = 24) (18 to 24)

II Semester: (6 + 3 + 3) (3 + 3 + 2) (4) = (20 + 4 = 24) (18 to 24)

III Semester: (6 + 3 + 3) (3 + 3 + 2) (0) = (20 + 0 = 20) (20 to 24)

IV Semester: (6 + 3 + 3) (3 + 3 + 2) (4) = (24 + 0 = 24) (20 to 24)

Semester	Hard core	Soft core	Open elective	Total credits	Minimum & Maximum
I	6 + 3 + 3 (12)	3 + 3 + 3 +3 (12)	0	24 + 0	18 to 24
II	6 + 3 + 3 (12)	3 + 3 + 2 (8)	4	20 + 4	18 to 24
III	6 + 3 + 3 (12)	3 + 3 + 2 (8)	0	20 + 0	20 to 24
IV	3 + 3 + 6 (12)	3 + 3 + 2 (8)	4	20 + 4	20 to 24
Total	48	36	8	84+8	

Eligibility for admission: Students of Bachelors of Science degree from any UGC recognized Universities with life science subjects are eligible. Students from professional degrees such as Pharmacy, Dental, Agricultural, Medicinal, Veterinary, Engineering with Life Science are also eligible. Students from Foreign National degree will apply through equivalence committee. Minimum percentage of marks is as prescribed by the University of Mysore regulations for admission.

1st Semester (Minimum 18 and Maximum 24 credits)						
Sl. No.	**Title of the Paper**	**Course Type**	**Credit Pattern**			**Total Credits**
			L	**T**	**P**	
1	Biological Techniques	HC	2	1	0	3
2	Biomolecules	HC	2	1	0	3
3	Membrane Biology	SC	2	1	0	3
4	Basics of Microbiology	SC	2	1	0	3
5	Human Physiology and Nutrition	SC	2	1	0	3
6	Human Pathology	SC	2	1	0	3
7	Seminars and Practical-1	HC	0	2	4	6

2nd Semester (Minimum 18 and Maximum 24 credits)						
Sl. No.	**Title of the Paper**	**Course Type**	**Credit Pattern**			**Total Credits**
			L	**T**	**P**	
1	Gene Expression-I	HC	2	1	0	3
2	Enzymology	HC	2	1	0	3
3	Carbohydrates and Lipid Metabolism	SC	2	1	0	3
4	Protein and Nucleic Acid Metabolism	SC	2	0	0	2
5	Plant Biochemistry	SC	2	1	0	3
6	Evolutionary Biology	SC	2	1	0	3
7	Molecular Basis of Human Diseases	OE	3	1	0	4
8	Seminars and Practical-2	HC	0	2	4	6

3rd Semester (Minimum 20 and Maximum 24 credits)						
Sl. No.	**Title of the Paper**	**Course Type**	**Credit Pattern**			**Total Credits**
			L	**T**	**P**	
1	Gene Expression-II	HC	2	1	0	3
2	Molecular Cell Biology	HC	2	1	0	3
3	Molecular Immunology	SC	2	1	0	3
4	Cell Communications	SC	2	1	0	3
5	Microbial Technology	SC	2	0	0	2
6	Bioinformatics and Biostatistics	SC	2	1	0	3
7	Seminars and Practical-3	HC	0	2	4	6

4th Semester (Minimum 20 and Maximum 24 credits)						
Sl. No.	**Title of the Paper**	**Course Type**	**Credit Pattern**			**Total Credits**
			L	**T**	**P**	
1	Genetic Engineering	HC	2	1	0	3
2	Principles of Genetics	HC	2	1	0	3
3	Animal Biotechnology	SC	2	1	0	3
4	Plant Biotechnology	SC	2	1	0	3
5	Neurobiology and Toxicology	SC	2	0	0	2
6	Molecular Basis of Human Diseases	OE	3	1	0	4
7	Practical, Seminars, and Project work	HC	0	2	4	6

First Semester

Biological Techniques (Hard core - 3 credits/48 hours)

Course objective: This course deals with the principle and application of routine biochemical, chromatographic, spectroscopic, electrophoretic, and centrifugation techniques that are often used by biologists to understand biological processes. Last part also deals with use of radioactive substances in biology.

Course outcome: Upon completion of this course, students will be familiar with the various biological techniques used in biology and understand their applications.

Unit-I

Acids and Bases: Review of Lewis acids, Lowry-Bronsted, weak acids and bases. Buffers: Preparation of buffer, buffer capacity, pKa, Henderson-Hasselbach equation. 3 h

Water: Its essentiality to life. Water as biological fluid, special properties of water, buffer and pH. 2 h

Cell fractionation techniques: Cell lysis, homogenization, extraction, salting in, salting out, dialysis and ultrafiltration. 3 h

Centrifugation: Svedberg's constant, sedimentation velocity and sedimentation equilibrium, differential and density gradient centrifugation, centrifugal elutriation. 4 h

Unit-II

Chromatographic techniques: Principles and applications of paper, TLC, adsorption, ion exchange, gel filtration, affinity, GLC, chromatofocusing, HPLC and FPLC. 8 h

Electrophoretic techniques: Polyacrylamide gel electrophoresis (PAGE), SDS-PAGE, 2D-electrophoresis, diagonal, agarose gel electrophoresis, isoelectric focusing 4 h

Unit-III

Pulsed field electrophoresis, high voltage electrophoresis, capillary electrophoresis. Visualizing proteins, glycoproteins, lipoproteins, and nucleic acids. Zymogram and reverse zymogram. 4 h

Blotting techniques: Dot blot, Southern, Northern, Western blot, DNA foot print assay, DNA finger print assay, gel retardation assay, nuclease protection assay, RFLP, RAPD, PCR, RT-PCR, Microarray. 8 h

Unit-IV

Spectroscopic techniques: Principles of colorimeter, spectrophotometer, fluorimeter. Beer-Lambert's Law and its limitations. Extinction coefficient, fluorescent probes and their applications. 6 h

Radioisotopes in Biology: ^{3}H, ^{14}C, ^{32}P, ^{131}I, ^{35}S, concept of half-life, decay constant, detection and quantitation - GM counter and solid and liquid scintillation counter. Specific activity, autoradiography and its applications, carbon dating. 6 h

References:

1. Wilson, K. Walker J. M., (2010). Principles and techniques of biochemistry and molecular biology. (7th edition), Cambridge University Press.
2. Plummer, D. T., (2017). An introduction to practical biochemistry. (3rd edition), McGraw-Hill.
3. Cooper, A., (2011). Biophysical chemistry. (2nd edition), Cambridge, RSC Pub.
4. Cooper, T. G., (2011). The tools of biochemistry. New York London, Wiley.
5. Jackson, M. B., (2006). Molecular and cellular biophysics. Cambridge, Cambridge University Press.
6. Upadhyaya, Upadhyaya, and Nath (2016). Biophysical chemistry -Principles and techniques. (4th edition), Himalaya publishing house.

Biomolecules (Hard core - 3 Credits/48 hours)

Course objective: The objective of this course is to enable the students to obtain detailed knowledge about the biological molecules that are essential for the sustenance of life. The paper elaborates on structural and functional aspects of carbohydrates, amino acids, peptides, proteins, lipids, and nucleic acids.

Course outcome: Upon completion of this course, students will be able to explain the basic aspects of carbohydrates, amino acids, peptides, proteins, lipids, and nucleic acids. They will also be able to interpret the different structures of biomolecules and their implications in health and diseases.

Unit-I

Carbohydrates: Structure and classification of carbohydrates, monosaccharides, disaccharides and polysaccharides. Chemistry of monosaccharides: Pentoses, hexoses, deoxysugars, amino sugars, muramic acid, neuraminic acid. Linkages in sucrose, lactose and maltose, trehalose and glycosides. Chemistry of polysaccharides: Homopolysaccharides and heteropolysaccharides, starch, cellulose, glycogen, hyaluronic acid, chondroitin sulphate, chitin, xylans, bacterial cell wall polysaccharides, blood group polysaccharides. Glycoproteins and proteoglycans 9 h

Amino acids: Nomenclature, classification and buffering properties, zwitterionic structure, reaction of amino acids, unusual amino acids, non-protein amino acids. 3 h

Unit-II

Peptide bond: Features of the peptide bond, naturally occurring peptides; glutathione, enkaphalins and endorphins. Chemical synthesis of peptides. 4 h

Determination of primary structure: Sequencing strategies; N-terminal and C-terminal, sequencing methods. Automated sequanators. Determination of S-S-bond position. Secondary structure of protein; α, β-sheet, β-bend, β-turn and super secondary structures. Secondary structure prediction methods; Ramachandran plot, Chou and Fasman algorithm. Tertiary and quaternary structures. 8 h

Unit-III

Factors responsible for protein folding: Anfinsen's experiment. Weak forces of interaction; hydrogen bonding, Vander Waal's forces, London force, ionic interactions, hydrophobic interactions, S-S bridges, allolysine. Denaturation and renaturation of proteins, molten globule. 3 h

3D Structure of myoglobin, hemoglobin, immunoglobulin, collagen, and keratin. Chaperons and Levinthal paradox. 3 h

Lipids: Classification of lipids; oils, fats, and waxes. Occurrence and properties of fatty acids, esters of fatty acids, cholesterol, phospholipids, glycolipids, sphingolipids, cerebrosides, gangliosides, and eicosanoids (prostaglandins, leukotrienes, peptidoleukotrienes, lipoxins). 6 h

Unit-IV

Nucleic Acids: Isolation of DNA and RNA from biological sources. Physiochemical properties of nucleic acids, melting of DNA, Tm; factors affecting Tm, Cot curve, classification of DNA based on cot curve. Chemical reactions of DNA and RNA. 6 h

Sequencing of DNA: Maxam Gilbert method, dideoxy method. Chargaff's rule, secondary structure of DNA. Watson and Crick model; A, B and Z-DNA models of DNA structure. Secondary structure of tRNA and clover leaf model. Other secondary structural features in DNA, stem loop structure, palindromic sequences, cruciforms. DNA protein interaction; zinc finger, leucine zipper, helix-turn-helix, other motifs, DNA bending and kinks. 6 h

References:

1. Nelson, D.L, Lehninger, A.L, Cox, M.M., (2021). Lehninger's principles of biochemistry. (8^{th} edition), Macmillan.
2. Voet, D., Voet, J.G., (2012). Principles of biochemistry Biochemistry. (4^{th} edition) New York: J. Wiley & Sons.
3. Berg, J. M., Tymoczko, J. L., Stryer, L., (2019). Biochemistry. (9^{th} edition), W.H.Freeman & Co.
4. Satyanarayana, U., (2020). Biotechnology. (12^{th} edition), Books & allied publishing.

