

Name of the Programme: B. Sc (Hons) Biomedical Science (ACBR)

Detailed Structure of various DSC, DSE and GE courses to be followed from 2025-26

Sem.	List of Discipline Specific Core (DSC)	List of Discipline Specific Electives (DSE)	List of Generic Electives (GEs) along with mandatory GEs (in Bold Minimum 3) to be studied if a student wishes to make it a minor in Biomedical Science
	Sem. I & II		Sem. I & II (Category I; Level 100)
I	DSC-1-Bioorganic Chemistry		GE 1: Landmark Discoveries in Science
I	DSC-2-Cell Biology		GE 2: Pandemic: Challenges and Preparedness
I	DSC-3-Human Physiology and Anatomy I		GE 3: Understanding The Human Body Systems
II	DSC-4-Biochemistry		
II	DSC-5-Principles of Genetics		
II	DSC-6-Human Physiology and Anatomy II		
	Sem. III-VI	Sem. III-VI	Sem. III-VI (Category II; Level 200)
III	DSC-7-Medical Microbiology	DSE-1-Drug Design and Discovery	GE 4: Biochemical Basis of Life
III	DSC-8-Medicinal Chemistry	DSE-2-Fundamentals of Neuroscience	GE 5: Concepts in Medicinal Chemistry
III	DSC-9-Biostatistics	DSE-3-Green Chemistry Methods in Pharmaceutical and Industrial Applications	GE 6: Environment Sustainability and Biomedical Waste Management[%]
IV	DSC-10-Immunobiology	DSE-4-Industrial Microbiology	GE 7: Genetic Basis of Diseases
IV	DSC-11-Molecular Biology	DSE-5-Intellectual Property Rights for Biologists	GE 8: Health and Body Defense System
IV	DSC-12-Pharmacology	DSE-6-Medical Biochemistry	GE 9: Practices in Biosafety[%]
V	DSC-13-Genome Organization and Function	DSE-7-Medical Laboratory Technology	GE 10: Statistical Concepts in Biology
V	DSC-14-Medical Biotechnology	DSE-8-Proteins and Enzymes	GE 11: Diseases in Everyday Life
V	DSC-15-Human Pathology	DSE-9-Research Methodology*	
VI	DSC-16-Biophysics	DSE-10-Social and Preventive Medicine	
VI	DSC-17-Human Genetics		
VI	DSC-18-Toxicology		
VII	DSC-19-Bioinformatics and Omics		

	Sem. VII-VIII	Sem. VII-VIII	Sem. VII-VIII (Category III; Level 300)
VIII	DSC-20-Developmental Biology	DSE-11-Advanced Cell Biology	GE 12: Concepts in Biotechnology
		DSE-12-Advances in Pharmaceutical Science	GE 13: Pathological Basis of Disease
		DSE-13-Protein Structure and Function: Advanced Concepts and Biomedical Applications	GE 14: Pharmacological Science
		DSE-14-Advanced Bioorganic Chemistry	GE 15: Toxic Substances and Human Health
		DSE-15-Advanced Techniques in Forensic Sciences	
		DSE-16-Immune Response to Infection and Diseases	
		DSE-17-Model Organisms in Biomedical Research	
		DSE-18-Advanced Molecular Biology and Genetic Engineering	
		DSE-19- Bridging Ancient Medicine and Practices with Modern Biomedical Research	
		DSE-9-Research Methodology*	

- # The Generic Elective Paper titled as “Understanding Genetic Basis of Diseases” has been renamed as “Genetic Basis of Diseases”. The course content for the previously approved Generic Elective paper entitled “Drug and Vaccine” has been revised and updated under the new title, “Pharmacological Science.” Consequently, the earlier approved “Drug and Vaccine” Generic Elective paper has been officially withdrawn.
- ** New GE Courses for which syllabus is included here. For rest of the GE courses, syllabus is already approved and available on the University portal.
- % The two red highlighted courses have been transferred from the Discipline-Specific Elective (DSE) pool to the Generic Elective (GE) pool, with their syllabi unchanged. These are to be considered as GE courses.
- *Research Methodology shall be offered as one of the DSE courses in the VI and VII semester. Students can opt it in either VI or VII semester. However, Students planning to pursue a 4 year UG program are advised to choose research methodology in the VI semester.

B.Sc (Hons.) Biomedical Science
Discipline Specific Core (BIOMED-DSCs)
SEMESTER- VII

DISCIPLINE SPECIFIC CORE COURSE -19 (BIOMED-DSC-19)

BIOINFORMATICS AND OMICS

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		
Bioinformatics and Omics BIOMED-DSC-19	4	2	-	2	XII Passed	Basic knowledge of genetics, molecular biology

Learning Objectives

The Learning Objectives of this course are as follows:

- Students will be introduced to the field of bioinformatics and omics and their applications in biomedical research.
- Students will develop scientific and hands-on practical skills in bioinformatics that will be useful for higher studies.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Students will be able to work on bioinformatics tools and databases.
- Students will be able to perform pairwise and multiple sequence alignments and construct phylogenetic trees.
- Students will learn features of genomic sequences with tools to annotate them. Various next generation sequencing technologies like the ones used for variant typing will also be taught.
- Students will be able to appreciate the role of high throughput technologies along with computational tools in deciphering the differential gene expression that is important to understand the pathogenesis and mechanism of various human diseases.
- Students will also be introduced to proteomics, epigenomics, metagenomics, and metabolomics.

SYLLABUS OF BIOMED-DSC-19

Unit-I: Biological Databases and Genome Browsers

(4 hours)

Basic description and significance of bioinformatics, Introduction to various databases and their classification (primary and secondary databases) e.g. NCBI, DDBJ, EMBL, ENSEMBL, UCSC and their use in laboratories: literature, sequence, structure, medical, enzymes and metabolic pathways databases.

Unit II: Sequence Alignment and Phylogenetic Analysis (10 hours)

Introduction to sequence alignment, Nucleotide and Amino acid substitution scoring matrices, local and global pairwise sequence alignments using Dynamic Programming approach (Needleman-Wunsch and Smith-Waterman algorithms), calculating the alignment score. Pairwise alignment using word/k-tuple method (BLAST). Variables in BLAST Interpretation: BLAST score, e-value, bit score, p-value.

