Based on Undergraduate Curriculum Framework 2022

UNIVERSITY OF DELHI

B.Sc (H) Biomedical Science

UNDER GRADUATE PROGRAMMES OF STUDY

STRUCTURE, COURSES & SYLLABI OF SEMESTER -I

Disclaimer: The syllabi are uploaded are as approved by the Academic Council on …… and Executive Council on ….

(B.Sc (H) Bimedical Science)

COURSES OFFERED BY DEPARTMENT OF BIOMEDICAL SCIENCE

Category I

DISCIPLINE SPECIFIC CORE COURSE -1 (DSC-1) BIOORGANIC CHEMISTRY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Bioorganic Chemistry	4	**3**	**0**	**1**	**Class XII with Chemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- Bioorganic Chemistry is a discipline that integrates organic chemistry and biochemistry.
- It aims at understanding the relevance of biological processes using the fundamental concepts of organic chemistry
- This course includes basic principles of organic chemistry like concepts of stereochemistry and their importance understanding various bio-molecular reactions along with introduction to biomolecules

Learning outcomes

The Learning Outcomes of this course are as follows:

- By studying this course, the student will be able to identify, assess and analyze different types of stereoisomers and their properties in organic compounds and biomolecules
- They will understand the structures and function of biomolecules (carbohydrates, amino acids, lipids and nucleotide).
- Student will understand the mechanism of biologically significant name reaction and their role in biological systems.

SYLLABUS OF DSC-1

UNIT – I : Stereochemistry (2 Weeks)

Optical isomerism: Optical activity, specific rotation, enantiomerism, D and L designation, racemic modification, R and S sequence rules, diastereoisomers.
Conformational isomers: conformation of ethane and butane, inter conversion of projection formula, cyclohexane (mono- and di-substituted), resolution, optical purity.
Geometrical isomerism: Definition, nomenclature– E and Z

UNIT – II: Introduction to Biomolecules I (4 Weeks)

Monosaccharides- cyclization of aldoses and ketoses, conformations, concept of mutarotation, anomers, epimers.
Disaccharides- structure, reducing and non-reducing sugars. Polysaccharides- Starch, glycogen and cellulose.
Lipids:

Fattyacids, triacylglycerols, phospholipids, lipid bilayer formation, steroids (cholesterol)

UNIT – III: Introduction to Biomolecules II (6 Weeks)

Amino Acids:
Structure and classification of amino acids, ionization, chemistry of peptide bond, non-ribosomal peptide bond formation, essential and non-essential amino acids, amino acids as precursors of other bioactive compounds, zwitterion, isoelectric point, optical properties of amino acids, Definition of a peptide, peptide unit, peptide group, bond length, cis and trans conformation, primary, secondary (alpha helix, beta sheet, beta turn, collagen helix), tertiary and quaternary structures(with examples).
Nucleotides:
Sugars and Bases, conformation of sugar phosphate backbone, hydrogen bonding and tautomerism in nucleic acid bases
Effect of structure on reactivity of biomolecules.

UNIT – IV: Biologically Significant Name Reactions (3 Weeks)
Aldolcondensation (Glucogenesis), retro-aldol(Glycolysis),benzoincondensation (umpolung-decarboxylation of pyruvate in the presence of TPP), Claisen condensation (synthesis of fattyacids), Michael addition (Dehydrases),Cannizzaro (Sugar metabolism), Bayer Villiger reaction (FAD dependent ketone synthesis), Pinacol pinacolone rearrangement(1,2-carboncarbonshift)

Practical component
(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Qualitative tests for carbohydrates to identify the given unknown carbohydrate solution: Mohlisch, Barfoed, Fehling/ Tollen/ Benedict tests
2. Qualitative tests for carbohydrates to identify the given unknown carbohydrate solution: Iodine test, Selvinoff, Osazone, Bial's tests
3. Qualitative tests for Amino acids and Proteins: Ninhydrin, Xanthoproteic, Million's, Lead Acetate, Biuret test
4. Qualitative test for Fats
5. To determine the Iodine number of the given oil/fat.
6. To find pKa value of acetic acid
7. To study the titration curve of glycine
8. Absorption spectrum of Protein
9. Absorption spectrum of DNA
10. Estimation of a Reducing sugar in a given sample.

Essential/recommended readings

- Nelson, D. L. and Michael M. Cox (2021) 8th Edition. Lehninger Principles of Biochemistry. New Jersey, USA: Prentice Hall Publishers.ISBN-13:978-1319228002.
- Nasipuri, D. (2020), Stereochemistry of Organic Compounds: Principles and Applications, 4 th Edition, New Age International. ISBN 10: 9389802474
- Solomons, T. W. G.; Fryhle, C. B.; Snyder, S. A. (2017), Organic Chemistry, 12th Edition, Wiley. ISBN: 978-1-119-24897-2

- Plummer, D. (2017) An Introduction to Practical Biochemistry, 3rd edition. McGraw-Hill College; ISBN-13: 978-0070841659.

Suggestive readings:

- Hoffman, A. 8th Edition (2018). Wilson And Walker's Principles and Techniques of Biochemistry and Molecular Biology. Cambridge: Cambridge University Press. ISBN- 13: 9781316677056

DISCIPLINE SPECIFIC CORE COURSE -2 (DSC-2) CELL BIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Cell Biology	4	**3**	**0**	**1**	**Class XII Biology/Biotech**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

The objective is to offer detailed knowledge about the cells, its various components, processes and interactions with other cells:

- Structure and functions of various cellular compartments and organelles
- Fundamentals of transport of biomolecules inside the cell and its cytoskeleton
- Cell growth, cell-division and cell-cycle control mechanisms
- Cell to cell communications and participation of signal transduction pathways, in driving cell response mechanics

Learning outcomes

The Learning Outcomes of this course are as follows:

- Students will learn about how the cell has evolved and the basic types of cells present. Students will acquire insights into the composition and structure of cell membrane by navigating through various proposed cell models. Students will also learn the functions in detail about the processes of transport across cell membranes.
- Students will learn about the structure and function of various cellular compartments and organelles along with the concept of protein sorting and distribution in unique ways. Students will understand the association between cells through unique types of communication and developing junctions for attachment between neighbouring cells.
- Students will understand various cytoskeleton elements and their participation in maintaining cell shape and integrity. Students will gain knowledge about an overview of cell response to its environment, and involvement of cell- cell signalling mechanisms and to study signal transduction pathways.

SYLLABUS OF DSC-2

Unit I: The Cell (01 Week)

Historical background, significant landmarks, cell theory, structure of prokaryotic and eukaryotic cells

Unit II: Cell Membrane and Membrane Transport (03 Weeks)

Functions, different models of membrane structure, types of membrane lipids, membrane proteins: types, methods to study membrane proteins (detergents, RBC ghosts), RBC membrane as a model, membrane carbohydrates, membrane asymmetry and fluidity, lipid rafts. Transport of small molecules: Passive transport (simple diffusion and facilitated diffusion) and active transport and their types (P, V, F and ABC transporter) with example of Na+/K+ pump. Transport of macromolecules: Endocytosis (pinocytosis, phagocytosis), exocytosis

Unit III: Cell Organelles (03 weeks)

Structure and functions of various organelles:

- Nucleus: Different components, nuclear envelope- its structure, pore complex, nucleocytoplasmic, interaction (NLS and NES), nucleolus- structure and functions.
- Endoplasmic reticulum: RER- Biosynthesis and processing of proteins, co-translational and post-translational transport of proteins, signal hypothesis, protein sorting. SER- detoxification, biosynthesis of membrane, carbohydrate metabolism, steroid synthesis.
- Golgi apparatus: Golgi stack (cis, trans and medial cisternae), flow of proteins through Golgi body, glycosylation and protein sorting.
- Lysosomes: Development of different forms of lysosomes, role in cellular digestion, lysosomal storage diseases- Hurler syndrome, Hunter syndrome, Tay-Sachs disease and Inclusion cell disease (I-cell disease).
- Peroxisomes: Assembly, functions- H2O2 metabolism, oxidation of Fatty acids, glyoxysomes
- Mitochondria: Detailed structure, endosymbiotic theory, its genome and functions in brief
- Chloroplast: Detailed structure, its genome and functions in brief

Unit IV: Cell -Cell communication (01 Weeks)

Structures and functions of different types of anchoring junctions (desmosomes and hemidesmosomes), tight junctions, communication junctions (gap junction and plasmodesmata).

Unit V: Cytoskeletal Elements (01 Weeks)

Structure, assembly and functions of:

A. Microtubules: Axonemal and cytoplasmic microtubules (cilia, flagella, centrioles, basal bodies).
B. Microfilaments: Globular and filamentous actin, general idea about myosin.

Intermediate filaments: Different classes.

Unit VI: Cell Signaling and Cell Cycle (02 Weeks)

Signaling molecules and their receptors (extracellular and intracellular), functions of extracellular receptors; Intracellular signal transduction pathways (cAMP, cGMP, steroid hormone response element). Different phases of cell cycle and their significance, mitosis and meiosis, checkpoints and regulation of cell cycle.

Practical component

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Light microscopy: Principle, construction and types. Study of positive and negative staining using photomicrographs.
2. Fluorescence microscopy: principle and applications. Concept of GFP
3. Electron microscopy: Principle, construction and types. Study of positive and negative staining, freeze fracture, freeze etching, shadow casting, endocytosis, exocytosis and phagocytosis using electron micrographs
4. To explain mitosis and meiosis using permanent slides.
5. To measure cell size using a stage micrometer.
6. To cytochemically demonstrate presence of total and basic proteins in cheek cells or onion peel using mercuric bromophenol blue or fast green.
7. To cytochemically demonstrate presence of carbohydrates in cheek cells or onion peel using periodic acid Schiff's reagent.
8. To cytochemically demonstrate presence of DNA in cheek cells or onion peel using Feulgen reagent.
9. To study the effect of isotonic, hypotonic and hypertonic solutions on cells

Essential/recommended readings

- Cooper, G. M. (2018). 8th Edition. *The cell: A molecular approach*. Massachusetts, USA: Sinauer Associates. ISBN-13:978-1605357072
- Hardin, J. Bertoni, G. P. Kleinsmith, L.J. and Becker, W.M. (2016). 9th Edition. *The world of the cell.* San Francisco, USA: Benjamin Cummings Publishers, ISBN-13: 978 -0321934925.
- Karp, G. (2019). 9th Edition. *Cell and molecular biology:* New Jersey, USA: Wiley Publishers. ISBN-978—1-119-59816-9.

Suggestive readings:

- Cooper, G. M. and Hausman, R. E. (2013). 6th Edition. *The cell: A molecular approach*. Massachusetts, USA: Sinauer Associates. ISBN-13:978-1605351551
- Hardin, J. Bertoni, G. P. Kleinsmith, L.J. and Becker, W.M. (2008). 7th Edition. *The world of the cell.* San Francisco, USA: Benjamin Cummings Publishers, ISBN-13: 978 0805393934.
- Karp, G. (2013). 7th Edition. *Cell and molecular biology: Concepts and experiments.* New Jersey, USA: Wiley Publishers. ISBN-978-0470483374.
- Alberts, B et al. (2014). 6th edition. *Molecular Biology of the Cell*. W. W. Norton & Company. ISBN-13 : 978-0815345244
- Lodish H et al. (2003). 5th Revised edition. *Molecular Cell Biology*. W.H.Freeman& Co Ltd; ISBN-13 : 978 0716743668

DISCIPLINE SPECIFIC CORE COURSE -3 (DSC-3) HUMAN PHYSIOLOGY AND ANATOMY I

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Human Physiology and Anatomy I	**4**	**3**	**-**	**1**	**Class XII pass with Physics, Chemistry and Biology as papers in Class XII.**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The course curriculum is a systematic presentation of physiological concepts to ensure appropriate depth and breadth of basic functioning of the human body and its interrelations with respect to heart, lung, kidney, gonads, endocrine glands and digestive system.
- It would give students exposure of physiological concepts needed as foundations for further studies in pharmacology, pathology and pathophysiology etc.
- It would provide a base to understand body defenses and the mechanisms of deranged function of human body
- The curricular objectives are focused primarily on normal body function. Accordingly, wherever possible clinical examples have been illustrated to the underlying physiological principles.

Learning outcomes

The Learning Outcomes of this course are as follows:

Having successfully completed this course, students shall be able to learn and appreciate:

- The usefulness of dividing the human body in different anatomical planes and sections, cavities, along with the role of feedback system in maintaining homeostasis. Functional anatomy of the epithelial and connective tissues while focusing on integumentary and skeletal system. Overview of structure, types and function of cartilage, bone and joints.
- Structure, function and regulation of components/different formed elements of blood and the mechanism of clotting. Students would be able to understand different blood groups, basis of their classification, their importance in blood transfusions and tissue grafting and basic concepts of blood and bleeding disorders
- Student would be able to understand neurons their role and significance and how as apart of the brain they help in brain physiology. Appreciation of basic concepts of action potential/ graded potential in the conduction of nerve impulse. Action and significance of different neurotransmitters at the synapse

along with the mechanism of synaptic transmission using different ligand gated ion channels, G protein coupled receptors and their ligands as example.

- Students would learn organization of brain, with identification of structures and functionof different brain regions. Identify different neural pathways and explain their significance. They would understand the innate responses and conditioned response of day today life by studying autonomic nervous system and effect of its stimulation on different organs.

- The five senses which help an individual to perceive the world would be studied in detail. Stimulus modality, sensory adaptation and the role of generator potential in the sensory physiology of touch, gustation, olfaction, hearing and vision. They would recognize and explain the common disorders related to the senses.

- Students would be able to describe and distinguish between the structure, mechanism and regulation of contraction of skeletal, cardiac and smooth muscles. Enlist the energy requirements, characteristic features of different muscle fibers and their role in generating muscle tension. Demonstrate the concept of muscle fatigue, adaptation to physical training, and muscle degeneration and associated disorders.

SYLLABUS OF DSC-3:

Unit I: Body organization and Integumentary system 03 Weeks

General Anatomy of the body, Introduction to various kinds of body planes, cavities and their membranes, Tissues level of organization (Types, origin, function & repair). Structure and functions of human skin.

Unit II: Blood (02 Weeks)

Composition and Function of Blood and its components (RBC, WBC, platelets and plasma). Hematopoiesis, Hemoglobin structure, function and abnormal hemoglobin. Basic concepts about Anemia and types. Blood Hemostasis (blood coagulation/ clotting, platelet function and role of endothelium).

Unit III: Nerve physiology (02 Weeks)

Structure, function and types of neuron, conduction of nerve impulse, Resting membrane potential, Action and graded potential. Synapse its types, Synaptic Transmission, Neurotransmitters and their receptors; types and function

Unit IV: Nervous System I: Organization of nervous system (02 Weeks)

Structure, function and organization of Central nervous system, Peripheral nervous system and Autonomic nervous system. Motor physiology: Reflexes, types and reflex arch

Unit V: Nervous System II: Sensory Physiology (03 Weeks)

Concept of receptors in the body and their types, structure, functional anatomy, regulation and common disorders of the following sensations: Vision, Hearing, Taste, Smell and other senses (Touch, Pain, Temp).

Unit VI: Muscular system (01 Weeks)

Functional anatomy of muscular system, types of muscles, neuromuscular junction structure property and transmission, General characteristics, molecular mechanism and properties of skeletal muscle excitation and contraction, energetics and characteristics of whole muscle contraction.

Unit VII: Skeletal System (02 Weeks)

Cartilage: structure, types and function. Bones: structure, function, location and types. Joints: structure, function and types

Practical component

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Estimation of haemoglobin (Sahli's method)
2. Determination of total erythrocyte count.
3. Determination of total leukocyte count.
4. Preparation of blood smears and identifying various WBC
5. To perform differential leukocyte count of blood.
6. To study a simple reflex arc
7. To study the sensation of taste, touch and smell.
8. To study different human organs and their sections through permanent histological slides T. S. of brain, spinal cord, skeletal fibres, cardiac muscles, skeletal muscles, cartilage joints and different tissues. (Minimum 8 slides covering the systems mentioned in theory.)

Essential/recommended readings:

- Principles of Anatomy and Physiology, 16th edition (2020), Gerard J. Tortora and Bryan H. Derrickson; Wiley and Sons, ISBN: 978-1-119-66268-6.(e book),ISBN: 978-1-119-70438-6 (for print book).
- Ganong'sReviewofMedicalphysiology,26thedition(2019),K.E.Barett,S.M.Barman,S. Boitano and H. Brooks; Tata McGraw Hill, ISBN 978-1-260-12240-4 (for print book) ISBN: 978-1-26-012241-1(for eBook)
- Textbook of Practical Physiology, 9th edition (2018), CL Ghai; Jaypee Publication, ISBN-13: 978-9352705320 ISBN-10: 9352705327

Suggestive readings:

- Guyton and Hall Textbook of Medical Physiology, 12th edition (2011), J. E. Hall; W B Saunders and Company, ISBN: 978-1-4160-4574-8 International Edition: 978-0-8089-2400-5
- Human Physiology, 12thedition (2011), Stuart I. Fox; Tata McGraw Hill, ISBN 978–0–07–337811–4MHID 0–07–337811–9.

DISCIPLINE SPECIFIC CORE COURSE -4 (DSC-4) – : BIOCHEMISTRY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Biochemistry	**4**	**3**	**-**	**1**	**Class XII pass with Physics, Chemistry and Biology as papers in Class XII.**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- To effectively incorporate the fundamentals of metabolism through key biochemical pathways.
- Make the learners appreciate the requirement for the stringency of the regulation of these pathways.
- Introduce various biochemical techniques used in the characterization of the proteins.
- To give a detailed account on how enzymes function: their kinetics, regulation, and inhibition.

Learning outcomes

The Learning Outcomes of this course are as follows:

- By studying this course, students will be able to gain an understanding of fundamental biochemical principles of metabolism of biomolecules (Carbohydrates, Proteins, Lipids and Nucleic acids) and the associated bio- energetics. They will learn the biochemical reactions in metabolic pathways and understand their interrelations, logics, and patterns.
- By studying this course, students will be able to understand the role of enzymes in the biochemical reactions and the connection between biochemical defects and metabolic disorders. Students would additionally gather a firm understanding and relevance of stringent regulation of metabolic pathways.
- By studying this course, students will be able to learn how biological molecules (especially proteins) are characterized through various analytical techniques such as types of column chromatography methods, Polyacrylamide Gel Electrophoresis (PAGE) that are used in contemporary biochemistry research laboratories.
- By studying this course, students will be able to grasp the central concepts underlying enzyme catalysis, kinetics, and their mechanism of action. Effects of different kinds of enzyme-inhibitors will also be learned.
- By studying this course, students will be able to learn how coenzymes assist enzymes in catalyzing biochemical reactions and what is the criterion for their classification.
- By studying this course, students will be able to learn the general properties of regulatory enzymes, their activity and kinetics.

SYLLABUS OF DSC-4

UNIT – I (6.3 Weeks)

Metabolic pathways and their allosteric regulation

Carbohydrates- Glycolysis, Gluconeogenesis, Tricarboxylic acid cycle and their regulation, Cori cycle, Hexose monophosphate shunt.

Lipids- Mobilization of triglycerides, Metabolism of glycerol, Biosynthesis and β- oxidation of saturated fatty acids (palmitic acid) and their regulation. Significance of ketone bodies.

Proteins- General over view, Transamination, Deamination, Glucose-Alanine cycle, Urea cycle and its regulation.

Nucleic acid- General overview, an outline of purine and pyrimidine metabolism. Electron transport chain, Oxidative phosphorylation, and Substrate-level phosphorylation.

UNIT – II (2.3 Weeks)

Analytical methods in protein characterization

Introduction to spectrophotometry & Lambert-Beer's law, Column chromatography: Ion exchange chromatography, Gel filtration and Affinity chromatography, SDS-PAGE

UNIT – III (2 Weeks)

Enzymes

Introduction to enzymes, Concept of Lock & key and 'Induced fit theory, Concept of activation energy and binding energy. Enzyme kinetics: Michaelis-Menten equation and its physiological significance. Concept of enzyme inhibition: types of inhibitors (competitive & non-competitive) and their examples.

UNIT – IV (0.6 Weeks)

Coenzymes

Classification: various types and their function.

UNIT-V (0.6 Weeks)

Regulatory Enzymes

General properties of allosteric enzymes. Enzyme regulation by covalent modification. Zymogens.

Practical component

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Measurement of absorbance & %transmittance of a solution using spectrophotometer/colorimeter.
2. Preparation of standard plot and estimation of protein concentration by any one method: Biuret/Lowry/Bradford.
3. Estimation of glucose concentration by an enzymatic/non-enzymatic method.
4. Separation of biomolecules (sugar/amino acids) by thin-layer chromatography (TLC).
5. Separation of biomolecules by gel filtration/Calculation of void volume of Sephadex G-25 column, using Blue Dextran.
6. Analysis of SDS-PAGE as a separation technique (gel analysis).
7. To perform an assay of an enzyme under optimal conditions.
8. Determination of Km, Vmax and Kcat value of a given enzyme from the provided experimental data.

Essential/recommended readings:

- Nelson, D. L., & Cox, M. M. (2021). Lehninger: Principles of Biochemistry (8th ed.). Macmillan. ISBN:9781319322328
- Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology (2018). 8th ed. Hofmann A. and Clokie S.(Eds.) Cambridge University Press, Cambridge, U.K.
- Plummer, D.T. (2012). An Introduction to Practical Biochemistry. New Delhi, India: McGraw-Hill College.
- S. K. Sawhney / Randhir Singh. (2009): Introductory Practical Biochemistry, Narosa Publishers, ISBN-13 : 978-8173193026
- Donald Voet, Judith G. Voet (2021) Voet's Biochemistry, Adapted ed 2021, ISBN: 9789354243820.

Suggestive readings:

- Berg, J., Gatto, G., Stryer, L. and Tymoczko, J. L. (2019). Biochemistry. New York, USA: W. H. Freeman and Company.
- Devlin, (2011). Textbook of biochemistry with clinical correlations. UK: Wiley T & Sons.

DISCIPLINE SPECIFIC CORE COURSE -5 (DSC-5) – : PRINCIPLES OF GENETICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Principles of Genetics	4	3	0	1	Class XII pass	Nil

Learning Objectives

The Learning Objectives of this course are as follows:

- The course intends to introduce students to Mendelian principles of inheritance, deviations from Mendelian inheritance and extra-nuclear inheritance.
- Introduction to pedigree analysis for autosomal and X-linked traits
- Understanding of differences between prokaryotic and eukaryotic genome organization, transposons, and basic cytogenetics.
- Understanding of mechanisms of sex determination.

Learning outcomes

The Learning Outcomes of this course are as follows:

- The flavour of genomics as a progression from Mendelian genetics will be introduced to the students. They will learn about classical experiments that led to discovery of the genetic material. They will also learn the structure of DNA.
- Students will be able to explain Mendelian laws of inheritance, deviations from monohybrid ratio (incomplete dominance, codominance, multiple alleles and lethal genes) and deviations from dihybrid ratio (gene-gene interactions, linkage). They must be able to distinguish sex-linked, sex-limited and sex-influenced traits. Students must also be able to interpret patterns of inheritance for autosomal and X-linked traits from pedigrees.
- Students would learn the concept of extra-nuclear inheritance.

- Students would learn the differences in genomes of prokaryotes and eukaryotes. They would also learn about transposable genetic elements with examples from prokaryotes and eukaryotes.
- The lectures will cover details of the structure of the chromosomes, the abnormalities that commonly occur at chromosomal level. Discussion of various types of mutations at the DNA level (deletion, addition, substitution), their consequence on gene structure/product and the diseases associated with these abnormalities.
- Students wouldgain insights into genetic and environmental sex determination mechanisms.

SYLLABUS OF DSC- 5

UNIT – I (01 Weeks)

Overview of Changing Paradigms in Genetics

A brief overview of how genetic principles took shape, leading to the concept of a blueprint of life within the cell to the physical entity of DNA. Basic structure of DNA, salient features of the double helix, semi-conservative replication– Meselson and Stahl experiment. Also mention the surprises we have from genomics such as genetic variation between individuals. There are popular videos/presentations that can be used. The purpose is to ignite the curiosity of the students.

UNIT – II (03 Weeks)

Concept of Genetic Inheritance

Concept of alleles, haploid and diploid status, phenotype and genotype, Mendel's laws of inheritance, dominant and recessive inheritance, test, back and reciprocal crosses with two examples each. Chromosomal theory of inheritance. Concept of linkage and crossing over, cytological proof of crossing over, genetic mapping: two and three-point cross over. Distinguishing recombination and complementation. Allelic interactions- dominance relationships- complete, incomplete and co-dominance, gene-gene interactions. Sex linked, sex-limited and sex-influenced traits. Gathering family history, pedigree symbols and construction of pedigrees for autosomal and sex linked traits (dominant and recessive).

UNIT – III (01 Weeks)

Extra Nuclear Inheritance

Criteria for extra nuclear inheritance, plastid inheritance in *Mirabilis jalapa*, kappa particles in *Paramecium*, maternal effect- snail shell coiling, cytoplasmic inheritance (mitochondria and chloroplast).

UNIT – IV (1.5 Weeks)

Genome Organization

Organization of Genomes in prokaryotes and eukaryotes. Establishing the Central Dogma. Nucleosomes organization and assembly. Euchromatin, heterochromatin- constitutive and facultative heterochromatin. Structure and significance of polytene and lampbrush chromosomes. Transposable genetic elements: Prokaryotic transposable elements- IS elements, Composite transposons; Eukaryotic transposable elements- Ac-Ds system in maize; Uses of transposons.

UNIT – V (1.5 Weeks)

Cytogenetics and Mutations

Chromosome: Structure- centromere and telomere, types of chromosomes based on centromere. Karyotyping- banding pattern and nomenclature (G and Q banding). Structural abnormalities (Duplication, Insertion, Deletion, Translocation-Reciprocal and Non-Reciprocal) and associated syndromes. Numerical abnormalities (Aneuploidy and Euploidy) and associated syndromes. Spontaneous and induced mutations. Types of mutations: Point (Non-sense, miss-sense, silent, frameshift, insertion, deletion). Effects on the Gene products- loss of function and gain of function.

UNIT – VI (01 Weeks)

Chromosomal theory of sex determination, mechanisms of sex determination, environmental factors and sex determination in human and *Drosophila*. Barr bodies and dosage compensation.

Practical component (8-10)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Observation of wild type and mutant phenotypes in *Drosophila.*
2. Preparation of culture media for *Drosophila* and study different stages of the life cycle of *Drosophila.*
3. Verification of Mendelian laws through *Drosophila*/ seeds – dominant, recessive and sex- linked
4. Study of Barr bodies.
5. Karyotyping with the help of photographs (normal and abnormal karyotypes).
6. Pedigree charts of some common characters like blood group, color blindness and PTC tasting.
7. Study of diploidy in onion root tip.
8. Study of polyploidy in onion root tip by colchicine treatment.
9. Study of polytene chromosomes.

Essential/recommended readings

- Klug, W. S., Cummings, M., Spencer, C. A., Palladino, M. A., Darrell K. (2019*).* 12th Edition. *Concepts of genetics.* San Francisco, NY:Pearson ISBN-13: 9780134604718.
- Snustad, D.P. and Simmons, M.J. (2019). 7th Asia Edition. *Principles of genetics.* New York, USA: John Wiley and Sons. ISBN-13: 9781119657552.
- Gardner E. J., Simmons M. J. and Snustad D. P. (2006). 8th edition *Principles of genetics.* USA. Wiley. ISBN-13: 978-8126510436.

Suggestive readings

- Cooper, G. M. and Hausman, R. E. (2019). 8th Edition. *The cell: A molecular approach.* Massachusetts, USA: Sinauer Associates. ISBN-13: 978-1605358635.
- Hardin, J., Bertoni, G. P., Becker, W.M. (2017). 9th Edition. *Becker's world of the cell.* NY:Pearso. ISBN-13: 978- 0805393934.
- Karp, G., Iwasa, J., Marshall W. (2018). 8th Edition. *Karp's Cell Biology.* New Jersey, USA: Wiley. ISBN-13: 978-1119456292.
- Kornberg, A. (2005). 2nd Edition. *DNA replication.* California, USA: University Science Books. ISBN-13: 978-1891389443.
- Griffith A. J. F., Wessler S. R., Carroll S. B. and Doebley J. (2011). 9th edition. *Introduction to Genetic Analysis.* W H Freeman & Co. ISBN-13 : 978-0716768876.
- Elrod, S and Stansfield, W. (2010). 5th edition. *Schaum's Outline of Genetics.* McGraw Hill. ISBN-13: 978-0071625036.

DISCIPLINE SPECIFIC CORE COURSE -6 (DSC-6) HUMAN PHYSIOLOGY AND ANATOMY II

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Human Physiology and Anatomy II	**4**	**3**	**-**	**1**	**Class XII pass with Physics, Chemistry and Biology as papers in Class XII.**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The course curriculum is a systematic presentation of physiological concepts to ensure appropriate depth and breadth of basic functioning of the human body and its interrelations with respect to heart, lung, kidney, gonads, endocrine glands and digestive system.
- It would give students exposure of physiological concepts needed as foundations for further studies in pharmacology, pathology and pathophysiology etc.
- It would provide a base to understand body defenses and the mechanisms of deranged function of human body
- The curricular objectives are focused primarily on normal body function. Accordingly, wherever possible clinical examples have been illustrated to the underlying physiological principles**.**

Learning outcomes

The Learning Outcomes of this course are as follows: Having successfully completed this course, students shall be able to learn and appreciate:

- The students will learn appreciate the structure and functioning of heart, pattern and significance of blood flow in the blood vessels, heart sounds, ECG and purpose of lymph and lymphatic circulation.

- The students would correlate how structure and function of lungs are so intricately designed and how they function with its blood flow and help giving vital oxygen to body. They would develop understanding for neural control and other regulators of respiration and understand daily phenomenon like coughing, sneezing, yawning etc.

- Kidneys are vital organs and students would learn the functional anatomy of a nephron and how it contributes in removing the toxic waste from our body in from of urine. The curriculum would outline the process of micturition and abnormalities associated with it. It would also highlight the role of kidney in controlling pH of the body and preventing acidosis/alkalosis

- The students would have insight into the anatomy of the female and male reproductive systems, including their accessory structures. The student would understand the role of hypothalamic and pituitary hormones in reproductive system. Trace the route of a sperm mother cell from its production till it can fertilize an oocyte. Explain the events in the ovary prior to ovulation, development and maturation of the sex organs and the emergence of secondary sex characteristics during puberty.

- The students would be able to integrate the role of the endocrine system to maintain homeostasis in human body. Understand the chemicalcomposition mechanisms of hormone action, their site of production, regulation, and effects of hormones of the pituitary, thyroid, parathyroid and adrenal, glands. Hormonal regulation of the reproductive system. The role of the pancreatic endocrine cells in the regulation of blood glucose In addition the contributions of hormones released by the heart, kidneys, and other organs with secondary endocrine functions. The student would be aware of several common diseases associated with endocrine system dysfunction.

- Students would be able to understand the organs of the alimentary canal from proximal to distal, and understand their function. Identify the accessory digestive organs and their functions. Describe the histology that is four fundamental tissue layers of the digestive tract. Contrast the contributions of the enteric and autonomic nervous systems to alimentary tract functioning. Gain awareness about common dysfunctions of digestive system like constipation, gastritis, ulcers, diarrhea etc.

SYLLABUS OF DSC-6:

Unit-I: Cardiovascular System (02 Weeks)

Functional Anatomy of heart, The Cardiac Cycle, Electrocardiogram. Circulatory system: Blood vessels, hemodynamics and regulatory mechanisms, Lymphatic circulation - hemodynamics and regulation, micro-circulation

Unit-II: Respiratory system (02 Weeks)

Functional Anatomy of the respiratory system. Mechanisms of pulmonary ventilation, alveolar ventilation, gaseous exchange, transport of gases, respiratory and nervous control and regulation of respiration

Unit-III: Renal Physiology (02 Weeks)

Body fluid and electrolytes: their balances and imbalances. Functional Anatomy of kidney, Histology of nephron and its physiology, Urine formation, renal regulation of urine volume and osmolarity, acid-base balance. Urinary bladder: structure, micturition and its regulation

Unit-IV: Reproductive System (02 Weeks)

Structure and function of male and female reproductive organ. Function and regulation of testicular and ovarian hormones. Gametogenesis (oogenesis and spermatogenesis), fertilization, implantation, parturition and lactation, menopause and basic concepts of infertility.