Membrane Biology (Soft core – 3 Credits/48 hours)

Course objective: To give a detailed and comprehensive knowledge on the physicochemical properties, functions, and dynamics of biomembranes.

Course outcome: On completion of the course, students will get insight into the various membrane models, membrane transport and the importance of membrane components in many physiological processes.

Unit-I

Biomembranes: Physicochemical properties of biological membranes; compositions, supra molecular organization. Membrane models- Gorter and Grendel model, Davson and Danielli model (sandwich), Robertson model (unit membrane), Green's protein crystal model, Singer and Nicholson's model (fluid mosaic). 8 h

Physico-chemical properties of membranes: membrane lipid phases, bilayer phase, non bilayer phase, phase transition, membrane potential, bilayer nature. 4 h

Unit-II

Membrane composition: lipids, proteins and carbohydrates and their lateral diffusion. Biogenesis of lipids and proteins, polarized cells, membrane domains; caveolae, rafts, membrane lipid and protein turnover, intracellular targeting of proteins. Biogenesis of subcellular organelles. 8 h

Muscle contraction: Mechanisms, role of calcium, calmodulin, phospholamban. 4 h

Unit-III

Methods to study of membrane structure: Lipid transfer proteins, phospholipases, chemical methods, amino-phospholipid translocation, TNBS reagent, freeze fracture and freeze etching. Lipid vesicles; liposome preparations and application, function of sterols in membranes. FRET, FRAP, single particle tracking, EM of membranes, calorimetry, confocal microscopy of membrane dynamics. Cell fusion, shedding of membrane. 12 h

Unit-IV

Membrane transport: Laws of diffusion across membranes, simple diffusion, facilitated diffusion and active transport. Glucose transporters, Ca2+ ATPase, Na+-K+ ATPase (Structure and mechanism of action), bacterial phosphotransferase system. Symport, uniport and antiport. Endocytosis, receptor mediated endocytosis, exocytosis, ion channels; gated and non-gated, aquaporin channel. 7 h

Nerve transmission: Acetylcholine receptor and neurotransmitters, mechanisms of nerve conduction, resting and action potential, ion channels, ionophores, patch clamp technique. Presynaptic and postsynaptic membranes. nicotinic and muscarinic neurons. GABA, NMDA, structure and function. 5 h

References:

1. Lodish, H., Berk. A., Chris, A., Kaiser, Krieger, M., Bretscher, A., Ploegh, H., Amon, A., Martin, K.C., (2016). Molecular cell biology. (8th edition), W.H. Freeman and company, New York.

2. Karp, G., (2015). Cell and Molecular Biology: Concepts experiments. (8th edition), John Wiley and sons, Inc.
3. DeRobertis and Saunders. (2017). Cell and Molecular Biology. (8th edition), Saunders College Publishers.
4. Nelson, D. L., Cox, M. M., (2017). Lehninger Principles of Biochemistry. (7th Edition), W.H.Freeman.
5. Voet, D., Voet, J. G., Pratt, C.W., (2016). Fundamentals of Biochemistry. (5th Edition), John Wiley and Sons Inc.
6. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., Walter, P., (2008). Molecular biology of the cell. (6th edition), Garland Science, Taylor & Francis Group.

Basics of Microbiology (Soft core – 3 Credits/48 hours)

Course objective: To introduce the students to the general aspects of microbes, chronological events of microbiology, routine microbial techniques, and to study host-microbe interactions.

Course outcome: Upon completion of this course, students will be able to understand the distribution, morphology, and physiology of microorganisms and their culturing methods.

Unit-I

Historical perspective: Discovery of microorganisms-contributions of Antony van Leeuwenhoek, Theory of spontaneous generation and biogenesis. Contributions of Edward Jenner, Louis Pasteur, Joseph Lister, Robert Koch, Metchnikoff, Beijerinck, Ivanowsky, Alexander Fleming, Selman Waksman. 6 h

Sterilization methods: Physical methods **(**dry heat-hot air oven, incineration, moist heat-autoclave, tyndallisation. Filtration- Types of filters. Laminar airflow. Radiation method- UV radiation). Chemical methods (disinfectants and antiseptics). 6 h

Unit-II

General characteristics: morphology, nomenclature and classification of bacteria, yeast, molds, fungi, actinomycetes, rickettesiae and protozoa. 3 h

Staining methods: Isolation and culture of microorganisms - aerobic and anaerobic culture methods, culture media. Isolation of pure colony, characterization. Types of stains, simple staining, negative staining, differential staining (Gram's staining and acid fast), endospore and flagella staining. 6 h

Strain improvement methods: Recombination using mutagens, protoplast fusion, r-DNA technology, selection of improved strains: Enrichment technique. 3 h

Unit-III

Microbial nutrition: Factors influencing growth, growth curve of bacteria. Measurement of growth, continuous culture, synchronous culture chemostat. Auxotrophs, autotrophs, heterotrophs, methods of cultivations and preservation of microorganisms. Uptake of nutrients- passive, facilitated, active (Binding-protein type), group translocation (PTS system) 6 h

Cultivation of Microbes: Media types. Pure culture techniques: Serial dilution, pour plate, spread plate and streak plate, cultural characteristics. Stress response, Preservation of pure cultures: subculturing, mineral oil overlay and lyophilisation. Microbial culture collection centers (ATCC, MTCC, ITCC). 6 h

Unit-IV

Viruses: Discovery of viruses, assay of viruses, classification based on nucleic acids, structure of typical viruses – Bacteriophage T4, TMV, HIV. Bacteriophages as antibiotics. Brief account on viroids and prions. 4 h

Mycoplasmas and Phytoplasmas: Importance and general characters, Ultrastructure and reproduction. Diseases caused by the Mycoplasma. Brief introduction to phytoplasmas and their diseases 2 h

Antibiotics: Discovery of antibiotics, mechanism of antibiotic resistance, ESKAPE organisms, new generation antibiotics. Antibiotics derived from bacteria, endophytes, and fungi. Metagenomics approach for the discovery of new antibiotics. 6 h

References:

1. Prescott, M.J., Harley, J.P., Klein, D.A., (2011). Microbiology. (11th edition), WCB McGraw-Hill, New York.
2. Dube, R.C., Maheswari, D.K., (2013). A textbook of Microbiology. (4th edition), S Chand, New Delhi.
3. Stanier, R.Y., Adelberg, E.A., Ingram, J.L., (1999). General Microbiology. (5th edition), Prentice Hall of India Pvt. Ltd., New Delhi.
4. Rao, A.S., (2004). Introduction to Microbiology. (13th edition), Prentice-Hall of India Pvt Ltd., New Delhi.
5. Pelczar, M.J., Chan, E.C.S., Krieg, N.R., Edwards, D.D.,. Pelczar, M.F., (2021). Microbiology: concepts and applications. (6th edition), Shree Hari publications

Human Physiology and Nutrition (Soft core – 3 Credits/48 hours)

Course objective: Human physiology paper will provide a thorough understanding of homeostatic functions of various organs and hormones. This paper will also provide basic knowledge on nutritional aspects of macro and micronutrients.

Course outcome: The students will have basic knowledge of each organ and its physiological functions, including the importance of human nutrition.

Unit-I

Introduction: Meaning and scope of animal physiology. Definition of cell types, tissue, organs and systems. 2 h

Circulatory system: Blood, composition, cells, plasma proteins and lipoproteins. Erythrocytes; shape and function. WBC; types, differential count and functions. Platelets and their function. Buffer systems, hemostasis, blood clotting, digestion of clot, anticoagulants, blood volume, blood pressure and their regulations. Plasma lipoproteins and their functions, HDL, LDL, VLDL, chylomicrons. 6 h

Nervous system: Structure of a neuron, nerve transmission, CSF; composition and function. 4 h

Unit-II

Respiratory System: Lungs, structure and functions, gas exchange, oxygen binding by hemoglobin, factors affecting oxygenation and acid-base balance. 4 h

Excretory System: Ultra structure of the nephron, glomerular filtration, formation of urine, acid - base balance. 3 h

Digestive System: GI tract, digestion and absorption of carbohydrates, proteins and lipids. Mechanism of HCI production in the stomach. Gastrointestinal hormones and role of pancreas in digestion. Basal metabolic rate (BMR), factors affecting BMR, specific dynamic action of foods. 5 h

Unit-III

Hepatobiliary System: Anatomy of the liver, blood supply, cells; hepatocytes, endothelial cells and Kupffer cells, secretory and excretory function and formation of bile. 3 h

Muscle physiology: Skeletal muscle and smooth muscle, muscle proteins; actin, myosin, tropomyosine, troponins. 3 h

Physiology of reproduction: Hormonal control of testicular and ovarian functions. estrous and menstrual cycle, implantation, gestation and parturition. Modern trends in reproduction – Invitro fertilization, cloning, sperm bank, artificial insemination, test tube baby. 6 h

Unit-IV

Introduction to endocrinology: Classification and functions of hormones produced by hypothalamus, pituitary, thyroid, parathyroid, pancreas. Adrenals, gonads and GI tract.