Multiple sequence alignment and its importance, Introduction to the basics of phylogenetic analysis. Tree-building methods: character-based methods (Maximum Parsimony) and distance-based methods (UPGMA and Neighbour joining). Construction of a phylogenetic tree and identification of homologs.

Unit III: Genomics (6 hours)

Structural and functional features of Genome sequences, Tools for the prediction of genes and regulatory elements; Gene Ontology, Next generation sequencing analysis (ILLUMINA, Oxford), Applications in SNP typing and copy number variation detection, ChIP seq

Unit IV: Transcriptomics and other Omics Technologies (10 hours)

Gene expression databases, Global profiling of gene expression, Differential gene expression, analysis using microarrays and RNA-seq- Principle, design and execution, data preprocessing (Exploration, normalization, filtering), Detection of differentially expressed genes (fold change and t-test), heatmaps, classification and prediction, Functional analysis and biological interpretation of differentially expressed genes, validation using qRT PCR, Applications of expression profiling in human diseases

Overview of other omics technologies like Proteomics, Epigenomics, Metagenomics, Metabolomics and their applications in biomedical research

Practical (60 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. Retrieval of information from databases like NCBI, ENSEMBL, UCSC, etc.
2. Pairwise Sequence alignment using BLAST
3. Multiple Sequence alignment using tools like CLUSTAL, MUSCLE, T-Coffee, etc.
4. Phylogenetic analysis using online tools like Simple Phylogeny (EMBL-EBI), Phylogeny.fr
5. Prediction of genes and genome annotation using tools like GENEID
6. Retrieval of gene expression data from GEO or SRA
7. Differential gene expression analysis using GEO2R
8. Gene Ontology using DAVID
9. Visualization of protein interactions using tools like Cytoscape, STRING, etc.

Essential readings:

- Baxevanis, A. D., Bader, G. D., & Wishart, D. S. (Eds.). (2020). Bioinformatics. John Wiley & Sons. ISBN: 9781119335955.
- Rastogi, S. C., Rastogi, P., & Mendiratta, N. (2022). Bioinformatics: Methods and Applications-Genomics, Proteomics and Drug Discovery, Fifth Edition. PHI Learning Pvt. Ltd. ISBN: 9789354437410.
- Lesk, A. M. (2017). Introduction to genomics. Oxford University Press. ISBN: 0199557489
- Ning, K. (Ed.). (2023). Methodologies of Multi-Omics Data Integration and Data Mining: Techniques and Applications (Vol. 19). Springer Nature. ISBN: 9811982104
- Mount, D. W. (2004). Bioinformatics: Sequence and Genome Analysis. Thailand: Cold Spring Harbor Laboratory Press. ISBN: 9780879697129.
- Campbell, A.M. & Heyer, L.J. (2007) Discovering Genomics, Proteomics and Bioinformatics, 2nd Edition. Benjamin Cummings. CSH Press, New York. ISBN: 8131715590
- Metzker, M. L. (2010). Sequencing technologies-the next generation. Nature Reviews Genetics, 11(1), 31-46.
- Pevsner, J. (2015). Bioinformatics and functional genomics, 2nd Edition. John Wiley & Sons. ISBN: 0471210048

Suggested readings:

- Arivaradarajan, P., & Misra, G. (2018). Omics Approaches, Technologies And Applications. Springer, Singapore. ISBN: 9811329257.
- Ghosh, Z., Mallick, B. (2008). Bioinformatics: Principles and Applications. India: Oxford University Press. ISBN: 9780195692303.
- Latest developments in the field of bioinformatics and omics technologies through research articles.

Examination scheme and mode:

Evaluation scheme and mode will be as per the guidelines notified by the University of Delhi.

B.Sc (Hons.) Biomedical Science

Pool of DSEs for VII and VIII semesters

DISCIPLINE SPECIFIC ELECTIVE COURSE –11 (BIOMED-DSE-11) ADVANCED 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
		Lecture	Tutorial	Practical/ Practice		
Advanced Cell Biology BIOMED-DSE-11	4	2	0	2	XII Passed	Must have studied basic Cell Biology

Learning Objectives

- The main aim of this paper is to acquaint students with advancements in cell biology.
- Students will learn in detail about the intricate and specialized processes of transport of molecules within different compartments of cells.
- Understanding the mechanism of Cell survival, cell death and cell-renewal and the ways in which this regulation can be disrupted will help the students to understand the cause of many diseases particularly cancer.
- There have been great advancements in the techniques used for visualizing, separating and studying detailed ultra structure of cells. The course will familiarize the students with some such techniques during the practical sessions.

Learning Outcomes

- Students who successfully complete this course will acquire in depth understanding and advanced knowledge of a range of general and specialized areas in cell biology.
- They will develop insight into the complexities of intracellular transport.
- They will learn the molecular controls that govern the cellular microenvironment and cellular interactions maintaining tissue integrity.
- Students will appreciate the advancements in the techniques developed to understand the micro structure

SYLLABUS OF BIOMED-DSE-11

Unit I: Transport of Molecules across Membrane and Organelles

(12 Hours)

- A. **Nucleus:** Unidirectional nature of protein export and import through nuclear pores. Mechanism for nuclear import and export of proteins (Ran-dependent and Ran-independent pathways).

- B. **Endoplasmic Reticulum and Golgi Complex:** Five topological classes of ER membrane proteins, Topogenic sequences: N-terminal signal sequences, internal stop-transfer anchor sequences, and Internal signal anchor sequences. Export of proteins (vesicular transport and significance of KDEL sequence),
- C. **Mitochondria:** Protein transport to Outer membrane, intermembrane space, inner membrane and matrix. Role of N-terminal targeting sequences, Membrane receptors and Translocons complexes
- D. **Peroxisomes:** Transport of proteins to peroxisomal membrane and matrix. PTS1-directed import of peroxisomal matrix proteins.
- E. **Mechanism of Vesicular Transport :** Overview of the secretory and endocytic pathways of protein sorting, Molecular Mechanisms of Vesicle Budding and Fusion (v-SNAREs and t-SNAREs), Targeting GTPases and Rab Proteins, types of coated vesicles (COPII, COPI and Clathrin-coated vesicles), Role of Mannose 6-phosphate in protein sorting, Trafficking of soluble lysosomal enzymes from the trans-Golgi network and cell surface to lysosomes, Receptor-Mediated Endocytosis,

Unit II: Mechanism of Cell Death and Renewal

(6 Hours)

Senescence (Role of CDK inhibitors, p16 and p21), Apoptosis (Intrinsic and extrinsic pathway, anti and pro apoptotic proteins like, BBC3, Bcl2, SMAC and survivin), Necrosis, Autophagy, Stem cells (pluripotency, types of Stem cells and their applications).