Unit V: Endocrine System (02 Weeks)

General mechanism of hormone action, Structure, function and regulation of the following glands and their secretions: Pituitary, Hypothalamus, Thyroid, Parathyroid, Adrenal, and Pancreas. Basic concepts about hypo and hyper secretion of hormones.

Unit VI: Gastrointestinal system (02 Weeks)

Anatomy and histology of digestive tract, gastrointestinal physiology: General principles of gut

motility secretion, digestion, absorption and assimilation. Gastrointestinal hormones: their formation and action. Physiological anatomy and functions of liver and pancreas.

Practical component

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Physiological data acquisition based experiments (ECG).
2. Physiological data acquisition-based experiments (EMG).
3. Physiological data acquisition-based experiments (PFT).
4. Blood Pressure recordings in humans.
5. Determination of specific gravity of blood.
6. Determination of osmotic fragility of RBC.
7. To study various types of contraceptives (condoms, IUD"s, oral and injectable contraceptives)
8. To study different human organs and their sections through permanent slides. T. S. of thyroid, liver, thymus, spleen, ovary, artery, vein, capillaries, testis, pancreas, esophagus, adrenal, kidney (cortex and medulla), urinary bladder, urethra, fallopian tubes, epididymis, prostate glands, lungs, trachea, bronchioles, pituitary, heart. (Minimum 8 slides covering the systems mentioned in theory.)

Essential/recommended readings:

- Guyton and Hall Textbook of Medical Physiology, 14th edition (2020), J. E. Hall; W B Saunders and Company, ebook ISBN: 978-0-3236-4003-9; Hardcover ISBN: 978-0-3235-9712-8
- Human Physiology, 16th edition (2011), Stuart I. Fox; Tata McGraw Hill, ISBN10: 1260720462; ISBN13: 978-1-26-072046-4.
- Principles of Anatomy and Physiology, 16th edition (2020), Gerard J. Tortora and Bryan H. Derrickson; Wiley and Sons, ISBN: 978-1-119-66268-6. (e book), ISBN: 978-1-119-70438-6 (for print book).
- Textbook of Practical Physiology, 9th edition (2019), CL Ghai; Jaypee Publication, ISBN-9789352705320.
-

Suggestive readings:

- Ganong's Review of Medical physiology, 26th edition (2019), K. E. Barett, S. M. Barman, S. Boitano and H. Brooks; Tata McGraw Hill, ISBN 978-1-26-012240-4 (for ebook) ISBN:978-1-26-012241-1 (for print Book)

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES

GENERIC ELECTIVES (GE-1): CONCEPTS IN BIOTECHNOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Concepts in Biotechnology	**3+1**	**3**	**0**	**1**			**Biomedical Science**

Learning Objectives

The Learning Objectives of this course are as follows:

- The purpose of this course is to introduce students to importance of Biotechnology in allied fields.
- It will enable students from diverse backgrounds to understand basic concepts in Gene Cloning and DNA Analysis, and appreciate applications of Biotechnology in everyday life.
- The course will provide students with an insight into the various molecular biology techniques commonly used in Biotechnology, and some of the relevant bio-safety issues and ethical concerns.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Learn about basic biotechnology techniques and key concepts that are used in isolation and characterization of biomolecules (DNA and proteins).
- Develop basic understanding of the robust techniques with wide applications (such as PCR, DNA sequencing) and appreciate their contribution in development of biotechnology.
- Comprehend the importance of gene cloning in biotechnology and learn the intricacies of gene cloning using plasmids and bacteriophages as cloning vectors.
- Understand the importance of construction of genomic libraries and their specialized screening methods to identify gene of interest.
- Learn the concept and application of DNA fingerprinting, recombinant protein expression, biopharmaceutical protein production, and gene therapy.
- Gain an insight of safe handling of GMO's, their environmental release and ethical practices.

SYLLABUS OF GE-1

UNIT – I: Techniques Used in Biotechnology (3.5 Weeks)

Brief history of biotechnology and its importance. Isolation and purification of plasmid DNA. Agarose and Polyacrylamide gel electrophoresis (Native and SDS). Southern and Western hybridization. Polymerase Chain Reaction (PCR): Principle, DNA polymerases in PCR, Primer

Designing, Types of PCR - Hot Start, Multiplex and Reverse Transcription and their Applications. Sequencing: Enzymatic (Sanger's dideoxy) method, Introduction to Automated Sequencing.

UNIT – II Process of Gene Cloning, Expression and Protein Purification (3.5 Weeks)

Restriction endonucleases: Restriction and Modification Systems, Nomenclature and Types of Restriction Enzymes (Type I-IV), Recognition of Restriction Sites. Joining of DNA Molecules: Sticky End and Blunt End Ligations, Role of DNA Ligase, Adaptors, Linkers, Homopolymer Tailing. Vectors: Plasmids (pUC Vectors), Bacteriophage (Lambda Phage Derived Replacement And Insertion Vectors), Cosmids, *In Vitro* Packaging, Expression Vectors (One example each of prokaryotic and eukaryotic expression vectors). Bacterial Transformation, Antibiotic Selection and Blue/White Screening of Transformants. Challenges in Expression of Eukaryotic Proteins in Prokaryotic Hosts.

UNIT – III Genomic and cDNA Libraries (1.5 Weeks)

Construction of Genomic and cDNA Libraries, their Screening by Nucleic Acid Hybridization (Colony and Plaque Hybridization).

UNIT – IV Applications of Biotechnology (2 Weeks)

DNA Fingerprinting. Using the Example of Human Insulin learn the Importance of Various Applications of Biotechnology: Recombinant Protein Expression, Biopharmaceutical Protein Production and Gene Therapy

UNIT – V Biosafety and Ethical Issues (1.5 Weeks)

Safe Handling and Disposal of GMOs and Relevant Ethical Issues. Impact of GMOs on the Environment (Bt. Toxin).

Practical component

Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. To prepare laboratory reagents.
2. To perform plasmid DNA isolation.
3. To perform agarose gel electrophoresis of isolated plasmid DNA.
4. To perform restriction digestion of plasmid DNA.
5. To perform agarose gel electrophoresis of digested DNA.
6. To study restriction mapping.
7. To amplify DNA using PCR.
8. To perform agarose gel electrophoresis of amplified DNA.

Essential/recommended readings

- Glick, B. R. and Patten, C. L. (2022). 6thEdition. *Molecular Biotechnology: Principles and Applications of Recombinant DNA*. USA: ASM press, ISBN-13: 978-1683673668.
- Brown, T. A. (2020). 8thEdition. *Gene cloning and DNA analysis: An introduction*. New York, USA: John Wiley and Sons, ISBN-13: 978-1119640783.
- Karp, G. (2016). 8th Edition. *Cell and Molecular Biology: Concepts and Experiments*. United states: Wiley. ISBN-13: 9781538832462.

- Primrose, S. B. and Twyman, R. B. (2014). 7th Edition. *Principles of Gene Manipulation and Genomics*. New York, USA: John Wiley and Sons. ISBN-13: 978-1118653883.
    - Green, M. R. and Sambrook, J. (2012). 4th Edition. *Molecular Cloning: A Laboratory Manual* (three-volume set). New York, USA: Cold Spring Harbor Laboratory Press ISBN-13: 978- 1936113422

Suggestive readings

- Cantor, C. R. and Smith, C. L. (2004). 1st Edition. *Genomics: The science and technology behind the human genome project*. New York, USA: John Wiley and Sons. ISBN-13: 978-0471461869.
- Old, R. W. and Primrose, S. B. (1994). 7th Edition. *Principles of Gene Manipulation: an Introduction to Genetic Engineering.* Boston: Wiley. ISBN-13: 978-0632037124.
- Joseph Sambrook, E.F. Fritsch, T. Maniatis. (1989). 2nd Edition. *Molecular Cloning: A Laboratory Manual. New York, USA: Cold Spring Harbor Laboratory*. Press ISBN- 978-0879693732.

GENERIC ELECTIVES (GE-2): LANDMARK DISCOVERIES IN SCIENCE

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Landmark Discoveries in Science	**3+1**	**3**	**0**	**1**			**Biomedical Science**

Learning Objectives

The Learning Objectives of this course are as follows:

- The objective of the course is to ensure students appreciate the convenience and comfort that they have is all because of discoveries and inventions of the past.
- Meticulous execution of historical experiments in very little resources would also motivate them towards doing valuable research with enormous facilities that they have.
- The historical accounts of science provide grounds for interpretation and may be useful in arousing appreciation of science.
- The course would provide: Detailed analysis of classically designed and executed experiments in Life Sciences over the years. It will provide a foundation of biology by uncovering various players in the machinery of biological processes.
- It will also be helpful in technical, scientific analysis with historical background for a robust understanding of various discoveries. Critical analysis of the history of biology would surely help students comprehend futuristic scientific discoveries.

Learning outcomes

- Students will be able to learn how was light manipulated during the past to peer into previously invisible world—those too small or too far away to be seen by the naked eye.
- Students will learn about experiments that had fundamental contribution to our present understanding of key molecular elements of life. They will understand how to examine microbial cells and colonies, using various techniques to manipulate color, size, and contrast in ways that helped Scientists to identify species and diagnose disease.
- Studying this unit, students would come to know that there were three group of Naturalists working simultaneously to find answers to inheritance, evolution and basic composition of life. Students will be divulged with hereditary aspects of life. They will get familiar with genes and their roles in living organisms.
- Having understood the relationship of genes and inheritance, students would find interesting to learn the mystical molecule that make up these genes. Sequential study of these experiments would step by step unravel the mystery of genetic material.
- Students at this point of course would be curious to know the structure of molecule that forms the genetic material. They would learn how the information present on DNA manifests itself as specific characteristic features and help in diversity among organisms.
- Students will be explained how the in depth knowledge about DNA became the most important tool for *in vitro* research, modification and applications thereof.

- Students will be briefed about some landmark discoveries which helped the field of medicine to grow tremendously and played a significant role in improving the overall health of the human population.
- Students can be given small projects to write discoveries done in conventional way.
- They will be required to provide a descriptive view of the topics assigned to them. Students should highlight the research topic with reference to current understanding.

SYLLABUS OF GE-2

UNIT – I: View of the invisible Biology (1 Weeks)

Rudimentary microscopes to magnify objects; Use of eye glasses as simplest microscopes - Flea or fly glasses; Observing nature in the new world under lens; Book of Optics; Scientific use of Microscopes; Importance of Malphigi microscope that used field lens; Compound Microscope; Robert Hooke's observations in Micrographia; Foldscope by Manu Prakash.

UNIT – II Origin of Life – A question (1 Weeks)
Spontaneous generation versus biogenesis; Problem of spores; Microbiology and Medicine - Germ theory of Disease; Recognition of agents of infection – Koch's Postulates.

UNIT – III Understanding Biology by observations (2 Weeks)
A) Study of evolution of life: Darwins Theory (B) Study of Inheritance of Life: classical era with contributions of Aristotle, Epicurus, and others; Modern genetics: Gregor Johann Mendel, his work on pea plants, theory of Mendelian inheritance (C) Study of composition of Life : Levels of cellular and molecular organization; Cells, tissues and organs in our body; Pioneers of chromosome studies; Discovery of nucleic acids; Nuclein verified as a distinct chemical entity; Early identification of purines and pyrimidines; building blocks of Nucleic acids and proteins; Chemistry of Nucleic acids; Levene's tetranucleotide hypothesis.

UNIT – IV DNA as the hereditary material – An experimental view (2 Weeks)
DTransformation: Classic work of Frederick Griffith; DNA as the Pneumococcal Transforming Factor; *In vitro* Transformation system; Announcement that the transforming Principle was DNA; Mirsky's Criticism; The Avery, MacLeod and McCarty proclamation; Additional experiments that supported DNA as the transforming principle; Hershey and Chase clinched the role of DNA as the Genetic MaterialNA Fingerprinting. Using the Example of Human Insulin learn the Importance of Various Applications of Biotechnology: Recombinant Protein Expression, Biopharmaceutical Protein Production and Gene Therapy

UNIT – V Solving the puzzle of DNA structure (2.5 Weeks)
Early studies of diffraction of X Rays by DNA fibers – contributions of Rosalind Franklin; Use of X – rays in medicines and research; Erwin Chargaff's discovery of base complementarity in DNA; Watson and Crick model of DNA; Contribution of Linus Pauling; DNA is replicated in Semi-conservative Fashion; Deciphering the Genetic Code; One Gene One Enzyme Edict.

UNIT – VI Technical advancements in biology (2 Weeks)

Polymerase Chain Reaction – a revolution in modern biology; DNA Manipulations using Restriction enzymes; Discovery of reverse transcriptase leading to development of RT-PCR for RNA amplification; Work of Stanley Cohen and Herbert Boyer; Advent of gene cloning - History and current applications

UNIT – VII Research as a backbone of modern medicine (2 Weeks)

(A) Discovery of antimicrobial agents; Contribution of Joseph Lister and later by Alexander Flemming leading to Discovery of Magic bullets; (B) Control of Infectious Diseases – Variolation, mithridatism and vaccination from the view of Edward Jenner; Vaccine production strategies – with examples of BCG and SARS-CoV2 vaccines; Historical timeline of vaccination strategies;(C) Marie Curie – Use of radiation in medicine.

UNIT – VIII Project Work [On any one topic]

Study historical research papers and provide a descriptive view of research that was carried out by Scientists as Minor Project.

(A) Ancient system of medicine

(B) Contribution of any one Indian Scientists in Biology

(C) Contribution of any Physicists or Chemists in Biology (for topics listed above)

Practical component

Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Comparison of invisible life under the view of microscopes versus foldscope.
2. Cells as a unit of life and observation under the microscopes.
3. How do the cells divide – a view under the microscope: (mount of an onion root tip, onion bud cells or grasshopper testis).
4. Mendel's laws of inheritance – clues from nature.
5. Extraction of genomic DNA
6. Use of electric field to analyse DNA and other biomolecules.
7. Sneak Peek through the discovery of Polymerase chain reaction (PCR): Demonstration of original method and comparison with today's sophistication.
8. To test Flemming's hypothesis that the mold killed the bacteria.
9. Group Discussion on Research Topics assigned to students.

Essential/recommended readings

- Watson, J. D. (2011) *The Double Helix – A personal account of the discovery of the structure of DNA*. Scribner. ISBN 9780743219174.
- Cooper, G. M. and Hausman, R. E. (2013). 6th Edition. *The cell: A molecular approach*. Massachusetts, USA: Sinauer Associates. ISBN-13:978-1605351551
- Karp, G. (2013). 7th Edition. *Cell and molecular biology: Concepts and experiments.* New Jersey, USA: Wiley Publishers. ISBN-978-0470483374.
- Cox, M. M. Doudna J. A. and Donnell, M. O. (2012). 1st Edition. *Molecular Biology: Principles and Practice.* London, United Kingdom: W H Freeman & Co Publishers, ISBN-13: 978-0-716-7998-8.
- Watson, J. D. Baker T. A. Bell, S. P. Gann, A. Levine, M. and Losick, R. (2013). 7th Edition. *Molecular Biology of the Gene.* New York, United States: Cold Spring Harbor Laboratory Press, ISBN-13: 978-0-321-76243-6.

Suggestive readings

- Alberts, B et al. (2014). 6th edition. *Molecular Biology of the Cell*. W. W. Norton & Company. ISBN-13 : 978-0815345244
- Bryson, B. (2003) *A short history of nearly everything.* Transworld Publishers. London W5 5SA. A Random House Group Company. ISBN: 9780552997041.
- Lodish H et al. (2003). 5th Revised edition. *Molecular Cell Biology*. W.H.Freeman& Co Ltd; ISBN-13 : 978-0716743668

- Green, M. R. and Sambrook, J. (2012). 4th Edition. *Molecular Cloning: A Laboratory Manual*, New York, United States: Cold Spring Harbor Laboratory Press, ISBN-13:978-1936113422.
- Kornberg, A. (2005). 2nd Edition. *DNA Replication.* California, United States: University Science Books, ISBN-13: 978-1891389443.

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GENERIC ELECTIVES (GE-3): TOXIC SUBSTANCES AND HUMAN HEALTH

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of t he course
		Lecture	Tutorial	Practical/ Practice		
TOXIC S UBSTANCES AND H UMAN HEALTH	4	3	-	1	Open to Students from all subjects	NA

Learning Objectives

The Learning Objectives of this course are as follows:

In daily life, humans are exposed to several toxic substances. Many household products, medicines, cosmetic products, paints, and even food and water may contain toxic substances.; Frequent or improper use of many consumer products or exposure to higher amounts than prescribed, may cause serious health problems. This paper introduces the common toxic substances to which humans are routinely exposed; and health related issues in case of toxicity.

Learning outcomes

The Learning Outcomes of this course are as follows:
After studying, students will be able to:

- Introduction to the various toxic substances and how humans come in contact with toxic hazards. Definitions of various terminologies used in toxicology, and methods of assessment of toxicity of a substance are also covered.
- Upon contact with humans, toxic compounds may be absorbed in the body, and distributed to various organs to show toxic effects. Toxic compounds, once inside the body, are also metabolized or chemically altered. In most cases, after metabolism, the physicochemical properties of toxicants are altered, which helps in their speedy removal from the body.
- Many household products contain substances/ingredients which, if properly not used or applied on the body in excess, can cause serious health effects. These substances include cleaners, household pesticides, cosmetics, disposable utensils, paints, polish, etc. Students will be introduced to few such ingredients and their harmful effects.
- In addition to nutrients, our food also contains several substances which are unavoidable or added unintentionally. These substances and food adulterants, if taken for long time can cause adverse effects.
- Drugs are used to treat diseases. However, if taken at high dose (such as overdosing), drugs act as potential toxic substances. Moreover, several drugs have side effects even at prescribed dose or if used for prolonged duration.
- Anthropogenic activity and natural causes in some cases leads to contamination of soil, water and air with several potential toxicants. These toxicants enter human body via air that we breathe, drinking water and food. With examples of a few toxic substances, students will be introduced how toxicants enter the body from the environment and the adverse health effects caused by them.

SYLLABUS OF GE-3

UNIT – I Introduction to toxic substances and assessment of toxicity (9 Hours)

Types of toxic substances, human contact/exposure with toxic substances (occupational, intentional, accidental etc.); various definitions (toxin, toxicants, xenobiotics, exposure, acute toxicity, chronic toxicity etc); Dose Response Relationship, efficacy, potency, LD50, TD50, NOAEL, ADI; selective toxicity.

UNIT – II Movement of toxic substances inside the body (6 Hours)

Brief introduction to absorption of toxicants via various routes, concept of bioavailability, first pass metabolism, distribution and excretion.

UNIT – III Household toxicants (9 Hours)

Route of exposure, mechanism of toxicity and health effects of common household toxicants:

i). Cleaners, disinfectants, air fresheners (sodium hypochlorite, ammonia, phenol, naphthalene, 1, 4-Dichlorobenzene, methanol).
ii). Garden products, and home mosquito repellents and rat kills (pesticides: organophosphates, pyrethroids, aluminium and zinc phosphide).
iii). Cosmetic products (metals: lead, cadmium; solvents: toluene, acetone).
iv). Other products: disposable utensils (styrene), antifreezing agents (ethylene glycol), Volatile Organic Compounds (VOCs).

UNIT – IV Toxicants and toxins in food **(6 Hours)**

Mechanism of toxicity and health effects of:

i. Pesticide residues (DDT, lindane)

ii. Toxins (amatoxin, muscarine, bacterial toxins)

Brief discuss on food preservatives, colouring agents and flavouring agents etc, and food adulterants.

UNIT – V Drugs as toxicants **(6 Hours)**

Brief introduction of drugs as toxicants with examples; adverse effects of drugs at therapeutic doses, and overdosing.

UNIT – VI Environmental toxicants **(9 Hours)**

Route of exposure, mechanism of toxicity and health effects of:

i. Industrial chemicals (mercury, Polycyclic Aromatic Hydrocarbons, dioxins).

ii. Gaseous air pollutants (nitrogen oxides, sulfur dioxide, carbon monoxide).

iii. Particulate matter (PM).

Practical component - (30 Hours)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Calculation of LD50 value of an insecticide from the data provided.
2. To estimate formaldehyde content in the given sample.
3. To detect presence of paracetamol in the given sample.
4. Analysis of sodium hypochlorite content in various household products.
5. To detect primary alcohol in sample/ household products.
6. To detect aromatic amines in the sample/ household products.
7. To study various toxic substances in terms of exposure, health effects, from various online resources (such as https://www.atsdr.cdc.gov/ , TOXNET or other sources)
8. To separate a mixture of naphthol and naphthalene by solvent extraction method.

Essential readings

- Klaassen, C.D. (2018). 9th Edition. Casarett and Doull's Toxicology, The Basic
- Science of the Poisons. McGraw Hill. ISBN-13: 978-1259863745.
- Stine, K.E. and Brown T.M (2015). 3rd Edition. Principles of Toxicology.
- Florida, USA: CRC Press. ISBN-13: 9781466503434.
- Timbrell. J. (2001). 3rd Edition. Introduction to Toxicology. CRC Press. ISBN13: 978-0415247634.

Suggestive readings

- https://www.atsdr.cdc.gov/
- https://www.cdc.gov/
- Klaassen, C.D and Watkins, J.B. (2015). 3rd Edition. Casarett and Doull's
- Essentials of Toxicology. McGraw Hill Education. ISBN-13:978-0071847087.
- Klaassen, C.D and Watkins, J.B. (2021). 4th Edition. Casarett and Doull's
- Essentials of Toxicology. McGraw Hill, ISBN-13: 978-1260452297.

Annexure-4.01.53
Item No. 4-1-53

INDEX

Faculty of Science

ACBR

Semester-III

B.Sc. (Hons) Course in
Biomedical Science: *II Year*
Discipline Specific Core (DSC)
Semester III

DISCIPLINE SPECIFIC CORE COURSE -7 (DSC-7) MEDICAL MICROBIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Medical Microbiology	**4**	**3**	**-**	**1**	**----**	**NA**

Learning objectives

The Learning Objectives of this course are as follows:

- The Medical Microbiology course has been formulated to impart basic and medically relevant information on microbes.
- The microbial structure, growth and development. Methods of isolation and characterization of microbes and role of sterilization in the context of study of microbes.
- Pathogenic microbes and the diseases caused by them are included to broaden the perspective of the subject.
- This course will also focus on mechanisms of microbial pathogenesis and the host response, and the scientific approaches that are used to investigate these processes.
- The course also deals with the problem of emerging antimicrobial resistance with reference to known pathogens.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Medical microbiology describes a broad perspective to study structure, classification, and diseases caused by microbes including bacteria, fungi, protozoa and viruses. The course helps to understand the nature of microorganism, their systematic classification and contribution of various scientists in the discovery of disease causing pathogen and its etiology. It also describes various culture media used for cultivation of microbes, their optimum physical, chemical and cultural requirements, techniques for purification and preservation of microbes.
- This course explains the various types of microbial cells, shape, size, molecular structure and their role in pathogenesis. The basic nutrient requirements of microorganism and how they behave in variable atmospheric conditions is also included. Analyzing optimum growth conditions that facilitate in growth and cultivation of useful microorganisms are also mentioned.
- Microbial genetics helps to understand the basic phenomenon of gene functioning and effects of various mutagens on microorganism, elucidates different methods of gene transfer and explains causes of genetic variation.
- Course also elucidates the interaction between host and their pathogens, mode of transmission of infectious diseases and their cure.
- This course also explains pathogenesis, etiology, clinical symptoms, control and cure of microbial diseases in addition to introducing antimicrobial action of antibiotics. Describes basic structural and morphological variation in various viruses, classification and their life cycle. Introduction to requirements of viruses for multiplication and detailed study of common disease causing viruses, virusoids and prions is also included.

SYLLABUS OF DSC-7

Unit I: Fundamental concepts (10Hours)

a) History of microbiology with special emphasis on contribution of Louis Pasteur and Robert Koch in Medical Microbiology.
b) Major Divisions of life- Domains, Kingdoms; Requirements for microbial growth, growth factors, culture media- synthetic and complex, types of media. Techniques for obtaining pure cultures of microbes, preservation and storage of bacterial cultures, growth curve and generation time, control of microbial growth.

Unit II: Bacterial cell: fine structure and function (10Hours)

Size, shape and arrangement of bacterial cells; Cell membrane, cytoplasmic matrix, inclusion bodies (e.g.Carboxysomes, magnetosomes, gas vacuoles, cyanophycean granules, PHB granules, glycogen granules), nucleoid, ultrastructure of gram positive and gram negative bacterial cell wall, sex pili, capsule, flagella & motility and endospore.

Unit III: Microbial genetics (08Hours)

Mutants-auxotrophs and prototrophs, bacterial recombination: general and site specific and replicative, bacterial plasmids fertility factor, col plasmid, bacterial conjugation (Hfr, F′, F^+, F^-), transformation, transduction- both generalized and specialized.

Unit IV: Host-pathogen relationship in the infectious diseases (05Hours)

Relationship between normal microbiota and host, opportunistic microorganisms, nosocomial infections. Development and spread of infectious diseases: invasion, pathogen, parasite, pathogenicity, virulence, carriers and their types. Routes, mechanisms of invasion and establishment of infection.

Unit V: Microbial diseases (06Hours)

Respiratory tract infections: with tuberculosis in detail, gastrointestinal tract infections, staphylococcal food poisoning. Life cycle of *Candida albicans* and *Plasmodium*.

Unit VI: Virus and virusoids (06Hours)

General life cycle of a virus, structure, enveloped and un-enveloped viruses, plaque assay, growth curve, classification based on genetic material and detail study of influenza, SARS COV-2 and HIV virus with curative agent. Viroids, virusoids and prions.

Practical component (30 Hours)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Preparation of different media: synthetic media Davis-Mingioli media, complex media- nutrient agar or Luria agar media.
2. Isolation and purification of pure bacteria: streaking for single colonies
3. Propagation of pure bacteria in liquid culture
4. Gram's staining; gram positive and gram negative bacteria
5. Capsule staining of *Bacillus subtilis*/*Klebsiella*
6. Endospore staining of *Bacillus subtilis*
7. Study and plotting the growth curve of *E. coli* using turbidometric method
8. Isolation of bacteriophages from soil/sewer water and calculation of the plaque forming units (pfu)
9. To perform antibacterial testing by Kirby-Bauer method
10. Field visit to a clinical microbiology lab/diagnostic lab to familiarize with latest tools and

techniques used in microbial research

Essential readings:

- Dorothy Wood, Joanne Willey, Kathleen Sandman (2022). 12th Edition. Prescott's microbiology. New York, USA: McGraw-Hill Education. ISBN-10: 1-264-77733-7 / 1264777337
- Cappuccino, J.G. and Sherman, N. (2013). 10th Edition. Microbiology: A laboratory manual. California, USA: Benjamin Cumming. ISBN-13: 978-0321840226.

Suggestive readings for basics:

- Madigan, M.T., Martinko, J.M., Stahl, D.A. and Clark, D.P. (2010). 13th Edition. Brock biology of microorganisms. California, USA: Benjamin Cumming. ISBN-13: 978- 0321649638.
- Pelczar, M.J (2001). 5th Edition. Microbiology. New York, USA: McGraw Hill International. ISBN-13: 9780074623206.
- Tille, P. (2013). 13th Edition. Bailey & Scott's diagnostic microbiology. Missouri, USA: Mosby Publishers. ISBN-13: 978-0323083300.
- Tortora, G.J., Funke, B.R. and Case C.L. (2006). 9th Edition. Microbiology: An introduction. California, USA: Benjamin Cummings. ISBN-13: 978-0536292117.

DISCIPLINE SPECIFIC CORE COURSE -8 (DSC-8) MEDICINAL CHEMISTRY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MEDICINAL CHEMISTRY	**4**	**3**	**-**	**1**		**Basic knowledge of Enzymes and proteins**

Learning objectives

The introduction of Medicinal Chemistry course at undergraduate level to Biomedical Science students has been conceived to make them understand:

- Concealed chemical science interlinked to other science disciplines such as biophysics, chemistry, biology, biochemistry, pharmacology etc.
- Application of the area in revealing new drug design and targets through studying the drug-receptor interactions and signaling mechanism in cell for lead discovery.
- Various drug targets in the body and drug development strategies with mechanism of action and concept of drug resistance.

Learning Outcomes

- After completing the course, students shall be able to understand the various stages involved in drug development. Further, they will be able to explore various kinds of drug targets including protein, enzymes, nucleic acids etc.
- They will also appreciate the process of drug-receptor interactions; identify association between chemical structure and its physicochemical properties. After the completion of the course, the learners will demonstrate a strong foundation via problem solving, critical thinking and analytical reasoning in the fundamentals of medicinal chemistry, physicochemical principles of drug action and measurement of drug effects, comprehend the physicochemical basis for the rational drug design, analogue synthesis, and mechanism of action of drugs.
- Additionally, this course will involve extensive laboratory work. The students will be able to design and carry out small molecule (low molecular drug-relevant compounds) synthesis. They will do the natural product isolation along with their purification and characterization through chromatography and spectroscopic methods and analyze the results of such experiments.
- They will also actively participate group exercises; communicate the results of experiments conducted in oral as well as written formats. Further, they will appreciate the central role of chemistry in our daily life and will also learn safe handling of hazardous chemicals and follow the SOP for chemical waste disposal.

SYLLABUS OF DSC-8

Unit-1: General introduction (02 Hours)
Definition and scope of Medicinal Chemistry

Unit-2: Principles of Drug Design (10 Hours)
Introduction to Structure Activity Relationship (SAR) of morphine/salicylic acid, strategies in the search for new lead compounds, analogue synthesis versus rational drug design, concept of prodrugs. Affinity, efficacy and potency of drugs. Concepts of agonist, antagonist and inverse agonist, competitive, non-competitive, suicide inhibitors.

Unit-3: Physicochemical principles of drug action and measurement of drug effects (10 Hours)
Partition coefficient, drug dissolution, acid-base properties, surface activity, bioavailability, stereochemical aspects of drug action, electronic structure (Hammett correlations) and determining relationship between chemical and biological data (Hansch approach). Kinetic analysis of ligand receptor interactions using Scatchard plot, Double reciprocal plot, Hill plot, forces involved, relationship between dose and effect (graded and quantal response).

Unit-4: Drug target classification (15 Hours)

a. Proteins as drug targets.
   i. Receptors: the receptor role, ion channels, membrane bound enzyme activation, desensitization and sensitization of receptors, agonist (e.g. endorphins) and antagonists(e.g. caffeine)
   ii. Enzymes: Enzyme inhibitors, medicinal use of enzyme inhibitors (e.g. clavulanic acid)
b. Nucleic acids as drug targets. Classes of drugs that interact with DNA: DNA intercalators (amsacrine), Groove binders (netropsin), DNA alkylators (amines: mechlorethamine; nitrosoureas: carmustine), concept of antisense therapy.

Unit-5: How drugs trigger the signals-molecular aspects (08 Hours)
Structure and functions of cell surface receptors, signal transduction mechanism (GPCRs, tyrosine kinase, guanylate-cyclase linked receptors and intracellular receptors that regulate DNA transcription).