Abnormalities due to over and underproduction of the hormones secreted by pituitary, thyroid, parathyroid, pancreas, adrenals and gonads. Regulation of hormone production and release. Pineal gland – Melatonin and circadian rhythm 7h

Nutrition: Concepts of macro and micro nutrients, essential nutrients and their classification, minerals. Sources, structure, and deficiency of vitamins. 5 h

References:

1. Chatterjee, C.C., (2020). Human physiology. (13th edition), CBS Publishers.

2. Devlin, T.M., (2010). Textbook of biochemistry: with clinical correlations. (7th edition), John Wiley & Sons.

3. Guyton, C., Hall, J. E., (2020). Text book of Medical Physiology. (14th edition), Elsevier India Pvt. Ltd. New Delhi.

4. Tortora, G.J., Derrickson, B.H., (2020). Principles of Anatomy and Physiology. (15th edition), Wiley & Sons.

5. Sembulingam, K., (2018). Essentials of Medical Physiology. (8th edition), Jaypee publication, India.

6. Dr. Swaminathan, (2018). Handbook of Food and Nutrition. Bappco.

7. Srilaxmi, B., (2017). Nutrition Science. (6th edition), New Age International Publishers.

Human Pathology (Soft core – 3 Credits/48 hours)

Course objective: To understand pathophysiological significance of various human ailments, their diagnosis and treatment.

Course outcome: After completion of this course, students will be able to understand the underlying molecular mechanism of various human diseases, their diagnosis and treatment options.

Unit-I

Infectious diseases: Mycobacterial diseases (Tuberculosis and Leprosy), Bacterial diseases (Typhoid, Diphtheria, Gram negative infection, and Syphilis), Viral diseases (Polio, Herpes, Rabies, Measles, Rickettsia, COVID19), Fungal diseases, Parasitic diseases (Filaria, Amebiasis, Kala-azar) 12 h

Unit-II

Non-communicable diseases:

Disorders of carbohydrate metabolism: diabetes mellitus, classification, etiology, management. Laboratory investigations; GTT, HbAlc, diabetic complications and advanced glycation end products. 4 h

Hypertension: Types, complications, diagnosis 2 h

Liver diseases: causes of liver diseases, hepatitis, hemochromatosis, cirrhosis, jaundice (pre-hepatic, hepatic, and post-hepatic), diagnosis and treatment. 4 h

Diagnostic enzymes: Clinically important enzymes; alkaline phosphatase, AST, ALT and isoenzymes of creatine kinase and LDH. 2 h

Unit-III

Cardiovascular disorders: CVD, atherosclerosis, LDL oxidation, foam cell formation, thrombosis. Risk factors, Lifestyle modification. 4 h

Blood: Composition, cells, functions of plasma proteins and lipoproteins in diseases. Disorders of hemoglobin; thalassemia, sickle cell anemia. Anemias; microcytic, normocytic and macrocytic. 4 h

Endocrine disorders: disorders of under and over production of hormones 2 h

AIDS: Aetiology, modes of transmission, diagnostic procedures and handling of infected material and health education. 2 h

Unit-IV

Inborn errors of metabolism – Disorders of amino acid, lipid, and carbohydrate metabolism 5 h

Nutritional deficiency diseases: Vitamins, minerals, and protein-calorie malnutrition, steatorhea - symptoms, diagnosis and treatment. 3 h

Chromosomal basis of disorders: Variation in chromosome number and structure. 4 h

References:

1. Strayer, D.S., Saffitz, J.E., (2019). Rubin's Pathology: Mechanisms of Human Disease. (8th edition), Wolters Kluwer Health.
2. Buja, L.M., Krueger, G.R., (2013). Netter's Illustrated Human Pathology. (1st edition). Saunders.
3. Reisner, E., Reisner, H., (2016). Crowley's An Introduction To Human Disease. (10th edition), Jones and Bartlett.
4. Rubin, E., (2019). Principles of Rubin's Pathology. (7th edition), LWW.

Practical 1: Experiments in Biological and Microbial Techniques

12 h/week (Practical and Tutorials – 6 Credits)

1. Determination of molar extinction co-efficient of para-nitrophenol.
2. Estimation of protein by Biuret method.
3. Estimation of protein by Lowry's method.
4. Estimation of reducing sugars by dinitrosalicylic acid method.
5. Estimation of glucose by anthrone method.
6. Estimation of amino acids by ninhydrin method.
7. Determination of saponification value of oils.
8. Estimation of DNA by diphenylamine method.
9. Estimation of RNA by orcinol method.
10. Familiarising tools and equipment used in Microbiology.
11. Simple staining of bacterial culture.

12. Negative staining of bacterial culture.
13. Distinguishing of bacteria using Gram's staining.
14. Isolation of pure bacterial cultures and their characterization (streak, pour, and spread plating methods).
15. Enumeration of microorganisms from soil by serial dilution method.
16. Effect of disinfectants and antibiotics on the growth of bacteria.

Seminar: Each student has to give 15-min seminar with PowerPoint presentation on a assigned topic.

Second Semester

Gene Expression-I (Hard core – 3 Credits/48 hours)

Course objective: The objective is to offer detailed knowledge about the central dogma of Molecular Biology, concept of genome, mechanisms of DNA replication, gene expression and translation in prokaryotes and eukaryotes.

Course outcome: Upon completion of this course, students will have clear idea about the central dogma of Molecular Biology and the historical discoveries that led to our current understanding of molecular mechanisms of life. They will also be able to describe the organization of prokaryotic and eukaryotic genome, processes of transcription, posttranscriptional editing, translation, and posttranslational modifications.

Unit-I

Introduction: composition of RNA and DNA. Bases, Chargaff's rule. Types of RNA, structure of RNA and DNA, central dogma of molecular biology, classical experiments that demonstrated DNA as the genetic material. 4 h

DNA-antiparallel nature: Nearest neighbour base frequency analysis. Replication of DNA, semiconservative nature (Messelson and Stahl experiment). Replication of double stranded DNA, discontinuous replication, Okazaki fragments. DNA polymerase I II and III, DNA ligase, DNA topoisomerases. Fidelity of replication, replication in viruses, rolling circle model, single stranded DNA virus. Applications of mitochondrial DNA. Trombon model, translesion synthesis (DNA pol IV and V). 8 h

Unit-II

Transcription: Colinerity of genes and proteins, RNA polymerase I, II and III. RNA biosyntehsis in prokaryotes and eukaryotes; initiation, elongation and termination. RNA dependent RNA synthesis. Processing of eukaryotic RNA, cap addition, poly A tail addition, RNA editing. Processing of tRNA and mRNA transcripts. 8 h

Genetic code: Triplet codon, universality features of the genetic code, assignment of codons, studies of Khorana, Nirenberg, triplet binding techniques. 4 h

Unit-III

Wobble hypothesis, contributions of Francis Crick, deciphering of genetic code and codon usage. 4 h

Translation: 3D structure of prokaryotic and eukaryotic ribosomes, ribosomal protein synthesis; initiation elongation and termination. Role of mRNA and tRNA. Aminoacyl tRNA synthesis and its role in translation accuracy. 8 h

Unit-IV

Post-translational modification of proteins: Signal peptide cleavage, disulphide bond formation, O- and N-glycosylation, folding of nascent protein, role of chaperones, attachment of glycosyl anchor, and other modifications. 8 h

Enzymes in DNA and RNA degradation: Nucleases, ribonucleases, classification and role. 4 h

References:

1. Watson, J. D., (2017). Molecular biology of the gene. (7^{th} edition), Pearson publishing.
2. Karp, G., (2015). Cell and Molecular Biology: Concepts experiments. (8^{th} edition), John Wiley and sons, Inc.
3. Cooper, G. M., Hausman, R. E., (2015). The Cell: A Molecular Approach. (7^{th} edition), Sinauer Associates.

Enzymology (Hard core – 3 Credits/48 hours)

Course objective: To provide a detailed knowledge on structural and functional aspects of various enzymes including their nomenclature, classification, catalytic reactions, kinetics, and regulation.

Course outcome: After completion of this course, students will be familiar with classification, nomenclature, structure, metabolic regulation, and mechanism of action of enzymes.

Unit-I

General aspects: Nature of enzymes, localization, isolation, purification and characterization of enzymes. Criteria of purity of enzymes, fold purity. Nomenclature and IUB classification of enzymes. Enzyme specificity, specific activity, assay methods; coupled enzyme assays, continuous, end point and kinetic assay. Units of enzyme activity, IU and Katal. 8 h

Rate of a reaction, order and molecularity. I order reaction kinetics. Rectangular hyperbola, Michaelis-Menten equation as rectangular hyperbola, linear transformation, calculation of slope, intercept. 4 h

Unit-II

Enzyme kinetics: Michaelis-Menten equation for uni substrate reactions, initial velocity approach, steady state approach. Vmax, Km and their significance. Linear transformation of Michaelis-Menten equation; Lineweaver-Burk plot, Eadie-Hofstee, Wolf and Cornish-Bowden. Scatchard plot. 5 h

Inhibition: Reversible and irreversible inhibition; competitive, non-competitive, uncompetitive product inhibition and suicide inhibition.

Determination of Ki and Kd. 2 h

Cooperativity: Binding of ligands to macromolecules; Scatchard plot, positive and negative cooperativity. Oxygen binding to hemoglobin. Hill equation, homotropic and heterotropic effectors, aspartyltranscarbamylase as an allosteric enzyme. 5 h

Unit-III

Bisubstrate reaction: Cleland's notation with examples of ordered, ping-pong, and random reactions. General rate equation. 2h

Mechanisms of enzyme catalysis: Active site structure; methods of determining active site structure. Isolation of ES complex, affinity labeling, chemical modification studies, site directed mutagenesis. 4 h

Nature of enzyme catalysis: Transition state theory, proximity and orientation, orbital steering, acid base catalysis, covalent catalysis, metal ion catalysis, nucleophilic and electrophilic catalysis, intramolecular catalysis, entropy effects. Effect of temperature and pH on enzyme catalysed reaction. 4 h

Metabolic regulation of enzyme activity: Feedback regulation, fine control of enzyme activity. Fast reactions-Stopped flow, temperature jump method with examples of enzymes. 2h

Unit-IV

Mechanisms of action of specific enzyme: Chymotrypsin; zymogen activation, acid-base catalysis, charge relay network. Lysozyme, alcohol dehydrogenase, ribonuclease, carboxypeptidase A, RNA as an enzyme, abzymes, coenzymic action of NAD+, FAD, TPP, PLP, Biotin, CoA, folic acid and lipoic acid. 8 h

Isoenzymes: LDH, multifunctional enzymes (DNA polymerase) and multi enzyme complex (PDC). 4 h

References:

1. Nelson, D.L., Lehninger, A.L., Cox, M.M., (2021). Lehninger's Principles of Biochemistry. (8th edition), Macmillan.
2. Palmer, T., Bonner, P.L., (2008). Enzymes: Biochemistry, Biotechnology, Clinical chemistry. (2nd edition), Elsevier.
3. Voet, D., Voet, J.G., (2012). Principles of Biochemistry. (4th edition), J. Wiley & Sons.
4. Dixon, M., Webb, E., (1993). Enzyme inhibition and activation. (3rd edition), Enzymes 3: 126-136.
5. Price, N.C., Frey, P.A., (2009). Fundamentals of Enzymology, Biochemistry and Molecular Biology. (3rd edition), Oxford university press.
6. Methods in enzymology volume series. ISSN: 0076-6879. Academic press.