Unit III: Tumor Cell Biology

(6 Hours)

Causes of cancer. Differences between tumor and normal cells: Genetic makeup, uncontrolled proliferation. Genetic basis of cancer: Oncogenes (Ras, Myc), Tumor Suppressor genes (Rb- LOH, p53). Inherited cancer genes (BRCA1 and 2, CDH1), altered signaling pathways controlling cell proliferation, Cancer stem cells (origin, properties and role in tumor initiation).

Unit IV: Cell-Cell Adhesion, Extracellular Matrix (ECM) and Cancer Progression (6 Hours)

Cell interaction with neighboring cells and ECM (integrins, cadherins, fibroblasts, collagen, fibronectin). Alterations leading to metastasis: release of matrix metalloproteinases (MMPs), epithelial to mesenchymal transition (EMT) and angiogenesis.

Practical

(60 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 isolate organelles by subcellular fractionation and validate the separated organelles by marker enzymes
2. To study the parts and working of confocal microscope
3. Flow cytometric analysis for separating the different type of blood cells
4. Flow cytometry based cell cycle analysis
5. To study cell viability/death by using trypan blue or MTT assay
6. Flow cytometry based detection of apoptosis
7. Preparation and culturing of cancer cell lines

8. To identify and study cancerous cells using permanent slides/ photomicrographs
- 9-10. To formulate the key hypothesis, summarize the results and the conclusions of the research papers on the related topics, and discuss the state-of-the-art of the research field and the contribution to the field and possible research applications of the main findings
11. To generate a graphical abstract to convey the scientific content of a research paper

Essential Reading:

- The Cell: A Molecular Approach, by Geoffrey M Cooper, Robert E Hausman, 15 Dec 2015
- Karp, G. (2013). 7th Edition. Cell and molecular biology: Concepts and experiments. New Jersey, USA: Wiley Publishers. ISBN-978-0470483374.
- Molecular Cell Biology Hardcover –by Harvey Lodish (Author), Arnold Berk , Chris Kaiser, Monty Krieger, Anthony Bretscher, 1 Apr 2016
- Molecular Biology of the Cell: by Bruce Alberts, Alexander Johnson, Julian Lewis. Publisher Garland Science, December 2014

Suggested Reading:

- James D. Watson (2014) 7th Edition. Molecular Biology of the Gene. Pearson, ISBN 0321762436, 9780321762436
- The Cell: A Molecular Approach, by Geoffrey M Cooper, Robert E Hausman, 15 Dec 2015
- 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. (2013). 7th Edition. Cell and molecular biology: Concepts and experiments. New Jersey, USA: Wiley Publishers. ISBN-978-0470483374.

**DISCIPLINE SPECIFIC ELECTIVE COURSE -12 (BIOMED-DSE-12) –
ADVANCES IN PHARMACEUTICAL 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 (if any)
		Lecture	Tutorial	Practical/ Practice		
Advances in Pharmaceutical Science BIOMED-DSE-12	4	2	-	2	XII Passed	Basic Knowledge of Chemistry and Biology

Learning Objectives:

- The course emphasizes the interdisciplinary nature of pharmaceutical research, integrating concepts from chemistry, biology, and biotechnology.
- Students will be introduced to the latest advancements in pharmaceutical research, including drug design principles, biotechnology-derived medications, and the use of biosensors in pharmaceutical industries.
- Knowledge of ethical considerations in clinical trials and pharmacovigilance ensures students are well-prepared to conduct responsible and ethical research.

Learning Outcomes:

Upon successfully completing this course, students will be able to:

- Understand the history and development of pharmaceutical research, including principles of drug design and the various phases of pharmacokinetics and pharmacodynamics.
- Recognize the importance of pharmacognosy and the application of herbal drugs in treating various ailments.
- Gain insights into pharmaceutical biotechnology, including the development and application of therapeutic proteins and monoclonal antibodies.
- Comprehend the principles and classification of drug formulations, including regulatory norms.
- Understand the processes and regulations involved in the approval of new drugs and the role of regulatory affairs in the pharmaceutical industry.
- Develop the foundational knowledge and skills for advanced studies and careers in pharmacology, pharmaceutical sciences, and related fields.

SYLLABUS OF BIOMED-DSE-12:

(30 hours)

Unit I: Introduction

(4 hours)

History and development of Pharmaceutical Research, Principles of drug design (QSAR-Hansch, Topliss, Lipinski, Computer aided drug design), Pharmacokinetics (ADME- Routes of drug administration, Absorption, Bioavailability, Distribution) Metabolism (biotransformation)-microsomal/P450, first pass metabolism, Excretion - kinetics of elimination), Pharmacodynamics (Enzymes-competitive/non-competitive inhibitors, Ion channels, Transporters, Receptors-agonist/antagonist, inverse agonist, partial agonist, Drug receptor interaction, Dose response relationship)

Unit II: Pharmacognosy and herbal drugs

(10 hours)

Importance of Pharmacognosy in herbal drug industry: Treatment of ailments related to- Central Nervous System (CNS)- Reserpine, Cardiovascular system (CVS)-Digoxin, GIT-Glycyrrhizin, Gymnema, Respiratory system -Codeine. Development of lead compound into effective drugs (Opium to pain killer, Cinchona bark to antimalarial, Taxus Baccata to taxol).

General methods of extraction (simple extraction with separatory funnel, industrial extraction using Soxhlet apparatus, isolation (steam distillation) and purification of phytoconstituents using column chromatography, HPLC.