Practical Component (30 hours)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Preparation, recrystallization and purity of following drugs/compounds by melting point and TLC
   i. Hippuric acid.
   ii. Benzocaine,
   iii. Benzoquinone
   iv. Phenacetin
   v. s-benzyl thiouronium salt.
2. Determination of partition coefficient of aspirin in octanol-water system.
3. Extraction of caffeine from tea leaves.
4. Study absorption properties of caffeine.
5. Extraction of piperine from black pepper.
6. Phytochemical screening of *Curcuma longa* by solvent extraction: Terpenes and polyphenols

Essential Readings:

- Patrick G.I. (2017). 6th Edition. Introduction to medicinal chemistry. Oxford, UK: OxfordUniversityPress.ISBN-13: 978-0198749691.
- Silverman, R.B. and Holladay, M.W. (2015). 3rd Edition. The organic chemistry of drug design and drug action. San Diego, USA:Elsevier,AcademicPress.ISBN-13:9780123820303.
- Ashutosh Kar (2020) Advanced Practical Medicinal Chemistry 3rd Edition New Age International Private Limited, ISBN-10 : 9388818458

Suggestive Reading for Basics:

- Gringauz, A. (1996). 1st Edition. Introduction to medicinal chemistry: How drugs act and why. Brooklyn, New York, USA: WileyVCH.ISBN-13:978-0471185451.
- King F.D. (2003). 2nd Edition. Principles and practice of medicinal chemistry. London, UK: The Royal Society of Chemistry. ISBN-13: 978-0854046317.
- Nogrady, T. and Weaver, D.F. (2005). 3rd Edition. Medicinal chemistry: A molecular and biochemical approach. New York, USA: Oxford University Press. ISBN-13:978-0195104561.
- Wermuth, C.G., Aldous, D., Raboisson, P. and Rognan, D. (2015). 4thEdition. The practice of medicinal chemistry. San Diego, USA: Elsevier, Academic Press. ISBN-13:978-0124172050.

DISCIPLINE SPECIFIC CORE COURSE- 9 (DSC-9) BIOSTATISTICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BIOSTATISTICS	4	3	-	1		NA

Learning objectives

The Learning objectives of this course are as follows:

- To acknowledge, appreciate and effectively incorporate the basic statistical concepts indispensable for carrying out and understanding biological hypotheses, experimentation as well as validations.
- The course is aimed to create awareness about the applications of statistics in biological sciences along with building confidence in students to test their experimental data with an appropriate test of significance.

Learning outcomes

Having successfully completed this course, students shall be able to:

- Appreciate the importance of statistics in biological sciences. They will also understand the concept of different variables and data types, and also the sampling techniques.
- Learn different measures of central tendency and dispersion with their applications. The students will also learn symmetric and asymmetric distributions, and kurtosis of distributions.
- Identify the degree of uncertainty in making important decisions, learning joint probability, conditional probability, Bayes' theorem and solving its application-level problems.
- Learn about the characteristics of normal, binomial and Poisson probability distributions. They will learn how to identify which type of distribution fits the given data and estimate probabilities for random variables in these distributions
- Determine the strength of the relationship between two variables and also to predict the value of one variable given a value of another variable.
- Learn how to formulate statistical hypotheses for testing and application of different tests of significance for hypothesis testing for different biological problems.

SYLLABUS OF DSC-9

Unit I: Introduction to Biostatistics **(02 Hours)**

Types of data in biology, random variables: discrete and continuous. sample and population, techniques of sampling (random and stratified), sampling and non-sampling errors.

Unit II: Descriptive Statistics **(08 Hours)**

Measures of central tendency: arithmetic mean, mode, median and partition values. Measures of dispersion: range, standard deviation, coefficient of variance and covariance, masures of skewness: Pearson's Coefficient of skewness, and concept of kurtosis (platykurtic, mesokurtic and leptokurtic).

Unit III: Probability (05 Hours)
Basic concepts, addition and multiplication, rules of probability, conditional probability, Bayes' theorem and its applications in biostatistics.

Unit IV: Probability distributions (06 Hours)
Binomial and normal distributions along with their properties and relationships. Introduction to poisson distribution.

Unit V: Correlation and Linear Regression (06 Hours)
Correlation analysis: scatter diagrams, Pearson's and Spearman's coefficient of correlation, coefficient of determination.
Simple linear regression analysis: method of least squares, equations of lines of regression and their applications in biostatistics.

Unit VI: Hypothesis testing (18 Hours)
Sampling distributions and standard error, Null and Alternate hypothesis, Basic concept and illustrations of type I and type II errors, concept of confidence interval estimation. Large sample tests for single mean and difference of means.
Student's t-distribution: test for single mean, difference of means and paired t-test. Chi-square distribution: test for goodness of fit, independence and homogeneity. F-test, one-way and two-way analysis of variance (ANOVA).Non-parametric analysis: The Sign test and The Wilcoxon signed-rank test.

Practical component (30 Hours)

The computer-based experiments are designed for students to solve biostatistics problems. All theoretical concepts would be covered in the practical using any spreadsheet software like MS EXCEL.

1. Represent different types of data in tables and graphs (Line chart, histogram, bar chart, frequency polygon, pie chart).
2. Calculate various measures of central tendency (Arithmetic mean, mode, median and partition values) and dispersion (Range, standard deviation, coefficient of variance and covariance).
3. Calculate probabilities for different distributions- normal and binomial.
4. Prepare scatter plot between two variables and interpret the relationship between them using correlation and simple linear regression analysis.
5. Perform large sample test for single mean and difference of means.
6. Perform Student's t-test for one sample, independent samples, and paired samples.
7. Perform Chi-square test.
8. Perform One-way ANOVA.
9. Perform Two-way ANOVA.
10. Perform Non-parametric analysis: The Sign test or The Wilcoxon signed-rank test.

Essential readings:

- Daniel, W.W. and Cross, C.L. (2019). 11th Edition. Biostatistics: A foundation for analysis in the health sciences. New York, USA: John Wiley & Sons. ISBN: 9781119588825.
- Pagano, M. and Gauvrean, K. (2018). 2nd Edition. Principles of biostatistics. California, USA: Duxbury Press. ISBN-13: 9781138593145.
- Schmuller, J. (2016). Statistical Analysis with Excel for Dummies. 5th Edition. New York, USA: John Wiley & Sons. ISBN: 9781119844549.

Suggestive readings for basics:

- Glantz, S. (2012). 7th Edition. Primer of biostatistics. New York, USA: McGraw-Hill Medical. ISBN: 9780071781503.
- Triola M.M., Triola M.F., Roy J. (2019). Biostatistics for Biological and Health Sciences. Harlow, UK: Pearson Education Ltd.
- Zar, J.H. (2014). 5th Edition. Biostatistical analysis. USA: Pearson. ISBN: 9789332536678.

DISCIPLINE SPECIFIC ELECTIVES (DSE) COURSES
SEMESTER III/IV

III/ IV	DSE 01	Proteins and Enzymes
	DSE 02	Practices in Biosafety
	DSE 03	Social and Preventive Medicine

DISCIPLINE SPECIFIC ELECTIVE COURSE –1 (DSE-1) PROTEINS AND ENZYMES

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
PROTEINS AND ENZYMES	4	3	-	1	----------	NA

Learning objectives

The Learning Objectives of this course are as follows:

- The objective of this course is to provide an overview of protein biochemistry and enzymology.
- Proteins and enzymes, being the most versatile functional entities, hold several applications in life sciences research as well as in industry and biomedicine.
- The biochemical, structural, and functional aspects of the interaction of proteins and enzymes will be introduced in this course.

Learning outcomes

The Learning outcomes of this course are as follows:Having successfully completed this course, students shall be able to learn and appreciate:

- The unique features and characteristics of proteins and enzymes and their applications in research, medicine, and industry.
- The relationship between three–dimensional structure of proteins and enzymes and their functions.
- The basic mode of action of enzymes and their remarkable regulation.
- The protein misfolding and the diseases associated with it.
- The students would be able to understand the various biomedical applications of enzymes.
- The students would be able to gain hands-on experience in working with proteins and enzymes from various sources. Hence, it will improve their learning skills and imbibe the basic concepts of this field.

SYLLABUS OF DSE 01

Unit I: Structural organization of proteins (08 Hours)

Organization of protein structure- primary, secondary, tertiary, and quaternary. Secondary structures – helices, sheets and turns. Motifs, domains and their functional importance. Native and denatured state of a protein. Physico-chemical interactions that maintain the native structure of a protein.

Unit II: Protein folding and diseases related to protein misfolding (10 Hours)

Protein folding (Hydrophobic collapse), Anfinsen theory, Levinthal paradox and protein folding in the cytoplasm. Protein denaturation by chaotropic agents such as urea, GnHCl.

Concept of how mutation causes protein misfolding (loss-of-function to toxic-gain-of function) and related diseases such as Alzheimer's disease, Prion diseases, Tay-Sachs disease and Huntington disease.

Unit III: Enzymes: characteristics and kinetics (14 Hours)

Classification of enzymes and nomenclature. Concept of multi-functional enzyme and multi-enzyme complex. Fischer's lock & key and Koshland's induced fit hypotheses. Enzyme specificity. Enzyme kinetics- Michaelis-Menten equation, Lineweaver-Burk plot. To understand the physiological significance of K_m, V_{max}, K_{cat} and the factors affecting enzyme activity. Basics of enzyme inhibition- reversible (competitive, uncompetitive, non-competitive) and irreversible inhibition.

Unit IV: Regulation of enzyme activity (06 Hours)

Allosteric regulation, feedback inhibition, reversible covalent modification (Phosphorylation, glycosylation and acetylation using example of glycogen phosphorylase/glycogen synthase). proteolytic activation- zymogens.

Unit V: Biomedical application of enzymes (07 Hours)

Applications of enzymes in the diagnosis of diseases using creatine kinase and glucose oxidase and in therapy (streptokinase). Enzyme inhibitors as drugs. Principle of enzyme immunoassay. Enzyme immobilization and its applications, concept of abzymes. Industrial applications of enzymes (biosensor - HRP; food industry- rennin; cosmetics-collagen, etc)

Practical Component (30 Hours)

(Wherever wet-lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs, etc.)

1. Enzyme-based diagnostic assay (any one).
2. Measurement of enzyme activity and calculation of specific activity of an enzyme.
3. Effect of pH on enzyme activity.
4. Effect of temperature on enzyme activity
5. Visualization of 3D protein structure using suitable software.
6. Analysis of type of enzyme inhibition from the given experimental data
7. To study the effect of protein denaturants such as acid, alkali, heat and any organic solvent on protein.
8. Study of images of various toxic protein oligomeric species, associated with human diseases (amyloids, disordered aggregates, amorphous aggregates).

Essential readings:

- Nelson, D. L., & Cox, M. M. (2021). *Lehninger: Principles of Biochemistry* (8th ed.). Macmillan. ISBN: 9781319322328.
- Berg, J., Gatto, G., Stryer, L. and Tymoczko, J. L. (2019). *Biochemistry*. New York, USA: W. H. Freeman and Company.
- Voet, D., Voet J., Pratt, C. (2018). *Principles of Biochemistry*(5thed.) Wiley Blackwell. ISBN: 978-1-119451662.
- Plummer, D. (2017) An Introduction to Practical Biochemistry, (3rd ed.). McGraw-Hill College; ISBN-13: 978-0070841659.

Suggestive readings for basics:

- Devlin, (2011). Textbook of Biochemistry with Clinical Correlations. UK: Wiley T & Sons.
- Campbell, M. K. and Farrel, S. O. (2012) (7thed.). Biochemistry. Boston, USA: Brooks/Cole Cengage Learning. ISBN: 13:978-1-111-42564-7
- Nicholes,C.P., Lewis, S. (1999). Fundamentals of Enzymology (3rd ed.). Oxford University Press Inc. (New York), ISBN:0 19850229 X
- Cooper, T.G. (2011). The Tools of Biochemistry (2nded.). Wiley-Inter science Publication (New Delhi). ISBN: 13:9788126530168.
- Sheehan, D. (2009). Physical Biochemistry (2nded.). Wiley-Blackwell (West Sussex), ISBN: 9780470856024/ISBN: 9780470856031.

DISCIPLINE SPECIFIC ELECTIVE COURSE –02 (DSE-02) PRACTICES IN BIOSAFETY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
PRACTICES IN BIOSAFETY	4	3	-	1	----------	NA

Learning objectives

- Recent advances in the field of Biomedical Research have brought into focus the need for certain practices and strategies to prevent exposure to pathogens and toxins.
- The inventions in the field of Genetic Engineering have significantly influenced agriculture, medicine and food processing industry. Thus implementation of biosafety enables number of procedures and rules that will be helpful in protecting humans and environment from disease causing microorganisms, pests, additives, contaminants and residues etc.
- Topics such as responsible use of biotechnology, biosafety levels, genetically modified (GM) food, biosafety regulations, impact of biotech processes on environment are of major significance in present scenario.

Learning outcomes

- In this students would understand application of biotechnology in different fields like agriculture, environment, industrial manufacturing, food processes, health and medicine etc. It will enable them to recognize implication of recombinant biomolecules and organisms on our society.
- This would enable students to know about various hazardous biological substances one can come across while working in the laboratory or day today life, and the steps taken to minimize the risk. The students would understand different regulations for handling biohazard and radioactive material.
- The course should kindle the inquisitiveness in students about genetically modified and living modified organisms (GMO & LMO) and their impact on the environment.

SYLLABUS OF DSE-02

Unit I: Introduction to biosafety (04 Hours)

Historical background of Biosafety, definition of biosafety, application of biosafety and need for biosafety.

Unit II: Social responsibility of biotechnology and biomedical research (08 Hours)

Legal and socio-economic impacts of biotechnology. Social responsibility towards safety measures.Social and ethical implications of biological weapons (Bioterrorism).Implication of recombinant biomolecules and organisms. Implication of gain of function research. Importance of biotechnology: benefits and limitations of transgenic to human health, society and the

environment.

Unit III: Biosafety and importance of containment facility (08 Hours)
Components of biosafety (biohazard and biosecurity), measures of biosafety, containment (good laboratory practices and techniques, safety equipment, design facility), types of containment (physical and biological). Biosafety levels (BSL 1, 2, 3, 4), barriers (physical and secondary).

Unit-IV: Genetically modified organism: concerns and challenges (10 Hours)
Government of India definition of genetically modified organisms (GMOs) and living modified organisms (LMOs), roles of institutional biosafety committee, review committee on genetic manipulation (RCGM), genetic engineering approval committee (GEAC) for GMO applications in food and agriculture, environmental release of GMO in rDNA biosafety guidelines of India. Biosafety assessment procedures for biotech foods and related products, including transgenic food crops, case studies of relevance. Biosafety assessment of pharmaceutical products such as drugs/vaccines etc.

Unit-V: Handling and transportation of GM, infectious and radioactive materials (09 Hours)
Classification of infectious organisms, transportation of genetically modified/infectious organisms, General preparation of shipments for transport: Basic triple packaging system, marking of packages, labelling, precautions, monitoring strategies and methods for detecting transgenic; radiation safety and non-radio -isotopic procedures.

Unit VI: Biosafety guidelines and regulations (06 Hours)
Aim of biosafety guidelines, biosafety and risk assessment issues; regulatory framework; national biosafety policies and law, the cartagena protocol on biosafety, WTO and other international agreements related to biosafety.

Practical component (30 Hours)

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs)

1. Protocol for development of recombinant / engineered proteins as therapeutics
2. Preparation of comparative account on BSL 1, 2,3,4. (poster, oral presentation, video)
3. Categorization of list of provided hazardous materials and its handling & disposal
4. To study GEAC guidelines on genetically modified crops (Bt-cotton/Bt-brinjal)
5. To develop an understanding of the role and composition of an ethical committee for research by a presentation mode.
6. To study and develop a flowchart to demonstrate spread and containment of any two infectious diseases (typhoid, SARS, Ebola, Dengue, Tuberculosis and Covid).
7. Preparation of chart explaining significance of various symbols used in chemistry and biology laboratories/ reagent bottles and equipment.

Essential Readings:

- Beauchamp, T.L and Childress, J.F. (2013). 8th edition. Principles of biomedical ethics. Oxford, UK: Oxford University Press. ISBN 9780190640873.
- Helga, K. and Peter, S. (2016). 3rdedition. A companion to bioethics. New Jersey, USA: John Wiley and Sons. ISBN 9781118941508.
- Hunt, E. F. and Colander, D. C. (2019). 17th edition. Social science: An introduction to the study of society. Boston, USA: Pearson/Allyn and Bacon. ISBN 9781138592537.

- Peter, A. S. and Viens, A. M. (2008). 1st edition. The Cambridge textbook of bioethics. Cambridge, UK: Cambridge University Press.ISBN 9780521872843.
- Sateesh, M.K. (2008). 1st edition. Bioethics and Biosafety. New Delhi, India: I K International Pvt Ltd. ISBN 978-8190675703.

Suggestive readings for basics:

- Rajmohan, J. (2006). 1st edition. Biosafety and bioethics. New Delhi, India: Isha Books. ISBN 13: 9788182053779.
- Rebecca, G.; James, F. H.; Karim, M. M.; Cholani,W. (2011). 1st edition. Environmental safety of genetically engineered crops. Michigan, USA: Michigan State University Press. ISBN 978-1611860085.
- Sreekrishna, V. (2007). 1st edition. Bioethics and biosafety in biotechnology. New Delhi, India: New Age International (P) Ltd. ISBN 978-8122420852.
- Tomme, Y. (2004). 1st edition. Genetically modified organisms and biosafety. Gland, Switzerland: World Conservation Union publications. ISBN 2831707986

DISCIPLINE SPECIFIC ELECTIVE COURSE –03 (DSE-03) SOCIAL AND PREVENTIVE MEDICINE

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
SOCIAL AND PREVENTIVE MEDICINE	**4**	**3**	**-**	**1**	Student should have studied science (Biological science/ Physical sciences)	**NA**

Learning objectives

- The origin of medicine to alleviate human suffering from disease, and control of disease is as old as origin of human itself. Various civilizations practiced their own methods to treat and control diseases.
- The modern form of medicine that has evolved over time, is composed of two main branches viz: Curative medicine and Preventive medicine/Public health. It has been realized that causes of diseases are multifactorial- a disease can have multiple causes/factors such as social, economic, genetic, psychological and environmental factors.
- In the centre of modern medicine is epidemiology, which is concerned with measuring distribution patterns and determinants of disease in a Population/community, and needs of health related services.
- The health related services are delivered through health programmes and health systems to various risk groups such as at risk-mothers, at risk-infants, elderly or chronically ill patients.

Learning outcomes

- Introduction to various concepts of health and disease, factors determining health of individuals or population/community, interaction of factors in causing disease. Students will also be introduced to the concepts of levels of prevention adopted to achieve a state of health or to preserve health.
- Epidemiology is in the core of basic science of social preventive and medicine, and is concerned with study/measurement of the distribution and determinants of health related issues. Students will be introduced to the concepts of epidemiology, various methods and approaches that are used to measure the intensity and distribution of health related issues in the community/population.
- Introduction to the various definitions/ concepts related to natural history of disease viz: mode of disease transmission and progress of infection/disease in the host. Students would get opportunity to learn natural history of communicable disease, diagnosis, treatment and control, and various health programmes for prevention (with examples of certain prevalent diseases in India. Through examples of few diseases prevalent in India and globally, epidemiology of those diseases which are considered as lifestyle diseases or multi-factorial diseases will be introduced.
- The definition of health also includes dimensions of social and mental well-being.

Therefore, mental illness has been recognized as one of the important health issues. Students will be introduced to the various types of mental illness and its prevention.

- Infertility is a worldwide problem, and estimates of infertility in India are about 4-6 percent. Childlessness is social and demographic implications. The etiology of infertility is variable. Mother and children are considered as special-risk group in a population, and is a priority group in any community. The mother, and the growth and development of fetus/ infants are at the risk of several health problems. Further, under certain circumstances, their survival too is at risk. The multitude of problems affecting the health of mother and child constitutes serious health problems in a developing country. Students will be introduced to the various maternal and child health related problems/ complications (and their prevention), from conception to the birth of infants.
- Health has been declared a fundamental human right and has to be delivered by the governments to all. Therefore, there is a system to promote and provide health services to every individual living in urban or rural settings. Students will be introduced briefly about the system of health care and various levels of health care in India.

SYLLABUS OF DSE-3

Unit I: Basic concepts of health and disease (06 Hours)

Definition, determinants and indicators of health and disease, demography (transition, and sources of demographic data, registries), survey methodology including census procedures and sampling. epidemiological triad. Multi-factorial aetiology of disease. Concepts of prevention and control.

Unit II: Epidemiology and epidemiological methods (06 Hours)

Definition and history, components of epidemiological studies viz. disease frequency, distribution and determinants. Basic measurements/tools in epidemiology: rates, ratios and proportions (mortality and morbidity rates and ratios, prevalence, incidence); epidemiological studies: descriptive, analytical, randomized controlled trials. Concept of association and causation. Brief introduction to modern epidemiological tools.

Unit III: Epidemiology of diseases (16 Hours)

Various definitions: epidemic, endemic, pandemic, sporadic, nosocomial infections etc. Cases, carriers, transmission of disease, concept of incubation period, generation time, communicable period and secondary attack rate.

a. Communicable diseases: control and health care programs for of national importance (extent of problem in India and worldwide, main clinical features, diagnosis, treatment & resistance, immunization and prevention practices, health programmes (if applicable):

Respiratory infections:	*Tuberculosis*
Intestinal infections:	*Cholera*
Arthropod-borne infections:	*Malaria*
Zoonosis:	*Rabies*
Sexually transmitted infection:	*AIDS*

b. Non-communicable disease: control and health care programs for of national importance (extent of problem, diagnosis, treatment and control, health programmes (if applicable): Hypertension, stroke, diabetes, breast cancer.

Unit IV: Mental health (05 Hours)

Introduction and scope. Features of mentally healthy person, signs of poor mental health, types of mental health (anxiety and depression), and prevention. National Mental Health Programme

(NMHP).

Unit V: Infertility, mother and child health (06 Hours)

Measures of fertility and factors affecting fertility, child health, maternal health, immunization programme.

Unit VI: Health care system in India (06 Hours)

Concept of health care, levels of health care, brief introduction to Primary Health Care in India (village level, sub-centre level, primary health centre level, community health centre level, hospitals).National Programme for Health Care of the Elderly (NPHCE).

Practical component (30 Hours)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. To explore any publically available database for tuberculosis/typhoid and study its epidemiology in the Indian population.
2. To study the epidemiology of malaria including geographical and seasonal distributions in India through a public database.
3. To study various parameters like risk factors, incidence, prevalence, mortality rate and DALYs. for any specific type of cancer prevalent in India through NCRP or any other public database.
4. To study the burden and causes of any hematological disorder in the Indian population.
5. To explore and analyse various national and international disease databases like ICMR/WHO/CDC/ etc.
6. To prepare a questionnaire for any health condition studied in S.No. 1-5.

7-10. To prepare a poster/ presentation using any digital media to communicate about the epidemiology and to create awareness about any health condition studied in S.No. 1-5.

Essential reading

- Park, K. (2021), 26th Edition, *Park's Textbook of Preventive and Social Medicine*, Banarsidas Bhanot Publisher, ISBN-13 : 978-9382219163.

Suggestive reading for basics

- Bonita, Ruth, Beaglehole, Robert, Kjellström, Tord& World Health Organization. (2006) 2nd edition. *Basic Epidemiology*, World Health Organization, ISBN 978 92 4 154707 9.

GENERIC ELECTIVES (GE) COURSES FOR SEMESTER III

1.	GE-04	BIOCHEMICAL BASIS OF LIFE
2.	GE-05	HEALTH AND BODY DEFENSE SYSTEM
3.	GE-06	UNDERSTANDING THE HUMAN BODY SYSTEMS

GENERIC ELECTIVE COURSE -04 (GE-04): BIOCHEMICAL BASIS OF LIFE

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
BIOCHEMICAL BASIS OF LIFE	4	3	-	1	-----	NA

Learning objectives

The Learning Objectives of this course are as follows:

- The objective of this course is to address how the wonderful and remarkable properties of living organisms arise from the various biomolecules, the building blocks.
- The course focuses on the chemical complexity and organization of molecules in a living cell, extraction and transformation of energy
- It gives insights into the changes that occurred during the gradual evolution of life.

Learning outcomes

The Learning Outcomes of this course are as follows:

- The fundamental Chemistry of Life: students will gain an understanding of the elements found in living systems and appreciate the importance of water as the solvent for living systems. It is important to learn about the units used for expressing the biochemical basis of a living system. Students will learn the unit system for the molecular mass of biomolecules, units used for the concentration of solutions, and units for expressing the distances, etc.
- Cellular foundations of life**: a** stepwise organization of a living system, starting from the smallest unit to an entire living organism would be the focal point in this unit.
- Molecular basis of life**: s**tudents will understand the monomeric forms of different types of biomolecules. In addition, the relationship between the structure and function of biomolecules would also be learnt.
- Physical foundation of life: students would learn the concept of enthalpy, entropy and free energy in a living system and understand the importance of the energy currency and the significance of coupled biochemical reactions.
- Biochemical events in the origin of life: students would learn the origin of life and the nature of transformative changes that occurred for life to evolve from the pre-biotic world to the modern times.

SYLLABUS OF GE-04

Unit I: The fundamentals of chemistry of life (06 Hours)

Carbon chemistry of life, structure and importance of water, diverse inorganic ions, major elements (C, H, O, N, S), trace elements. Units used in biochemistry such as those expressed for the atomic mass unit (daltons), concentration (moles/litre) and distance (in nanometer-scale).

Unit II: Cellular foundations of life (06 Hours)

Levels of organization in a living system. The important features of living cells, subcellular

organelles in eukaryotic cells and subcellular organization in prokaryotic cells. Brief description on phototrophs, chemotrophs, autotrophs and heterotrophs.

Unit III: Molecular basis of life (12 Hours)

Common functional groups and linkages in biomolecules.

Macromolecules: classification, building blocks, structural and functional diversity. Structural and functional forms of macromolecules: Proteins (collagen, albumin, hormones (insulin), enzyme (proteases, nucleases, amylases and lipases); Polysaccharides (starch, glycogen, cellulose), Nucleic acids, Lipids (cholesterol and triglycerides).

Unit IV: Physical foundation of life (11Hours)

Enthalpy, Entropy, Free Energy, Standard Free Energy, Equilibrium constant, Open and closed systems, endergonic and exergonic reactions, the energy currency in a biological system (ATP), energy coupling reactions.

Unit V: Biochemical events in the origin of life (10Hours)

Landmark events in the evolution of life. Biochemical basis of the origin of aerobic and anaerobic world. Evolution of biological monomers and polymers from pre-biotic compounds. Properties of DNA as genetic material. Structural and functional analysis of eukaryotes and prokaryotes, with suitable examples.

Practical components (30 Hours)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Preparation of buffer at a specific molarity and pH.
2. Numerical problems based on Enthalpy, Free Energy and Entropy.
3. Comparative analysis of protein content in egg white and egg yolk using Bradford method.
4. Detection of a glucose polymer (starch) in rice/potato/corn, using iodine test.
5. To assess the differential solubility of lipids in aqueous and organic solvents.
6. Extraction of DNA from plant/microbial cells by the spooling method.
7. Demonstration of agarose gel electrophoresis for analyzing the isolated DNA.
8. To compare the structural features of a prokaryotic and eukaryotic cell by studying their electron micrographs.

Essential readings

- Nelson, D.L. and Cox, M.M. (2021). Lehninger: Principles of Biochemistry(7th ed.). W.H. Freeman & Company (New York), ISBN:13:9781319322328
- Pratt, C.W. and Cornely, K.(2017). Essential Biochemistry (4th ed.) John Wiley& Sons, Inc.ISBN:9781119012375
- Plummer, D.T. (2012). An Introduction to Practical Biochemistry. New Delhi, India: McGraw-Hill College.

Suggestive readings for basics

- Berg, J., Gatto, G., Stryer, L. and Tymoczko, J. L. (2019). Biochemistry. New York, USA: W. H. Freeman and Company.
- Campbell, M. K. and Farrell, S. O. (2017) 9th Edition. Biochemistry. Boston, USA: Brooks/Cole Cengage Learning. ISBN-13: 978-1305961135

GENERIC ELECTIVE-05 (GE-05) HEALTH AND BODY DEFENSE SYSTEM

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
HEALTH AND BODY DEFENSE SYSTEM	4	3	-	1	------	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Characteristics of a healthy body and ways to improve one's health and well-being.
- Body defense system is a comprehensive study of the organization and functioning of the immune system with its network of cells and molecules. Understanding the biology of the immune system is key to developing strategies towards prevention and cure to a number of disorders and diseases that result due to malfunctioning and dysregulation of the immune system.
- This paper covers the organization and functioning of the various branches of immune system, namely, Innate and adaptive Immunity to combat different pathogens. Various Immunological techniques will also be taught to the students.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Students learn various aspects of health and immune system in normal and infectious stage which equips students to design better strategies for combating the immunological disorders. Students will be given an overview to various pathogens and immune system in Invertebrates and Vertebrates.
- Students learn historical perspective of the extensive field of Immunology. They are introduced to the important concepts of Immunology.
- Students will be familiarized with origin and maturation of all blood cell types in bone marrow and thymus. They will understand the process of haematopoiesis, functions of various types of cells and roles played by them in generating immune responses against pathogens.
- The unit entails different barriers of Innate Immunity, Cells, Complement system, Patterns on the pathogens recognized by receptors of Innate Immune system, pathogen killing by the immune cells and concept & the importance of the Inflammation in an Immune response.
- Students will learn about the cells of adaptive immune system, the concept of antigen, antibody molecules and role of major histocompatibility complex & associated cells in the processing and presentation of antigen. The students will explore the branches of adaptive immunity - the humoral and cell mediated, their components and interplay of these components in combating the infection. The students will also be able to understand the significance of various kinds of growth factors and cytokines in the activations of various

lymphocytes

- The students will be given knowledge about the principle, methodology and applications of various laboratory techniques involving antigen-antibody reaction.
- Vaccine based immunotherapies and their designing will assist them to think about new path for combating with pathogens and working mechanisms of immune system.
- The students will be made aware about the importance of diet and lifestyle in promoting Immunity and health.

SYLLABUS OF GE-05

Unit I: Hallmarks of health (06 Hours)

Basic aspects of healthy body: cells, tissue and organ system, difference between prokaryotes and eukaryotes. Key differences between bacteria, fungi, protozoans and viruses.

Requirements for ahealthy body according to age and gender. Survival strategies of host against the invading pathogens: bacterial defense against bacteriophage, immune system of plants, invertebrates (mollusca) and vertebrates.

Unit II: Introduction to and Organization of Immune System (06 Hours)

Historical background, general concepts of the immune system, innate and adaptive immunity; active and passive immunity, contributions of Sir Edward Jenner and Louis Pasteur in vaccine development. Lymphoid organs: thymus, bone marrow and haematopoiesis, lymph nodes, spleen

Unit III: Innate Immune response (9 Hours)

Physical and chemical barriers; cells of the innate immune system: natural killer cells, monocytes and macrophages; neutrophils, eosinophils, basophils, mast cells and dendritic cells: structure, phenotypic and functional aspects.

Complement system: components of the complement activation classical, alternative and lectin pathways; biological consequence of complement activation.

Mechanisms of pathogen killing by macrophages and neutrophils: receptor/non receptor mediated endocytosis, phagosome formation, phagolysosome formation, respiratory burst phenomenon.

Inflammation: concept, hall marks of inflammation.

Unit IV: Adaptive Immune Response (10 Hours)

Cells of the adaptive immune system: T and B lymphocytes; characteristics of adaptive immune response: self and non-self recognition, specificity, diversity and memory, primary and secondary immune response, allergen/ allergy.

Antigens: antigenicity and immunogenicity, haptens. Properties (foreignness, molecular size, heterogeneity, route and dose of administration, solubility and degradability); host factors (genotypes, gender, nutrition);blood group antigens and transfusion reactions.

Basic function of major histocompatibility complex

Importance of Antigen presentation; types of antibodies and their function; cell mediated immune response. Major steps in T cell differentiation in thymus: thymic selection, self MHC restriction, T cell receptor assembly. Phenotypic characteristics of naïve T-cells ($CD4^+$ and $CD8^+$ T-cells). Migration of naïve T-cells from thymus to secondary lymphoid organs. Activation of T-cells, proliferation of clonally selected T cells and their effector functions, concepts of T-helper 1 (TH_1) and T-helper 2 (TH_2) cells. Basic introduction to cytokines: IL-2, IL-4 and IFN-γ. Contribution of MHC, B-cell receptor (BCR) and T-cell receptor (TCR) to diversity in adaptive immune response

Unit V: Immunological principles of various reactions and techniques (05 Hours)

Basic concepts of antigen-antibody interactions (epitope-paratope), affinity and avidity,

cross reactivity, precipitation, agglutination, immunodiffusion, immune-electrophoresis, ELISA (indirect, sandwich, competitive, chemiluminescence, and ELISPOT assay), western blotting, immunofluorescence microscopy, immunohistochemistry and lateral flow assay.