Carbohydrate and Lipid Metabolism (Soft core – 3 Credits/48 hours)

Course objective: This course will enable the students to understand various anabolic and catabolic pathways along with their bioenergetics in carbohydrate and lipid metabolism.

Course outcome: Upon completion of this course, students will have a deep knowledge of carbohydrate and lipid metabolism along with their regulatory mechanisms.

Unit-I

Introduction - Catabolism, anabolism, catabolic, anabolic and amphibolic pathways. 2 h

Carbohydrates: Cellular ingestion of glucose, glycolysis, energetics regulation. Pathways of utilization of pyruvate-lactate, ethanol, gluconeogenesis, regulation, Cori cycle, glucose paradox, citric acid cycle its regulation, energetics, anaplerosis, glyoxylate cycle. 6 h

HMP shunt pathway, interconversion of hexoses. Utilization of non-glucose sugars. Biosynthesis of sucrose, starch and glycogen. 4 h

Unit-II

Lipids: Degradation of triacylglycerols, phospholipids and sphingolipids and regulations; Fatty acid degradation; β-oxidation Knoop's experiment, saturated and unsaturated fatty acids. 4 h

Regulation, α and ω oxidation. Energetics and biosynthesis of fatty acids; fatty acid synthetase complex, chain elongation and desaturation. Pathways in plants and animals, conversion of linoleate to arachidonante. 4 h

Phospholipid biosynthesis and regulations: De novo pathway and interconversion, biosynthesis of phospholipids, sphingolipids, ether lipids and glycolipids. Biosynthesis of prostaglandins, thromboxanes, and leukotrienes. 4 h

Unit-III

Cholesterol metabolism: Metabolism of circulating lipids; chylomicrons, HDL, LDL and VLDL. Reverse cholesterol transport by HDL, regulation of cholesterol biosynthesis, cholesterol lowering drugs 2 h

Integration of metabolic pathways: Integration of carbohydrate and lipid metabolism, and their regulation and manipulation. 3 h

Thermodynamics: I, II and III laws of thermodynamics. Enthalpy, entropy, free energy and chemical equilibrium. 2 h

High energy compounds: Energy currency, ATP, ADP, creatine phosphate, phosphoenol pyruvate as energy rich compound 3 h

Substrate level phosphorylation, futile cycles and their application. 2 h

Unit-IV

Mitochondrial electron transport: Entry of reducing equivalents for oxidation; malate-aspartate shuttle, glycerol phosphate shuttle. Organization of respiratory chain complexes, structure and function of the components; Fe-S proteins, cytochromes, Q cycle, proton

transfer, P/O ratio, respiratory control, oxidative phosphorylation, uncouplers and inhibitors, sequence of electron carriers based on redox potentials. 7 h

ATP synthesis, ATP synthase complex, binding change mechanism, proton motive force, Mitchell's hypothesis. 5 h

References:

1. Cox, M. M., Nelson, D. L. (2021). Lehninger principles of biochemistry. (4th edition), W.H. Freeman & Co.
2. Berg, J. M., Tymoczko, J. L., Stryer, L., (2019). Biochemistry. (9th edition), W.H. Freeman & Co.
3. Murray, R. K., Granner, D. K., Mayes, P. A., Rodwell, V. W., (2014). Harper's illustrated biochemistry. Mcgraw-hill.
4. Voet, D., Voet, J. G., Pratt, C. W., (2016). Fundamentals of Biochemistry: life at the Molecular level. (5th edition), John Wiley & Sons.
5. Garrett, R. H., Grisham, C. M., (2012). Biochemistry. (5th edition), Cengage learning.

Protein and nucleic acid metabolism (Soft core – 2 Credits/32 hours)

Course objective: This course will enable the students to understand various anabolic and catabolic pathways of amino acids, proteins, and nucleic acids.

Course outcome: Upon completion of this course, students will have a deep understanding of amino acids, protein and nucleic acid metabolism along with their regulatory mechanisms.

Unit-I

Proteins: General mechanisms of degradation in cells; ubiquitin-proteasome pathway, lysosomal pathway, N-end rule, PEST sequence in protein stability. 3 h

Degradation and biosynthesis of glycoproteins and proteoglycans. 2 h

General mechanisms of amino acid metabolism and regulations: Role of cofactors; PLP and THF in amino acid metabolism. Deamination, transamination, decarboxylation desulphuration process. 3 h

Unit-II

Degradation and biosynthesis of individual ammo acids: Aliphatic, aromatic, and branched chain amino acids, regulation of amino acid biosynthesis, transglutaminase cycle, urea cycle. 8 h

Unit-III

Biosynthesis of cofactors: NAD+, FAD and coenzyme A. 2 h

Purines and pyrimidines: Pathways of degradation of nucleic acids, purines and pyrimidines, uric acid formation. Salvage pathways, de novo biosynthetic pathways and regulations. 6 h

Unit-IV

Inborn errors of nucleic acid and amino acid metabolism: Gout and Lysch-Nyhan syndrome, Toxoplasmosis. Conversion of nucleotides to deoxynuclotides. Mechanism of action of methotrexate, 5-fluorouridine, pentostatin, azathymidine. Phenylketonuria, alkaptonuria, maple syrup urine. 6 h

Polyamine biosynthesis and their metabolic role. 2 h

References:

1. Cox, M. M., Nelson, D. L., (2021). Lehninger Principles of Biochemistry. (8th edition), W.H. Freeman & Co.

2. Berg, J. M., Tymoczko, J. L., Stryer, L., (2019). Biochemistry. (9th edition), W.H.Freeman & Co.

3. Murray, R. K., Granner, D. K., Mayes, P. A., Rodwell, V. W., (2018). Harper's illustrated biochemistry. (31st edition), Mcgraw-hill.

4. Voet, D., Voet, J. G., Pratt, C. W., (2016). Fundamentals of biochemistry: life at the Molecular level. (5th edition), John Wiley & Sons.

Plant Biochemistry (Soft core – 3 Credits/48 hours)

Course objective: The primary objective of this course is to provide basic knowledge of various biochemical reactions occurring in plants including secondary metabolite production, stress responses, and host – pathogen interactions.

Course outcome: Upon completion of this course, the students will understand the structure, function, and biosynthetic pathways of various phytochemicals along with their pharmacological importance.

Unit-I

Photosynthesis: Photosynthetic apparatus in plants, photosystems I and II, light harvesting antenna complex. 4 h

Electron flow and photophosphorylation; cyclic and noncyclic, oxygen evolution, Calvin cycle. C3, C4 and CAM cycle. Photorespiration, bacterial photosynthesis. Regulation of photosynthesis. RUBISCO. 8 h

Unit-II

Nitrogen metabolism: Importance of nitrogen in biological systems, nitrogen cycle. nitrogen fixation; symbiotic and nonsymbiotic, nitrogenase complex, energetics, and regulation. Formation of root nodules in legumes. Assimilation of nitrate and ammonium ion. 6 h

Plant hormones: Biosynthesis, storage, breakdown and transport. Physiological effects and mechanisms of action of auxines, gibberlines, cytokinins, ethylene, abscisic acid. 4 h

Stress physiology: Responses of plants to biotic (pathogen and insects) and abiotic (water, temperature and salt stresses; mechanisms of resistance to biotic stress and tolerance to abiotic stress. 2 h

Unit-III

Sensory photobiology: Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins, stomatal movement, photoperiodism and biological clocks. Seed dormancy, inception of germination. Growth regulators of germination, juvenility, vernalization. 6 h

Solute transport and photo assimilate translocation: Uptake, transport and translocation of water, ions, solutes, and macromolecules from soil through xylem and phloem. Transpiration, mechanisms of loading and unloading of photoassimilates. 6 h

Unit-IV

Phytochemicals: Extraction, fractionation and characterization. 2 h

Secondary metabolites - Terpenes, phenolics, flavonoids, nitrogenous compounds as source of therapeutics, and role of secondary metabolites in plant physiology. 5 h

Host parasite interaction: Recognition and entry processes of different pathogens like bacteria, viruses, alteration of host cell behavior by pathogens, virus-induced cell transformation, pathogen-induced diseases in plants, cell-cell fusion in both normal and abnormal cells and defence system in plants. 5 h

References :

1. Dey, P.M., Harborne, J.B., (2013). Plant Biochemistry. (1st edition), Hart Court Asia Pte Ltd.
2. Goodwin and Mercer, (2005). Introduction to Plant Biochemistry. (2nd edition), CBS Publisher.
3. Buchanan, B., Greussem W., Jones, R., (2015). Biochemistry and Molecular Biology of Plants. (2nd edition), AAPS.
4. Lea, P.J., Leegood, R. C., (1998). Plant Biochemistry and Molecular Biology. (2nd Edition),Wiley
5. Heldt, H., Piechulla, B., (2004). Plant Biochemistry. (3rd edition), Academic Press.
6. Tiaz, L., Zeiger, E., (2018). Fundamentals of Plant Physiology. (6th edition), OUP, USA.

Evolutionary Biology (Soft core – 3 Credits/48 hours)

Course objective: This paper offers different concepts of evolution in a chronological order, and also proposes the theories associated with adaptation, survival ability, and origin of species.

Course outcome: After completion of this course, students will have a detailed knowledge on various concepts and theories of evolution including the formation of complex multicellular organisms from the first cell.