Primary metabolites: General introduction and pharmaceutical applications of primary metabolites in therapy of CNS, CVS, Liver, Kidney, Intestine and Lung diseases and their pharmaceutical preparations. Carbohydrates (Acacia as emulsifying and stabilizing agent, Agar as surgical lubricant and stabilizer in preparation of suspensions, capsules etc.) Proteins and Enzymes (Gelatin as shell for capsules, Casein as therapeutic agent in dressing wounds, cosmetics) Lipids and Waxes/Oils (Castor oil as stiffening agent and laxative)

Secondary metabolites: General introduction -therapeutic application of secondary metabolites in CNS, CVS, Liver, Kidney, Intestine and Lung diseases and their pharmaceutical preparations.(Ephedrine as bronchodilator and decongestant, Morphine for pain management), Glycosides (Digitoxin in heart failure and treatment of arrhythmias) Polyphenols, Tannins, Flavonoids (Quercetin as antioxidant for treatment of heart conditions).

Nutraceuticals as health care products: General introduction and their formulations, classification and importance of nutritional supplements such as Vitamin supplements, Digestive enzymes, Probiotics, Prebiotics, Dietary fibers, Cereals, Health drinks for the treatment of ailments (as adjuvants) and lifestyle disorders.

Unit III: Pharmaceutical Biotechnology

(8 hours)

Introduction to Pharmaceutical Biotechnology, DNA sequence to therapeutic proteins, Production and Downstream processing, Interferons, Interleukins.

Monoclonal Antibodies: From structure to therapeutic applications in Cancer and Organ Transplantation.

Biologics and Biosimilars, Biosimilars as low cost treatment options in various ailments (eg. Humira for curing autoimmune diseases) and Regulatory framework for biosimilars. Personalized Medicine and applications.

Process of developing Biotechnology Derived Medications: Vaccines (Hepatitis Vaccine), oligonucleotides, Recombinant engineered protein -Insulin, Recombinant engineered hormones-Follicle Stimulating Hormone, Human Growth Hormone, Recombinant Coagulation factors and

Thrombolytic agents. Biosensors- Working and applications of biosensors in Pharmaceutical Industries for sensing enzymes, small molecules such as blood gases, glucose etc.

Unit IV : Drug Formulation, Release & Regulatory Framework (8 Hours)

(a) : Pharmaceutical formulation, drug release and dissolution

Introduction to drug formulations and their classification with suitable examples (Simple and compound powders; Monophasic and Biphasic liquids; Emulsions; Semisolid Dosage forms- Pastes, Ointments, Creams and Gels; Oral solid dosage forms- Tablets, Capsules; Aerosols). Pharmaceutical excipients. Pharmaceutical coating processes and equipment.

Drug release and dissolution: Theoretical Concepts for the Release of the Drug from drug formulations.

(b) : The New Drug Approval Process and regulatory affairs

Drugs and Cosmetics Act (1940) and Rules (1945). Pharmacy Act 1948. Investigational New Drug Applications (INDs): Approval processes and timelines involved, Preclinical testing, Clinical testing - Phase I, II, III and IV, Clinical trial protocols, Institutional Review Board / Independent Ethics committee - formation and working procedures, Informed consent process. Pharmacovigilance - Safety monitoring in clinical trials.

Practical: (60 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 alcohol from rectified spirit by distillation.
2. Extraction of vasicine (quinazoline alkaloid) from the leaves of *Adhatoda vasica* by modified acid-base extraction and purification by column chromatography and purity check by TLC.
3. Extraction of curcuminoids (phenolics) from *Curcuma longa* using ethanol and purification by column chromatography and purity check by TLC.
4. Extraction of Eugenol oil from steam co-distillate of cloves using dichloromethane.
5. Screening of the natural products for biological activity like antidiabetic (by inhibition of alpha-amylase) or anti-microbial (Gram+/Gram- bacteria) (by MIC/Disc-diffusion method).
6. Study the effect of polarity of solvents (water/ethanol/ethyl acetate/ether/hexane) and pH (buffer/water - pH 4, 7, 8.5) of the solution on the solubility of drugs (aspirin/penicillin/sulphonamides) using UV spectroscopy.
7. Disintegration/Dissolution studies of different formulations (Capsule, tablet, syrup) of the drugs (e.g., paracetamol) using UV spectroscopy.
8. Visit to a pharmaceutical industry to understand how drug formulations are prepared.
9. Synthesis of paracetamol, preparation of paracetamol tablets by wet granulation method and virtual demonstration of formulation of film coated tablets of paracetamol.

Essential Readings:

- Roche, V.F., Zito, S.W., Lemke, T.L., & Williams, D.A. (2019). 8th Edition. *Foye's Principles of Medicinal Chemistry*. Philadelphia, PA: Lippincott Williams & Wilkins. ISBN-13: 9781496385024.
- Shah, B. (2018). *Textbook of Pharmacognosy and Phytochemistry*. New Delhi, India: CBS Publishers & Distributors. ISBN-13: 978-9386217738.

- Wildman, R.E.C., & Bruno, R.S. (2020). 3rd Edition. *Handbook of Nutraceuticals and Functional Foods*. CRC Press. ISBN-13: 978-1498703727.
- Gupta, R.C., Lall, R., & Srivastava, A. (2021). 2nd Edition. *Nutraceuticals: Efficacy, Safety and Toxicity*. Cambridge, MA: Academic Press. ISBN-13: 978-0128210383.
- Crommelin, D.J.A., Sindelar, R.D., & Meibohm, B. (2013). *Pharmaceutical Biotechnology: Fundamentals and Applications* (4th ed.). New York, NY: Springer. ISBN-13: 978-1461464860, ISBN-10: 1461464862.
- Adejare, A. (Ed.). (2020). *Remington: The Science and Practice of Pharmacy* (23rd ed.). Elsevier. ISBN-13: 978-0128200070 (hardback), ISBN-13: 978-0128223895 (eBook)
- Kokate, C.K. (2017). *Practical Pharmacognosy* (18th ed.). Nirali Prakashan. ISBN-13: 978-8185790367.
- Sreelekshmi U, Sarathchandra G, Vijayarani K, Sp P. Isolation & purification of vasicine from leaves of *Adhatoda vasica* by modified acid-base extraction method. J Pharm. Innov. 2021;10(1):171-3.
- Kulkarni SJ, Maske KN, Budre MP, Mahajan RP. Extraction and purification of curcuminoids from Turmeric (*Curcuma longa* L.). International Journal of Pharmacology and Pharmaceutical Technology. 2012;1(2):81-4.
- <https://assets.thermofisher.com/TFS-Assets/CAD/Vector-Information/pS45-pS80-Extraction-of-Eugenol-from-Cloves.pdf>

Suggestive Readings:

- Patrick, G.I. (2017). *Introduction to Medicinal Chemistry* (6th ed.). Oxford, UK: Oxford University Press. ISBN-13: 978-0198749691.
- Tripathi, K.D. (2018). 8th Edition. *Essentials of Medical Pharmacology*. New Delhi, India: Jaypee Brothers Medical Publishers. ISBN-13: 978-9352704996.
- Evans, W.C. (2009). 16th Edition. *Trease and Evans' Pharmacognosy*. Edinburgh, UK: Elsevier. ISBN-13: 978-0702029349.
- Kokate, C.K., Purohit, A.P., & Gokhale, S.B. (2007). *Textbook of Pharmacognosy* (37th ed.). New Delhi, India: Nirali Prakashan. ISBN-13: 978-8190791136.
- Gupta, S.K. (2019). *Textbook of Pharmacovigilance* (2nd ed.). Jaypee Brothers Medical Publishers. ISBN-13: 978-9352707034.
- https://cdsco.gov.in/opencms/export/sites/CDSCO_WEB/Pdf-documents/acts_rules/2016DrugsandCosmeticsAct1940Rules1945.pdf

DISCIPLINE SPECIFIC ELECTIVE COURSE-13 (BIOMED-DSE-13) PROTEIN STRUCTURE AND FUNCTION: ADVANCED CONCEPTS AND BIOMEDICAL 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 (if any)
		Lecture	Tutorial	Practical/ Practice		
Protein Structure and Function: Advanced Concepts and Biomedical Applications BIOMED-DSE-13	4	2	-	2	Passes Class XII	Should have studied the basics of proteins.

Learning Objectives:

The Learning Objectives of this course are as follows:

- This course is designed to deepen students' understanding the protein structure & function relationships and the remarkable protein folding processes.
- It also aims to help students understand enzyme kinetics and regulatory mechanisms, bridging the molecular intricacies of enzymology to the development of therapeutics and the underlying causes of diseases.
- The experiments have been designed for students to experience the molecular basis of protein biochemistry, connecting theoretical concepts to real-world biomedical challenges. By the end of the course, students will appreciate the fundamentals of protein biochemistry and its transformative applications in life science, industry and medicine.

Learning Outcomes:

Upon completing this course, students will:

- Understand the structural organization and key characteristics of proteins, their folding mechanisms, and the critical role of chaperons in achieving functional three-dimensional structures.
- Analyse protein misfolding and its association with various diseases.
- Comprehend enzyme function, regulation, kinetics and inhibition mechanisms, linking these concepts to developing therapeutic drugs and biomedical applications.
- Explore and appreciate the diverse applications of proteins and enzymes in pharmaceuticals, biomedicine, and industrial processes through theoretical insights and hands-on experience.

SYLLABUS OF BIOMED-DSE- 13

Unit I: Protein Structure and Functional Regulation:

10 Hours

Structure and function of proteins: membrane proteins (Aquaporin 1, ABC Transporter Protein), structural proteins (Keratin/ Collagen), DNA-binding regulatory proteins (Leucine Zipper motif/ Zn-Finger motif, with examples). Functional Allostery: limited proteolysis and ligand binding, with appropriate examples. Structural cooperativity (including oxygen saturation curves of hemoglobin and myoglobin). Post-translational modifications: phosphorylation (Protein Kinase A) and glycation. Domain swapping in proteins.

Unit II: Protein Folding:

6 Hours

Introduction to Protein Folding: Levinthal Paradox, Anfinsen's Experiment, hydrophobic collapse. Functional and evolutionary significance of intrinsically disordered proteins. Molecular chaperones (structure and functional mechanisms of Hsp90, Hsp70, & Hsp40), Chaperonin (structure of GroEL-GroES system).

Unit III: Modern Techniques for Protein Characterization:

9 Hours

Manual protein sequencing (Edman Degradation, Sanger's Method), N-terminal and C-terminal analysis; Analysis of amino acid composition, Peptide mass fingerprinting (PMF), de-novo protein sequencing. Protein purification techniques: Isoelectric focusing (IEF), 2D-Gel electrophoresis and fast protein liquid chromatography (FPLC). Methods for determining protein stability (heat or chemical-induced denaturation).

Unit IV: Pharmaceutical & Industrial Applications of Proteins:

5 Hours

Use of proteins in industry: protease, amylase and cellulase as detergents, pectinase and xylanase in fruit drinks, alkaline phosphatase and HRP in protein detection; Pharmaceutical applications: therapeutic proteins (thrombin/growth hormones, vaccines); Medical research: Abzymes, enzyme replacement therapy, diagnostic and prognostic biomarkers. Bioethics in protein research.

Practical:

60 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. Salting out of proteins by Ammonium Sulphate Precipitation.
2. Desalting by dialysis.
3. Protein estimation by Bradford/BCA method
4. Tryptic digest of a given protein and analysis by SDS Polyacrylamide Gel Electrophoresis.
5. Protein estimation by using the molar extinction coefficient.
6. To study protein denaturation by urea and estimation of melting concentration (C_m).
7. Protein structure prediction using *in-silico* tools/approaches.
8. Project Practical: To visually score the changes in the structure of a protein due to mutations using Pymol or similar software. Examples: Mutation in Beta-globin gene in Sickle cell

anaemia and Cystic fibrosis transmembrane conductance regulator (CFTR) gene in cystic fibrosis. Similarly, more genes can be identified and analysed.

Essential Readings:

- Lehninger: Principles of Biochemistry (8th ed.). Nelson, D. L., & Cox, M. M. (2021). Macmillan. ISBN: 9781319322328.
- Biochemistry by Reginald H. Garrett, Charles M. Grisham; Ed. 6th; Cengage Learning, 2016.
- Biochemistry, by G., Stryer, L. and Tymoczko, J., Gatto, L. (2015) 8th Edition. New York, USA: W. H. Freeman and Company. ISBN-10 1464126100
- Fundamentals of Protein Structure and Function, Buxbaum Engelberg; Ed. 6th; Springer, 2015.

Suggested Readings:

- Biochemistry by Mary K. Campbell, Shawn O. Farrell; Ed. 8th; Cengage Learning, 2014.
- Proteins: Structure and Function; David Whitford; John Wiley & Sons, 2013.
- Biochemistry by Donald Voet and Judith G. Voet; Ed. 4th; John Wiley & Sons, Incorporated, 2012.
- <https://www.nobelprize.org/uploads/2024/10/advanced-chemistryprize2024.pdf>
- Proteins: Structures and Molecular Properties by Thomas E Creighton; Ed. 3rd; Freeman, 2010.