Unit VI: Diet, nutrition and life style in promoting health and Immunity (09 Hours)
Importance of a well- balanced nutrition, the role of Immunity boosters and immunomodulators from kitchen shelf (Any two: turmeric, ashwagandha, tomato & giloy), vitamins and minerals in improving health and defense. Role of probiotics, gut microbiota and prebioticsin regulating health and immunity. Role of physical activity and emotional & Mental state in regulation of immunity status, holistic health and happiness. A primer on our traditional practices, yogic lifestyle and meditation in creating homeostasis in the body (balancing *Vatta, Pitta* and *Kapha*) will also be given.

Practical component (30 Hours)
(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Visualization of antigen-antibody interaction by Ouchterlony method
2. To perform Immuno-diffusion by Mancini Method
3. To perform Complement fixation assay
4. To perform sandwich dot ELISA
5. To perform Widal test (Indirect/passive agglutination) for the detection of typhoid antigen and blood group determination (direct agglutination)
6. To perform SARS-CoV-2 rapid antigen test(Lateral flow Assay)
7. Project work based on historical research work in the area of immunology.
8. Case studies on hypersensitivity reactions(seafood hypersensitivity, erythroblastosis fetalis)

Essential readings:

- Delves, P.J. Martin, S.J. Burton, D.R. and Roitt, I. M. (2017). 13th Edition. Roitt's Essential Immunology. New Jersey, USA: Wiley-Blackwell Science. ISBN: 13: 978- 1118415771.
- Punt, J. Stranford, S. Jones, P. and Owen, J. (2019). 8th Edition. Kuby Immunology. New York, USA: W.H. Freeman and Company. ISBN- 13: 978-1464189784.

Suggestive readings for basics:

- Kindt T. J., Osborne B. A. , Goldsby R. A. (2007). 6th Edition *Kuby Immunology*. New York, USA: W.H. Freeman and Company. ISBN-13: 978-1429202114 ISBN-10: 1429202114.
- Willey, J. Sherwood, L and Woolverton, C.J. (2016). 10th Edition. *Prescott's Microbiology*. New York, USA: McGraw-Hill Education. ISBN-13:978-1259281594.
- Ananthanarayan R and Jayaram Paniker CK (Author), Reba Kanungo (Editor) (2020) Ananthanarayan and Paniker's Textbook of Microbiology, Eleventh Edition. Universities Press (India) Pvt. ISBN **9389211433**
- Hay, F.C. and Westwood, O.M.R. (2002). 4th Edition. *Practical Immunology*. New Jersey, USA: Blackwell Science. ISBN:9780865429611
- Satomi Oshima; Zhen-Bo Cao; Koichiro Oka (2015) 'Physical Activity, Exercise, Sedentary, Behavior and Health' Springer Tokyo Heidelberg New York Dordrecht London ISBN 978-4-431-55333-5 (eBook)
- Practical Ayurveda: Find Out Who You Are and What You Need to Bring Balance to Your Life Paperback – 5 June 2018 by Sivananda Yoga Vedanta Centre. Publisher : DK; Illustrated edition (5 June 2018) ISBN-10 : 1465468498, ISBN-13 : 978-1465468499.

- BYG-002 Yoga and Health, Block 4 Yogic Lifestyle, School of Health Science, Indira Gandhi National Open University (https://drive.google.com/file/d/10j00rWXLsCEV5cTbzK-hM43ezlNvn0hl/view)
- Guglielmo M Trovato (2012) Behavior, nutrition and lifestyle in a comprehensive health and disease paradigm: skills and knowledge for a predictive, preventive and personalized medicine. Trovato EPMA Journal 2012, 3:8 (Review Article)

GENERIC ELECTIVE -06 (GE-06) UNDERSTANDING THE HUMAN BODY SYSTEMS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
UNDERSTANDING THE HUMAN BODY SYSTEM	4	3	-	1		

Learning objectives

The Learning Objectives of this course are as follows:

- This is an introductory course dealing with the structure and function of the human organism and the issues facing the human in today's world.
- It is intended for students with limited science background. It would make them familiar with basic physiological concepts.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Students will have an increased understanding and appreciation for the workings of the human body. They will be familiar with the terminology and physiology of the major organ systems
- They will be able to explain the relation between form and function in biology, as expressed in molecular, cellular, and whole-organism physiology.
- Students will be able to recognize the anatomical structures and explain the physiological functions of the body systems.
- Recognize the anatomical structures and explain the physiological functions of the body systems. Develop scientific terminology to describe the parts and processes of the human body.

SYLLABUS OF GE- 06

Unit I: Body organization and integumentary system (05 Hours)

General anatomy of the body, introduction to various kinds of body planes, cavities and their membranes, tissues level of organization and classification (types, origin, function & repair). Structure and functions of human skin. Blood as connective tissue

Unit II: Nervous and Endocrine system (10 Hours)

Organization of the central and peripheral nervous system. Nerve physiology, motor and sensory physiology(special senses). General mechanism of hormone action, structure, function and regulation of the major gland of the body: pituitary, hypothalamus, thyroid, pancreas and adrenals. Basic concepts about hypo and hyper secretion of hormones.

Unit III: Muscular and skeletal system (05 Hours)

Functional anatomy of muscular system, types of muscles, neuromuscular junction structure, property and transmission, general characteristics of muscle contraction using skeletal muscle as example.

Unit IV: Cardiovascular and respiratory system (08 Hours)

Functional anatomy of heart, the cardiac cycle, electrocardiogram. Circulatory system: Blood vessels, hemodynamics and regulatory mechanisms. Lymphatic circulation - hemodynamics and

regulation, micro-circulation, functional anatomy of the respiratory system. Mechanisms of pulmonary and alveolar, gaseous exchange, transport of gases, respiratory and nervous control and regulation of respiration.

Unit V: Gastrointestinal system and Renal physiology (11 Hours)
Anatomy and histology of the digestive tract. General principles of gut motility secretion, digestion, absorption and assimilation. Functional anatomy of kidney, histology of nephron and its physiology, process of urine formation. Urinary bladder: structure, micturition and its regulation

Unit VI: Reproductive System (06 Hours)
Structure and function of male and female reproductive organs. Basic concepts of gametogenesis (oogenesis and spermatogenesis), fertilization, implantation, menopause and contraception.

Practical component (30 Hours)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. To prepare a blood smear and identify different types of white blood cells.
2. Estimation of hemoglobin (Sahli's method)
3. Physiological data acquisition based experiments (ECG/PFT/EMG).
4. Blood Pressure recordings in humans.
5. To study a simple reflex arc
6. To study the sensation of taste, touch and smell.
7. To study various types of contraceptives (condoms, IUDs, oral and injectable contraceptives)
8. To study different human organs and their sections through permanent histological slides T.S. of brain, spinal cord, skeletal fibers, cardiac muscles, skeletal muscles, T. S. of thyroid, liver, thymus, spleen, ovary, artery, vein, capillaries, testis, pancreas, esophagus, adrenal, kidney (cortex and medulla), urinary bladder, fallopian tubes, epididymis, lungs, trachea, heart. (minimum 8 slides covering the systems mentioned in theory).

Essential readings:

- Guyton and Hall Textbook of Medical Physiology, 14th edition (2020), J. E. Hall; W B Saunders and Company, ebook ISBN: 978-0-3236-4003-9; Hardcover ISBN: 978-0-3235-9712-8
- Human Physiology, 16th edition (2011), Stuart I. Fox; Tata McGraw Hill, ISBN10: 1260720462; ISBN13: 978-1-26-072046-4.
- Principles of Anatomy and Physiology, 16th edition (2020), Gerard J. Tortora and Bryan H. Derrickson; Wiley and Sons, ISBN: 978-1-119-66268-6. (e book), ISBN: 978-1-119-70438-6 (for print book).
- Textbook of Practical Physiology, 9th edition (2019), CL Ghai; Jaypee Publication, ISBN-9789352705320.

Suggestive readings for basics:

- Ganong's Review of Medical physiology, 26th edition (2019), K. E. Barett, S. M. Barman, S. Boitano and H. Brooks; Tata McGraw Hill, ISBN 978-1-26-012240-4 (for ebook) ISBN:978-1-26-012241-1 (for print Book)
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BIOMEDICAL SCIENCE
Faculty of Science

B.Sc (Hons.) Biomedical Science

Discipline Specific Core (BIOMED-DSCs)

SEMESTER- IV

DISCIPLINE SPECIFIC CORE COURSE -10 (BIOMED-DSC-10) IMMUNOBIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Immunobiology **BIOMED-DSC-10**	**4**	**3**	**-**	**1**	**XII Passed**	**Basic knowledge of biology**	**Biomedical Science**

Learning objectives

The students will learn

- The organization and functioning of the immune system and its branches- Innate and Humoral, its complex network of cells, molecules, tissues and organs
- Various Immunological techniques and their applications
- Various types of vaccine based immunotherapies

Learning outcomes

Having successfully completed this course, students shall be able to learn

- The human immune system and its components and how the immune system responds to 'non-self' entities.
- The principle, methodology and applications of various laboratory techniques involving antigen-antibody reaction.
- Various types of vaccine based immunotherapies will help them to think about new approaches for combating pathogens.

SYLLABUS OF BIOMED-DSC-10:

Unit I: Overview of Immune System (05 hrs)

Historical background, general concepts of the immune system, innate and adaptive immunity, primary and secondary immune response, active and passive immunity. Haematopoiesis

Lymphoid Organs: Thymus, Bone marrow, Lymph nodes, Spleen, MALT, GALT and SALT.

Unit II: Innate Immune response (10 hrs)

Physical and Chemical barriers.

Cells of the innate immune system: NK cells, Monocytes and Macrophages; Neutrophils, Eosinophils, Basophils, Mast cells and Dendritic cells.

Complement system: Components of the complement activation-classical, alternative and lectin pathways; biological consequence of complement activation.

Introduction to Pathogen Associated Molecular Pattern and Pattern Recognition Receptors Mechanisms of pathogen killing by macrophages and neutrophils.

Concept of inflammation.

Unit-III Antigens and their presentation in immune responses: (06 hrs)

Antigenicity and immunogenicity, haptens. Properties (foreignness, molecular size, heterogeneity, route and dose of administration, solubility and degradability); Types of antigens.

Major Histocompatibility Complex: Genome Organization of MHC and inheritance in humans; concepts of polygeny and polymorphism with respect to MHC and its contribution in survival of host population.

Antigen presenting cells, antigen processing, loading (Bimolecular complex formation) and presentation pathways (cytosolic and endocytic).

Unit IV: Adaptive Immune Response (10 hrs)

Cells of the adaptive immune system: T and B lymphocytes, Characteristics of adaptive immune responses.

Humoral immune response: Stages of B cell development in bone marrow, stages of B cell activation in the secondary lymphoid organs. Antibodies: structure, function and properties of the antibodies; different classes (isotypes) and subclasses. Biological activities of antibodies, concepts of antibody diversity, monoclonal and polyclonal antibodies, Hybridoma technology.

Cell mediated immune response: Major steps in T cell differentiation in thymus- thymic selection, self MHC restriction, T cell receptor complex. Phenotypic characteristics of naïve T-cells ($CD4^+$ and $CD8^+$ T-cells). Stages of activation of naïve T-cells in secondary lymphoid organs and effector functions of $CD4^+$ and $CD8^+$ T lymphocytes.

Basic introduction and properties of cytokines: IL-2, IL-4 and IFN-γ.

Concept of hypersensitivity.

Unit V: Principles of Antigen- Antibody Interactions and Techniques (09 hrs)

Basic concepts of antigen-antibody interactions (epitope-paratope), Affinity and avidity, cross reactivity, precipitation, agglutination, immunodiffusion, ELISA, ELISPOT, western blotting.

Unit VI: Vaccines (05 hrs)

Contribution of Sir Edward Jenner and Louis Pasteur in vaccine development. Major types of vaccine and their characteristics, adjuvants. National Immunization programme.

Practical (30 hrs)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Virtual demonstration of lymphoid organs and phagocytosis.
2. To perform immuno-diffusion by Ouchterlony method.
3. To perform Immuno-diffusion by Mancini method.
4. To perform Lateral Flow assay/ Immunochromatography.
5. To perform Complement fixation assay.
6. To perform direct (blood group) agglutination assay.
7. To perform indirect (Widal test) agglutination assay.
8. To perform sandwich dot ELISA

Essential readings:

- Delves, P.J. Martin, S.J. Burton, D.R. and Roitt, I. M. (2017). 13th Edition. *Roitt's Essential Immunology*. New Jersey, USA: Wiley-Blackwell Science. ISBN: 13: 978- 1118415771.

- Punt, J. Stranford, S. Jones, P. and Owen, J. (2019). 8th Edition. *Kuby Immunology*. New York, USA: W.H. Freeman and Company. ISBN- 13: 978-1464189784.

Suggestive readings:

- Kindt T. J., Osborne B. A. , Goldsby R. A. (2007). 6th Edition *Kuby Immunology*. New York, USA: W.H. Freeman and Company. ISBN-13: 978-1429202114 ISBN-10: 1429202114.
- Willey, J. Sherwood, L and Woolverton, C.J. (2016). 10th Edition. *Prescott's Microbiology*. New York, USA: McGraw-Hill Education. ISBN-13: 978-1259281594.
- Hay, F.C. and Westwood, O.M.R. (2002). 4th Edition. *Practical Immunology*. New Jersey, USA: Blackwell Science. ISBN: 9780865429611.

DISCIPLINE SPECIFIC CORE COURSE –11 (BIOMED-DSC-11) MOLECULAR BIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical/Practice			
Molecular Biology **BIOMED-DSC-11**	**4**	**3**	**-**	**1**	**XIIth Passed**	**Basic knowledge of biology**	**Biomedical Science**

Learning objectives

- The objective of the course is to offer detailed and comprehensive knowledge about the mechanisms of DNA replication, repair, transcription and translation in prokaryotes and eukaryotes so that students can apply this knowledge in enhancing their analytical and research problem solving skills.
- As the course progresses, students would comprehend the basic mechanism of DNA replication in prokaryotes and eukaryotes along with associated discerning features.
- Students would also understand the mechanism of introduction of mutations and how these are repaired inside the cell.
- Students would be able to understand that, molecular biology as a field started with an in-depth research and studies on prokaryotes and only recently our understanding of life processes in eukaryotes have increased considerable.

Learning outcomes

- This course focuses on the molecular processes involving biomolecules and provides students with a range of theoretical knowledge and associated practical skills.
- Students would comprehend biological processes such as Replication, Transcription and Translation. While studying the unit on Replication, students would also appreciate how various kinds of errors can be introduced and if not removed may manifest themselves as mutations.
- The course would help them understand established repair mechanisms to take care of these mutations. Hand-in-hand and related practical knowledge would help students build their foundation for future courses like Medical Biotechnology and Genome Organization and Function.

- Students would appreciate the recent advances in molecular biology that have led to the completion of genomic projects that are changing the face of modern biology, especially in areas of medicine, agriculture and biotechnology. Research in this field has also helped in understanding the molecular basis of illnesses and use of genetic manipulation in biotechnology to make valuable products including blood clotting factors, insulin and vaccines.

SYLLABUS OF BIOMED-DSC-11

Unit-I: The Replication of DNA in Prokaryotes and Eukaryotes (14 hrs)

An introduction to chemistry of DNA synthesis. Enzyme and proteins involved in DNA replication–helicase, topoisomerases, DNA polymerases, DNA ligase, primase, RNaseH, telomerase, sliding clamp, sliding clamp loader and SSBs. Mechanism of action of DNA polymerase, DNA transactions during replication-bidirectional replication, semi-conservative, discontinuous. Mechanics at the DNA replication fork: RNA priming, initiation and termination of DNA replication (comparing prokaryotes with eukaryotes), regulation of bacterial DNA replication, replicating the 5' end of linear chromosome, replication coupled to chromatin synthesis in eukaryotes. Various models of DNA replication including Trombone model, D-loop (mitochondrial), Theta mode of replication, Rolling circle model, replication of linear ds-DNA.

Unit-II: The Mutability and Repair of DNA (6 hrs)

Replication Errors (transitions, transversion and thymine dimer), DNA Damage (deamination, depurination and dimerization). DNA repair: Direct repair, Mismatch repair, Excision Repair, Photo reactivation, Recombination Repair, SOS response.

Unit-III: Information Transfer–I: Mechanism of Transcription. (8 hrs)

Basic transcription apparatus. Transcription in Prokaryotes: Initiation, elongation and termination of transcription, Promoter sequences and concept of abortive initiation. Transcription in Eukaryotes: Types of RNA polymerases, RNA polymerase II, Promoters, TBP and other transcription factors. Transcription by RNA polymerase I and III. Inhibitors of transcription- rifampicin and- amanitin.

Unit-IV: Post-Transcriptional Modifications (8 hrs)

Split Genes, Concept of introns and exons, RNA splicing pathways: Spliceosomes and Self splicing introns (Group I and Group II introns), Ribozymes, Variants of splicing: alternative splicing, exon shuffling and RNA

editing, Mutually exclusive splicing (example Drosophila Dscam gene), Mechanism determining the sex of Drosophila.

Unit-V: Information Transfer-II: Mechanism of Translation (9 hrs)

Features of genetic code and exceptions in some systems. Types of RNA: Messenger RNA, Ribosomal RNA and Transfer RNA, Ribosomal structure, Charging of tRNA, Amino-acyl tRNA synthetases, Proteins and factors involved in translation. Process of translation: Initiation, elongation and termination (Prokaryotes and Eukaryotes), Fidelity of translation, Translation-Coupled removal of defective mRNA. Inhibitors of protein synthesis–tetracyclins, aminoglycosides, chloramphenicol and aminoglycosides.

Practical (30 hrs)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Calculations and preparation of various stock and working solutions of Molecular Biology experiments (Number 2 to 9).
2. Isolation of genomic DNA from bacterial cells.
3. Isolation of genomic DNA from blood/tissue.
4. Fractionation of DNA by agarose gel electrophoresis.
5. To determine the lambda max for DNA and protein.
6. Quantify and analyze the purity of DNA using spectrophotometer (estimating at 260 nm, 280 nm and 320 nm).
7. Quantitative estimation of salmon sperm/calf thymus DNA using colorimetric assay using Diphenylamine reagent.
8. In vitro gene amplification method of Polymerase Chain Reaction (PCR): Primer designing and setting up of the reaction.
9. Analysis of the PCR products.

Essential readings:

- Karp, G. (2020). 9th Edition. *Cell and molecular biology: Concepts and experiments.* NewJersey, USA: Wiley Publishers, ISBN-13: 978-1119598244
- Cox, M. M. Doudna J. A. and Donnell, M. O. (2015). 2nd Edition. *Molecular biology: Principles and practice.* London, UK: W H Freeman & Co Publishers, ISBN-13: 978-1464126147

- Watson, J. D. Baker T. A. Bell, S. P. Gann, A. Levine, M. and Losick, R. (2013). 7thEdition. *Molecular Biology of the Gene.* New York, USA: Cold Spring Harbor Laboratory Press, ISBN-13: 978-0-321-76243-6.
- Green, M.R. and Sambrook, J. (2012). 4th Edition. *Molecular cloning: A laboratory manual,* New York, USA: Cold Spring Harbor Laboratory Press, ISBN-13:978-1936113422.
- Hardin, J. Bertoni, G.P. Kleinsmith, L.J. and Becker, W.M. (2008). 7thEdition. *The world of the cell.* San Francisco, USA: Benjamin Cummings Publishers, ISBN-13:978-0805393934.

Suggestive Readings

- Kornberg, A. (2005). 2nd Edition. *DNA replication.* California, USA: University Science Books, ISBN-13: 978-1891389443.

DISCIPLINE SPECIFIC CORE COURSE -12 (BIOMED-DSC-12) PHARMACOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)	Biomedical Science
		Lecture	Tutorial	Practical/ Practice			
Pharmacology **BIOMED-DSC-12**	**4**	**3**	**-**	**1**	**XII Passed**	**Basic knowledge in Functioning of human body.**	**Biomedical Science**

Learning objective

- This course is concerned with the study of drugs and how they can be used in the treatment of various diseases.
- The students will be able to learn about various formulations and administration of drugs in the body. The course provides basic mechanisms by which various drugs modify/affect physiology of the body leading to the treatment of various diseases.
- Students will also get an insight into making choice and functioning of drugs given to treat microbial infections, and various diseases due to imbalance of hormones in the body.

Learning outcomes

- Students will be familiarized with the naming and formulation of drugs; routes of drug administration and conditions under which one route is preferred over another in patients; various macromolecular targets (receptors, enzymes, etc.) of drugs in the body.
- They will also learn basic mechanisms of absorption, transport, excretion of drugs and effects of metabolism on drug action; basics of quantification of half-life, bio-availability and elimination of drugs in the body and factors affecting them; an insight into measurement of response, efficacy and potency of drug, and factors affecting action of the drugs.
- Students will also be imparted knowledge of the classification, mechanism of action, uses and contraindication of various classes of drugs. Assessment of the choice of antimicrobial drugs; problems arising from indiscriminate/inadequate use of antimicrobial drugs. Use of hormones and hormone

antagonists as drugs in endocrine system related disorders; hormone replacement therapy and its application.

SYLLABUS OF BIOMED-DSC-12

Unit-I: Introduction to pharmacology (07 hrs)

Nomenclature of drugs, various dosage forms of drugs (solid, liquid, semi-solid and inhalation forms) routes of drug administration, their advantages and disadvantages, various macromolecular targets of drugs (membrane receptor, transporters, enzymes, channels etc.).

Unit-II: Pharmacokinetics and pharmacodynamics (09 hrs)

Drug absorption, distribution, metabolism, and excretion, bio-availability, excretion and kinetics of elimination, biological half-life of drug and its significance, drug-drug interactions.

Unit-III: Mechanism of action of different classes of drugs (18 hrs)

General aspects; classification and mechanism of action of following classes of drugs along with side effects and contraindication of the drugs mentioned against each class should also be covered.

(a) General Anesthetics: Halothane
(b) Sedatives and Hypnotics: Diazepam
(c) Cholinergics: Bethanechol, Rivastigmine
(d) Skeletal Muscle Relaxants: Succinylcholine
(e) Adrenergics: Isoprenaline, Propranolol
(f) Dopaminergics: L-Dopa, Carbidopa
(g) Diuretics: Furosemide
(h) Analgesics and Antipyretics: Aspirin, Celecoxib

Unit-IV: Chemotherapy of microbial disease (05 hrs)

General aspects of anti-microbial therapy, Antibacterial (Quinolones: Ciprofloxacin).

Unit-V: Hormones and hormone antagonists (06 hrs)

Brief introduction to hormones; insulin and oral hypoglycemic agent (tolbutamide, metformin), HRT, estrogen and progestins (progesterone, hydroxylprogesterone caproate).

Practical **(30 hrs)**

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Handling of laboratory animals.
2. Routes of drug administration (Oral, I.M.)
3. To study the presence of acetaminophen in given sample.
4. To study the stages of general anesthesia.
5. To determine partition coefficient of general anesthetics.
6. Effect of analgesic (Tail-flick test).
7. Anti-anxiety effect of Valium (Plus maze test).
8. Fixing of organ bath and kymograph.
9. To record CRC of acetylcholine using guinea pig ileum/ rat intestine.
10. Determination of dose ratio.
11. Study of competitive antagonism using acetylcholine and atropine.

Essential reading

- Kulkarni, S.K. (2014). 4th Edition, Reprint. *Handbook of Experimental Pharmacology*, Vallabh Prakashan, India, ISBN-13: 978-8185731766.
- Tripathi, K.D. (2018). 8th Edition. *Essentials of Medical Pharmacology*. Jaypee Brothers, India, ISBN-13: **.9352704996-978**

Suggestive readings

- Ritter, J.M., Flower, R., Henderson, G., *et al*. (2019). 9th Edition (International). *Rang and Dale's Pharmacology*. Relx India Pvt. Ltd, ISBN-13: 978-0702074479.
- **Katzung, B. G.**, (2021) Basic and Clinical Pharmacology, 15th Edition, McGraw-Hill Education, ISBN: 978-1260452310

Pool of DSEs

DISCIPLINE SPECIFIC ELECTIVE COURSE– 04 (BIOMED-DSE-04) MEDICAL BIOCHEMISTRY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the Course	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Medical Biochemistry **BIOMED-DSE-04**	**4**	**3**	**-**	**1**	**XII Passed**	**Basic knowledge of biology**	**Biomedical Science**

Learning objectives

The Learning objectives of this course are as follows:

- The objective of this course is to educate students on the clinical significance of Biochemistry. Students would learn the principle and applications of the diagnostic enzymology, interplay of hormones in the metabolism and details of various biomolecules of diagnostic significance.
- These topics are incorporated in the course to impart relevant information on clinical biochemistry. This course will also focus on the contemporary methods and practical approaches that are used in the clinical laboratories for the investigation of the parameters to ascertain normal and diseased state.

Learning outcomes

The Learning outcomes of this course are as follows:

- Having successfully completed this course, students shall be able to learn and appreciate:
- To integrate the biochemical pathways of different biomolecules; the point of divergence and convergence and will have a comprehensive overview of the metabolic and hormonal regulation of pathways and cycles.

- Students will understand how disruptions in intermediary metabolism can lead to manifestations of diseases. Additionally, hormonal actions in maintaining body mass shall be understood and factors leading to disorders such as obesity and diabetes will also be learnt.
- The diagnostic significance of enzymes and isoenzymes as diagnostic markers in clinical tests. They will learn to assess how biochemical tools accomplish diagnostic and therapeutic interventions on metabolic and genetic disorders. They will also learn to correlate the tissue/organ-specific metabolic indicators with the physiological and clinical state of a patient.
- Students would be able to gain knowledge about several bimolecular conjugates, their structural complexities, physiological significance and clinical correlations, especially the disorders related to lipid metabolism.
- Students will learn about recommended daily allowance for vitamins, their role as dietary precursors and clinical significance of deficiency diseases.
- With the help of diagnostic kits that are used in clinical laboratories students will learn to perform qualitative and quantitative analyses of samples. Through the presentations made on the known case studies, students will learn how to apply the gained knowledge in diagnosis and prognosis of a disease and know the relevance of preventive measures taken in healthcare. Also, they will be introduced to quantitative analysis of biomolecules in clinical biochemistry and evaluation of relevant data.

SYLLABUS OF BIOMED-DSE-04

Unit I: Introduction to Medical Biochemistry with an Overview of Integrative Metabolism (12 hrs)

Basic Concepts and Scope of Medical Biochemistry.

Local and global regulation in tissue specific metabolism. Interplay of insulin and glucagon hormones. Integration of various metabolic pathways of proteins, lipids and carbohydrates. Obesity, role of leptin, ghrelin and adiponectin in regulation of body mass, hunger and satiety.

Unit II: Enzymes - Distribution and Diagnostic Significance (12 hrs)

Properties of enzymes used in diagnosis. Factors affecting levels of diagnostic enzymes in blood and the selection of a test. Clinical significance of diagnostically important enzymes: Creatine kinase, Lactate dehydrogenase, alanine- and aspartate aminotransferases, with a detailed account of the biochemical reactions catalyzed by these enzymes and of their clinical assays. Kinetic assay and end point assay for the enzymes.

Isoenzymes: types of isoenzymes, allozymes, hybrid isoenzymes, isoforms,their tissue distribution, clinical and diagnostic significance.

Unit III: Structural Complexities and Diseases Associated with Carbohydrates and Lipids (14 hrs)

Carbohydrates: Sugars as information molecules. Detailed account on Lectins: their role in physiological functions and their potential as drug targets in various infectious diseases. Dietary fibres

Lipids: Types of Lipoproteins (chylomicrons, VLDL, LDL, HDL). Disorders associated with lipid metabolism (hyperlipidemia). Prostaglandins: classification, biosynthesis, role of COX-1, COX-2, NSAIDS in synthesis, functions.

Steroids: Cholesterol- biosynthesis and regulation, inhibitors of cholesterol biosynthesis (Statins - structure and biochemical basis).

Unit IV: Vitamins (7 hrs)

Definition, classification, functions, recommended dietary allowances, and dietary precursors. Diseases (1 each, due to deficiency of water-soluble and fat-soluble vitamins): symptoms and clinical significance

Practical (30 Hrs)

(Wherever wet-lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs, etc.)

1. Virtual demonstration of preparation of serum or plasma from whole blood.
2. Quantitative determination of the following (any 4):
    i) SGPT/SGOT
    ii) Albumin/Total protein and A:G ratio
    iii) Urea
    iv) Uric acid
    v) Total Cholesterol, HDL, LDL
    vi) Triglycerides
3. Interpretation of case studies (any 3)
4. Analysis of a given Diagnostic Test Report for KFT/LFT/Myocardial Infarction.
5. Profiling of Iron and Vitamin D/B12 deficiency in Indian Population, using recent published data.

Essential Reading:

- Nelson, D.L. and Cox, M.M. (2021). *Lehninger: Principles of Biochemistry* (8th ed.). Macmillan. ISBN: 9781319322328
- Burtis, C.A., Bruns, D.E.,Sawyer, B.G, Tietz,NW (2015). *Tietz Fundamentals of Clinical Chemistry and Molecular Diagnostics*. United States Of America:WB Saunders Company, ISBN: 9781455741656
- Chatterjee & Shinde (2012). *Textbook of Medical Biochemistry* (8th ed). New Delhi, India: Jaypee Publications ISBN: 978-93-5025-484-4
- Literature provided by Diagnostic Kit's manufacturer.

Suggestive reading

- Murray, R. Bender, D.Botham, M.K.Kennelly, P.J.Rodwell, V.Weil, P.A. (2018). *Harpers Illustrated Biochemistry*; New Delhi, India: McGraw-Hill Medical.
- Devlin, T.M. (2011). *Textbook of Biochemistry with Clinical Correlations*. New Jersey, United States of America: John Wiley & Sons, Inc.

DISCIPLINE SPECIFIC ELECTIVE COURSE –5 (BIOMED-DSE-05) INDUSTRIAL MICROBIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical/Practice			
Industrial Microbiology **BIOMED-DSE-05**	**4**	**3**	**-**	**1**	**XII Passed**	**Basic knowledge of biology**	**Biomedical Science**

Learning objectives

- The Industrial Microbiology course has been formulated to train students on how microbiological techniques are carried out in industrial practices.
- Students will be able to learn usage of microorganism for industrial applications.
- This course will concentrate on experimental practice and their theoretical aspects. Study of this course will develop trained manpower ready for industry and bridge the huge gap that exists between knowledge based conventional education and market demands.
- This would further help inculcate sense of job responsibilities, while maintaining social and environment awareness.
- Students would eventually build-up a progressive and successful career in industries with a biotechnological perspective.

Learning outcomes

- The course on Industrial Microbiology starts with the fundamental basics and scope of industrial microbiology. Students would learn the requirements for setting up an Industrial Microbiological unit along with the kind of microbial products that can be made available.
- The course would help the students to explore the benefits of microbial kingdom.
- Students would also understand the process of selection of potent strains suitable for industrial application and use of mutants/genetically modified organism for this purpose. Methods associated with usage and selection of appropriate fermentation process will enhance the learning of students enable them to think in new horizons.

- Selection of appropriate nutrient for the multiplication of microorganism plays a significant role at industrial level. Through understanding of the current scenario might help them setting their own ventures.
- Students would be given a glimpse of extraction of fermentation products and maintenance of sterility in fermenters. Different types of nutritive products/beverages such as beers, wines, spirits, bread, single cell proteins can be obtained using fermenters.
- At the end of syllabus students would learn the process of waste water treatment by municipal corporations.

SYLLABUS OF BIOMED-DSE-05

Unit I: Scope of Industrial Microbiology (6 hrs)

Scope of Industrial Microbiology; Industrial microbiology in comparison to Chemical/any other industry; emphasis on functioning of fermentation industry; examples of products and microbes; Industrial Microbiology and Biotechnology; History (An Art from the Past, a Skill for the Future); Obsolescence in Industrial Microbiology.