Unit-I

Emergence of evolutionary thoughts: Lamarck; Darwin–concepts of variation, adaptation, struggle, fitness and natural selection. 4 h

Mendelism; spontaneity of mutations; the evolutionary synthesis. Basis for Darwin's theory; confounding observations from embryology, comparative anatomy and biochemistry. Haeckel's drawings of embryos to fit the theory of evolution. 8 h

Unit-II

Origin of cells and unicellular evolution: Origin of basic biological molecules; abiotic synthesis of organic monomers and polymers; concept of Oparin and Haldane; experiment of Miller (1953); the first cell; evolution of prokaryotes; origin of eukaryotic cells; evolution of unicellular eukaryotes; anaerobic metabolism, photosynthesis and aerobic metabolism. 12 h

Unit-III

Molecular evolution: Concept of Neutral theory of evolution. Molecular divergence and molecular clocks, molecular tools in phylogeny, classification and identification; protein and nucleotide sequence analysis; origin of new genes and proteins; gene duplication and divergence. 12 h

Unit-IV

Evolutionary history: Major events in the evolutionary time scale; origins of unicellular and multicellular organisms; major groups of plants and animals. Punctuated equilibrium and phylectic gradualism, stages in primate evolution including Homo. 4 h

Geological time scale, prebiotic conditions. Dating of fossils, different methods, current controversies concerning theory of evolution. 4 h

Controversies concerning evolution of prokaryotes vs. eukaryotes, birds vs. dinosaurs, age of humans, asexual vs. sexual reproduction, cold blooded vs. warm blooded; living fossils, evolution of birds and dinosaurs, hoaxes and falsification of data (Javaman). 4 h

References :

1. Hall, B. K., Hallgrimsson, B., (2013). Strickberger's Evolution. (5th edition). Jones and Bartlett Publishers.
2. Rastogi, V. B., (2017) Organic Evolution. (13th edition). Meditech.
3. Strickberger, M. W., (2000). Evolution. (3rd edition). Jones and Bartlett Publishers.

Molecular Basis of Human Diseases (Soft core – 4 Credits/48 hours)

Course objective: This course will enable the open-elective students from other disciplines to understand the basic pathobiology of communicable and non-communicable diseases.

Course outcome: Upon completion of this course, student will be familiar with various diseases, disease causing organisms and pathobiology associated with them.

Unit-I

Infectious diseases:

Mycobacterial diseases (Tuberculosis and Leprosy), Bacterial diseases (Typhoid, Diphtheria, Gram negative infection, and Syphilis), Viral diseases (Polio, Herpes, Rabies, Measles, Rickettsia), Fungal diseases, Parasitic diseases (Filaria, Amebiasis, Kala-azar) 12 h

Unit-II

Non-communicable diseases:

Diabetes: Types, GTT, Role of insulin, progression, complications and treatment.

Hypertension: Types, complications, diagnosis

Cancer, types, risk factors, treatment 8 h

Chromosomal basis of disorders: Variation in chromosome number and structure. 4 h

Unit-III

Diseases of vital organs:

Diseases of the liver-causes of liver diseases, hepatitis, cirrhosis jaundice, diagnosis and treatment. 5 h

Heart - CVD, CHD, atherosclerosis, LDL oxidation, foam cell formation, plaque formation, plaque rupture, thrombosis. Risk factors, Lifestyle modification. 5 h

Endocrine disorders – disorders of under and over production of hormones 2 h

Unit-IV

Inborn errors of metabolism – Disease of amino acid metabolism, lipid metabolism, carbohydrate 6 h

Nutritional deficiency diseases: Vitamins, mineral and protein-calorie malnutrition. Symptoms, diagnosis and treatment. 3 h

AIDS: Aetiology, modes of transmission, diagnostic procedures and handling of infected material and health education. 3 h

References:

1. Murray, R. K., Granner, D. K., Mayes, P. A., Rodwell, V. W., (2018). Harper's illustrated biochemistry. (31st edition), Mcgraw-hill.
2. Delvin, T. M., (2010). Textbook of biochemistry with clinical correlations. (7th edition), Wiley & Sons.
3. Cox, M. M., Nelson, D. L., (2021). Lehninger Principles of Biochemistry. (8th edition), W.H. Freeman
4. Oser, B. L., (2012). Hawk's Physiological Chemistry. (14th edition), McGraw-Hill.

Practical 2: Experiments in Metabolism and Enzymology

12 h/week (Practical and Tutorials – 6 Credits)

1. Isolation of invertase from yeast/Calotropis gigantia and determination of its specific activity.
2. Determination of optimum pH of invertase.
3. Determination of optimum temperature of invertase.
4. Determination of optimum time of invertase.
5. Determination of K_m and V_{max} of invertase.

6. Determination of effect of heavy metals on the activity of invertase.
7. Isolation of esterase from green peas and determination of its specific activity.
8. Determination of specific activity of salivary amylase from human saliva.
9. Estimation of urea by DAMO method.
10. Estimation of keto acid by DNPH method.
11. Estimation of creatinine by picric acid method.
12. Estimation of inorganic phosphate by Fiske-Subbarow's method.
13. Extraction of phospholipids from egg yolk.
14. Glucose tolerance test

Seminar: Each student has to give 15-min seminar with PowerPoint presentation on a topic from the assigned subjects.

Third Semester

Gene Expression-II (Hard core – 3 Credits/48 hours)

Course objective: The objective is to offer detailed knowledge about the regulatory aspects of gene expression at the level of DNA structure, transcription, and translation in prokaryotes and eukaryotes. The course also elaborates on the role of various non-coding RNAs in regulation of gene expression.

Course outcome: At the end of this course, students will be able to explain the basic concepts of gene expression regulation from prokaryote to eukaryotes.

Unit-I

Gene structure: Structural organization of prokaryotic and eukaryotic gene. Complexity of gene in eukaryotes. 2 h

Regulation of gene expression in prokaryotes: Operon model; lac operon, structure and regulation. Galactose operon; role of two promoters. Arabinose operon; positive control. Tryptophan operon; repression and attenuation control. 8 h

DNA binding protein motifs: Zinc finger, leucine zipper, helix-turn-helix and other motifs. 2 h

Unit-II

Regulation of gene expression at the level of DNA structure: Structure of nucleosome, Chromatin structure (euchromatin and heterochromatin regions), Chromatin remodeling, Swi/Snf, histone code-acetylation, deacetylation, methylation, demethylation, phosphorylation and other histone modifications. DNA methylation by DNMTs. Role of nucleosome structure in eukaryotic gene expression: glucocorticoid gene, DNA kinking and bending, ChIP assay. 10 h

Regulation at the level of transcription: Transcription factors and their classification, cis-acting elements, transacting elements, transacting factors, promoter-proximal elements 2 h

Unit-III

Regulation at the level of translation: Secondary structure in the 5' and 3' untranslated region (regulation of ferritin and transferrin mRNA). Role of upstream AUG codons (GCN 4 gene regulation), trans-splicing, inteins, Role of aminoacyl tRNA synthetases in the regulation of accuracy of translation. 6 h

Regulation at the level of RNA processing and translation: RNA export, RNA stability, RNA degradation, Degradation mRNAs that are incomplete or have premature stop codons, Rescue of ribosomes that translate broken mRNAs by SsrA RNA 6 h

Unit-IV

Codon for selenocystiene, alternative splicing, Role of activators and repressors in alternative splicing. 4 h

Gene expression regulation by non-coding RNAs: Types of RNAs- miRNA, long noncoding RNA, circRNA, piRNA, siRNA. LncRNA in gene expression regulation (Xist in X-chromosome inactivation), miRNA in gene expression regulation, riboswitches in regulation of transcription and translation (glucosamine-6-phosphate and SAM sensors), biogenesis of miRNA, bacterial small RNAs. 8 h

References:

1. Watson, J. D., (2017). Molecular biology of the gene. (7^{th} edition), Pearson publishing.
2. Karp, G., (2015). Cell and Molecular Biology: Concepts experiments. (8^{th} edition), John Wiley and sons, Inc.
3. Cooper, G. M., Hausman, R. E., (2015). The Cell: A Molecular Approach. (7^{th} edition), Sinauer Associates.

Molecular Cell Biology (Hard core – 3 Credits/48 hours)

Course objectives: This course will enable the student to understand the cell structure and cell organelles. This course will also emphasize on molecular aspects of cell division, cell death, and oncogenesis.

Course outcome: Upon completion of this course, students will understand the structure and function of cell organelles and their functioning during health and diseases.

Unit-I

The origin and evolution of cells: From molecules to cell, from prokaryotes to Eukaryotes, from single cells to multicellular organisms, endosymbiotic theory. 2 h

Microscopy as a tool in cell biology: Microscopy - compound and light microscope, electron microscope (SEM, TEM), confocal microscopy, fluorescence microscopy, phase contrast microscopy, use of flow cytometry for sorting cells. 4 h

Compartmentalization in cells: Overview and role of cell organelles-cytosol, endoplasmic reticulum, the Golgi apparatus, lysosomes and Peroxisomes, ribosomes, vesicles, vacuoles, mitochondria, chloroplast, nucleus, nucleolus, nuclear membrane, centrioles and cell wall. 6 h

Unit-II

Cell cycle: cell cycle overview, cell cycle check points, cell cycle regulatory genes, cyclins (D, E, A, and B), cyclin dependent kinases, phase transition regulation (G1-S, S-G2, G2-M), S phase replication initiation regulation by CDKs and MCM proteins, role of microtubule & kinesin, dynein in anaphase, anaphase promoting complex, and cytokinesis. Mitosis and meiosis, comparison of cell division in prokaryotes and eukaryotes. 10 h

Cell junctions: Plasmodesmata, gap junction, septate junction 2 h

Unit-III

Cytoskeletal elements: cytoskeleton, microfilaments, microtubules, lamins, and intermediate filaments. 3 h

Extracellular matrix and cell adhesion molecules: Proteoglycans, glycosaminoglycan (hyaluronic acid), fibres (collagen, elastin), fibronectin. Integrins, selectins, cadherins, classification and role in maintaining cell integrity. 6 h

Stem cells: Origin of stem cells, differentiation, development, and applications. 3 h

Unit-IV

Cell death: Apoptosis, necrosis, autophagy, ferroptosis. Apoptosis – biochemical changes in cell, extrinsic pathway, intrinsic pathway, caspases, Bcl-2 family proteins, intracellular inhibitors of apoptosis. 6 h

Cancer: Properties of cancer cells, oncogenes, tumor-suppressor genes, mutations, virus-induced cancers, cancer markers, therapeutic targets and interventions. 6 h

References:

1. Lodish, H., Berk, A., Kaiser, C. A., Kaiser, C., Krieger, M., Scott, M. P., Matsudaira, P., (2016). Molecular cell biology. (8th edition), Macmillan.