DISCIPLINE SPECIFIC ELECTIVE COURSE-14 (DSE-14)**ADVANCED 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		
Advanced Bioorganic Chemistry BIOMED-DSE-14	4	2	-	2	XII Passed	Basic knowledge of chemistry and biology

Learning Objectives:

The introduction of Advanced Bioorganic Chemistry course at undergraduate level to the students has been conceived to make them understand:

- Concepts of organic chemistry and its application in the field of medicinal chemistry and biology.
- Application of supramolecular chemistry and use of macromolecules in molecular diagnosis and therapeutics
- Different phases in clinical testing and new drug approval processes.

Learning Outcomes:

- After completing the course, students shall be able to understand the structure and function of different heterocyclic molecules and their use in modern day medicine, chemistry of stereoisomers and importance of asymmetric synthesis.
- Student will also learn and appreciate the polymer supported synthesis and its relevance in drug synthesis.
- They will also get insights into use of macromolecules and molecular frame work in molecular diagnosis and therapeutics.
- Student will learn rational drug design methods, various phase of clinical testing of drugs and process involved in new drug testing and approval.
- They will get grasp of industrially relevant insilico techniques useful for identification of suitable drug candidate during rational drug design.

SYLLABUS OF BIOMED-DSE-14

30 hours

Unit I: Heterocyclic Chemistry

(6 hours)

Aromaticity and Huckel rule, Active methylene groups, aldol and mixed aldol reaction, Michael addition and schiffs base reaction. Nomenclature and Reactivity of the five and six membered heterocycles, Pyrrole, Furan, thiophene, indole, oxazole, thiazole, Pyridine, Quinoline and Isoquinoline, Industrial methods for the synthesis of medicines involving heterocyclic compounds.

Unit II: Stereochemistry

(6 hours)

Optical activity, specific rotation, enantiomerism, D and L designation, racemic modification, R and S sequence rules, diastereoisomers. conformation of ethane and butane, inter conversion of projection formula, optical purity. E and Z nomenclature. Prochirality (enantiomer, diastereomer) Stereochemical aspects of drug action Strategies. Enantiotopic and diastereotopic faces, (endo and exo faces). Regioselective, enantioselective, stereoselective and stereospecific reactions, Walden inversion, syn and anti addition on double bond. Asymmetric synthesis (definition and its use in drug synthesis).

Unit III: Polymer-Supported Synthesis & Supramolecular Nanostructures

(8 hours)

(a): Introduction to Polymer Supported synthesis

Concept of combinatorial and mixed combinatorial synthesis, Limitations of combinatorial synthesis. Polymer supported organic reactions: different types of resins, protecting and deprotecting group, activating group coupling group (Merrified synthesis), Phase transfer catalysis.

(b): Applications of Synthetic macromolecules and Nanomolecules

Macromolecules and molecular framework (crown ether and supra molecular probes) in molecular diagnosis and therapeutic applications of supramolecular chemistry. Synthetic artificial systems that mimic biological entities. Nanomolecules and application in nanotechnology.

Unit IV : Drug Formulation, Release & Regulatory Framework

(10 Hours)

(a) Pharma-informatics : Drug discovery pipeline, Rational drug design methods, Optimization of lead compounds, Drug target identification and validation for microbial pathogen, Selection of gene unique to the pathogen/target, screening for its presence in other microbes and human host.

Various Databases to search for new molecules, calculating drug-like properties of molecules, virtual screening of the drug like compounds with biomolecule- such as receptor/protein using online tools, Pharmacophore generation- principle and methods, prediction methods of 3D structure of protein. Drug interaction with Protein.

(b) New Drug Approval Process and regulatory affairs : New Drug Approval processes and timelines, Preclinical testing, Clinical testing - Phase I, II, III and IV, Developing clinical trial protocols, Safety monitoring in clinical trials, Introduction of Drugs and Cosmetics Act (1940 and 1945) and patent act 1970. Process of patent filing- specifications, framing of claims and various forms.

Practical:

(60 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. Thin Layer Chromatography (mixture of 2 compounds)/(mixture of 3 compounds)
2. Perform Claisen Schmidt reaction and report yield
3. Perform Cannizarro reaction and report yield
4. Column chromatography using Silica gel to separate mixture of 2 compounds
5. Perform Schotten Baumann reaction and report yield
6. Carry the hydrolysis of ethyl benzoate and report the melting point and yield of benzoic acid
7. Prepare Semicarbazone derivative of one the following compounds: acetone, ethyl methyl ketone, diethylketone, cyclohexanone, benzaldehyde. and and report the melting point and yield of the product.
8. Determine the antioxidant activity of any compound by DPHH scavenging assay/FRAP assay.
9. Measurement of total phenolic content of any compound by Folin Ciocateu Method.
10. Synthesis and characterization of nanoparticles.
11. Finding the active sites in a receptor/proteins (eg glucose Dehydrogenase).
12. Molecular docking of ligand with receptor/protein (Glucose dehydrogenase) using AutoDock or HEX.

Essential Readings:

- Silverman, R. B. (2020). *Organic Chemistry of Drug Design and Action* (4th ed.). Academic Press. ISBN-13: 9780123820303.
- Patrick, G. L. (2021). *An Introduction to Medicinal Chemistry* (6th ed.). Oxford University Press. ISBN-13: 978-0198749691.
- March, J. (2020). *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure* (8th ed.). Wiley. Ed. 8th
- Kalsi, P. S. (2020). *Stereochemistry: Conformation and Mechanism* (6th ed.). New Age International Publishers
- Sengupta, A., & Sarkar, C. K. (2015). *Introduction to Nano: Basics to Nanoscience and Nanotechnology*. Springer.
- Lehn, J.-M. (1995). Supramolecular chemistry. *Chemical Reviews*, 71, 199–223.
- Stromgaard, K., Krogsgaard-Larsen, P., & Madsen, U. (Eds.). (2016). *Textbook of drug design and discovery*, Fifth Edition. United States: Taylor & Francis.
- Gu, J., & Bourne, P. E. (Eds.). (2011). *Structural bioinformatics*, Second Edition. John Wiley & Sons. ISBN: 9781118210567
- Finar, I. L. (2002). *Organic Chemistry: Volume 1* (6th ed.). Pearson Education.
- Finar, I. L. (2002). *Organic Chemistry, Volume 2: Stereochemistry And The Chemistry Natural Products* (6th ed.). Pearson Education
- Ashutosh Kar (2020) *Advanced Practical Medicinal Chemistry* 3rd Edition New Age International Private Limited.
- Vogel, A. I. *Practical Organic Chemistry* (5th ed.) Longman Group Ltd., 2012.
- V.K Ahluwalia and Sunita Dhingra, *College practical chemistry*, University Press (India) Ltd.