Organizational set-up in an industrial microbiology establishment: Upstream processing (USP) and downstream processing (DSP); unit downstream processing. Bioprocess: introduction, advantages and limitations. Industrial fermentation products and their producer microorganisms.

Unit II: Industrial Microorganisms (8 hrs)

Taxonomic diversity of industrially useful bacteria and Fungi: Brief Discussion, general feature and taxonomic position; Bacterial genomes and genomics of bacterial plasmids; Useful Characteristics in microbes used in Industrial Microbiology and Biotechnology; Isolation of suitable producer microorganisms from environment.

Concept of Microorganisms classified as Generally Regarded As Safe (GRAS); Culture Collections of industrial microorganisms; Industrial producer strains and strain improvement: Outline and importance of the process; Use of mutants / Genetically Modified Microorganisms (GMM) as against Wild type isolates for production; ethical issues related to release of GMM in the environment. Aseptic and non-aseptic fermentations; Fermentation types according to organization of biological system: Suspended and support culture; Screening for productive strains. Good manufacturing processes.

Unit III: Industrial Media and the Nutrition of Industrial Organisms (6 hrs)

Basic Nutrient Requirements of Industrial Media; Criteria for the Choice of Raw Materials Used in Industrial Media; Raw Materials Used in Compounding Industrial Media; Potential Sources of Components of Industrial Media; Use of Plant Waste Materials in Industrial Microbiology: Saccharification of Polysaccharides, Standard microbes used in Industry, like useful *E.coli* and *Pichia.*

Unit IV: Fermenters and its Operation (7 hrs)

Definition of a Fermenter; Aerated Stirred Tank Batch Fermenter; Temperature control in a fermenter; Foam production and control; Process control in a fermenter; Anaerobic Batch Fermenters; *Continuous fermentations;* Design of New Fermenters on the Basis of Physiology of the Organisms; Place of the Pilot Plant; Inoculum Preparation; Surface or Solid State Fermenters; Extraction of Fermentation Products; Maintenance of sterility in Fermenters

Unit V: Production of fermented foods and Metabolites (13 hrs)

Single Cell Proteins and its nutrition value; Yeast Production; Other fermented foods – from bread, corn etc; Production of Beers: Barley and Sorghum Beers; Production of wines and spirits: Grape wines; Palm wines and Distilled Alcoholic (or Spirit) Beverages; Production and processing of vinegar. Production of Organic Acids and Industrial Alcohols; Amino Acids; Biocatalysts; Microbial Fertilizers; Microbial Insecticides; Antibiotics and Anti-Tumor Agents; Ergot Alkaloids; Microbial Transformation and Steroids and Sterols; Vaccines; Microbial Products with Bioactive properties.

Unit VI: Treatment of wastes in industries (5 hrs)

Methods for determination of organic matter content in Waste Waters – Dissolved oxygen, Biological oxygen demand, Permanganate value (PV) test, Chemical oxygen demand, Total organic carbon, Total suspended solids, Volatile suspended solids; Wastes from Major Industries; Systems for the Treatment of Wastes; Treatment of the Sludge; Waste Water Disposal in the Pharmaceutical Industry. Municipal waste water treatment plant, Microbial degradation of pollutants (Bioremediation), Recovery of resources from waste using microbes (biomining/metal recovery).

Practical **(30 hrs)**

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Field trip to any industrial setup / research organization for demonstration of fermenters.
2. Antibiotic/anticancer drugs production using Streptomyces species.
3. Replicate the classic experiment of Sir Alexander Fleming experiment for the production of penicillin.
4. Fermentation of sugarcane syrup using yeast and detection of alcohol percentage.
5. Microbial biomass production: manufacturing of baker's yeast.
6. Mushroom cultivation strategies.
7. Maintenance of starter culture for probiotics.
8. Demonstration of production/extraction of microbial production.
9. Commercial microbial production.

Essential Readings

- Willey, J., Sherwood, L., and Woolverton, C.J. (2019). 11th Edition. Prescott's microbiology. New York, USA: McGraw-Hill Education. ISBN-13: 1260211887-978 .
- Tortora, G.J., Funke, B.R., Case C.L. Weber, D. and Bair, W. (2018). 13th Edition. Microbiology: An introduction. Addison-Wesley, ISBN-13 : 978-0134605180.
- Cappuccino, J.G. and Welsh, C. T. (2017). 11th Edition. Microbiology: A laboratory manual. Pearson Publishers. ISBN-13: 1292175782-978.

Suggestive Readings

- Tille, P. (2013). 13th Edition. Bailey & Scott's diagnostic microbiology. Elsevier's Publishers. ISBN-13 : 978-0323681056
- Pelczar, M.J (2001). 5th Edition. Microbiology. New York, USA: McGraw Hill International. ISBN-13: 9780074623206.

DISCIPLINE SPECIFIC ELECTIVE -6 (BIOMED-DSE-06) ENVIRONMENT SUSTAINABILITY AND BIOMEDICAL WASTE MANAGEMENT

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Environment Sustainability And Biomedical Waste Management **BIOMED-DSE-06**	**4**	**3**	**-**	**1**	**XII Passed**	**Basic knowledge of biology**	**Biomedical Science**

Learning objectives

The Learning objectives of this course are as follows:

- To promote awareness among students about the importance of environment and its sustainable usage and development
- To highlight the components affecting environment and factors responsible for deterioration of environment
- To familiarize with the techniques available for waste management, use of refuse/ reduce/re-use/ recover/re-cycle of substances toxic for environment

Learning outcomes

Having successfully completed this course, students shall be able to learn and appreciate:

- Surroundings and environment, renewable/non-renewable natural resources and their exploitation. Sensitizing about environmental crisis can promote them to for search alternatives to reduce our dependence of non-renewable natural resources and their usage.
- Studies on pollution and deforestation will help them to understand their impact on environment and human health. Conservation of forests and recycling policies will promote social awareness about sustainable development.
- Learning about various methods of sustainable development is an important for skill development in students so that they can design better strategies to protect our environment.

- Generation of biomedical waste is alarmingly increasing but the awareness of appropriate waste disposal methods is completely lacking. Development of new methods for waste management and strategies in this area will help them to reduce and segregate waste at point source.
- At the end of this course, students will be able to understand the severity of the problem and influence of biohazards on human health

SYLLABUS OF BIOMED-DSE-06

Unit I: Environment and Environmental Crisis (08 hrs)

Function of environment, resources (biotic and abiotic), renewable resources (air, water, land) and non-renewable resources (fossil fuels), worldwide Environmental Crisis: Global Warming, Ozone Layer Depletion, Measures to protect environment: environmental pollution and its control measures, air pollution in metropolitan cities of India, Deforestation and conservation, steps for social awareness, Reduce, Reuse and Recycle policy for waste management, water conservation, implementation of policies and programmes for environment sensitization, Environmental tribulations in India: Environmental degradation, Indian government proposals and plans to protect environmental degradation

Unit II: Role of green technologies in Sustainable development (14 hrs)

- Definition and aspects, requirements, strategies and way for sustainable development , Role of education for sustainable development (ESD); Management of resources for human consumption and its impacts assessment, Influence of biodiversity on ecosystem services, Land use changes for agriculture and food, Indian government initiatives to implement sustainable development, Challenges to acquire SDGs.
- Surfacing green technologies and sustainable growth, Different aspects of sustainable development: bioprospect of plant essential oils for medicinal uses-revival of Indian ancient practice; Nanotechnology: potential for environmental sustainability, Role of photo-catalyst in environmental remediation, Applications and future prospective of biopolymers in industries; Green and self-sustainable buildings: Opportunities and challenges

Unit III: Measures for Sustainable development (09 hrs)

Phytoremediation of chemopollutants, bioconversion of industrial wastes into value-added polyhydroxyalkanoate (eg sugar and oils), Role of fungal and bacterial resources in heavy metal/radioactive

waste material contaminated soil remediation and ecological restoration, xenobiotics bioremediation using fungi, Impact of pesticides usage in agricultural practices on microbial communities and soil bioprocesses: a biochemical, physiological, and molecular perception; Possibilities of biofuel production from microalgae as renewable energy source for environmental sustainability, integrated algal industrial waste treatment and bioenergy generation

Unit IV: Biomedical waste management **(07 hrs)**

Definition and classification of biomedical waste, Infectious, non-infectious and chemical waste;
Waste management: designation of waste, segregation, packaging and transportation.
Treatment: steam sterilization, chemical disinfection, incineration, emerging treatment technologies, treated waste disposal, regulatory and advisory considerations, Training of supportive staff

Unit V: Health and safety of workers in hazardous environment **(07 hrs)**

Exposure of workers at hazardous waste sites: chemical exposure, explosion and fire, ionizing radiation, biologic hazards, oxygen deficiency, heat stress, blood borne pathogens, safety hazards, electrical hazards, noise hazards, cold exposure, other physical hazards, hazardous waste operations and emergency response

Practical **(30 hrs)**

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Document the Biological Wealth (flora and fauna) of your campus.
2. Calculate the water footprint of your organization.
3. Examine the current status of organization for waste management. Develop guidelines to reduce waste by improved methods of handling and disposing of wastes.
4. Plan guidelines for the safety of workers working at hazardous waste sites.
5. A case study on “Make sustainability more than just the right thing to Do”
6. A case study on handling and disposal of wastes.
7. Develop green design of organization to maintain and enrich the biological wealth.
8. Understandings of energy missions and follow up for classroom energy audit.

9. Prepare a questionnaire to asses knowledge, attitude and practices among students about Sustainable Development
10. Prepare a poster on Bio-augmentation and Bio-stimulation**.**
11. Make a poster on success stories of environment polices and movements that have reduced pollution or reversed diminishing populations of unique species.
12. Determine your carbon foot printing.

Essential readings

- Sangeetha, J; Thangadurai, D; David, M and Abdullah, M.A. (2021) 1st Edition. Environmental Biotechnology: Biodegradation, Bioremediation, and Bioconversion of Xenobiotics for Sustainable Development. Edited by. Apple Academic Press Inc, 9 Spinnaker Way, Waretown, NJ 08758, USA. International Standard Book Number-13: 978-1771883627.
- Fulekar, M.H.; Pathak, B; Kale, R.K. (2014) Edition 2014th Environment and Sustainable Development. Publisher-Springer Nature ISBN: 978-8132211655
- William C. Blackman, Jr (2001) Basic hazardous waste management.. Third Edition, Lewis Publishers, Boca Raton London New York Washington, D.C. ISBN 1-56670-533-9 (alk. paper)

Suggestive readings:

- Tweedy, James T., Healthcare hazard control and safety management-CRC Press_Taylor and Francis (2014).

SEMESTER-V
BIOMEDICAL SCIENCE

DISCIPLINE SPECIFIC CORE COURSE –13 (BIOMED-DSC-13) GENOME ORGANIZATION AND FUNCTION (GOF)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical /Practice			
Genome Organization and Function **BIOMED-DSC-13**	**4**	**3**	**-**	**1**	**XII Passed**	**Basic knowledge of biology**	**Biomedical Science**

Learning objectives

- The course on Genome Organization and Function (GOF) will review the basic concepts of organization and architecture of human genome.
- This course would equip the students with intriguing concepts of genome packing within the nucleus, the regulatory strategies either at transcriptional or translational level, gene silencing, RNAi and mechanisms of regulatory effects of non-coding RNA.
- The objective is to remain competitive and relevant in international sense by offering high quality academic programs and research activities.

Learning outcomes

- Students will acquire basic concepts of genome, its organization and maintenance, packaging of DNA into chromosome structure, changes in histone and chromosome remodeling proteins.
- Students will learn the concept of regulatory mechanisms governing over-expression and under-expression of genes. They will understand transcriptional and translational control in prokaryotes and in eukaryotes.

- Students will also learn about post-translational control-mRNA decay and Proteolysis. Students will understand regulatory RNA in prokaryotes and in eukaryotes (sRNA, riboswitches, CRISPER- Cas system, RNA interference, miRNA and siRNA, Piwi interacting RNA) and Regulatory RNA in X-inactivation.

SYLLABUS OF BIOMED-DSC- 13

Unit-I: Organization of Human Genome (7 hrs)

General features: Genome size, gene density and diversity. Types of repetitive DNA. Nucleosomes: Basic unit of DNA condensation, packaging of DNA in to chromosome structure, nucleosome assembly. Protein and RNA encoding genes. Gene-families and super families. Processed and non-processed Pseudogenes.

Unit II: Gene Regulation at DNA level (6 hrs)

Prokaryotic gene regulation- Histone like proteins, overlapping genes.

Eukaryotic gene regulation: Genomic control – gene amplification and deletions, DNA rearrangements, chromosome puffs, DNA methylation, CpG islands. Changes in histone and chromosome remodeling proteins- HAT and HDAC, Chromodomain and Bromodomain proteins, nucleosome modifications and nucleosomes positioning.

Unit-III: Transcriptional Regulation in Prokaryotes (6 hrs)

Principles of transcriptional regulation. Activators and Repressors and their mechanism of working. Bacterial gene regulation with reference to Operons- Lactose, Tryptophan and Arabinose operon. Combinatorial control. Role of sigma factors in gene expression.

Unit-IV: Transcriptional Regulation in Eukaryotes (10 hrs)

Difference between gene regulation in Prokaryotes and Eukaryotes. Cis-acting regulatory sequences- Promoters, Enhancers, Insulators, Boundary elements. Regulatory proteins-Activators, Repressors and Co-activators, their structure and mechanism of working, Structural difference among the different DNA binding domains,

Regulation of LCR, Signal integration and Combinatorial control, Signal transduction pathways- MAP kinase and STAT pathways. Techniques for studying DNA-Protein interaction: EMSA, DNA foot printing, ChIP assay.

Unit-V: Regulatory RNAs (6 hrs)

Regulation by RNAs in Prokaryotes: sRNA (6S RNA, RybB, DsrA, RprA, OxyS), Riboswitches, Attenuation in trp operon. Structure, Origin and Functioning of CRISPR-Cas system. Regulation by RNAs in Eukaryotes: RNA interference-need and mechanism. Therapeutic uses of RNAi. RNA Induced silencing complex (RISC) and Argonaute (AGO). miRNA- structure, origin and working. siRNA- structure, origin and working. Piwi-interacting RNA- structure, origin and working. Regulatory RNA and X-inactivation: long non-coding RNA. Mechanism of X-inactivation.

Unit-VI: Translational and Post-Translational Regulation (10 hrs)

Rationale of gene regulation at translation level. Regulation of Prokaryotic translation-protein and RNA bonding to RBS, Ribosomal proteins as translational repressor, Tm RNA. Regulation of Eukaryotic translation-Global regulation and Gene specific regulation. Regulation of Oscar protein by Cup protein in Drosophila, Regulation of Ferritin in Humans, Regulation of Gcn4 in yeast, Eukaryotic mRNA structure and stability. mRNA decay pathway in Eukaryotic cells: De-adenylation dependent pathway and De-adenylation independent pathways- Endoribonucleolytic decay, Nonsense and Nonstop mediated decay, No-Go decay and RNAi dependent pathway of mRNA decay. Proteolysis in Prokaryotes and Eukaryotes, Lysosome and Proteasome mediated protein decay, Ubiquitin-Proteasome pathway.

Practical (30 hrs)

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Preparation of various stock solutions for mentioned experiments.
2. Isolate plasmid/ genomic DNA of the sample provided.
3. Comparative analysis of genomic DNA and plasmid DNA by restriction enzyme digestion and estimation of size of a DNA fragment after electrophoresis using DNA markers.
4. Quantification of unknown DNA using Lambda-Hind III marker.
5. Study transfer of DNA through Southern Blotting.
6. Perform hybridization of DNA using Southern Blot.

8. Separation of proteins using SDS PAGE.
9. Perform Western hybridization.
7. Bioinformatic analysis of Prokaryotic gene.
8. Bioinformatic analysis of Eukaryotic gene.

Essential Readings

- Klug, W. S. Cummings, M. R. Spencer, C. A. and Palladino, M. A. Killian, D. (2019*).* 12th Edition. *Concepts of genetics.* San Francisco, USA: Benjamin Cummings Publishers. ISBN-13:978-0134604718
- Strachan, T. and Read, A. (2018). 5th Edition. *Human molecular genetics*. Florida, USA: CRC Press, Garland Science. ISBN: 978-0815345893.
- Cox, M. M. Doudna J. A. and Donnell, M. O. (2015). 2nd Edition. *Molecular biology: Principles and practice.* London, UK: W H Freeman & Co Publishers, ISBN-13: 978-1464126147
- Watson, J.D. Baker T.A. Bell, S.P. Gann, A. Levine, M. and Losick, R. (2013). 7th Edition. *Molecular biology of the gene.* New York, USA: Cold Spring Harbor Laboratory Press.ISBN-13:9780321762436.
- Snustad, D. P. and Simmons, M. J. (2011). 6th Edition. *Principles of genetics.* New York, USA: John Wiley and Sons.ISBN-13: 978-0470903599

Suggestive Readings

- Karp, G. (2020). 9th Edition. *Cell and molecular biology: Concepts and experiments.* NewJersey, USA: Wiley Publishers, ISBN-13: 978-1119598244
- Cooper, G.M. and Hausman, R.E.(2013). 6th Edition. *The cell: A molecular approach.* Massachusetts, USA: Sinauer Associates. ISBN-13:978-1605351551.
- Green M.R. and Sambrook J. (2012). 4thEdition, (three-volume set). *Molecular cloning: A laboratory manual.* Cold Spring Harbor Laboratory Press. ISBN-13: 978-1936113422.
- Snustad, D. P. and Simmons, M. J. (2011). 6th Edition. *Principles of genetics.* New York, USA: John Wiley and Sons. ISBN-13: 978-0470903599.
- Hardin ,J. Bertoni, G. P. Kleinsmith, L.J. and Becker, W.M.(2008).7thEdition. *The world of the cell.* San Francisco, USA: Benjamin Cummings Publishers. ISBN-13:978-0805393934.
- Kornberg, A. (2005). 2nd Edition. *DNA replication.* California, USA: University Science Books. ISBN-13: 9781891389443.

- Cantor, C. R. and Smith, C. L. (1999). 1st Edition. *Genomics: The Science and technology behind the human genome project.* NewYork, USA: JohnWiley and Sons. ISBN-13:978-0471599081.

DISCIPLINE SPECIFIC CORE COURSE –14 (BIOMED-DSC-14) MEDICAL BIOTECHNOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical / Practice			
Medical Biotechnology **BIOMED-DSC-14**	**4**	**3**	**-**	**1**	**XII Passed**	**Basic knowledge of biology**	**Biomedical Science**

Learning objectives

- The objective of this course is to enable the students to comprehend the concepts of recombinant DNA technology and apply the gained knowledge towards cloning and expression of genes and purification of the recombinant proteins.
- In the process, students would get a grasp on the cutting-edge technologies used in the analysis of nucleic acids and expressed proteins. The course aims to give students training in modern molecular techniques and help them make a connection between biological concepts and the technologies developed for various applications in biotechnology.
- The course finally aims to augment students' understanding of the role biotechnology plays/can play in various aspects of human medicine and provide them the platform to appreciate the drivers of emerging innovations in medical biotechnology along with biosafety and ethical concerns.

Learning outcomes

- Students will learn the contemporary techniques being applied in the field of medical biotechnology which include PCR, Gene Cloning, Gel electrophoresis etc.
- Students will gain a comprehensive understanding of DNA manipulation techniques and how to create recombinant DNA molecules by making a suitable choice of vectors and expression hosts.

- An in-depth understanding of gene cloning, expression in prokaryotic and eukaryotic systems and on the production of recombinant proteins shall prepare students to apply the gained knowledge on different organisms.
- Having grasped the fundamentals of recombinant DNA technology, its robust potential and the limitations & challenges, students shall discern the applications of biotechnology in human medicine. Their gained knowledge shall be imbued with a deeper understanding of the safety and limitations of molecular tools used in the diagnostics of infectious diseases, production of biopharmaceuticals and gene therapy.

SYLLABUS OF BIOMED-DSC-14

Unit I: Introduction to Recombinant DNA Technology and its applications in Medical Biotechnology

(13 hrs)

Brief history and scope of molecular biotechnology, concept of manipulation of DNA, cloning vectors and gene cloning. Restriction and modification system: Type I-IV restriction endonucleases, nomenclature and sequence recognition, isochizomers, blunt end and sticky ends, restriction mapping. Joining of DNA molecules: role of DNA ligase enzymes, adaptors, linkers, homopolymer tailing.

Cloning vectors: bacterial plasmids (T-vector, pUC vector), Lambda phage-derived vectors (replacement and insertion vectors), Cosmids, *in vitro* packaging. Gene cloning: Blunt end and directional.

Unit II: Expression of cloned genes in prokaryotes (13hrs)

Prokaryotic expression vector (pET vector). Bacterial transformation (*E.coli*): Preparation of competent cells ($CaCl_2$ method), selection of the transformants (antibiotic-resistance) and screening (blue/white & by colony PCR). Challenges in the expression of foreign proteins in a heterologous host, Factors affecting the expression: Promoters, Codon usage, Plasmid copy number. Fusion proteins and tagged protein cleavage system. Gene Probe preparation, Use of enzymatic and chemiluminescent methods for the detection of proteins.

Unit III: Cloning and expression in a eukaryotic system (09hrs)

Concept of auxotrophic mutants of yeast (eg. *Saccharomyces cerevisiae*) as cloning host. Cloning vectors (yeast Integrative (yIP), Replicative (yRP) and Episomal (yEP) plasmid, YAC), Shuttle vectors. Expression in eukaryotic cells, screening and selection of recombinants. cDNA cloning.

Unit IV: Applications of Medical Biotechnology (10hrs)

(a) Production of recombinant biopharmaceuticals: Insulin and Factor VIII.

(b) Gene Therapy: Strategies and limitations, Somatic and germline gene therapy, Vectors used in gene therapy (viral and non-viral) and their comparison.

(c) Polymerase chain reaction (PCR): Principle and applications. Importance of RT PCR in diagnosis of infectious diseases.

(d) Biosafety and ethical concerns in medical biotechnology.

Practical (30 hrs)

The below listed practicals are based on a guided project: 'PCR-based gene cloning' where students need to work in a group (4-6 students) to perform *in vivo* gene cloning. For this, any prokaryotic gene of interest may be chosen.

1. Plasmid DNA isolation
2. Designing of gene-specific primers
3. PCR amplification of the desired gene
4. Agarose gel analysis of plasmid DNA and PCR product(s).
5. Restriction digestion of plasmid DNA (vector) and PCR product (insert)
6. Ligation of the insert and vector using T4 DNA ligase
7. Preparation of competent cells (*E.coli*) using the calcium chloride method
8. Transformation of competent bacterial cells with ligation mixture along with suitable controls.
9. Screening of transformants by blue/white selection OR by colony PCR.

Essential Readings

- Bernard, R. G. Jack, J. P. and Cheryl, I. P. (2022). 6th Edition. *Molecular biotechnology: Principles and applications of recombinant DNA.*USA: ASM press, ISBN-978-1-683-6736-8
- Brown, T. A. (2016). 7th Edition. *Gene cloning and DNA analysis: An introduction.* NewYork, USA: John Wiley and Sons, ISBN-978-1-119-07256-0.
- Primrose, S. B. and Twyman, R. B. (2006). 7th Edition. *Principles of gene manipulation and genomics.* Oxford, UK: Blackwell Scientific Publishers. ISBN:978-1405135443.

Suggestive Readings

- Karp, G. (2020). 9th Edition. *Cell and molecular biology: Concepts and experiments.* NewJersey, USA: Wiley Publishers, ISBN-13: 978-1119598244
- Green, M.R. and Sambrook, J.(2012). 4th Edition, (three-volume set). Molecular cloning: A laboratory manual. New York, USA: Cold Spring Harbor Laboratory Press ISBN-13:978-1936113422.

DISCIPLINE SPECIFIC CORE COURSE –15 (BIOMED-DSC-15) HUMAN PATHOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)	Department offering the course
		Lecture	Tutorial	Practical			
Human Pathology **BIOMED-DSC-15**	**4**	**3**	**-**	**1**	**XII Passed**	**Basic knowledge of biology**	**Biomedical Science**

Learning objectives

The Learning objectives of this course are as follows:

- The course of Human Pathology will build upon the existing knowledge that the students have gained in physiology, cell biology, immunology to help them understand how alteration of normal state takes place and diseases develop. The curriculum is a systematic presentation of the various internal and external stimuli that initiate pathogenesis of diseases.
- Topics like cellular adaptations, inflammation, repair and hemodynamic disorders would assist students for better understanding of the subject.
- Study of neoplasia and a few infectious and non-infectious diseases would help in understanding and integration of all concepts.

Learning outcomes

Having successfully completed this course, students shall be able to learn and appreciate:

- Basics of disease in human body
- Adaptation of the human body under stress and injury
- Repair and healing of wounds
- Importance of early detection, diagnosis and treatment in any disease
- Prevention is better than cure and one needs to follow the discipline and healthy lifestyle

SYLLABUS OF BIOMED-DSC-15

Unit-I: Introduction, Cellular Adaptations, Cell Injury and Cell responses (7 hrs)

History of pathology with respect to medical science, basic definitions and familiarization with the common terms used in pathology, Causes and mechanisms of cell injury: reversible and irreversible injury, Overview of pathogenesis (salient steps) and Cellular responses: (subcellular, intracellular and intercellular response, Hyperplasia, Metaplasia, Hypertrophy, Atrophy, dysplasia, Necrosis, Apoptosis) with one example each.

Unit-II: Inflammation and its significance in Diseases (7 hrs)

Hallmarks of Inflammation and why inflammation ensues with suitable examples. General features of acute and chronic inflammation: Vascular changes, cellular events, termination of acute inflammatory response, Molecular mediators of inflammation, morphological effects and outcome of acute inflammation. Systemic effects of inflammation

Unit-III: Hemodynamic Pathology (7 hrs)

Edema, hyperaemia, congestion, hemorrhage, haemostasis and thrombosis, Embolism, Infarction, shock and hypertension.

Unit-IV: Tissue Repair and Remodeling (8 hrs)

Control of cell proliferation, maintenance of cellularity and differentiation, mechanism of tissue and organ regeneration. Wound healing by repair (first and second intention), scar formation and fibrosis, role of extracellular matrix. Angiogenesis and pathological aspects of remodeling (eg Atherosclerosis).

Unit-V: Tumor Pathology and Pathogenesis (8 hrs)

Definitions, nomenclature, characteristics of benign and malignant neoplasms, biology of tumor growth, mechanism of tumor invasion, metastasis cancer progression. Overview of genetic changes in transformed cells and cancer stem cells.

Unit-VI: Pathophysiology of Diseases (8 hrs)

Etiopathogenesis of following diseases: Communicable (Tuberculosis), Non-communicable (CAD, Myocardial Infarction and Asthma, Diabetes).

Practical (30 hrs)

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.- minimum 8 practicals)

1. Urine Analysis: Gross examination of urine for colour, odor etc. Abnormal constituents like protein, ketone bodies, glucose, blood, urea (any three)
2. Histopathology Tissue Processing, embedding, sectioning. Staining and preparation of permanent histological slides.
3. Study of four distinct stages of alcoholic liver disease through permanent slide.
4. Study of histological slides showing hypertrophy, hyperplasia, dysplasia, leukemia, cirrhosis
5. Hematological assessment: Study and analysis of a blood report: CBC, KFT, LFT, lipid profile, thyroid profile.
6. Measurement of Erythrocyte Sedimentation Rate.
7. To perform Platelet count and its pathological significance
8. To perform reticulocyte count its pathological significance
9. Study of fractures
10. Diagnostic tests: Detection of various Diseases – Montoux test, CRP, VDRL, RA, Pregnancy (any two)

Essential Readings

- Kumar, V., Abbas, A.K., Aster, J.C. and Fausto, N. (2020). 10th Edition. Robbins and Cotran Pathologic basis of disease. Philadelphia, USA: Saunders Publishers. ISBN 13: 9780323531139.
- Cross, S.S. (2019). 7th Edition. Underwood's Pathology: a Clinical Approach: with STUDENT CONSULT Access ISBN-13: 978-0702072123.
- Sood, R. (2009). 6th Edition Volume 1 and 2. Medical laboratory technology methods and interpretations. India: Jaypee Brothers Medical Publishers. ISBN-13:978-8184484496. There is no recent edition but another book which i have not seen

Suggestive Readings

- Goswami, P; Kalla, A.R; Khatri, K. Dubey, A and Goswami, K. (2022) 1st Edition, Comprehensive Pathology Practical and Technical book , Scientific Publishers. ISBN: 9789392590313

  Copstead-Kirkhorn, L. C. (2021). 7th Edition. Pathophysiology. Philadelphia, USA: Saunders. ISBN: 9780323761550

Pool of DSEs

DISCIPLINE SPECIFIC ELECTIVE COURSE –(BIOMED-DSE-07) MEDICAL LABORATORY TECHNOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical /Practice			
Medical Lab Technology BIOMED-DSE-07	**4**	**3**	**-**	**1**	**XII Passed**	**Basic knowledge of biology**	**Biomedical Science**

Learning objective

- The course on Medical Lab Technology would enable students to have an in-depth understanding of key concepts required in Clinical Laboratory set-ups.
- Students would be precisely trained to assist Physicians, in Laboratory set-ups and Hospitals, in handling samples, centrifuging, making slides, using specified stains etc, under proper guidance.
- After completion of the course, students would have an opportunity to work as research fellows in molecular diagnostics, molecular biotechnology companies and in research labs.

Learning outcomes

At the end of the course student would be able to:

- Develop specific laboratory skills, such as accurate pipetting, mixing, filtration, dispensing etc. using multi-step methods.
- Learn about ethics of working in biomedical labs and concerns about the medico legal aspects in Medical Laboratory Science.

- Comply with laboratory safety regulations and standards. Analyze and appreciate the quantum of biomedical waste that is generated and managed in various Labs.
- Exhibit skills essential to identify and determine blood group incompatibility. These skills would help them to analyze any mismatch during the blood transfusion reactions.

SYLLABUS FOR BIOMED-DSE-07

Unit 1: Clinical laboratory- Basic Principal and Procedure (06 hrs

Standardized clinical lab setup, Lab safety and First-aid measures, Laboratory Calculations. Definition of Biomedical Waste: Types of waste generated from Health Care Facility, Segregation, Collection, Transportation, Treatment, and Disposal (including color coding) of biomedical waste. Medical Ethics - Definition - Goal - Scope, Autonomy and informed consent - Right of patients, Obtaining an informed consent, Ethics in the profession of Medical Laboratory Science.

Unit II: Classical Instruments and Automation used in Medical Laboratory (09 hrs)

Working Principle of: Distillation setup, RO system, Weighing balance, Centrifuge, Bio safety cabinet, Spectrophotometer – Visible and UV-Visible, Water bath, Incubators, Hot Air Oven, Vortex mixer, Magnetic stirrer, Autoclave, Automation in clinical labs.

Unit-III: Clinical Biochemistry (10 hrs)

Organ Function Tests: Liver Function Tests, Renal Function Tests, Thyroid function tests and Pancreatic Function tests, Cardiac Profile, Diabetic Profile: Regulation of Blood Glucose, FBS, PP, Glucose tolerance test (GTT), Glycosylated Hemoglobin (HbA1C), Microalbuminuria etc. Gonadal Hormonal Profile: FSH, LH, Testosterone, Estradiol.

Unit-IV: Clinical Hematology (8 hrs)

Anticoagulants: Mechanism of action and Selection of anticoagulant- Wintrobe's mixture, EDTA, Heparin, Citrate, ACD. Erythropoiesis and Thrombopoiesis. Synthesis of hemoglobin and iron metabolism. Anemia: Definition, Causes, Classification & lab findings of Iron Deficiency Anemia, Megaloblastic Anemia, Hemolytic Anemia. Hemoglobinopathies: Hemophilia, Thalassemia, Sickle cell anemia. Leukemia: Classification, Blood Picture, Differentiation of Blast Cells. Hematological tests- CBC, Fetal hemoglobin test, Osmotic fragility test, Serum iron, TIBC. Blood groups-RH and ABO system. Blood transfusion: Prerequisites of transfusion.