2. Karp, G., (2015). Cell and Molecular Biology: concepts and experiments. (8th edition), John Wiley & Sons.

3. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Watson, J. D., (2008). Molecular Biology of the Cell. (5th edition), Garland Science.

4. Cooper, G. M., (2019). The Cell: a Molecular Approach. (8th edition), Oxford University Press.

5. Gilbert, S. F., (2020). Developmental Biology, the stem cell of biological disciplines. (12th edition), Oxford University Press.

6. Pollard, T. D., Earnshaw, W. C., Lippincott-Schwartz, J., Johnson, G., (2017). Cell Biology. (3rd edition), Elsevier Health Sciences.

Molecular Immunology (Soft core – 3 Credits/48 hours)

Course objective: To provide a comprehensive aspect about the principles of immune system and its disease relevance at molecular level.

Course outcome: On completion of the course, students will understand the importance of immune cells, immune system, and immunological responses. The course also emphasises on immunological diseases, organ transplantation, vaccine production, and associated techniques.

Unit-I

Introduction: Historical development and milestones in immunology. Definitions; antigenicity, immunogenicity, innate and acquired immunity. Primary and secondary lymphoid organs, self and non-self-discrimination. Antigens and antibodies; haptens and determinants, epitopes and paratopes. Antigenicity, carbohydrates, proteins, nucleic acids, and cells as antigens. Valency of antigen, epitope analysis. 8 h

Classes and subclasses of immunogloblins, structure of immunoglobulins, hyper variable region; isotypic, allotypic and idiotypic variation. 4 h

Unit-II

Cellular Basis of Immunity: Primary and secondary immune response. Reticuloendothelial system, B and T and accessory cells. Development of B and T cells. Sub sets of B and T cells. T-helper cells, T-killer cells, T-suppressor cells. B and T cell receptors, antigen processing and presentation. B and T interaction. Cytokines and co-stimulatory molecules; lymphokines, interleukins, structure and function of IL-lβ, IL-2, TNFα. Suppression of immune response, immunoglobulin genes, generation of immunoglobulin diversity, gene rearrangement and other mechanisms, clonal selection theory of Burnet. 9 h

Vaccines: Adjuvants, vaccines and their preparations. Polyclonal and monoclonal antibodies; hybridoma technique. 3 h

Unit-III

MHC: MHC gene and its polymorphism, role of MHC in immune response and transplantation. 4 h

Non-specific defenses in man: Barriers to infection; skin, mucous membrane, inflammation, complement hyper sensitivity reactions (Type I, II, III and IV). 4 h

Tumour immunology: Tumour associated antigens, factors favoring tumour growth, immune surveillance. Tumour necrosis factor α and β. Antitumour drugs. 4 h

Unit-IV

Transplantation: Autograft, isograft, allograft and xenograft. Graft rejection, graft vs. host reaction. Immunosuppressive drugs. 2 h

Disorders of immunity: Immunological tolerance, auto immune disorders, AIDS, SCID. Systemic Lupus Erythomatosus. 4 h

Immunological techniques: Precipitation, agglutination, complement fixation, immuno diffusion, immunoelectrophoresis, immunofluorescence, RIA, ELISA. 6 h

References:

1. Owen, J., Punt, J., Stranford, S., Patricia, J., (2018). Kuby Immunology. (8th edition), W.H. Freeman and Company, USA.

2. Martins, S.J., Burton, D.R., Roitt, I.M., Delves, P.J., (2017). Roitt's Essential Immunology. (13th edition), Wiley Blackwell.
3. Abbas, A., Lichtman, A., Pillai, S., (2018). Cellular and Molecular Immunology. (8th edition), Saunders, Elsevier, USA.
4. Parija, S.C., (2016). Textbook of Microbiology and Immunology. (2nd edition), Elsevier.
5. Hay, F.C., Westwood, O.M.R.. (2002). Practical Immunology. (4th edition), Cold spring Harbour.

Cell communications (Soft core – 3 Credits/48 hours)

Course objective: This course deals with the signalling pathways involved in cell communication both in prokaryotes and eukaryotes.

Course outcome: Completion of this course enables the student to understand the signal transduction pathways at the molecular level.

Unit-I

Concept of cell signaling: Endocrine, paracrine, merocrine, juxtacrine, autocrine signaling, second messengers. 2 h

Second messengers and components of cell signaling: cAMP-Discovery and function. SH and PH motifs, PI3K, PLC, SMase. Cholera toxin and Pertussis toxin. IP3, DAG and ceramide. G-protein coupled receptors (cAMP pathway), monomeric and trimeric G-proteins. 10 h

Unit-II

Signaling by receptor and non-receptor Kinases: receptor tyrosine kinases (EGFR pathway), cytokine receptors (TNF signaling), MAPK pathway, JAK-STAT pathway 6 h

Insulin signaling, GSK3β-signaling pathway, non-receptor tyrosine kinases (NRTKs), serine/threonine kinases. Desensitization mechanisms, signaling crosstalk. NF-κB pathway. 6 h

Unit-III

Signaling by hydrophobic molecules: Steroid hormone signaling, Glucocorticoid and estrogen receptors and their mechanism of action, antihormones (Eg. RU 486) Hormone replacement therapy. Signaling by pheromones and insect hormones. 8 h

Sensory physiology: Vision (Rhodopsin signaling), gustation (gustducin pathway), olfaction. Signaling by gaseous molecules (Nitric Oxide, Hydrogen Sulfide) 4 h

Unit-IV

Signaling in plants: Phytochrome system, cryptochromes, histidine kinase signaling, signaling by ethylene, light, and stress. 8 h

Signaling in Bacteria: Quorum sensing in bacteria, mechanism of chemokine signaling. 4 h

References:

1. Lodish, H., B., A., Kaiser, C. A., Kaiser, C., Krieger, M., Scott, M. P., Matsudaira, P., (2016). Molecular Cell Biology. (8th edition), Macmillan.

2. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Watson, J. D., (2008). Molecular Biology of the Cell. (5th edition), Garland Science.

3. Cooper, G. M., (2019). The Cell: a Molecular Approach. (8th edition), Oxford University Press.

4 Pollard, T. D., Earnshaw, W. C., Lippincott-Schwartz, J., Johnson, G., (2017). Cell Biology. (3rd edition), Elsevier Health Sciences.

Microbial Technology (Soft core – 2 Credits/32 hours)

Course objective: Students will learn about industrially important microorganisms, fermentation techniques, downstream processing of metabolites, and production of various microbial products.

Course outcome: Upon completion of this course, students will have a thorough knowledge of industrial applications of microbes and their products.

Unit-I

Industrially Important Microorganisms: Development, Growth cycle, effect of nutrients, energetic of growth, growth rate and cell cycle. 5 h

Metabolites: Primary and secondary metabolites. 3 h

Unit-II

Fermentors and Bioreactors: Fermentor; stirred fermentor, microcarrier, Batch culture. Bioreactors; control systems, operation, optimization, control and monitoring of variables such as temperature, agitation, pressure, pH, online measurements and control, use of biosensors in bioreactors. 8 h

Unit-III

Downstream processing of metabolites: Separation of cells, foam and flocculation. Disintegration of microorganisms, mechanical and enzymatic methods. Filtration: Plate filters, rotary vacuum filter, membrane filtration, ultra-filtration and reverse osmosis. 6 h

Centrifugation, chromatographic techniques, absorption, spray drier, drum dryers, freeze dryers. 2 h

Unit-IV

Microbial products: Microbial production of vitamins (Vitamin B12, Riboflavin), enzymes (α-amylase, Invertase), organic acids (Citric acid, Lactic acid, Acetic acid), amino acids (L-Glutamic acid, L-Lysine, L-Threonine)), polysaccharides (Xanthan, Dextran), antibiotics (Pencillin, Chloraphenicol), ethanol, biosurfactants. 5 h

Drug development and pharmaceutical process: Production of pharmaceuticals by genetically engineered cells (hormones, interferons), microbial transformation for production of important pharmaceuticals (steroids and semi-synthetic antibiotics), new generation antibiotics, protein engineering, drug design, drug targeting Nanotechnology. 3 h

References:

1. Stanbury, P.F., Whitaker, A., Hall, S.J., (2008). Principles of Fermentation Technology. (2nd edition), Aditya Books (P) Ltd. New Delhi.
2. Cassida, L.E., (2019). Industrial Microbiology. (2nd edition), Wiley Eastern Ltd. & New Age International Ltd., New Delhi.

3. Crueger, W., Crueger, A., (2017). Biotechnology – A Text Book of Industrial Microbiology. (3rd edition), Panima Publishing Corporation, New Delhi
4. Reed, G., (2004). Prescott & Dunn's Industrial Microbiology. (4th Edition), CBS Publishers & Distributors, New Delhi.
5. Reddy, S. M., (2012). Basic Industrial Microbiology. (1st edition), New age international.

Bioinformatics and Biostatistics (Soft core – 3 Credits/48 hours)

Course objective: This course provides an understanding of basic aspects of genomics, proteomics, and use of computational methods and statistics to analyse biological data.

Course outcome: After completion of this course, students will be able to use various biological databases and tools to understand the structural and functional aspects of biomolecules. They also learn to use statistical tools to analyse biological data.