Suggested Readings:

- Rostron, C. (2020). Drug Design and Development. United Kingdom: Oxford University Press.
- Adejare, A. (Ed.). (2020). Remington: The Science and Practice of Pharmacy (23rd ed.).
- Bajorath, J., (2013) Chemo informatics for Drug Discovery, John Wiley & Sons.
- Jhoti, H., & Leach, A. R. (Eds.). (2007). Structure-based drug discovery. Springer Netherlands.
- Gasteiger, J., & Engel, T. (Eds.). (2006). Chemo informatics: a textbook. John Wiley & Sons.
- Leach, A. R. (2001). Molecular modelling: Principles and applications. Pearson Education.
- Ager, D. J., & East, M. B. (1996). *Asymmetric Synthetic Methodology*. CRC Press.
- Mahrwald, R. (Ed.). (2011). *Enantioselective Organocatalysed Reactions II*. Springer.

DISCIPLINE SPECIFIC ELECTIVE COURSE-15 (BIOMED-DSE-15)**ADVANCED TECHNIQUES IN FORENSIC 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 (if any)
		Lecture	Tutorial	Practical/ Practice		
Advanced Techniques in Forensic Science BIOMED-DSE-15	4	2	0	2	XII Passed	Basic Knowledge of Biological Science

Learning Objectives:

- Present forensic science course is designed for students to explore how forensic scientist's work, the tools and techniques they use and how they reach the conclusions they present in court.
- This will engage students in using a creative, problem solving and inquiry-based approach to investigate the crime scene and criminal profiling.
- Questioned document analysis will help students understand the ways of determining the authenticity of various documents.
- The course aims to cover different aspects of forensic science including forensic toxicology wherein a brief introduction will be provided on commonly used poisons in criminal cases and their detection methods.
- The course will explain different methods of individualization of a person like fingerprinting, blood profiling and DNA profiling.
- The marks of injury and the type of death will be used to correlate the events that might have occurred during a crime scene.
- Forensic anthropology is very useful in cases particularly where the victim's body is found quite late after the occurrence of crime and in an unidentifiable state.

Learning Outcomes

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

- The students are expected to learn the management and documentation of indoor and outdoor crime scenes. Simulation of a crime scene will familiarize them with situations during a crime scene investigation.

- Major security features in various educational documents, bank notes, cheques and other essential documents of identification.
- The identification of poisons commonly used for committing crime through biochemical tests and post mortem changes.
- The methods for individualization of human beings on the basis of their blood, fingerprint and DNA.
- The clinical features of different types of injuries and death to understand the cause of death.
- Overall the course will provide a platform to the students to take up Forensic Science course at their Master's level

SYLLABUS OF BIOMED-DSC-15

30 hours

Unit I : Crime Scene Investigation

(5 Hours)

Introduction and development of Forensic Science in India & Abroad, Pioneers in Forensic Science, 7 Principles of forensic science, Branches of forensic science. Motive of crime, *Modus operandi* and their role in criminal investigation. Methods of searching a crime scene (spiral, grid, line and quadrant search). Macro and microphotography of crime scene. Potential Evidences: Biological (blood, hair, urine, saliva, semen), physical (soil, fiber, bullet, cartridge, weapon), chemical (ink, dye, paint, explosive, drugs/alcohol) and psychological evidences (interview, interrogation, polygraph test reports). Introduction to Bhartiya Nyaya Samhita for the offences against a person.

Unit II : Forensic Investigation of Physical Evidence

(8 Hours)

(a): Examination of Questioned Documents

Preliminary examination of questioned documents: Handwriting, Forgeries, Age of Document & Alterations. Introduction to various security features in important documents (like water marks, intaglio and embossed printing, microprinting, holograms etc). Examination of documents like currency notes, stamp papers, mark sheets, Passports/Visas etc. Methods of examining questioned documents (imaging with visible, UV and IR light, electrostatic detection device, Raman spectroscopy)

(b): Types of Injuries and Death

Classification of injuries into Blunt-end (abrasions, contusions and lacerations) and Sharp-end (incision, stab, fracture). Different types of deaths (natural, accidental, suicidal and homicidal), manner of death (strangulation, drowning and drug overdose), modes of death (coma, syncope and asphyxiation) and their diagnosis. Medico-legal aspects of different types of injuries and deaths.

Unit III: Criminal Identification

(8 Hours)

Introduction to Criminalistics, Means of criminal identification by:

- Fingerprinting: Fingerprint as forensic evidence (Dactylography, Dermatoglyphic, and Dactyloscopy), Fundamental principles and classification of fingerprinting (latent, patent and plastic fingerprints). Unique features of fingerprints (minutiae). Physical and chemical methods of developing fingerprints.
- Preliminary Blood Examination: Various parameters of blood as forensic evidence (blood identification, blood grouping, blood typing, and analyzing patterns of blood spatter/splashes).

- DNA Profiling: Principle, methodology and applications of DNA profiling in criminal identification. Inheritance disputes, Paternity and infidelity testing. Lineage markers, DNA databanks and their utility in various criminal investigations.

Unit IV: Forensic Analysis of Biological Evidence

(9 Hours)

(a) : Forensic Toxicology

Importance, Role of a toxicologist, Difference between intoxicant (carbon monoxide, alcohol) and poison (arsenic, cyanide). Classification of poisons (metallic, gaseous, volatile, non-volatile, alkaloids, pesticides, animal based and vegetable based).

(b): Forensic Anthropology

Analysis of skeletal remains. Personal identification (age, sex, stature) by bones like skull, vertebral column and pelvic. Taphonomy (fossilization) to determine the time of death.