Unit-V: Body Fluid Examination (04 hrs)

Urine examination: Physical, Chemical, Microscopic and Culture. Routine examination of faeces. Examination of body fluids, Cell counts, Semen analysis, CSF (Cerebrospinal Fluid), Chemical Tests of Gastric Content, Collection and Transportation of specimens: General Principles, Containers, Rejection, Samples- Urine, Faeces, Sputum, Pus, Body fluids, Swab, Blood.

Unit-VI: Diagnostic Cytology and Molecular Biology (08 hrs)

Normal chromosomal structure, Pre and Post-natal Cytogenetics, Cancer and Tumor markers-FISH. Aspiration Cytology: Principles, Indications, Fine Needle Aspiration Cytology (FNAC) and Fluid cytology. Exfoliative cytology: Introduction, Preparation of vaginal & cervical smears, Papanicolaou technique for the staining of cervical smears (PAP smear). Histopathology: HE staining and IHC. Role of molecular biology in diagnostics, Common techniques used in molecular biology for the detection of infectious and non-infectious disease-PCR and its variants.Stem cell banking: Applications, Procedure & Requirements of cord blood cells.

Practical:

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Preparation of reagents routinely used in Medical Laboratories.
2. Standardization of 1.0 ml of volumetric pipette.

3. Working of various instruments used in Medical laboratory: Water baths, Incubators & Hot Air Oven, Centrifuges, Balances, Autoclave, pH Meter, Vortex mixer and magnetic stirrer. Maintenance of working manuals provided with the Instruments, formulating SOPs and LOG Books for each of the Instruments.
4. Calibration and standardization of spectrophotometer and other Instruments.
5. Selection of a filter for determining the intensity of a coloured solution.
6. Determination of an unknown concentration of a coloured solution by photometric method.
7. Organize a poster making competition for standard biomedical waste disposal procedure.
8. Medico legal experts maybe invited to deliver lecture on specific topics and share their experiences.
9. Visit to hospital for demonstration of Biomedical Waste Management.
10. Visit to hospital for demonstration of advanced instrumentation and auto-analyzers.

Essential Reading:

- Sood Ramnik. (2006). Textbook of Medical Laboratory Technology.*1st edition.*Jaypee Brothers Medical Publishers. ISBN: 978-8180615917.
- Dacie and Lewis. (2017).Practical Hematology. *12th edition.* Elsevier IE. ISBN: 978-0702069307.

Suggested Reading:

- Devlin, T.M. (2011).Textbook of Biochemistry with Clinical Correlations. *7th edition*. John Wiley & Sons, Inc. (New York). ISBN: 978-0-470-28173-4.
- R. S Khandpur. (2014).Handbook of Biomedical Instrumentation. *3rd edition.* McGraw-Hill Education ISBN 978-9339205430.
- Mary C. Haven, Gregory A. Tetrault, Jerald R. Schenke. (2010).Laboratory Instrumentation. *4th edition.*Wiley India Pvt Ltd. ISBN 978-8126528578.

DISCIPLINE SPECIFIC ELECTIVE COURSE –(BIOMED-DSE-08) INTELLECTUAL PROPERTY RIGHTS FOR BIOLOGISTS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the Course
		Lecture	Tutorial	Practical / Practice			
Intellectual Property Rights for Biologists **BIOMED-DSE-08**	**4**	**3**	**-**	**1**	**XII Passed**	**Basic knowledge of biology**	**Biomedical Science**

Learning objectives:

Upon successful completion, the certificate level course on Intellectual Property Rights (IPR) aims to achieve the following objectives:

- Familiarize students with national and international IP protection systems.
- Provide a foundation for further career development and specialization in the field of Intellectual Property Rights.
- Enhance students' understanding of Intellectual Property Rights and their significance in various fields.
- Prepare students for future career opportunities in diverse fields such as patent office/law firm clerks, patent agents, trademark agents, patent attorneys, business strategists, enforcement officers, and banks.

Learning outcomes:

The syllabus on Intellectual Property Rights (IPR) for biologists aims to equip students with a comprehensive understanding of the subject. The course outcomes include:

- Knowledge of various forms of Intellectual Property Rights, including patents, copyrights, trademarks, and trade secrets, legal frameworks and regulations governing these rights.

- Understanding of Biological Innovations and how Intellectual Property Rights apply specifically to biological innovations, such as genetically modified organisms, biotechnological inventions, pharmaceuticals, and plant varieties.
- Importance of IPR in Biotechnology and Biomedical Research.innovation, safeguards investments, and promotes the commercialization of research outcomes.
- Understanding of IP Protection Strategies in the field of biology, drafting patent applications, conducting patent searches, and navigating the patent filing process, would learn alternative forms of protection such as copyrights and trademarks, applicable to biological inventions.
- Patents of Trade mark, copyright & Design: The students will understand the legal issues related to the trade marks, logo design and the works related to arts.
- Ethical and Legal Considerations: Students will develop an understanding of the ethical and legal implications associated with Intellectual Property Rights in biology and explore issues of patent infringement, licensing, technology transfer, and access to genetic resources.

SYLLABUS FOR BIOMED-DSE-08

Unit 1: Indian Patent Act and National Policy (12 hrs)

- Understanding Intellectual Property Rights: Introduction to Intellectual Property Rights. Significance of IP and its Role in society and business, Indian Patent Act and International treaties on IP Rights (Birds eye view)

- Patent Laws and Policies : History of Patent Protection & Rational, Introduction to Indian Patent Act and its sections, National IPR Policy

Unit II: Patent Protection Procedure (10 hrs)

Function of a patent and Patentability criteria, Elements of a Patent and Application forms (Form 1 and Form 2). Types of Patent Applications. Signification of Provisional patent Filing. PCT system, IP infringement and IP enforcement. Plant variety protection and farmers rights Acts and authority in India

Unit III: Patent Prosecution and IP issues in the current scenario (10 hrs)

First Examination Report (FER) and Responding to FER and hearing notice. Exercises and Ecommerce. Interaction Between IP Law and Competition Law regulating anti-competitive conduct of companies. IP

Rights in digital environment and open source & open Access, Plagiarism. Importance of IP policy for an organization

Unit IV: Geographical indications & Trademarks (**08 hrs)**

Brief introduction to Legal framework for GIs in India and Impact of GI registration in India. Importance of Trademarks , Salient features of Trademark law of India and Trademark filing and prosecution in India. Madrid System

Unit V: Registration of Copyright, Designs and Lay out of Integrated circuits (05hrs)

Salient elements of Indian Copyright Act, Law relating to Layout designs of Integrated Circuits and Design Act. Registration of Copyrights, Designs, The Industrial Property System

Practical (30 hrs)

1. Drafting of specifications, claims and Patent Filing:

a) Drafting a patent specification
b) Claims Drafting
c) Patent filing – examples (05)
d) Exercises (05)

2. Industrial Designs and Layout design of Integrated circuits in India.
3. **Case studies** : (a) Patents as assets; (b) Drug pricing as a result of patent filing. (c) Recent cases related to the provisions of Section 3(d) of The Patents Act (Novartis vs Generic Manufacturers, Roche vs Cipla, Astra Zeneca Vs Natco Pharma). (d) Traditional knowledge and IP system; (e) Patenting of genetically-engineered micro-organism (Diamond Vs Chakravarthy); (f) Infringement cases; (g) Biopiracy cases *(Hoodia case, the Quinoa case, the Enola bean case, The neem patents);* (h) Trade secrets;

Essential Reading

- Intellectual property: A power tool for Economic Growth: Kamal Idris, Published by World Intellectual Property Organization, 2003. ISBN: 9280511149, 9789280511147

- Intellectual property and Human Development : Current trends and future Scenarios: T. Wong and G. Dutfield, Publisher Cambridge University Press, 2010. ISBN-13 : 978-0521190930
- Intellectual Property laws, Publisher: Universal Law Pub Co. P. Ltd., Delhi, 2015. ISBN-13 : 978-9350355855
- Intellectual property Law in India, Third Edition. Tamali Sen Gupta, Dhruv Shekhar, Publisher: Kluwer Law International, 2022. ISBN-13 : 9789403548111
- IIMA Business and Intellectual Property: Protect Your Ideas: Anurag K. Agarwal, Random House Publishers India Pvt. Limited, 2016. ISBN-13, 978-8184001402
- Technology Licensing and Development Agreements By Cynthia Cannady, Oxford University Press, 2013. ISBN-13: 978-0195385137
- Deborah Bouchoux : The Law of Trademarks, Copyright, Patents and Design, 2012. ISBN-13 , 978-1111648572.

Suggested Reading

- Office of the Controller General of Patents, Designs & Trade (CGPDTM): Manual of Geographical Indications Practice and Procedure; Manual of Patent Office Practice and Procedure; Manual of Designs Practice and Procedure; Revised Draft Manual of Trademarks Practice and Procedure.
- WIPO: WIPO Guide To Using Patent Information; WIPO Intellectual Property (IP) Audit, : WIPO Patent Drafting Manual, WIPO: The Value of Intellectual Property, Intangible Assets and Goodwill.
- Journal of Intellectual Property Rights 2007 and 2009.
- OECD Report on Patents and Economic Performance, IP guidelines from Patent office.
- Patentability of Software in India - (Lex Orbis).
- Acts : Indian Patent Act (amended), Indian Trademark Act (amended), Indian Copyright Act (amended), Indian Design Act (amended), Indian Plant variety and Farmers Right Act (Amended), Indian Biodiversity Act ,Indian GI Act

DISCIPLINE SPECIFIC ELECTIVE COURSE (BIOMED-DSE-09) DRUG DESIGN AND DISCOVERY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)	Department offering the Course
		Lecture	Tutorial	Practical/ Practice			
Drug Design and Discovery **BIOMED-DSE-09**	**4**	**3**	**-**	**1**	**XII Passed**	**Basic Knowledge of Medicinal Chemistry**	**Biomedical Science**

Learning objectives

The Learning Objectives of this course are as follows:

1. The students will learn the fundamental computational techniques used in drug design and discovery that can be applied to study problems in biology.
2. The students will develop scientific and hands-on practical skills and abilities to plan and carry out drug design projects to design a druggable ligand using computer-aided drug design tools.
3. The students will develop skills that will be useful for higher studies in biomedical research.

Learning outcomes

Having successfully completed this course, students shall be able:

1. To use structural databases and computer programs to visualize three-dimensional structures of the proteins and to analyse the relationship between structure and function.
2. To describe molecular mechanics force fields, parameterization, and their limitations and procedure for energy minimization of simple systems.
3. To understand the principle and carry out basic steps involved in molecular dynamics simulations.
4. To interpret molecular dynamics results vis-a-vis their biological significance and limitations.
5. To understand the drug discovery process from molecules to new medicines, challenges encountered in the development, manufacturing, and regulatory approval.

SYLLABUS OF BIOMED -DSE- 9:

Unit I: Structure of Proteins (08 hrs)

Basics of biomolecular structure- primary, secondary tertiary and quaternary protein structures, Ramachandran plot, various parameters of protein secondary structure, introduction to peptide planarity, chirality, side-chain packing.

Molecular structure databases and visualization, The PDB and mmCIF formats, structure classification databases (SCOP and CATH), structure comparison and alignment, structure and functional assignment; secondary structure assignment, identifying structural domains in proteins.

Unit II: Proteins as Drug Targets (08 hrs)

Chemical attributes of drug targets, candidate gene prioritization, experimental validation, practical aspects and case studies, structural bioinformatics in drug discovery, protein structure prediction (homology modelling, fold recognition and, *ab initio* methods).

Unit III: Ligand and Pharmacophore-based screening methods for Lead Discovery (07 hrs)

Traditional and rational drug discovery methods, SAR, drug discovery pipeline, , hit and lead discovery, chemical databases and 2D substructure searching, , molecular descriptors and fingerprints, molecular similarity (or diversity) and similarity searching, selecting 'diverse sets of compounds', ligands and targets, chemical libraries, Lipinski's rule of five, QSAR, deriving and using 3D pharmacophores, 3D database searching, strengths and limitations of pharmacophore-based virtual screening

Unit IV: Structure based drug design methods (07 hrs)

Introduction to structure-based drug design methods, , , library design, binding site prediction, virtual screening, , docking and scoring methods, rigid and flexible docking, induced fit methods, *de novo* drug design, calculation of binding free energies molecular affinities and assemblies, design against protein-protein interactions.

Unit V: Introduction to Molecular Mechanics (08 hrs)

Scope of computational chemistry, Potential energy surfaces and optimization methods, , Introduction of *ab initio* methods. Electrostatics for force fields, basics of molecular dynamics simulation, introduction to Monte Carlo methods, electrostatics and solvation in biomolecules; calculation of free energy, Poisson-Boltzmann surface area.

Unit VI: Overview of the Clinical Evaluation and Development Process (07 hrs)

Introduction to drug development pathway: how to go from molecule to medicine, pharmacological and toxicological evaluation (prediction as well as *in vitro/ in vivo* methods), preclinical evaluation methods, an overview of the clinical process, clinical safety and pharmacovigilance.

Practical **(30 hrs)**

1. To predict secondary e.g PSIPred, and tertiary structures of proteins e.g. Swiss Model.
2. To calculate the total energy of a biomolecule e.g Charmm-GUI, AMBER, Chimera.
3. To build a ligand- *ab initio* from similar ligands with and without a known macromolecular target. SWISS-DOCK
4. To perform virtual screening and molecular docking using Autodock, Chimera.
5. To calculate energy minimization (EM) through different EM methods. Charmm-GUI, Chimera
6. To calculate binding free energy/MMPBSA through tools/ servers. AMBER
7. To perform MD simulations e.g. Charmm GUI, NAMD
8. To design a druggable ligand using computer-aided drug design tools.

Essential readings:

- Stromgaard, K., Krogsgaard-Larsen, P., & Madsen, U. (Eds.). (2016). Textbook of drug design and discovery, Fifth Edition. United States: Taylor & Francis. ISBN: 9781315354545.
- Gu, J., & Bourne, P. E. (Eds.). (2011). Structural bioinformatics, Second Edition. John Wiley & Sons. ISBN: 9781118210567.

Suggested readings:

- Rostron, C. (2020). Drug Design and Development. United Kingdom: Oxford University Press. ISBN: 9780198749318.
- Jhoti, H., & Leach, A. R. (Eds.). (2007). Structure-based drug discovery. Springer Netherlands. ISBN: 9781402044076.
- Gasteiger, J., & Engel, T. (Eds.). (2006). Chemoinformatics: a textbook. John Wiley & Sons. ISBN: 9783527306817.
- Bajorath, J., (2013) Chemoinformatics for Drug Discovery, John Wiley & Sons, ISBN: 978-1-118-13910-3.
- Leach, A. R. (2001). Molecular modelling: principles and applications. Pearson Education. ISBN: 9780582382107.

Pool of Generic Electives (Semester III Onwards)

GENERIC ELECTIVES (BIOMED-GE-04): PANDEMIC: CHALLENGES AND PREPAREDNESS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Pandemic: Challenges and Preparedness **BIOMED-GE-04**	**4**	**3**	**-**	**1**	**XII Passed**	**Basic knowledge of Biology-**	**Biomedical Science**

Learning Objectives

The Learning Objectives of this course are as follows:

- Current scenario of covid outbreak all over the world made everyone curious about pandemic, its challenges and how to prepare for dealing with it.
- In this context we designed this paper to make students aware about pandemics caused by various pathogens.
- Course describes different pandemic outbreaks and strategies adapted to combat the transmission of pathogen and their neutralization.
- The course also explains the different therapeutic approaches for the elimination and cure of patients suffering from pandemic infections.

Learning outcomes

The Learning Outcomes of this course are as follows:

- This unit helps students to understand the difference between endemic, epidemic and pandemic.
- It makes students familiar with various pandemics that have spread in last century and are caused by different types of pathogens such as virus, bacteria and fungi.

- Students will learn extent of spread of pandemic worldwide, its timeline, death rate and other statistical data.
- This unit will explain about the infectious diseases and process of invasion by microbes.
- It will also helpful to understand preventive measures of infection transmission and about mutant strains which are associated with recurrent outbreaks.
- Students will learn about different treatment strategies for the patients suffering from any infection, along with specific precautions for handling patients with co-morbidities/ elderly persons. The content of this unit will be helpful to explain about plasma therapy and booster doses. Some basic concept of psychological counselling will help to reduce the depression and anxiety faced by individuals during pandemic outbreak.
- This unit describes different methods and equipments used during an out breaks to minimize the contamination and cross transmission of infection and its spread.
- This will help students to learn the usage of PPE kits, mask, sanitization, quarantine and significance of social distancing.
- Current unit, emphasizes about the history of vaccine, process of active and passive immunization, different types of vaccines and their effectiveness to control any pandemic, vaccines developed in India against covid-19.
- Students will learn hands-on training for important techniques used in the detection and diagnosis of various types of pathogens and associated protocols.
- Last unit of the course will focus on awareness and sensitization programs (eg. SOPs), health and hygiene and many issues related to public health. Also possible global approach to strengthening the health infrastructure and disease surveillance shall be elaborated.

SYLLABUS OF BIOMED-GE-04

Unit I: Introduction to Pandemics: (07 Hrs)

General concepts of endemic, epidemic and pandemic; Historical background of pandemics: Rabies, plague, small pox, cholera, Spanish Influenza, AIDS, Avian bird flu, Swine flu, MERS, SARS and covid-19 pandemic. Timeline of Covid- 19. Extent of spread, worldwide statistics and death rate. Statistics of affected nations worldwide and in India; symptoms, extent of spread and containment

Unit II: Infectious Disease: (05 Hrs)

Structure of causative agent, invasion into human body, etiology and strategies currently used to block infection process, common mutant strains responsible further outbreaks of the pandemics

Unit III: Emerging Therapies, Natural Protection and strengthening immune system: (06 Hrs)

Drugs used to cure Avian bird flu, Swine flu and covid-19. First line of treatment at home additional care of person with co-morbidities / elderly person. Convalescent plasma therapy, Placebo effect, alternative therapies and immunity boosters used during pandemic and psychological counseling and countering depression.

Unit IV: Precautions and Prevention: (06 Hrs)

Quarantine protocol at home, for frequent fliers, hospital exposure, and workplace exposure. Precautionary measures such as PPE clothing, gloves, masks, social distancing, frequent washing of hands with soap, use of sanitizers, disinfection strategies.

Unit V: Vaccines: An effective tool for prevention of pandemics: (09 Hrs)

Historical perspective of vaccination, active and passive immunization; Vaccination drive, types of vaccines: Live attenuated vaccines, inactivated vaccines, subunit vaccines, multivalent vaccine, recombinant vector vaccines and DNA vaccines. Types of vaccines developed against Covid-19 worldwide, Their effectiveness and side effects. Vaccines developed in India for adults (Covaxin and Covishield) and vaccines for children. Limitations in effective development of covid-19 vaccine.

Unit VI: Techniques for diagnosis and detection of disease: (06 Hrs)

Antigen-antibody based detection techniques: Lateral flow technique, RAPID and RT-PCR test with complete protocol. Probes for virus detection.

Unit VII: Challenges and Preparedness: **(06 Hrs)**

Awareness and sensitization programs (SOPs) about general health and hygiene. Funding in research on issues related to public health and protection of environment. Global health approach with multidisciplinary collaborations. Pandemic preparedness and disease surveillance with strong health infrastructure.

Practical component (30 Hrs)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. A case study of any one pandemic of past.
2. A case study of any one emerging pandemic.
3. Detection and diagnosis using antigen and antibody in the sample.
4. Demonstration of the PCR machine
5. Video demonstration of Covid-19 lateral flow technique
6. Demographic analysis of extent of spread both national and international.
7. Project work

Essential readings:

- Park, K. (2021), 26th Edition, *Park's Textbook of Preventive and Social Medicine*, Banarsidas Bhanot Publisher, ISBN-13 : . 978-9382219163
- Madigan M. T, Bender K.S, Buckley D.H, Sattley W.M, Stahl D.A (2021) 16th edition, Brock Biology of Microorganisms, Pearson Publisher, ISBN-139780135861717.
- Punt, J. Stranford, S. Jones, P. and Owen, J. (2019). 8 th Edition. Kuby Immunology. New York, USA: W.H. Freeman and Company. ISBN- 13: 978-1464189784.
- Willey, J., Sherwood, L., and Woolverton, C.J. (2016). 10th Edition. Prescott's microbiology. New York, USA: McGraw-Hill Education. ISBN-13: 978-1259281594.

Suggestive readings:

- Bonita, Ruth, Beaglehole, Robert, Kjellström, Tord & World Health Organization. (2 (2006nd edition. *Basic Epidemiology*, World Health Organization, ISBN 978 92 4 154707 9.

GENERIC ELECTIVE-05 (BIOMED-GE-05) UNDERSTANDING GENETIC BASIS OF DISEASES

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Understanding Genetic Basis of Diseases **BIOMED-GE-05**	**4**	**3**	**-**	**1**	**XII Passed**	**Basic knowledge of Biology**	**Biomedical Science**

Learning Objectives

- The course is designed to provide insight about the importance of our genetic material.
- Students will be taught different types of changes that can take place in our genetic material and their repercussions.
- Students will be briefed as to how even minor changes in such a complex genetic system can lead to serious defects and disorders.

Learning outcomes

Having successfully completed this course, students will understand:

- The basic structural arrangement of our genetic material, its location within the cells and how it contributes to the unique features of each individual organism.
- Possible changes that can occur in the chromosomes at the macro level and what serious consequences this might have to the bearing individuals will be taught to the students.
- Not only the structural features but also the correct dose of the chromosomes present in our cells plays an important role in regulating normal body functioning. The same will be taught by citing examples of disorders associated with both extra as well as deficient chromosome numbers.

- The basic Mendelian pattern of inheritance. Students will also learn about different changes that can occur within a single gene, the diseases associated with them and how these changes can be inherited from one generation to the next.

SYLLABUS OF BIOMED-GE-05:

Unit I: Organization of human genome (09 Hrs)

Basic structure of DNA and chromosomes, euchromatin, heterochromatin. A brief overview of the human nuclear and mitochondrial genome, Concept of allele, haploid and diploid. Genetic Variations- Polymorphism vs mutations. Types of mutations: Somatic vs germline.

Unit II: Structural chromosomal abnormalities (06 Hrs)

Different types of structural chromosomal abnormalities (deletions, duplications, inversions and translocations) and their associated disorders (Cri-du-chat, Wolf-Hirschhorn, Charcot-Marie-Tooth disease Type 1, Pallister Killian, Hunter syndrome, Walker-Warburg, CML).

Unit III: Numerical Chromosomal abnormalities (06 Hrs)

Concept of non-disjunction anaphase lagging, genomic imprinting, uniparental disomy, euploidy, aneuploidy and associated disorders (Down Syndrome, Edward Syndrome, Patau Syndrome, Turner Syndrome, Klinefelter Syndrome, Prader-Willi Syndrome, Angelman Syndrome).

Unit IV: Monogenic Disorders (12 Hrs)

Mendelian inheritance (autosomal and sex-linked). Types of gene mutations (substitution, indels, dynamic) and associated disorders: (Achondroplasia, Huntington's disease, sickle cell anaemia, cystic fibrosis, thalassemia, Rett Syndrome, haemophilia, colour blindness, phenylketonuria, albinism, maple syrup urine disease, alkaptonuria).

Unit V: Other genetic disorders (07 Hrs)

Multifactorial disorders like Cancer, Alzheimer's disease, Arthritis, Diabetes

Unit VI: Genetic counselling (05 Hours)

Invasive and non-invasive methods of prenatal diagnosis and screening (Down syndrome, Thalassemia). Genetic counselling for risk assessment and possible treatment and management strategies.

Practical component **(30 hrs)**

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. PCR for polymorphism detection
2. Study of chromosomal abnormalities through karyotypes
3. Pedigree charts for disorders likeHuntington's disease, colour blindness, sickle cell anaemia
4. Pedigree analysis for determining inheritance and risk assessment
5. Case studies for disorders like cancer, diabetes
6. Case studies for genetic counselling
7. Determination of linkage and cross-over analysis (through two point test cross and three point test cross data).
8. Analysis of Tetrads from *Saccharomyces cerevisiae.*

Essential readings:

- Klug, W. S., Cummings, M., Spencer, C. A., Palladino, M. A., Darrell K. (2019). 12th Edition. Concepts of genetics. San Francisco, NY:Pearson ISBN-13: 9780134604718.
- Snustad, D.P. and Simmons, M.J. (2019). 7th Asia Edition. Principles of genetics. New York, USA: John Wiley and Sons. ISBN-13: 9781119657552.
- Strachan, T. and Read, A. (2018). 5th Edition. *Human molecular genetics*. Florida, USA: CRC Press, Garland Science. ISBN: 978-0815345893.
- Gardner E. J., Simmons M. J. and Snustad D. P. (2006). 8th edition Principles of genetics. USA. Wiley. ISBN-13: 978-8126510436.

Suggestive readings:

- Speicher, M.R., Antonarakis, S.E. and Motulsky, A.G. (2010). 4th Edition. *Vogel and Motulsky's Human genetics: Problems and approaches*. Berlin, Germany: Springer Verlag. ISBN: 978-3540376538.
- Wilson, G.N. (2000). 1st Edition. *Clinical genetics: A short course*. New York, USA: Wiley-Liss, ISBN: 978-0471298069.

GENERAL ELECTIVE -06 (BIOMED-GE -06): STATISTICAL CONCEPTS IN BIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Statistical Concepts in Biology **BIOMED-GE-06**	**4**	**3**	**-**	**1**	**XII Passed**	**Basic knowledge of Biology**	**Biomedical Science**

Learning Objectives

- The purpose of the course is to teach fundamental concepts and techniques of descriptive and inferential statistics with applications in health care, medicine, public health, and epidemiology.
- The course will prepare students to collect, analyze and interpret biological data sets and provide quantitative evidence to support scientific conclusions

Learning outcomes

Having successfully completed this course, students shall be able to:

- Recognise the importance of statistics in biological sciences, understand the different types of data and difference between population and sample.
- Learn how to group data into tabular form and present it in various graphical forms.
- Learn the calculation and application of measures of central tendency and measures of dispersion in data representation.
- Understand concepts of discrete and conditional probability and apply these concepts to biological applications.

- Understand the significance and basic concepts of correlation and simple linear regression analysis.
- The student will be able to learn the process of hypothesis formulation, and utilization of appropriate test of significance for biological data analysis.

SYLLABUS OF BIOMED-GE-06

Unit I: Types of Statistical Data and Measurement (06 Hrs)

Importance of Statistical Studies in Biology. Types of Data in Biology: Qualitative, Quantitative and Random (Discrete and Continuous) Variables. Scales of Measurement: Nominal, Ordinal, Interval and Ratio scale. Sample and Population.

Unit II: Data Organization and Graphical Representation (06 Hrs)

Ordered array, Grouped Frequency Distribution Table. Charts and Diagrams: Bar diagram, Pie chart, Histogram, Frequency Polygon, Line chart, Cumulative Frequency Curve and Scatter diagram.

Unit III: Descriptive Statistics (10 Hrs)

Measures of Central Tendency: Mean, Mode, Median, Partition Values. Measures of Dispersion: Range, Standard Deviation, Coefficient of Variance, Covariance. Concept and Importance of Skewness and Kurtosis.

Unit IV: Probability (07 Hrs)

Concepts of Probability, Addition and Multiplication Rules and Conditional Probability. Use of Probability in Assessing Validity (Sensitivity/Specificity) of a Diagnostic Test.

Unit V: Correlation and Linear Regression Analysis (07 Hrs)

Correlation Analysis: Scatter diagram, Pearson's and Spearman's Coefficients of Correlation, Coefficient of Determination. Regression Analysis: Concept of Line of Best Fit, Equations of Lines of Regression and their Applications in Biostatistics.

Unit V: Inferential Statistics (09 Hours)

Sampling Distribution and Standard Error. Concept of Null and Alternate Hypothesis. Biological Data Analysis using Z-Test (Single Mean and Difference of Means), Student's T-Test (Single Mean, Difference of Means and Paired T-Test) and F-Test.

Practical **(30 hrs)**

The experiments are designed for students to learn the usage of statistical methods for biological data analysis using spreadsheets.

1. Hands-on training of Microsoft excel software to perform basic operations, commands and functions.
2. Organize the given data set and make frequency distribution table.
3. Present data in various charts or diagrams (bar diagrams, histograms, pie charts, Line graph and scatter diagrams).
4. Computing measures of central tendency and dispersion using biological data.
5. Correlation analysis to determine the strength of relationship between a set of dependent and independent variable.
6. Compute regression equations to predict the value of dependent variable.
7. Perform Z-test (Single Mean and Difference of Means).
8. Perform student's t-test (Single Mean, Difference of Means and Paired T-Test)

Essential readings:

- Daniel, W.W. and Cross, C.L. (2019). 11th Edition. Biostatistics: A foundation for analysis in the health sciences. New York, USA: John Wiley & Sons. ISBN-13: 9781119588825.
- Triola M.M., Triola M.F., Roy J. (2019). 2nd Edition. Biostatistics for Biological and Health Sciences. Harlow, UK: Pearson Education Ltd. ISBN-13: 9789353436537.
- Pagano, M. and Gauvrean, K. (2018). 2nd Edition. Principles of Biostatistics. California, USA: Duxbury Press. ISBN-13: 9781138593145.
- Schmuller, J. (2016). 5th Edition. Statistical Analysis with Excel for Dummies. New York, USA: John Wiley & Sons. ISBN-13: 9781119844549.

Suggestive readings:

- Zar, J.H. (2014). 5th Edition. Biostatistical analysis. USA: Pearson. ISBN-13: 9789332536678.
- Glantz, S. (2012). 7th Edition. Primer of biostatistics. New York, USA: McGraw-Hill Medical. ISBN-13: 9780071781503

GENERIC ELECTIVE COURSE -07 (BIOMED-GE-07): BIOCHEMICAL BASIS OF LIFE

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Biochemical Basis of Life **BIOMED-GE-07**	**4**	**3**	**-**	**1**	**XII Passed**	**Basic knowledge of Biology**	**Biomedical Science**

Learning Objectives

The Learning Objectives of this course are as follows:

- The objective of this course is to address how the wonderful and remarkable properties of living organisms arise from the various biomolecules, the building blocks.
- The course focuses on the chemical complexity and organization of molecules in a living cell, extraction and transformation of energy
- It gives insights into the changes that occurred during the gradual evolution of life.

Learning outcomes

The Learning Outcomes of this course are as follows:

- The fundamental Chemistry of Life: Students will gain an understanding of the elements found in living systems and appreciate the importance of water as the solvent for living systems. It is important to learn about the units used for expressing the biochemical basis of a living system. Students will learn the unit system for the molecular mass of biomolecules, units used for the concentration of solutions, and units for expressing the distances, etc.
- Cellular foundations of life**:** A stepwise organization of a living system, starting from the smallest unit to an entire living organism would be the focal point in this unit.

- Molecular basis of life**:** Students will understand the monomeric forms of different types of biomolecules. In addition, the relationship between the structure and function of biomolecules would also be learnt.
- Physical foundation of life: Students would learn the concept of enthalpy, entropy and free energy in a living system and understand the importance of the energy currency and the significance of coupled biochemical reactions.
- Biochemical events in the origin of life: Students would learn the origin of life and the nature of transformative changes that occurred for life to evolve from the pre-biotic world to the modern times.

SYLLABUS OF BIOMED-GE-07

Unit I: The fundamentals of chemistry of life (06 Hrs)

Carbon chemistry of life, structure and importance of water, diverse inorganic ions, major elements (C, H, O, N, S), trace elements. Units used in biochemistry such as those expressed for the atomic mass unit (Daltons), concentration (moles/litre) and distance (in nanometer-scale).

Unit II: Cellular foundations of life (06 Hrs)

Levels of organization in a living system. The important features of living cells, subcellular organelles in Eukaryotic cells and subcellular organization in Prokaryotic cells. Brief description on Phototrophs, Chemotrophs, Autotrophs and Heterotrophs.

Unit III: Molecular basis of life (12 Hrs)

Common functional groups and linkages in biomolecules.

Macromolecules: classification, building blocks, structural and functional diversity.

Structural and functional forms of macromolecules: Proteins (collagen, albumin, hormones (insulin), enzyme (proteases, nucleases, amylases and lipases); Polysaccharides (starch, glycogen, cellulose), Nucleic acids, Lipids (cholesterol and triglycerides).