Unit-I

Biological databases: Introduction, classification of biological databases, retrieval of biological database systems. Molecular Modeling Database at NCBI, Molecular visualization software (RASMOL). Phylogenetics Clustal. Prediction of genes (Gene finder, ORF finder). 4 h

Sequence comparison and database search: Introduction, pair wise alignment, global alignment, local alignment, multiple sequence alignment. 3 h

Scoring a multiple alignment, multiple sequence alignment, methods-dynamic programming approach, progressive alignment, iterative refinement methods. Pattern matching in DNA and protein sequences, PAM matrices, BLAST, FAST and FASTA. 5 h

Unit-II

Nucleotide sequence analysis, tools and methods, single nucleotide polymorphism. 5 h

Molecular phylogenetics: Introduction, application of phylogenetic trees, basic terminology, taxa, taxanomy, root, leaf, node, tree, branch, clade, dendogram, cladogram, rooted tree, unrooted tree, scaled tree. Phylip, Clustal. 7 h

Unit-III

Protein sequence analysis using software: Emboss, data mining proteomes, motif mapping using prosite, prodom, protein expression profiling, protein-protein interactions, protein complexes. Mapping protein modifications. Protein secondary structure analysis, Molecular visualization, protein 3D structure using Rasmol, pdb file format. 3 h

Protein and secondary structure prediction: Secondary structure prediction methods, software for secondary structure prediction, protein families and classification, prediction of transmembrane regions. CATH and SCOP. 3 h

Molecular modelling: Introduction, methods of protein modelling, homology or comparative modelling, model refinement, evaluation of the model. molecular structure and internal energy, energy minimization of small molecules, Ab initio, and semi-empirical methods, Construction of initial model, refining the model, manipulating the model, three-dimensional structure prediction, comparative modelling, homology modelling, threading, energy based prediction of protein structures, modelling software. 6 h

Unit-IV

Introduction to Biostatistics: Population, sample, sampling techniques, random sample. Mean, median, mode, range, variance, coefficient of variation, frequency, standard deviation, standard error. Representation of statistical data line graph, histogram, bar diagram, pie chart, scatter diagram. 6h

Probability: Rules of probability, binomial distribution, normal distribution, area under the curve, Z value, P value, choosing sample size, hypothesis testing, Student's t test. One way ANOVA, correlation and regression. 6h

References :

1. Primrose, S.B., Twyman, R., (2013). Principles of Gene Manipulation and Genomics. (3rd edition), John Wiley & Sons.
2. Polanski, A., Kimmel, M., (2007). Bioinformatics. (7th edition), Springer.
3. Mount, D. H., (2002). Bioinformatics: Sequence and genome analysis. (1st edition), Cold Spring Harbor, Laboratory Press.

4. Rastogi, S.C, Mendiratta, N., Rastogi, P., (2013). Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery. (4th edition), Oxford. University Press.
5. Daniel, W. W., Cross, C. L., (2014). Biostatistics : Basic concepts and Methodology for Health Sciences. (10th edition), Wiley & Sons.
6. Balaji, K., Raghavaiah, A. V. S., (2020). Biostatistics. Dreamtech press.
7. Rastogi, V. B., (2015). Biostatistics. (3rd edition), Medtech.

Practical 3: Experiments in Cell Biology and Immunology

12 h/week (Practical and Tutorials – 6 Credits)

1. Isolation and quantification of genomic DNA from coconut endosperm.
2. Isolation and quantification of genomic DNA from chicken liver.
3. Isolation and quantification of total RNA from chicken liver.
4. Isolation and quantification of plasmid DNA from bacteria.
5. Agarose gel electrophoresis of DNA.
6. Isolation and purification of proteins from various biological sources.
7. Separation of proteins using SDS-PAGE from the biological samples.
8. Determination of amylase activity using zymogram.
9. Determination of human blood groups.
10. Determination of antibody and antigen interaction using Ouchterlony double diffusion technique.
11. Isolation of neutrophils from human blood sample.
12. Determination of myeloperoxidase assay in biological sample.
13. Study of platelet aggregation.

Seminar: Each student will give a 15-min seminar with PowerPoint presentation on a topic from the subjects assigned.

Fourth Semester

Genetic Engineering (Hard core – 3 Credits/48 hours)

Course objective: This course is designed to familiarize students with the concept of gene cloning and the basic steps involved in recombinant DNA technology.

Course outcome: Students will learn about the basic principles of recombinant DNA technology, as well as its modern-day applications.

Unit-I

Genetic Engineering: Extraction and purification of nucleic acids (DNA and RNA) from biological sources. Definition, aims and objectives of recombinant DNA technology. 4 h

Restriction-modification systems: restriction enzymes; type I, II and III, specificity, sticky ends and blunt ends, isoschizomers. Gene cloning; genomic cloning, shot gun cloning, cDNA cloning. 8 h

Unit-II

Vectors: Plasmids, phage, cosmids and phagemid. Yeast cloning vectors, plant vectors, bacterial artificial chromosome, SV40, shuttle vectors, construction of expression vectors. 8 h

Ligation: Blunt end and sticky end ligation, use of linkers and adopters, homo polymer tailing, colony hybridization, plaque hybridization. 4 h

Unit-III

Transformation: Micro injection, electroporation, lipofection, calcium phosphate method, protoplast fusion/somatic cell hybridization and biolistic methods. 4 h

Transgenic plants and animals, gene knock out. 2 h

Techniques: DNA sequencing, shot gun and orderly sequencing, chromosome walking, PCR; analysis of products, nested PCR, applications of PCR in cloning, agriculture and medicine. RT-PCR technique and applications. Real time PCR for quantification. 6 h

Unit-IV

Identifying the right clones: Direct screening; insertional inactivation of marker gene, visual screening, plaque phenotype. Indirect screening; immunological techniques, hybrid arrest translation, hybrid select translation. Screening using probes; construction of gene probes, hybridization and labelling. 4 h

Mapping in Prokaryotes and Viruses: Bacterial transformation and transduction, conjugation; F+ plasmids, Hfr cells, time of entry mapping. Arrangement of genes in phage

chromosome, plaque formation and lytic cycle. Fine structure of rII locus of T4. Lysogeny and λ phage. 4 h

Applications: Gene editing (CRISPR), RNA interference, Gene therapy, applications in agriculture medicine, industry. GM foods, terminator gene, negative impact of genetic engineering. 4 h

References:

1. Lewin, B., (2007). Genes IX. (12th edition), Oxford University Press.
2. Primrose, S.B., Twyman, R., (2013). Principles of gene manipulation and genomics. (3rd edition) John Wiley & Sons.
3. Glick, B.R., Paternak, J.J., (2017). Molecular Biotechnology: Principles and applications of recombinant DNA. (5th edition), ASM Press.
4. Green, M. R., (2012). Molecular Cloning; A laboratory manual (4th edition), CSHL Press.
5. Brown, T. A., (2020) Gene Cloning and DNA analysis- An Introduction. (8th Edition), Wiley-Blackwell Publishing.
6. Madigan, M. T., Martinko, K. M., Bender, K. S., Buckley, D. H., Stahl, D.A., (2014). Brock Biology of Microorganisms. (15th edition). Pearson's MyLab & Mastering products.

Principles of Genetics (Hard core – 3 Credits/48 hours)

Course objective: The course aims to teach the fundamentals aspects of molecular genetics, such as Mendelian inheritance, genome organization, gene linkage, mutation, DNA repair mechanisms, and chromosomal abnormalities.

Course outcome: Upon completion of this course, students will understand the principles of heredity at the molecular and cellular level in prokaryotes and eukaryotes.

Unit-I

Basic Principles of Mendelism: Laws of inheritance, dominance, codominance, epistasis, (coomb shape in chickens) pleiotropism. Cytoplasmic inheritances (male sterility in plants, shell coiling), model organisms 8 h

Gene linkage and chromosome: Linkage and recombination of genes in a chromosome. X-linked inheritance. Polygenic inheritance, mitochondrial inheritance, Y-chromosome inheritance. Map unit. 4 h

Unit-II

Organisation of genes in prokaryotic and eukaryotic Chromosome: Genome size and evolutionary complexity, C-value paradox. 4 h

Chromosome number: Ploidy, Karyotyping, sex chromosome and dosage compensation. Mobile genetic elements. 4 h

Structure of bacterial chromosome, structure of eukaryotic chromosome, nucleosome organization, arrangement of chromatin fibers in a chromsome. Polytene chromosomes, Centromere and telomere structure. Allocating genes to chromosomes. 4 h

Unit-III

Mutations: Nature of mutations, spontaneous and induced mutation, conditional, lethal (temperature sensitive) mutation, biochemical basis of mutations: Point mutation, base substitution mutation, missense, nonsense and silent mutation. Mutation rates. Chemical and physical mutagens. 12 h

Unit-IV

Reverse mutations and suppressor mutations - intergenic and intragenic suppression, reversion as a means of detecting mutagens - Ames test. 4 h

Repair Mechanism: Reciprocal recombination, site specific recombination, E.*coli* rec system. Holliday model of recombination. 4 h

Chromosomal Basis of Human Diseases: Extra or missing chromosome, abnormality in chromosome structure; deletion, duplication, inversion, translocation. 4 h

References:

1. Griffiths A. J. F., Muller, H. J., Suzuki, D. T., Lewontin, R. C., Gelbart, W. M., (2000). An introduction to genetic analysis. (7th edition), W. H. Greeman. New York.
2. Watson, J. D., Baker, T. A., Bell, S. P., Cann, A., Levine, M., Losick, R., (2017). Molecular Biology of Gene. (7th edition), Pearson Education RH Ltd. India.
3. Lewin. B, (2007). Genes IX. (12th edition), Oxford University Press.
4. Miglani G. S. (2002). Adavanced Genetics. Narosa Publishing House, New Delhi.

5. Pierce, B. A., (2017). Genetics : A Conceptual Approach. (6th edition), W.H. Freeman.

6. Tamarin, R., (2017). Principles of Genetics. (7th edition), McGraw Hill.

7. Hartl, D. L., (2018). Essential Genetics And Genomics. (7th edition), Jones and Bartlett.

8. Simmons, M. J., Snustad, D. P., (2012). Genetics. (6th edition), John Wiley & Sons.

Plant Biotechnology (Soft core – 3 Credits/48 hours)

Course objective: Plant biotechnology course will help students to understand the principles and methodology of plant tissue culture and the implications of genetic engineering tools.

Course outcome: Students will learn the principles of plant tissue culture and get familiarise with the biotechnological applications of tissue culture techniques.

Unit-I

Cell and Tissue Culture Technology: Role of hormones in growth and development of plants, tissue-specific hormones. Callus Induction, Organogenesis, Somatic embryogenesis, cell suspension culture and synthetic seeds. 6 h

Micropropagation: Propagation from pre-existing meristem, shoot apical meristem, shoot and node culture, micropropagation stages and applications. 4 h

Haploid Technology: Methods of haploid culture, Factors affecting anther and microspore cultures, applications. 2 h

Unit-II

Protoplast Technology: Isolation, purification and culture of protoplasts, protoplast fusion and somatic hybridization, applications of somatic hybrids/ cybrids. 4 h

Plant transformation techniques: Methods of gene transfer in plants, Agrobacterium mediated transfer- mechanism of DNA transfer. General features of Ti and Ri plasmids, role of vir genes, design of expression vectors, use of promoters and reporter genes; viral vectors, direct gene transfer methods- electroporation, microinjection, particle bombardment, selection of transformants, screening and field trials. 8 h

Unit-III

Secondary metabolite production: Induction of secondary metabolites by plant cell culture, technology of plant cell culture for production of chemicals, biotransformation using plant cell culture. Bioreactor systems and models for mass cultivation of plant cells. 8 h

Transgenic plants: Herbicide resistance, resistance against biotic stress- bacterial, viral, fungal and insect resistance, abiotic stress, improved crop productivity, improved nutritional quality, transgenic plants for floriculture, Qualitative trait loci and marker studies. 4 h

Unit-IV

Germplasm preservation: Preservation of seed-propagated species, preservation of pollen, preservation of vegetatively propagated species, pre-treatment of plant and propagule, cryopreservation, cryoprotectant, warming rate and recovery, gene banks, applications. 8 h

Molecular farming and pharming: Transgenic plants as production systems-production of alkaloids, steroids, colouring agents, flavouring agents, biodegradable plastics, industrial enzymes, therapeutic proteins, biopharmaceuticals, edible vaccines, plantibodies. 4 h

References:

1. Indra K. Vasil and Trevor A. Thorpe, (2010) Plant Cell and Tissue Culture, Kluwer Academic Publishers.
2. Singh B.D., (2018). Plant Breeding Principles and Methods. (4th edition). Kalyani Publishers.
3. Chawala H. S., (2020) Introduction to plant Biotechnology, (3rd edition) oxford and IBH Publication co.
4. Nirmala C.B., Rajalakshmi G., Chandra K., (2021). Plant Biotechnology. (9th edition). MJP publishers.
5. Primrose S. B., (2014). Principles of Gene Manipulation and Genomics, (7th edition).
6. Satyanarayana U., (2020). Biotechnology. (12th edition). Books & allied publishing.
7. Dubey R C, (2014) A Textbook of Biotechnology. (5th edition). S Chand.
8. Kumar, A., Neumann K.H., Imani, J., (2020). Plant Cell and Tissue Culture A tool in Biotechnology. (2nd edition). Springer.

Animal Biotechnology (Soft core – 3 Credits/48 hours)

Course objective: This course will enable students to understand the principles and applications of animal cell culture techniques, embryo culture, tissue engineering, and genetically modified organisms.

Course outcome: Upon completion of this course, students will be aware of routine animal cell culture techniques including embryo culture and methods involved in genetically modified organisms.

Unit-I

Culture of animal cells: Advantages and limitations of tissue culture, aseptic handling, and facilities required media and cell lines. 2 h

Primary culture: Isolation of mouse and chick embryos, human biopsies, methods for primary culture, nomenclature of cell lines, sub culture and propagation, immortalization of cell lines, cell line designation, selection of cell line and routine maintenance. 4 h

In vitro fertilization and Embryo transfer: In vitro fertilization in Humans, Embryo transfer in Humans, Super ovulation and embryo transfer in farm animals (Cow). 6 h

Unit-II

Cloning and Selection: Cloning protocol, stimulation of plating efficiency, suspension cloning, isolation of clones, isolation of genetic variants, interaction with substrate, selective inhibitors. 4 h

Cell separation and characterization: Density based, antibody based, magnetic and fluorescence based cell sorting. 2 h

Characterization of cells based in morphology, chromosome analysis, DNA content, RNA and protein, enzyme activity, antigenic markers, cytotoxicity assays. 4 h

Cell quantitation, cell culture contamination: monitoring and eradication, cryopreservation. 2 h

Unit-III

Culturing of specialized cells: Epithelial, mesenchymal, neuro ectodermal, hematopoietic gonad and tumor cells, Lympocyte preparation, culture of amniocytes, fish cells, confocal microscopy. Stem cell culture and its applications. 4 h

Organ and embryo culture: Choice of models, organ culture, histotypic culture, filter-well inserts, neuronal aggregates, whole embryo culture eggs, chick and mammalian embryos. 4 h

Cell and Tissue engineering: Growth factors for in situ tissue regeneration, biomaterials in tissue engineering, approaches for tissue engineering of skin, bone grafts, nerve grafts. Haemoglobin-based blood substitutes, bio artificial or biohybrid organs. Limitations and possibilities of tissue engineering. 4 h

Unit-IV

Cloning of Animals: Methods and uses. Introduction, nuclear transfer for cloning, cloning from embryonic, adult, and fetal cells. Cloning from short-term cultured cells. Cloning from long-term cultured cells. Cloning efficiency, cloning for production of transgenic animals, gene targeting for cloned transgenic animals, cloning for conservation. 4 h

Transfection methods and transgenic animals: Gene transfer, transfection of fertilized eggs or embryos, unfertilized eggs, cultured mammalian cells, targeted gene transfer. Transgenic animals and applications. The legal and socio-economic impact of biotechnology at national and international levels. 4 h

Biosafety regulations: guidelines for research in transgenic animals, public awareness of the processes of producing transgenic organisms. 4 h

References:

1. Freshney, R. I., (2015), Culture of animal cells: a manual of basic technique and specialized applications (6th edition), John Wiley & Sons.
2. Masters, J. R., (2000), Animal cell culture: a practical approach (3rd edition), Oxford University Press.
3. Butler, M., (2004), Animal cell culture and technology, Taylor & Francis.
4. Clynes, M., (2012). Animal cell culture techniques. Springer Science & Business Media.
5. Dhawan, R., (2010), Cloning, Genetics and Stem Cell Technology, Axis publications
6. Friedmann, T., (2007), Gene Transfer: Delivery and Expression of DNA and RNA, Cold Spring Harbor.
7. Pinkertl, (2014), Transgenic Animal Technology, (3rd edition), Academic publisher.
8. Gordon, I.,(2005), Reproductive Techniques in Farm Animals, CABI press.

Neurobiology and Toxicology (Soft core – 2 Credits/32 hours)

Course Objective: The aim of this course is to provide the students with the basic understanding of neurobiology and diseases associated with it. The paper also deals with various aspects of toxicology.

Course outcomes: Upon completion of this course, students will understand the general aspects of neurobiology, toxicology, and implications of these in health and diseases.

Unit-I

Neuron: Neurocellular anatomy, neural membrane, classification of neuron, nerve fibers, axonal transport, neuroglia, nervous system, blood brain barrier, cerebrospinal fluid. 4 h

Neuronal signaling: Membrane potentials, ion channels, recording neuronal signals, ionic basis of resting potential and action potential, propagation of action potential. 4 h

Unit-II

Synaptic transmission: Synapse, Electrical synapse transmission, chemical synaptic transmission, synaptic transmitter release, synaptic potentials, synaptic delay, synaptic plasticity, molecular mechanism of synaptic transmission, myoneural junction. 4 h

Neurotransmitters: Chemistry, synthesis, storage, release, receptors and function – acetyl choline, catecholamines, serotonin, histamine, glutamate, aspartate, GABA, glycine, neuropeptides, nitric oxide. 4 h

Unit-III

Neural processing and neurodegenerative disorders: Learning and memory, neurochemical basis of drug abuse, neurodegenerative disorders, Parkinson's disorders, Alzheimer's disorder, Amyotrophic lateral sclerosis, Senile dementia. 4 h

Toxins and their mode-of-action: Composition of toxins, Dendrotoxins, scombrotoxin, botulinum toxin A, muscarine, bufotoxin, diphtheria toxin 4 h

Unit-IV

Toxicology: Origin and scope of toxicology, distribution, absorption, Excretion of toxicants, Bioaccumulation, biotransformation of toxicants, Effects on development. Toxicity evaluation (LD_{50} and LC_{50}), Factors affecting toxicity, metal toxicity (cadmium, lead, mercury), radiation hazards. 4 h

Detoxication mechanisms: Xenobiotic metabolism, oxidation, reduction, hydrolysis, conjugation, role of glutathione in detoxication. 4 h

References:

1. Kandel, E., Schwartz, J., (2013), Principles of Neural Science (5^{th} edition), McGraw-Hill.
2. Squire, L., Berg D.,(2013), Fundamental Neuroscience (4^{th} Edition), Elsevier.
3. Brunton, L. L., Knolmann, B. C., (2017). Goodman and Gilman pharmacological

chemistry. (13th edition). McGraw-Hill.

4. Richard, C., (2004). Medical toxicology.(3rd edition), Lippincott.
5. Curtis, D., (2001). Casarett and Doull's toxicology. (6th edition), Oxford University Press.

Practical 4: Experiments in Genetics and Genetic Engineering

12 h/week (Project and Practical– 6 Credits)

1. Isolation and quantification of genomic DNA from fungi.
2. Amplification of DNA using polymerase chain reaction.
3. Isolation and quantification of plasmid from the bacteria.
4. Preparation of competent cells for the bacterial transformation.
5. Bacterial transformation.
6. Identification of transformed bacteria using blue white screening.
7. Determination of transformation efficiency.
8. Restriction digestion of λ-DNA and visualization on agarose gel electrophoresis.
9. Ligation of digested λ-DNA using T4 DNA ligase and visualization on agarose gel electrophoresis.
10. Dissection of salivary gland and observation of polytene chromosome in *Drosophila melanogaster*.
11. Identification of drosophila mutants.

Project and seminar

Four months minor research project is executed by individual students under the supervision of a specific faculty and a report is prepared followed by submission of the certified report in the form of the project thesis. Subsequently, the work is presented in front of examiners as a PowerPoint presentation.

Additionally, each student gives a 15 – 20 min seminar with PowerPoint presentation on a selected recent research paper.