Unit IV: Physical foundation of life (11 Hrs)

Enthalpy, Entropy, Free Energy, Standard Free Energy, Equilibrium constant, Open and Closed systems, Endergonic and Exergonic reactions, the energy currency in a biological system (ATP), Energy coupling reactions.

Unit V: Biochemical events in the origin of life (10 Hrs)

Landmark events in the evolution of life. Biochemical basis of the origin of aerobic and anaerobic world. Evolution of biological monomers and polymers from pre-biotic compounds. Properties of DNA as genetic material. Structural and functional analysis of eukaryotes and prokaryotes, with suitable examples.

Practical components (30 Hours)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Preparation of buffer at a specific molarity and pH.
2. Numerical problems based on Enthalpy, Free Energy and Entropy.
3. Comparative analysis of protein content in egg white and egg yolk, using Biuret's method.
4. Detection of a glucose polymer (starch) in rice/potato/corn, using iodine test.
5. To assess the differential solubility of lipids in aqueous and organic solvents.
6. Extraction of DNA from plant/microbial cells by the spooling method.
7. Demonstration of agarose gel electrophoresis for analyzing the isolated DNA.
8. To compare the structural features of a prokaryotic and eukaryotic cell by studying their electron micrographs.

Essential readings

- Nelson, D.L. and Cox, M.M. (2021). *Lehninger: Principles of Biochemistry* (7th ed.). W.H. Freeman & Company (New York), ISBN:13:9781319322328
- Pratt, C.W. and Cornely, K.(2017). *Essential Biochemistry* (4th ed.) John Wiley& Sons, Inc.ISBN:9781119012375
- Plummer, D.T. (2012). *An Introduction to Practical Biochemistry*. New Delhi, India: McGraw-Hill College.

Suggestive readings

- Berg, J., Gatto, G., Stryer, L. and Tymoczko, J. L. (2019). *Biochemistry*. New York, USA: W. H. Freeman and Company.
- Campbell, M. K. and Farrell, S. O. (2017) 9th Edition. *Biochemistry*. Boston, USA: Brooks/Cole Cengage Learning. ISBN-13: 978-1305961135

GENERAL ELECTIVE -08 (BIOMED-GE-08): DISEASES IN EVERYDAY LIFE

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Diseases in Everyday Life **BIOMED-GE-08**	**4**	**3**	**-**	**1**	**XII Passed**	**Basic knowledge of Biology**	**Biomedical Science**

Learning Objectives

The Learning Objectives of this course are as follows:

- Diseases are not new to human beings but if we are familiar with them, it is easy to manage.
- The course has been designed to familiarize students with most common diseases in everyday life. Students will be able to differentiate between infectious and non-infectious diseases.
- Students will learn about the causative organism of these diseases and their symptoms. A brief description related to treatment and management methods will also be included in the syllabus.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Initially students will understand about diseases and various approaches to classify different types of diseases.
- A detailed description of various diseases caused by infectious agents has been included in the syllabus. As all the diseases are not infectious, students will learn differentiate between communicable and non-communicable diseases with examples of most common disorders.
- A brief overview about degenerative disorders such as Parkinson's, Alzheimer's, Osteoarthritis, Osteoporosis have also been included in the syllabus to enrich the learning of students.

- Majority of human population is malnourished and suffer from many deficiency disorders, thus students are familiarized with common deficiency diseases such as Anaemia, Goitre, Kwashiorkor, Beri-Beri, Scurvy and Rickets have also been included.
- Many cell types in blood and immune components sometime leads to anomalies which may be associated with any disorder. Keeping this in mind, some common immune disorders are briefly added to the syllabus.

SYLLABUS OF BIOMED-GE-08

Unit I: Introduction: (12 Hrs)

Disease classification: Overview of disease condition related to human body: Communicable and non-communicable diseases. Five "F' of communicable diseases [Food (contaminated), Fingers (unclean), Faeces, Fomites, and Flies] Genetic Diseases, Toxic effect of drugs and Chemicals (toxic gases and radiation),Auto immune disorders, nutritional deficiency (Effect of nutrition) (deficiency of Vitamin B12, Vitamin C), Route of transmission, Infectious dose, Communication by vector, Allergic diseases

Unit II: Communicable (Infectious) diseases: (09 Hrs)

a. Diseases transmitted directly: air borne (Mycobacterium) and water borne (Cholera) food borne (typhoid).Epidemiology, cause, clinical feature and prevention. STDs (with examples).Diseases caused by Virus, bacteria, fungus and protozoa/ helminths.
b. Vector borne diseases: mosquito, (Malaria, dengue and Chikungunya), cockroaches and flies, how they spread diseases and methods of prevention, diagnosis (basic).

Unit III: Non-communicable diseases: (06 Hrs)

a. Diabetes, hypertension and cancer (Brief discussion and special emphasis on prevention).
b. Down syndrome and colour blindness.

Unit IV: Degenerative Diseases: (07 Hrs)

Parkinson's/Alzheimer's, Osteoarthritis, Osteoporosis.(Special focuses on factors related to Lifestyle).

Unit V: Deficiency Diseases: (05 Hrs)

Anaemia, Goitre, Kwashiorkor, Beri- Beri, Scurvy and Rickets (Main emphasis on nutritional factors)

Unit VI: Blood disorders and Autoimmune Disease: (06 Hrs)

a. Sickle cell anaemia,haemophilia, thalassemia, blood incompatibility disorder, Rh factor.
b. Graves' disease, Rheumatoid Arthritis and Psoriasis.

Practical component (30 Hrs)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. A case study of any communicable disease outbreak.
2. A case study on the prevalence of degenerative diseases (Parkinson's diseases/ Alzheimer's) in our country
3. Study different parameters responsible for malnutrition in human population and appropriate management strategies
4. Brief case study non communicable disease associated with lifestyle (hypertension and colourblindness)
5. How much we are aware about immune disorders? Give a small intra college survey to support the statement.
6. Preparation of a brief flow chart depicting classification of diseases.
7. Case study about minamata disease / Hiroshima and Nagasaki / Bhopal gas tragedy.
8. Effect of pesticides on human beings (taking example of anyone state in India).
9. Identification of common diseases caused by vectors.

Essential readings:

- Park, K. (2021), 26th Edition, *Park's Textbook of Preventive and Social Medicine*, Banarsidas Bhanot Publisher, ISBN-13 : . 978-9382219163
- Punt, J. Stranford, S. Jones, P. and Owen, J. (2019). 8 th Edition. Kuby Immunology. New York, USA: W.H. Freeman and Company. ISBN- 13: 978-1464189784.
- Cappuccino, J.G. and Sherman, N. (2013). 10th Edition. Microbiology: A laboratory manual. California, USA: Benjamin Cumming. ISBN-13: 978-0321840226.
- Willey, J., Sherwood, L., and Woolverton, C.J. (2016). 10th Edition. Prescott's microbiology. New York, USA: McGraw-Hill Education. ISBN-13: 978-1259281594

Suggestive readings:

- Tille, P. (2013). 13th Edition. Bailey & Scott's diagnostic microbiology. Missouri, USA: Mosby Publishers. ISBN-13: 978-0323083300.
- Madigan, M.T., Martinko, J.M., Stahl, D.A. and Clark, D.P. (2010). 13th Edition. Brock biology of microorganisms. California, USA: Benjamin Cumming. ISBN-13: 978- 0321649638.
- Tortora, G.J., Funke, B.R. and Case C.L. (2006). 9th Edition. Microbiology: An introduction. California, USA: Benjamin Cummings. ISBN-13: 978-0536292117.
- Bonita, Ruth, Beaglehole, Robert, Kjellström, Tord & World Health Organization. (2 (2006nd edition. *Basic Epidemiology*, World Health Organization, ISBN 978 92 4 154707 9.
- Pelczar, M.J (2001). 5th Edition. Microbiology. New York, USA: McGraw Hill International. ISBN-13: 9780074623206.

GENERAL ELECTIVE -09 (BIOMED-GE-09): HEALTH AND BODY DEFENSE SYSTEM

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Health and Body Defense System **BIOMED-GE-09**	**4**	**3**	**-**	**1**	**XII Passed**	**Basic knowledge of Biology**	**Biomedical Science**

Learning Objectives

The Learning Objectives of this course are as follows:

- Characteristics of a healthy body and ways to improve one's health and well-being.
- Body defense system is a comprehensive study of the organization and functioning of the immune system with its network of cells and molecules. Understanding the biology of the immune system is key to developing strategies towards prevention and cure to a number of disorders and diseases that result due to malfunctioning and dysregulation of the immune system.
- This paper covers the organization and functioning of the various branches of immune system, namely, Innate and adaptive Immunity to combat different pathogens. Various Immunological techniques will also be taught to the students.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Students learn various aspects of health and immune system in normal and infectious stage which equips students to design better strategies for combating the immunological disorders. Students will be given an overview to various pathogens and immune system in Invertebrates and Vertebrates.

- Students learn historical perspective of the extensive field of Immunology. They are introduced to the important concepts of Immunology.
- Students will be familiarized with origin and maturation of all blood cell types in bone marrow and thymus. They will understand the process of haematopoiesis, functions of various types of cells and roles played by them in generating immune responses against pathogens.
- The unit entails different barriers of Innate Immunity, Cells, Complement system, Patterns on the pathogens recognized by receptors of Innate Immune system, pathogen killing by the immune cells and concept & the importance of the Inflammation in an Immune response.
- Students will learn about the cells of adaptive immune system, the concept of antigen, antibody molecules and role of major histocompatibility complex & associated cells in the processing and presentation of antigen. The students will explore the branches of adaptive immunity - the humoral and cell mediated, their components and interplay of these components in combating the infection. The students will also be able to understand the significance of various kinds of growth factors and cytokines in the activations of various lymphocytes
- The students will be given knowledge about the principle, methodology and applications of various laboratory techniques involving antigen-antibody reaction.
- Vaccine based immunotherapies and their designing will assist them to think about new path for combating with pathogens and working mechanisms of immune system.
- The students will be made aware about the importance of diet and lifestyle in promoting Immunity and health.

SYLLABUS OF BIOMED-GE-09

Unit I: Hallmarks of Health (03 Hrs)

Basic aspects of healthy body: Cells, Tissue and Organ system, difference between prokaryotes and eukaryotes. Key differences between bacteria, fungi, protozoans and viruses.

Requirements for ahealthy body according to age and gender. Survival strategies of host against the invading pathogens: bacterial defense against bacteriophage, immune system of Plants, invertebrates (Mollusca) and vertebrates

Unit II: Introduction to Immune system: (03 Hrs)

Historical background, general concepts of the immune system, innate and adaptive immunity; active and passive immunity.

Unit III: Organization of Immune System: (03 Hrs)

Lymphoid Organs: thymus, bone marrow and haematopoiesis, lymph nodes, spleen.

Unit IV: Innate Immune response (08 Hrs)

- Physical and Chemical barriers
- Cells of the innate immune system: Natural Killer cells, monocytes and macrophages; neutrophils, eosinophils, basophils, mast cells and dendritic cells: Structure, Phenotypic and functional aspects.
- Complement system: Components of the complement activation classical, alternative and lectin pathways; biological consequence of complement activation.
- Mechanisms of pathogen killing by macrophages and neutrophils: Receptor/non receptor mediated endocytosis, phagosome formation, phagolysosome formation, respiratory burst phenomenon, basic pathways of oxygen dependent and oxygen independent killing mechanism.
- Inflammation: concept, hall marks of inflammation.

Unit V: Adaptive Immune Response (10 Hrs)

- Cells of the adaptive immune system: T and B lymphocytes
- Characteristics of adaptive immune response: self and non-self recognition, specificity, diversity and memory, primary and secondary immune response, allergen/ allergy.
- Antigens: antigenicity and immunogenicity, haptens. Properties (foreignness, molecular size, heterogeneity, route and dose of administration, solubility and degradability); host factors (genotypes, gender, nutrition) Blood group antigens and transfusion reactions.
- Basic function of Major Histocompatibility Complex
- Importance of Antigen presentation
- Types of antibodies and their function,
- Cell mediated immune response: Major steps in T cell differentiation in thymus: thymic selection, self MHC restriction, T cell receptor assembly. Phenotypic characteristics of naïve T-cells ($CD4^+$ and $CD8^+$ T-cells). Migration of naïve T-cells from thymus to secondary lymphoid organs. Activation of T-cells,

proliferation of clonally selected T cells and their effector functions, concepts of T-helper 1 (TH_1) and T-helper 2 (TH_2) cells. Basic introduction to cytokines: IL-2, IL-4 and IFN-γ

- Contribution of MHC, B-cell receptor (BCR) and T-cell receptor (TCR) to diversity in adaptive immune response

Unit VI: Immunological Principles of Various Reactions and Techniques (05 Hrs)

Basic concepts of antigen-antibody interactions (epitope-paratope), Affinity and avidity, cross reactivity, precipitation, agglutination, immunodiffusion, immune-electrophoresis, ELISA (indirect, sandwich, competitive, chemiluminescence, and ELISPOT assay), western blotting, immunofluorescence microscopy, immunohistochemistry and lateral flow assay.

Unit VII: Vaccines and Immunotherapeutics (04 Hrs)

Contributions of Sir Edward Jenner and Louis Pasteur in vaccine development; Major types of vaccine and their characteristics, importance of adjuvants in the development of artificial and active immunity. The concept of passive immunity and immunotherapeutics (Plasma therapy in COVID-19, anti-rabies therapy, anti-toxin therapy), National immunization programme

Unit VIII: Diet, Nutrition and Life style in promoting health and Immunity (09 Hrs)

Importance of a well- balanced nutrition, the role of Immunity boosters and immunomodulators from kitchen shelf (curcumin , ginseng, lycopene &Giloy), vitamins (Vitamin A, B, C, D and Vitamin B12) and minerals (Zn) in improving health and defense.Role of probiotics, gut microbiota andprebioticsin regulating health and immunity. Role of physical activity and emotional & Mental state in regulation of Immunity status, holistic health and happiness. A primer on our traditional practices, yogic lifestyle and meditation in creating homeostasis in the body (balancing Vatta, Pitta and Kapha) will also be given.

Practical component (30 Hours)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Visualization of antigen-antibody interaction or To perform Immuno-diffusion by Ouchterlony method
2. To perform Immuno-diffusion by Mancini Method

3. To perform Complement fixation assay
4. To perform sandwich dot ELISA
5. To perform Widal test (Indirect/passive agglutination) for the detection of typhoid antigen and blood group determination (direct agglutination)
6. To perform SARS-CoV-2 Rapid Antigen Test(Lateral flow Assay)
7. Project work based on historical research work in the area of immunology.
8. Case studies on hypersensitivity reactions(seafood hypersensitivity, Erythroblastosis Fetalis)

Essential readings:

- Punt, J. Stranford, S. Jones, P. and Owen, J. (2019). 8th Edition. *Kuby Immunology*. New York, USA: W.H. Freeman and Company. ISBN- 13: 978-1464189784.
- Delves, P.J. Martin, S.J. Burton, D.R. and Roitt, I. M. (2017). 13th Edition. *Roitt's Essential Immunology*. New Jersey, USA: Wiley-Blackwell Science. ISBN: 13: 978- 1118415771.

Suggestive readings:

- Ananthanarayan R and Jayaram Paniker CK (Author), Reba Kanungo (Editor) (2020) Ananthanarayan and Paniker's Textbook of Microbiology, Eleventh Edition. Universities Press (India) Pvt. ISBN **9389211433**
- Practical Ayurveda: Find Out Who You Are and What You Need to Bring Balance to Your Life Paperback – 5 June 2018 by Sivananda Yoga Vedanta Centre. Publisher : DK; Illustrated edition : ISBN-10)June 2018 5) : ISBN-13 ,1465468498 978-1465468499.
- Willey, J. Sherwood, L and Woolverton, C.J. (2016). 10th Edition. *Prescott's Microbiology*. New York, USA: McGraw-Hill Education. ISBN-13:978-1259281594.
- Satomi Oshima; Zhen-Bo Cao; Koichiro Oka (2015) 'Physical Activity, Exercise, Sedentary, Behavior and Health' Springer Tokyo Heidelberg New York Dordrecht London ISBN 978-4-431-55333-5 (eBook)
- Guglielmo M Trovato (2012) Behavior, nutrition and lifestyle in a comprehensive health and disease paradigm: skills and knowledge for a predictive, preventive and personalized medicine. Trovato EPMA Journal 2012, 3:8 (Review Article)
- Kindt T. J., Osborne B. A. , Goldsby R. A. (2007). 6th Edition *Kuby Immunology*. New York, USA: W.H. Freeman and Company. ISBN-13: 978-1429202114 ISBN-10: 1429202114.

- Hay, F.C. and Westwood, O.M.R. (2002). 4th Edition. *Practical Immunology*. New Jersey, USA: Blackwell Science. ISBN:9780865429611
- BYG-002 Yoga and Health, Block 4 Yogic Lifestyle, School of Health Science, Indira Gandhi National Open University (https://drive.google.com/file/d/10j00rWXLsCEV5cTbzK-hM43ezlNvn0hl/view)

GENERAL ELECTIVE -10 (BIOMED-GE -10): UNDERSTANDING THE HUMAN BODY SYSTEMS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Understanding The Human Body System **BIOMED-GE-10**	**4**	**3**	**-**	**1**	**XII Passed**	**Basic knowledge of Biology**	**Biomedical Science**

Learning Objectives

The Learning Objectives of this course are as follows:

- This is an introductory course dealing with the structure and function of the human organism and the issues facing the human in today's world.
- It is intended for students with limited science background. It would make them familiar with basic physiological concepts.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Students will have an increased understanding and appreciation for the workings of the human body. They will be familiar with the terminology and physiology of the major organ systems
- They will be able to explain the relation between form and function in biology, as expressed in molecular, cellular, and whole-organism physiology.
- Students will be able to recognize the anatomical structures and explain the physiological functions of the body systems.
- Recognize the anatomical structures and explain the physiological functions of the body systems. Develop scientific terminology to describe the parts and processes of the human body.

SYLLABUS OF BIOMED-GE-10:

Unit I: Body organization and Integumentary system (05 Hrs)

General Anatomy of the body, Introduction to various kinds of body planes, cavities and their membranes, Tissues level of organization and classification (Types, origin, function & repair). Structure and functions of human skin. Blood as connective tissue

Unit II: Nervous System (06 Hrs)

Organization of the Central and Peripheral nervous system. Motor and sensory physiology. Nerve Physiology and Sensory Physiology (Special Senses)

Unit III: Muscular and Skeletal System (04 Hrs)

Functional anatomy of muscular system, types of muscles, neuromuscular junction structure property and transmission, General characteristics of muscle contraction using skeletal muscle as example.

Unit IV: Cardiovascular and Respiratory System (06 Hrs)

Functional Anatomy of heart, The Cardiac Cycle, Electrocardiogram.

Circulatory system: Blood vessels, hemodynamics and regulatory mechanisms.

Lymphatic circulation - hemodynamics and regulation, micro-circulation

Functional Anatomy of the respiratory system. Mechanisms of pulmonary and alveolar, gaseous exchange, transport of gases, respiratory and nervous control and regulation of respiration.

Unit V: Endocrine System (06 Hrs)

General mechanism of hormone action, Structure, function and regulation of the major gland of the body: Pituitary, Hypothalamus, Thyroid, Pancreas and Adrenals. Basic concepts about hypo and hyper secretion of hormones.

Unit VI: Gastrointestinal system (06 Hrs)

Anatomy and histology of the digestive tract. General principles of gut motility secretion, digestion, absorption and assimilation.

Unit VII: Renal Physiology (06 Hrs)

Functional anatomy of kidney, histology of nephron and its physiology, process of urine formation. Urinary bladder: structure, micturition and its regulation

Unit VII: Reproductive System (06 Hrs)

Structure and function of male and female reproductive organs. Basic concepts of gametogenesis (oogenesis and spermatogenesis), fertilization, implantation, menopause and contraception.

Practical component (30 Hrs)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. To prepare a blood smear and identify different types of white blood cells.
2. Estimation of hemoglobin (Sahli's method)
3. Physiological data acquisition based experiments (ECG/PFT/EMG).
4. Blood Pressure recordings in humans.
5. To study a simple reflex arc
6. To study the sensation of taste, touch and smell.
7. To study various types of contraceptives (condoms, IUD"s, oral and injectable contraceptives)
8. To study different human organs and their sections through permanent histological slides T.S. of brain, spinal cord, skeletal fibers, cardiac muscles, skeletal muscles, T. S. of thyroid, liver, thymus, spleen, ovary, artery, vein, capillaries, testis, pancreas, esophagus, adrenal, kidney (cortex and medulla), urinary bladder, fallopian tubes, epididymis, lungs, trachea, heart.(Minimum 8 slides covering the systems mentioned in theory.)

Essential readings:

- Guyton and Hall Textbook of Medical Physiology, 14th edition (2020), J. E. Hall; W B Saunders and Company, ebook ISBN: 978-0-3236-4003-9; Hardcover ISBN: 978-0-3235-9712-8

- Principles of Anatomy and Physiology, 16th edition (2020), Gerard J. Tortora and Bryan H. Derrickson; Wiley and Sons, ISBN: 978-1-119-66268-6. (e book), ISBN: 978-1-119-70438-6 (for print book).
- Textbook of Practical Physiology, 9th edition (2019), CL Ghai; Jaypee Publication, ISBN-9789352705320.
- Human Physiology, 16th edition (2011), Stuart I. Fox; Tata McGraw Hill, ISBN10: 1260720462; ISBN13: 978-1-26-072046-4.

Suggestive readings:

- Ganong's Review of Medical physiology, 26th edition (2019), K. E. Barett, S. M. Barman, S. Boitano and H. Brooks; Tata McGraw Hill, ISBN 978-1-26-012240-4 (for ebook) ISBN:978-1-26-012241-1 (for print Book)

GENERAL ELECTIVE -11 (BIOMED-GE -11): DRUGS AND VACCINES

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Drugs and Vaccines **BIOMED-GE-11**	**4**	**3**	**-**	**1**	**XII Passed**	**Basic knowledge of Biology**	**Biomedical Science**

Learning Objectives

The Learning Objectives of this course are as follows:

- This course integrates the concept of chemistry, biochemistry, pharmacology and immunology for understanding the process of drug action in the body.
- The focus is on various targets present in body that can be useful in rational drug design.
- The course entails different approaches to drug discovery and design, sources of drugs and measurement of drug target interaction.
- It also aims to understand the human immune system and the immunotherapies used to combat disease.

Learning outcomes

The Learning Outcomes of this course are as follows: Having successfully completed this course, students shall be able to learn and appreciate:

- The student will understand the concept of drugs and vaccines, their effect on body and different routes used to administer them in body.
- They will be able to identify the various drug targets in the body
- Students will learn to identify various parameters for comparison of different drugs with ways to analyse how safe a drug is for use. Also, they will understand the overall process of drug design, various approaches used in drug discovery and the concept of rational drug design. They will also learn about mode of action of different types of Drugs

- Students will also learn about the Organization, Properties and Functioning of the Immune System. Innate and adaptive immune responses. Antigen-antibody interactions.
- Students will familiarize themselves with the need for vaccines, concepts and principles of vaccines, types of vaccines and available vaccines: BCG, DPT, HBV, HPV, Polio, Covid-19. Finally, the student will be able to grasp the use of immuno-therapeutics in dealing with certain infections rabies vaccine, plasma therapy) and the concept of using antibodies as drug carriers.

SYLLABUS OF BIOMED-GE- 11

Unit-I: Introduction of Drugs (06 Hrs)

Definition and scope of Drugs, source of drugs, routes of drug administration and their advantages anddisadvantages (with emphasis on oral and I.V), Bioavailability and first pass metabolism, drug formulations and delivery agents. Introduction to pharmacodynamics and pharmacokinetics (brief introduction on ADME)

Unit-II: Drug Target Classification and Measurement of Drug Receptor Interactions (10 Hrs)

Classification of Drug targets: Proteins, Nucleic acid, lipids and carbohydrates

Proteins as drug targets: Receptors: Receptor role, Ion channels, membrane bound enzyme activation, concept of Agonist, antagonists, partial agonist (Cholinergic agonist and antagonist, Dopaminergic agonist and antagonist)

Enzymes: Enzyme inhibitors (competitive, non- competitive (ethylene glycol for antifreeze poisoning, ACE inhibitor, Aspirin, 6-mercapto purine)

Analysis of ligand receptor interaction, relationship between dose and effect (graded and quantal response). Affinity, Efficacy and potency, therapeutic index.

Unit-III: Drug Design and Mechanism of Action of Drugs (07 Hours)

Introduction to Drug design, Analogue synthesis versus rational drug design, Strategies in the search for new lead compounds (random and non-random screening), SAR, Concept of prodrugs (to tackle toxicity and membrane permeability)

Mode of action of following class of drugs: Antipyretics (Paracetamol), Anti-inflammatory drugs (Ibuprofen), Anticancer drugs (cisplatin), Antibiotics and Antibacterial drugs (sulphonamides, Penicillin), Antifungal drugs (Amphotericin B).

Unit-IV: Introduction to the Immune System (12 Hours)

Historical background, organization of the immune system, lymphoid organs: Bone marrow, thymus, lymph nodes and spleen.

Innate Immune System: Physical and chemical barriers, brief overview of the cells of the innate immune system: Natural Killer cells, monocytes and macrophages; neutrophils, eosinophils, basophils, mast cells and dendritic cells, Mechanisms of pathogen killing by phagocytes: macrophages and neutrophils, Inflammation: brief overview

Adaptive Immune System: Cells of the adaptive immune system: B and T lymphocytes: characteristics viz; Specificity, diversity, immunologic memory, self and nonself recognition. B cell and T cell development, Antigens: Properties: foreignness, molecular size, route and dose of administration, Antibodies: Structure, classes and distribution, B cell and T cell epitopes, MHC molecules: structure and functions, Antigen processing and presentation on MHC molecules

Unit V: Vaccines and Immuno-therapeutics (10 Hours)

Principles and concepts of vaccines: History of vaccines- Contribution of Sir Edward Jenner and Louis Pasteur I n vaccine development. Major types of vaccines and their characteristics: while cell based vaccines, subunit based vaccines, vectored vaccines, nucleic acid based vaccines. Importance of adjuvants in development of artificial and active immunity.

Common vaccines: BCG, DPT, HBV, HPV, Polio, Covid-19. Immuno-therapeutics: Rabies Vaccine and Plasma therapy. Antibody and receptors as drug carriers and targets. National immunization program.

Practical component (30 Hours)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. To study different routes of administration of drugs.
2. To study the presence of acetaminophen in a given sample.

3. Quantitative estimation of acetaminophen in a given sample using spectrophotometer.
4. Extraction of caffeine from tea leaves.
5. Study the absorption properties of caffeine using spectrophotometer
6. Phytochemical screening and qualitative chemical examination of various plant constituents by solvent extraction. (Detection of alkaloids, carbohydrates, glycosides, phytosterols, oils and fats, tannins, proteins, gums).
7. To record CRC of acetylcholine using guinea pig ileum/ rat intestine (virtually)
8. Study of competitive antagonism using acetylcholine and atropine.
9. Determination of dose ratio.
10. To perform blood grouping (direct agglutination)
11. To perform Widal test (indirect agglutination).

Essential readings:

- Punt, J. Stranford, S. Jones, P. and Owen, J. (2019). 8th Edition. Kuby Immunology. New York, USA: W.H. Freeman and Company. ISBN- 13: 978-1464189784.
- Patrick G.I. (2017). 6 th Edition. Introduction to medicinal chemistry. Oxford, UK: Oxford University Press. ISBN-13: 978-0198749691.
- Silverman, R.B. and Holladay, M.W. (2014). 3 rd Edition. The organic chemistry of drug design and drug action. San Diego, USA: Elsevier, Academic Press. ISBN-13: 9780123820303.

Suggestive readings:

- Wermuth, C.G., Aldous, D., Raboisson, P. and Rognan, D. (2015). 4 th Edition. The practice of medicinal chemistry. San Diego, USA: Elsevier, Academic Press. ISBN-13: 978-0124172050.
- Nogrady, T. and Weaver, D.F. (2005). 3rd Edition. Medicinal chemistry: A molecular and biochemical approach. New York, USA: Oxford University Press. ISBN-13: 978-0195104561.
- King F.D. (2003). 2 nd Edition. Principles and practice of medicinal chemistry. London, UK: The Royal Society of Chemistry. ISBN-13: 978-0854046317.
- Hay, F.C. and Westwood, O.M.R. (2002). 4th Edition. Practical Immunology. New Jersey, USA: Blackwell Science. ISBN: 9780865429611.
- Gringauz, A. (1996). 1 st Edition. Introduction to medicinal chemistry: How drugs act and why. Brooklyn, New York, USA: Wiley VCH. ISBN-13: 978-0471185451.

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Discipline Specific Core Course (BIOMED-DSCs)
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DISCIPLINE SPECIFIC CORE COURSE -16 (BIOMED-DSC-16) BIOPHYSICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Biophysics **BIOMED-DSC-16**	4	3	-	1	**Class XII Passed**	**Basic knowledge of Bio-physical Techniques**	**Biomedical Science**

Learning objectives

The Learning objectives of this course are as follows:

- The course will demonstrate the role of fundamentals of chemistry and physics in understanding the biological processes including the methods to study the structure and functions of macro molecules and the chemical reactions occurring in living cells.
- The students will be able to learn theoretical basis of various analytical and biomedical techniques including various spectroscopic techniques, hydrodynamic methods, molecular biophysics.
- The students will be introduced to various physical principles responsible for maintaining the basic cellular function and integrity of biological membranes including transport across them.

Learning outcomes

Having successfully completed this course, students shall be able to learn and appreciate:

- The interdisciplinary frontier of science in which the principles and techniques of physics are applied to understand biological problems at every level, from atoms and molecules to cells, organisms and environment and analyze the data generated through spectroscopic techniques such as UV-Visible, Infrared, Mass spectroscopy, NMR, etc.
- Understand the concepts of viscosity and sedimentation methods and their biological applications.
- Comprehend the thermodynamics of the structure of biomolecules and consequences of their structural instability and apply their biophysics knowledge to analyze the known experiments and to develop newer experimental methods for new biophysical applications.

- Understand the physical basis of transport across biological membranes. Additionally, they will be able to perform the experiments and demonstrate the interpretation of the data and further be able to deliver scientific conclusions. Further, they can apply their biophysics knowledge to analyze the known experiments and to develop newer experimental methods for new biophysical applications.

SYLLABUS OF BIOMED-DSC-16

Unit-I: Basic Spectroscopic Techniques (10 hrs)

Basic principles of electromagnetic radiation: Energy, wavelength, wave numbers and frequency, Review of electronic structure of molecules.

UV-visible spectrophotometry: Beer Lambert law, Light absorption and its transmittance, Factors affecting absorption properties of achromophore, Structural analyses of DNA/protein using absorption of UV light.

Fluorescence spectroscopy: Theory of fluorescence, Static and dynamic quenching, Resonance energy transfer, Fluorescent probes in the study of protein and nucleic acids.

Infra-red spectroscopy: Theory of IR, Identification of exchangeable hydrogen, Number of hydrogen bonds, Tautomeric forms, Biological significance of IR.

Unit II: Advanced Biophysical Techniques (10 hrs)

Optical rotatory dispersion and Circular dichroism: Principle of ORD and CD, Analysis of secondary structure of proteins (denatured and native form) and nucleic acids using CD.

Magnetic resonance spectroscopy: Basic theory of NMR, Chemical shift, Medical applications of NMR.

Mass Spectrometry (MALDI-TOF): Physical basis and uses of MS in the analysis of proteins/nucleic acids.

X-ray crystallography: Diffraction, Bragg's law and electron density maps (concept of R-factor and B-factor), Growing of crystals (Hanging drop method), Biological applications of X-ray crystallography.

Unit-III: Hydrodynamic Methods (10 hrs)

Viscosity: Methods of measurement of viscosity, Specific and intrinsic viscosity, Relationship between viscosity and molecular weight, Measurement of viscoelasticity of DNA.

Sedimentation: Physical basis of centrifugation, Svedberg equation, Differential and density gradient centrifugation, Preparative and analytical ultracentrifugation techniques, Fractionation of cellular components using centrifugation with examples.

Flow Cytometry: Basic principle of flow cytometry and cell sorting, Detection strategies in flow cytometry.

Unit-IV: Molecular Biophysics (7 hrs)

Basic thermodynamics: Concept of entropy, enthalpy, free energy change, heat capacity. Forces involved in biomolecular interactions with examples: Configuration versus conformation, Vander Waals interactions, Electrostatic interactions, Stacking interactions, Hydrogen bond and hydrophobic effect, Ramachandran plot.

Supercoiling of DNA: Linking number, twist and writhe.

Protein folding: Marginal stability of proteins, Thermodynamic and kinetic basis of protein folding.

Unit-V: Biological Membranes **(8 hrs)**

Biophysical basis of transport of solutes and ions, Fick's laws of diffusion, Transport equation, Membrane potential, an introduction to ionophores.

Practical **(30 hrs)**

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Effect of different solvents on UV absorption spectra of proteins.
2. Study of structural changes of proteins at different pH using UV spectrophotometry.
3. Study of structural changes of proteins at different temperature using UV-spectrophotometry.
4. Determination of melting temperature of DNA.
5. Study the effect of temperature on the viscosity of a macromolecule (Protein/DNA).
6. Use of viscometer in the study of ligand binding to DNA/protein.
7. Crystallization of enzyme lysozyme using hanging drop method.
8. Analysis, identification and comparison of various spectra (UV, NMR, MS, IR) of simple organic compounds.

Essential readings

- Skoog D.A., Holler, F.J. and Crouch, S.R. (2017). 7thEdition. Principles of Instrumental Analysis. Boston, USA: Cengage Learning. ISBN-13:978-1305577213.
- Sheehan, D. (2009). 2nd Edition. Physical biochemistry: Principles and applications. Oxford, UK: JohnWiley.ISBN-13:978-0470856031.
- Freifelder, 1983). 2nd Edition. Physical biochemistry: Applications to biochemistry and molecular biology. NewYork, USA: W.H. Freeman and Company. ISBN-13:978-0716714446.

Suggestive readings

- Hofmann, A. and Clokie, S. (2018). 8th Edition. Wilson and Walker's principles and techniques of biochemistry and molecular biology. Cambridge, UK: Cambridge University Press. ISBN: 978-1108716987.
- Watson, J.D., Baker T.A., Bell, S.P., Gann, A., Levine, M., Losick, R.(2013).7th Edition. Molecular Biology of the Gene. New York, USA: Cold Spring Harbor Laboratory Press, ISBN-13:978-0321762436.
- Tinoco I., Sauer, K. Wang, J.C., Puglisi, J.D., Harbison, G. and Rovnyak, D. (2013). 5thEdition. Physical chemistry: Principles and applications in biological sciences Pearson, Prentice Hall. ISBN-13:978-0136056065.

- Kuriyan, J., Konforti, B. and Wemmer, D. (2012). 1st Edition. The molecules of life: Physical and chemical principles. New York, USA: Garland Science. ISBN-13: 978-0815341888.
- Frauen felder, H., Chan, S.S. and Chan, W.S. (2010). 1stEdition. The physics of proteins: An introduction to biological physics and molecular biophysics. NewYork, USA:Springer, ISBN-13: 978-1441910431.
- Rhodes, G. (2006). 3rd Edition. Crystallography made crystal clear: Guide for users of macro molecular models. Massachusetts, USA: Academic Press. ISBN-13:978-0125870733.
- Van Holde, K.E., Jhonson, W.C. and Shing Ho, P. (2005). 2nd Edition. Principles of physical biochemistry. NewJersey, USA: Prentice Hall Inc.ISBN-13:978-0130464279
- Branden, C. and Tooze, J. (1999). 2nd Edition. Introduction to protein structure. New York, USA: Garland Science, ISBN-13: 978-0815323051.
- Hoppe, W., Lohmann, W., Markl, H. and Ziegler, H.(1983). 1st Edition. Biophysics. Berlin, Germany: Springer-Verlag and Heidelberg GmbH & Co., ISBN-13:978-3540120834.
- Cantor, C.R. Schimmel, P.R. (1980). 1st Edition. Biophysical Chemistry. New York, USA: W.H. Freeman and Company. ISBN-13:9780716711889.

DISCIPLINE SPECIFIC CORE COURSE- 17 (BIOMED-DSC-17) HUMAN GENETICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Human Genetics **BIOMED-DSC-17**	**4**	**3**	**-**	**1**	**Class XII Passed**	**Basic Knowledge of Genetics**	**Biomedical Science**

Learning objectives

The Learning objectives of this course are as follows:

- This course is designed to develop an appreciation for the groundwork carried out so far in areas that contributed to our understanding of human genetics and diseases, relates to how it has been built on the numerous genetic studies carried out over decades to contribute to the understanding of the relationship between genotype and phenotype.
- The course will also introduce the sequencing of the Human Genome and new methods of investigating biological function, research into the genetic and molecular basis of human disease.

Learning outcomes

Having successfully completed this course, students shall be able to:

- Students will understand the patterns of inheritance of monogenic traits from pedigree data for both Mendelian and non-Mendelian traits.
- They will comprehend the techniques and advances in the analysis of DNA, identification of genes involved in diseases, and gene/sequence mapping strategies.
- Students will be able to describe objectives, tools, approaches and outcomes of the Human Genome Project (HGP). They will be aware of the ethical and societal issues raised by the new knowledge derived by using new technologies.
- Students will be able to apply principles of genetics at population level.
- They will understand the genetic basis of common diseases and methods of prenatal diagnosis.
- Students will be able to proficiently explore relevant literature, web sites and databases for research into human genetics.

SYLLABUS OF BIOMED-DSC-17:

Unit- I: Inheritance for Monogenic Traits (08 hrs)

History of Human Genetics: Early Greek concepts about inheritance, Cytogenetics history (the works of Winiwater, Painter and Tjio and Levan), Landmark achievements of Galton, Garrod etc. Patterns of Inheritance: Recapitulation of principles of human inheritance pattern through pedigree analysis: Autosomal inheritance- dominant, recessive, sex-linked inheritance, sex- limited and sex- influenced traits and mitochondrial inheritance. Deviations from the basic pedigree patterns- non-penetrance, variable expressivity, pleiotropy, late onset, anticipation, consanguinity and its effects, mosaicism and chimerism, genetic heterogeneity, uniparental disomy, and genomic imprinting.

Unit- II: Genetic and Physical Maps (06 hrs)

Genetic markers and their applications. Overview of genetic maps. Physical maps (different types- restriction, cytogenetic maps, use of FISH in physical mapping, radiation hybrids and clone libraries in STS mapping)

Unit- III: Identification of Human Disease Genes (08 hrs)

Principles and strategies, positional and candidate gene approaches, (examples- HD, CFTR), concept of twin and adoption studies.DNA sequencing (Principles of Maxam-Gilbert and Sanger Method, introduction to NGS with an example of illumina based sequencing), DNA fingerprinting, polymorphism screening (genotyping of SNPs and microsatellite markers)

Unit- IV: Human Genome Project (04 hrs)

History, organization and goals of human genome project, Tools (Vectors- BAC, PAC, YAC)) and approaches (Hierarchical and whole genome shotgun sequencing), outcomes ethical issues and applications in human diseases

Unit- V: Population Genetics (05 hrs)

Genotypic and allelic frequencies, Hardy-Weinberg Equilibrium, linkage disequilibrium, haplotype construction (two loci using SNPs and/or microsatellites).

Unit- VI: Clinical Genetics **(08 hrs)**

Inborn errors of metabolism and their genetic basis (example- phenylketonuria), genetic disorders of hematopoietic systems (examples- sickle cell anemia and thalassemia), genetic basis of color blindness, familial cancers (example- retinoblastoma) and mental retardation.

Prenatal Diagnosis: Brief introduction, methods of prenatal diagnosis (invasive and non-invasive such as Amniocentesis, Chorionic villus sampling, Ultrasonography, Fetoscopy, Maternal serum screening, Fetal cells in maternal blood) and its application with examples of Aneuploidy and Thalassemia.

Pharmacogenetics and Pharmacogenomics(genetic polymorphism in drug metabolism genes e.g. cytP450 and GST and their effect on drug metabolism and drug response), genetic counseling.

Unit- VII: Guided short project **(06 hrs)**

Short project involving, data analysis/*in silico* analysis of genomes/ literature-based project; guiding the students through identification of the project, discussions on approach and methodology, and strategies for data analysis.

Practical **(30 hrs)**

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Pedigree construction of some common phenotypic characteristics of humans.
2. Pedigree analysis and risk assessment.
3. Restriction mapping/ STS mapping from the given data.
4. Demonstration of DNA fingerprinting.
5. Polymorphism analysis using PCR.
6. Analysis of the given DNA sequencing data based on Maxam-Gilbert and Sanger sequencing methods.
7. Study of Hardy-Weinberg equilibrium by PTC tasting and ABO blood grouping.
8. Video based demonstration of tools for prenatal diagnosis.
9. Exploring DNA, RNA, and Protein Sequence Databases for retrieval of a desired human sequence and sequence alignment using BLAST.
10. Preparation of human metaphase chromosomes and Giemsa staining.

Essential readings:

- Strachan, T. and Read, A. (2018). 5th Edition. *Human molecular genetics*. Florida, USA: CRC Press, Garland Science. ISBN: 978-0815345893.

- Pasternak, J.N. (2005). 2nd Edition. *An introduction to human molecular genetics*. New York, USA: Wiley-Liss. ISBN: 978-0-471-47426-5.
- Cantor, C.R. and Smith, C.L. (1999). 1st Edition. *Genomics: The science and technology behind the human genome project*. New York, USA: Wiley-Interscience. ISBN: 9780471599081.

Suggestive readings:

- Brown, T.A. (2023). 5th Edition. *Genomes 4*. New York, USA: Garland Science. ISBN-13: 978-0815345084.
- Speicher, M.R., Antonarakis, S.E. and Motulsky, A.G. (2010). 4th Edition. *Vogel and Motulsky's Human genetics: Problems and approaches*. Berlin, Germany: Springer Verlag. ISBN: 978-3540376538.
- Wilson, G.N. (2000). 1st Edition. *Clinical genetics: A short course*. New York, USA: Wiley-Liss, ISBN: 978-047129806.

DISCIPLINE SPECIFIC CORE COURSE- 18 (BIOMED-DSC-18) TOXICOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)	Department offering the course
		Lecture	Tutorial	Practical / Practice			
Toxicology **BIOMED-DSC-18**	**4**	**3**	**-**	**1**	**Class XII Passed**	**Basic Knowledge of Pharmacology**	**Biomedical Science**

Learning objective

- The present course content is designed to provide the basics of toxicology. The course would help to understand the influence of toxic substances on various body organs. It provides insight into measurement of toxicity, principles of exposure, molecular mechanism of toxicity and toxicants that harm our environment.
- Relevant importance has been given to those topics which can build a strong foundation in the subject, based on which, facts can be assimilated during subsequent higher studies.

Learning outcomes

- Familiarity with the form of toxicology practiced during antiquities across the world; and how the modern form of toxicology emerged. Nature of toxic substances and how humans are exposed to them. Spectrum of toxic responses. Types of toxicity and factors affecting the toxicity by a chemical.
- Basics methods and biological parameters used to measure toxicity of a chemical. General mechanisms whereby toxicants cause toxicity; interaction of toxicants with target bio-molecules in the body and resultant toxicity. Basics of safety evaluation of toxicants.
- Mechanisms/processes involved in absorption, transport, chemical modification and excretion of toxicants from the body.
- Through examples of few common classes of toxicants such as pesticides and metals, students are able to learn; how humans are exposed to them, their mechanism of action and symptoms of toxicity.
- The process by which certain anthropogenic chemicals cause harm to wildlife/ ecosystem.

- Basics of management, clinical evaluation of toxic patients, methods used to prevent further toxicity, and use of antidotes.

SYLLABUS OF BIOMED-DSC-18

Unit-I: Introduction (07hrs)

Brief history, Different areas of modern toxicology, Classification of toxic substances, various definitions of toxicological significance, characteristic and types of toxic responses and tolerance to toxicants.

Unit-II: Toxic exposure, response, evaluation of toxicity and mechanism of toxicity (14hrs)

Effect of duration, frequency, route and site of exposure of xenobiotics on its toxicity, various types of dose response relationships, assumptions in deriving dose response, LD50, LC50, TD50, NOAEL, ADI, MOE and therapeutic index. Concept of ultimate toxicant, general mechanisms by which various toxicants cause toxicity (up to molecular and cellular level).

Unit-III: Fate of xenobiotics in human body (12 hrs)

Absorption, distribution, excretion and metabolism of xenobiotics (biotransformation, Phase-I reactions including oxidations, hydrolysis, reductions and phase II conjugation reactions). Toxic insult to liver, its susceptibility to toxicants with reference to any two hepatotoxicants.

Unit-IV: Toxic agents (06hrs)

Human exposure, mechanism of action and resultant toxicities of the following xenobiotics: Metals: lead, arsenic; Pesticides: organophosphates, bipyridyl compounds and anticoagulant pesticides.

Unit-V: Eco-toxicology (02hrs)

Brief introduction to avian and aquatic toxicology, movement and effect of toxic compounds in food chain (DDT, mercury), concept of bio-accumulation, bio-magnification.

Unit-VI: Clinical toxicology (04hrs)

Management of poisoned patients, clinical methods to decrease absorption and enhance excretion of toxicants from the body, use of antidotes.

Practical **(30 hrs)**

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Separation of a mixture of benzoic acid, beta- naphthol and naphthalene by solvent extraction and
2. Identification of their functional Groups.
3. Determination of Dissolved oxygen (DO) using Winkler method.
4. Determination of Biological oxygen demand (BOD) of water.
5. To perform quantitative estimation of residual chlorine in water samples.
6. To determine the total hardness of water by complexo-metric method using EDTA.
7. To determine acid value of the given oil sample.
8. To estimate formaldehyde content of given sample.
9. Calculation of LD50 value of an insecticide from the data provided.
10. Determination of COD (chemical oxygen demand) of the given water sample.

Essential reading

- Klaassen, C.D and Watkins, J.B. (2021). 4th Edition. *Casarett and Doull's Essentials of Toxicology.* McGraw Hill, ISBN-13: .1260452297-978
- Klaassen, C.D. (2018). 9th Edition. *Casarett and Doull's Toxicology, The Basic Science of the Poisons.* McGraw Hill. ISBN-13: 978-1259863745.

Suggestive readings

- Stine, K.E. and Brown T.M (2015). 3rd Edition. *Principles of Toxicology.* Florida, USA: CRC Press. ISBN-13: 9781466503434.
- Timbrell. J. (2001). 3rd Edition. *Introduction to Toxicology.* CRC Press. ISBN-13: 978-0415247634.

Pool of DSEs

DISCIPLINE SPECIFIC ELECTIVE COURSE– 10 (BIOMED-DSE-10)
FUNDAMENTALS OF NEUROSCIENCE

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the Course	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Fundamentals of Neuroscience **BIOMED-DSE-10**	**4**	**3**	**-**	**1**	**Class XII Passed**	**Basic knowledge of Physiology, biochemistry and Cell biology**	**Biomedical Science**

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide a comprehensive overview of the basic principles and concepts in neuroscience, including the structure and function of the nervous system, neural communication, and basic neuroanatomy.
- The paper aims to investigate the neural mechanisms underlying a particular phenomenon, such as perception, memory, learning, decision-making, or emotion.
- To prepare students to undertake further research in the area of neuroscience.

Learning outcomes

Having successfully completed this course, students shall be able:

- To understand the fundamental organization, function and development of the nervous system.
- To conceptualize and compare the role of different neurotransmitters.
- To understand the mechanisms of different disorders associated with the nervous system.
- To appreciate the principles and applications of different tools and techniques used in neuroscience.
- To proficiently explore relevant websites and databases related to latest initiatives in the field of neuroscience.

SYLLABUS OF BIOMED-DSE-10

Unit I: Introduction to Neuroscience (10hrs)

Brief overview of Neuroanatomy: Timeline of the nervous system development, Organization of Central Nervous System (CNS), Peripheral Nervous System (PNS), Autonomic Nervous System (ANS). Meninges and Cerebrospinal Fluid (CSF), Vascular Supply of the Brain: blood brain barrier and blood CSF barrier.

Unit II: Neurochemistry and Neurophysiology (10hrs)

Introduction to Neurochemistry, overview of synaptic transmission and cellular signaling. Neurotransmitters and their receptors: Acetylcholine, Glutamate, GABA, Dopamine, Serotonin and Epinephrine. Neuropeptides, Gut-Brain axis. Membrane potentials, Post synaptic potential and synaptic integration, Neuromuscular junctions.

Unit III: Brain and Behavior (06 hrs)

Neuroplasticity, learning and memory, cognition, sleep, circadian rhythm, Affective immunology: emotions and Immunity

Unit IV: Diseases of the nervous system (10hrs)

Overview of neuroinflammation, Neurochemical and molecular mechanisms of different neurological conditions: Autism, Attention Deficit Hyperactivity Disorder (ADHD), Epilepsy, Anxiety and depression, Alzheimer Disease, Parkinson Disease/ Schizophrenia, and Amyotrophic Lateral Sclerosis (ALS)

Unit V: Tools and Techniques in Neuroscience / Kaleidoscopic Dimensions of Neuroscience(09hrs)

Methods and tools to study brain and behavior: neuroimaging techniques (MRI, PET), electrophysiological studies (EEG). *In vitro* models of neurosciences including cell culture, tissue culture and animal models. Introduction to Neuroinformatics.

Practical (30 hrs)

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Gross examination of the brain and its different parts (human and animal) through videos.
2. Histology of different brain sections through permanent slides.
3. Microanatomy of neurons using virtual labs.

4. Electrophysiological studies using physiological data acquisition systems (teaching modules)
5. Exploration and extraction of information about the brain from NCBI, NIF, Allen Brain Atlas, the virtual brain, Human Connectome Project, etc.
6. Behavioral studies using virtual lab- Motor functions tests (Rotarod Test, Grip Strength Test), Cognitive Functions tests – Learning and memory related test (Water Maze, open field test, etc.)

Essential readings:

- Kandel, E. R., Koester, J. D., Mack, S.H., et al. (2021). 6th Edition. Principles of Neural Science. McGraw Hill, ISBN: 978-1259642234
- Sontheimer, H. (2021). 2nd Edition. Diseases of the Nervous System. Elsevier, ISBN: 978-0128212288
- Squire, L., Spitzer, N. C., Berg, D., et al. (2012). 4th Edition. Fundamental Neuroscience, Academic Press, ISBN: 978-0123858702
- Brady, S. T., Siegel, G. J., Albers, R. W., et al. (2011). 8th Edition. Basic Neurochemistry. Academic Press, ISBN: 0125468075
- Zigmond, M. J., Bloom, F. E., Roberts, J. L., et al. (2008). 3rd Edition. Fundamental Neuroscience. Academic Press, ISBN: 978-0123740199

Suggested readings:

- Sanes, D. H., Reh, T. A., Harris, W. A., et al. (2019). 4th Edition. Development of the Nervous system. Academic Press, ISBN: 978-0128039960
- Gilbert, S. F., & Barresi, M. J. F. (2016). 11th Edition. Developmental Biology. Sinauer Associates Inc, ISBN: 978-1605354705
- Hall, J.E. (2015). 13th Edition. Guyton and Hall textbook of Medical Physiology. Philadelphia, USA: W B Saunders and Company. ISBN-13: 978-1455770052
- Aminoff, M., Greenberg, D., Simon, R. P. (2015). 9th Edition. Clinical Neurology. McGraw Hill Education, ISBN: 978-0071841429

DISCIPLINE SPECIFIC ELECTIVE COURSE –11 (BIOMED-DSE-11) GREEN CHEMISTRY METHODS IN PHARMACEUTICAL AND INDUSTRIAL APPLICATIONS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical /Practice			
Green Chemistry Methods in Pharmaceutical and Industrial Applications **BIOMED-DSE-11**	**4**	**3**	**-**	**1**	**Class XII Passed**	**Basic knowledge of organic reactions**	**Biomedical Science**

Learning objectives

The objective of this course is to make students aware of

- The toxicity, hazard and risk of chemical substances as well as to be aware of the importance of green chemistry in today's world.
- To familiarize students with environment-friendly alternatives for the synthesis of various chemicals.
- ·Course will help to understand the usage of various green approaches in synthetic chemistry and their applications for sustainable development.

Learning outcomes

After studying this course students should be able to:

- Understand the twelve principles of green chemistry and gain an in-depth understanding of chemical toxicity, hazard, and associated risk.
- Learn to create non-toxic chemicals, products, and processes than current alternatives.
- Comprehend the importance of inherently safer design for accident prevention
- ·Understand the advantages of using catalysts and biocatalysts, use of renewable feedstocks and green solvents for environmental protection.
- Appreciate the role of green chemistry in innovatively solving environmental issues.

- Green chemistry is a mean to maximize revenues, productivity, and sustainability while producing zero waste. They are also motivated to practice green chemistry by success stories and real-life examples.

SYLLABUS OF BIOMED-DSE-11

Unit I: Introduction to Green Chemistry (10 hrs)

Importance of Green Chemistry: Green Chemistry in nature (for example nitrogen fixation, photosynthesis, glucogenesis/ glycolysis), Twelve principles of green Chemistry:Prevention of waste, Atom economy, Designing less hazardous chemical synthesis, Designing safer products, Safer solvents and auxiliaries, Design for energy efficiency, Renewable resources, Reduce derivative, Use of selective catalyst, Design for degradation, You cannot control what you cannot measure, Inherently safer chemistry for accident prevention, Important environmental laws, the Pollution Prevention Act of 1990, Limitations and Obstacles in the Pursuit of the Goals of Green Chemistry.

Unit II: Conventional Chemistry vs Green Chemistry (10 hrs)

General concept of mixing of orbitals (Hybridization), Role of various electronic effects in the modulation of reactions; Homolytic and Heterolytic cleavage. Substitution reactions (hydrolysis of alkyl halides and Hydrolysis of esters), Addition reactions (Hydrogenation of alkenes), Elimination reactions (Hoffman elimination, Decarboxylation), Rearrangement (Diels-Alder reactions), Cis-trans isomerisation of alkenes, Condensation reactions: Aldol (replacement of ethanol with solvent free reaction) and Benzoin (replacement of KCN, TPP, Thiamine HCl). Prevention of waste/by-product pollution, calculation of atom economy with reference to above reactions.

Unit III: Green Solvents (10 hrs)

- Conventional solvents (Ethanol, Acetone, chloroform, DCM) and Green Solvents (water/buffer, supercritical fluids, ethyl lactate, Ionic liquids). Buffers (Phosphate, Acetate) and buffer action (concept of pKa), Relative acids/basic strength of organic acids and bases (aliphatic and aromatic).
- Advantages of green solvents in chemical synthesis: Supercritical CO_2 in the separation of coffee from coffee beans and perfume industry, water as a green solvent in reactions (Benzoin condensation, Hofmann Elimination, methyl benzoate to benzoic acid and Decarboxylation reaction).
- Ionic liquids: physicochemical properties, Advantages and Disadvantages (purification of complex mixtures and cost), Reactions of Ionic liquids: Imidazolium based ionic liquid for the synthesis of

antiviral drug trifluridine, hydrogenation of alkenes, Diels-Alder reaction with copper (II) bisoxazolium complex having imidazolium tag.

Unit IV: Various Approaches to Green reaction synthesis (10 hrs)

- Enzyme-based reactions: Biocatalyst (concept of stereoselectivity and stereospecificity, and turnover number), Biocatalyst mediated synthesis of Sitagliptin drug and ethanol; Nanocatalysis (oxazole synthesis using nanocatalyst). Photocatalysis: Visible light induced Reactions (syntheses of vitamin D3, cis-trans isomerization of alkenes, waste water treatment with TiO2).
- Microwave-assisted green approach: Principle, merits, demerits and effect of solvent; Microwave-assisted reactions: solvent-free synthesis of aspirin, Renewable starting materials: Synthesis and properties of 5-Aminolevulinic acid (DALA) from levulinic acid. Design of degradable reactions (pesticides), Inherently Safer design in chemical synthesis: Principle and Subdivision eg. Bhopal Gas Tragedy.

Unit V: Pharmaceutical and Industrial Applications for revenue, productivity and sustainability (5 hrs)

Vitamin C used in cosmetics/neutraceuticals industry: Synthesis using enzymes, commercial production of drugs/pharmaceutical product: anti-depressant drug sertraline, Removal of Drug from Waste water: Levofloxacin, an anti-bacterial drug with ZnO nanoparticles, Enzymatic synthesis of Zero Trans-Fats and Oils,

Practical: (30 hrs)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.) (Any seven)

1. Preparation and characterization of biodiesel from vegetable oil preferably waste cooking oil.
2. Benzoin condensation using thiamine hydrochloride as a catalyst instead of cyanide
3. Mechanochemical solvent-free synthesis of succinic anhydride/phthalic anhydride
4. Hydrolysis of esters/ esterification using green methods.
5. Solvent-free, microwave-assisted one-pot synthesis of phthalocyanine complex of copper (II).
6. Cross aldol condensation reaction using base catalyzed green method.
7. Microwave-assisted synthesis of drug/ drug intermediates (Knoevenagel reaction, Aspirin)
8. Photoreduction of benzophenone to benzopinacol in the presence of sunlight.
9. Acetylation of primary aromatic amine using the green method.
10. Synthesis of nanoparticles using green approach.

Essential Reading:

- Matlack, A.S., Andraos. J, (2022); Introduction to Green Chemistry, 3rd Edition, CRC press (ISBN: 978-1032199429).
- Sharma, R.K.; Bandichhor, R. (2018), Hazardous Reagent Substitution, Royal Society of Chemistry. (ISBN: 978-1-78262-050-1)
- Lancaster, M. (2016), Green Chemistry: An Introductory Text, 3rd Edition, RSC Publishing. (ISBN: 978-1-78262-294-9)
- Wei Zhang, Berkeley W. Cue Jr (2012) "Green Techniques for Organic Synthesis and Medicinal Chemistry" John Wiley & Sons, Ltd (ISBN:9780470711828)
- Sharma, R.K.; Sidhwani, I.T.; Chaudhari, M.K. (2012), Green Chemistry Experiments: A monograph, I.K.International Publishing House Pvt Ltd. (ISBN: 978-9381141557)
- Kirchhoff, M.; Ryan, M.A. (2002), Greener approaches to undergraduate chemistry experiment. American Chemical Society, Washington DC. (ISBN: 8412-3866-9)
- Anastas, P.T.; Warner, J.C. (2000), Green Chemistry: Theory and Practice, Oxford University Press. (ISBN: 9780-198506980).
- El-Maraghy, C. M., El-Borady, O. M., & El-Naem, O. A. (2020). Effective Removal of Levofloxacin from Pharmaceutical Wastewater Using Synthesized Zinc Oxid, Graphen Oxid Nanoparticles Compared with their Combination. *Scientific Reports*, *10*(1), Article 1. https://doi.org/10.1038/s41598-020-61742-4

Suggestive readings

- Batra. S.K; Gulati, S; Shukla, S, (2020); Practical Green Chemistry: Strategies, Tools & Experiments, Shri Kala Prakashan (ISBN: 978-9385329456)
- Sidhwani, Tucker I; Sharma, R.K, (2020); An Introductory Text on Green Chemistry: For Undergraduate Students, Wiley (ISBN: 978-8126554072)
- Benyus, J.M. (2002); Biomimicry:Innovations Inspired by nature, HarperCollins. (ISBN: 9780060533229)
- Garay,A. L; Pichon, A.; James,S.L. "Solvent-free synthesis of metal complexes" Chem Soc Rev, 2007, 36,846-855.
- James H. Clark, Duncan Macquarrie (2002); Handbook of Green Chemistry and Technology, Wiley (ISBN: 9780632057153)

DISCIPLINE SPECIFIC ELECTIVE -12 (BIOMED-DSE-12) RESEARCH METHODOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Research Methodology **BIOMED-DSE-12**	**4**	**3**	**-**	**1**	**Class XII Passed**	**Basic knowledge of biology, mathematics and computers**	**Biomedical Science**

Learning objectives

The Learning objectives of this course are as follows:

- The syllabus aims to educate students on the fundamentals of research methodology and familiarize them with the different search engines used in literature surveys.
- It will guide them in identifying research problems and developing research strategies to address them.
- The course will cover different approaches used in research, along with ethical considerations related to clinical research.
- In addition, students will learn about scientific writing and presentation skills.

Learning outcomes

Upon completion of this course, students will achieve the following learning outcomes:

- Develop the ability to identify a research problem, design and execute experiments, and analyze the resulting data.
- Comprehend and follow ethical guidelines for conducting research and accurately document research activities.
- Utilize various tools to write research papers and review articles effectively.
- Demonstrate effective presentation skills to communicate scientific work.

SYLLABUS OF BIOMED-DSE-12

Unit I: Introduction (6 hrs)

Basics of research methodology: Background of research area and generation of hypothesis, Types of Research: Experimental vs Theoretical; Descriptive vs Analytical; Fundamental vs Applied; Quantitative vs Qualitative.

Unit II: Literature Review (08 hrs)

Importance of literature review, common search engines such as NCBI, Google Scholar etc. used for literature surveys. Exploring various types of academic journals and publications fundamental to research: journals and e-books. Introduction to reference and citation management tools like Mendeley, Zotero and EndNote.

Unit III: Identifying a Research Problem and Designing of Experiment: (10 hrs)

Identification of a research problem (any one disease of national importance: tuberculosis/leprosy/diabetes/cardiovascular disease/neurodegenerative disorders), its national and international status. Experimental strategies: number and types of replicates and control, Statistical analysis of data using MS Excel/ R-Statistical tools.

Unit IV: Methods in Biomedical Research (08hrs)

Clinical Research and associated methodology, Epidemiology: Concepts and methods in the context of illustrative projects. Classical examples of epidemiological studies such as TB and leprosy, its challenges and limitations.

Unit V: Research Ethics and Intellectual Property (07hrs)

Understanding research ethics and its significance in scientific writing, Plagiarism, peer-review, conflict of interest, and research misconduct. Introduction to Intellectual Property Rights (IPR) such as Patent, Trademarks, Copyright, and Trade Secrets. Importance of IPR in research and innovation.

Unit VI: Research Presentation (06 hrs)

To write a research paper and review article. To prepare an oral and poster presentation of a research paper.Steps in writing a research grant proposal

Practical **(30 hrs)**

1. Literature survey on any one disease of national importance: tuberculosis/leprosy/diabetes/cardiovascular disease/neurodegenerative disorders
2. Creating bibliography in different formats using any available tools like Mendeley/ Zotero/ EndNote, etc.
3. Group exercise by students
    1. Writing a review article
    2. Writing a research report
    3. Powerpoint presentation
    4. Poster presentation

Essential Readings

- Walliman, N. (2017) Research Methods: The Basics, **(**2nd ed.), London; New York: Routledge; ISBN-10:1138693995
- Kumar, R. (2014) Research Methodology: A Step-by-Step Guide for Beginners (4th ed.), SAGE publisher; ISBN-10: 9789351501336
- The Craft of Research (Guides to writing, editing and publishing) (2008), Booth, W.C., Colomb, G.G., Williams, J.M., University of Chicago Press, 2008. (ISBN-13: 978-0226065663)

Suggestive Readings

- Research Methodology: A Step-by-Step Guide for Beginners (2010) 3rd ed., Kumar R., Pearson Education. (ISBN-13: 978-1849203012)
- Cresswell, J. (2009) Research Design: Qualitative and quantitative Approaches Thousand Oaks CA, (3rd ed.), Sage Publications
- Research in Education (2005) 10th ed., Best, J.W. and Kahn, J.V., Prentice Hall of India Pvt. Ltd. (ISBN-13: 978-0205458400)
- At the Bench: A Laboratory Navigator (2005) Barker, K., Cold Spring Harbor Laboratory Press (New York). ISBN: 978-087969708-2.
- Research Methodology - Methods and Techniques (2004) 2nd ed., Kothari C.R., New Age International Publishers. (ISBN-13 / EAN: 9788122415223)