Practical

(60 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. Drawing and documentation of an artificially created indoor/outdoor crime scene by using drawing templates and taking field notes such as area of crime, victim's condition, all the evidences marked/acquired etc.
2. Micro and macrophotography of an artificially created indoor/outdoor crime scene and marking/labelling potential evidences such as fingerprints, murder weapon, traces of blood/hair/fiber and footprints etc.
3. Examination of important documents (currency notes, stamp papers, mark sheets, Passports/Visas) and their security features (like water marks, optically variable ink, micro-printing, intaglio printing) by oblique/UV light and digital microscopy.
4. Qualitative tests for detection of intoxicant alcohol by potassium dichromate or ceric ammonium nitrate and poison (chloroform) by aniline/pyridine based and/or arsenic by Marsh test using arsenic trioxide).
5. Determine the pattern and total ridge count (TRC) in individual fingerprints.
6. Preliminary blood analysis: detection by luminol/phenolphthalein and blood group analysis by kits.
7. RFLP based DNA profiling using a kit (includes steps like cutting of given DNA samples by restriction enzymes, separation of fragments on gel electrophoresis and comparison of bands for finding the correct match).
8. Mini / Microsatellite based DNA profiling; theoretical or kit based. (Students will be introduced to both southern hybridization-based method and also PCR based method).
9. Depiction of different types of injuries and death (as covered in the theory) through various pictures and videos.
10. Estimation of age and sex of victim's body by analyzing various features of the skull (like mandible, orbits, sagittal suture etc) and pelvis (like ischiopubic ramus bridge, subpubic angle, pubic symphysis etc).
11. Use of long bones for estimation of stature of the victim's decomposed body (using length of tibia, femur and humerus for correlation with height).

- 12 – 15. Case study presentations by students based on different modes of death (like strangulation, drowning, accident, blunt end injury, sharp incision, fire, firearm etc) and analysis of postmortem parameters.

Essential Readings:

- Archana Mahakalkar (2023). *Introduction to Basics of Forensic Anthropology (A Short-Focused Book)*. Walnut Publication. ISBN-13: 978-9359110851
- Mary H. Dudley (2021) 1st Edition. *Forensic medicolegal injury and death investigation*. Florida, USA: CRC Press. ISBN-13: 978-1032097688
- Richard, S. (2019). 4th Edition. *Forensic science: From the crime scene to the crime lab*. London, UK: Pearson Education, Inc. ISBN 13: 978-0-13-480372-2
- James, S.H. Nordby, J.J. and Bell, S. (2015). 4th Edition. *Forensic science: An introduction to scientific and investigative techniques*. Florida, USA: CRC Press. ISBN-13: 978-1439853832

Suggested Readings:

- Bardale, R. (2024). 4th Edition. *Principles of forensic medicine and toxicology*. New Delhi: Jaypee Brothers Medical Publishers. ISBN-13: 978-9350254936.
- Pankaj Shrivastava *et al.* (Ed). (2023) *Textbook of Forensic Science*. Springer Singapore. ISBN: 978-981-99-1376-3

DISCIPLINE SPECIFIC ELECTIVE COURSE -16 (BIOMED-DSE-16)**IMMUNE RESPONSE TO INFECTION AND 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)
		Lecture	Tutorial	Practical/ Practice		
Immune Response to Infection and Diseases BIOMED-DSE-16	2	2	-	2	XII Passed	Basic knowledge of Immunology and Microbiology

Learning Objectives

The students will learn:

- Molecular aspects of infections caused by various pathogenic microorganism followed by induction of host mediated immune responses.
- Defense evasive mechanisms adopted by the pathogen and their correlation with disease appearance and manifestation.
- Mechanisms associated with the generation of a huge diversity of T cell receptors and immunoglobulins from limited number of genes.
- Responses of the body during transplantation, cancer, hypersensitive reactions and autoimmune disorders.

Learning Outcomes:

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

- Mechanisms behind the infection and elimination of pathogens by various components of the immune system.
- Diversity of T cell receptors and antibody repertoire arisen by the different combinations of genes that can lead to detection of an enormous diversity of antigenic entities.
- Immune responses of the host during grafting and transplantation of tissues and suppression of the immune system in order to accept the graft.
- Most importantly, students will have an understanding about the different types of allergic reactions, onset of cancer from an immunological perspective, autoimmune disorders and their mechanisms.

SYLLABUS OF BIOMED-DSE-16:

(30 hours)

Unit I: Overview of the Immune System:

(4 Hours)

Components of the immune system: Innate immunity, adaptive immunity, humoral immunity and cell mediated immunity. Entry of bacteria and viruses through respiratory tract and gastrointestinal tract into the host, their establishment and infection. Factors influencing the pathogen load, role of complement and innate immune responses in early immune responses, adaptive immunity and its collaboration with innate immunity to counter pathogenic microorganisms. Lymphoid organs and their significance in immune responses.

Unit II: Mechanisms of Diversity of T cell repertoire and B cell repertoire–T Cell Receptor: Organization and Expression (6 Hours)

An introduction to cell mediated immunity, structure of TCR, germ-line organization of TCR gene segments, mechanism of TCR DNA rearrangements, assembly of rearranged TCR genes
B - Cell Receptor: Organization and Expression- An introduction to humoral immune response and role of innate immunity in the activation of humoral immune response, generation of antibody diversity, association of heavy and light chains. Class switching among constant region genes, expression of immunoglobulin gene, synthesis, assembly, and secretion of immunoglobulins as antibodies.

Unit III: Immune Response to Infectious Organisms (6 Hours)

Viral infections: Viral detection and neutralization by humoral immunity, cell mediated antiviral mechanisms, viral evasion of host defense mechanisms; with influenza virus as an example.
Bacterial infections: Immune responses to bacteria such as; *Salmonella typhi* and *Mycobacterium tuberculosis*, that causes typhoid and tuberculosis, respectively.
Parasitic diseases: Host responses to *Plasmodium* infection.

Unit IV: Immune Dysregulation & Clinical Immunology (14 Hours)

(a) Transplantation immunology

Concepts of MHC and role of HLA in tissue typing, Immunological basis of graft acceptance and rejection: Role of cell mediated responses, mechanisms involved in graft rejection. Clinical manifestations of graft rejection, general immunosuppressive therapy with cyclosporin A

(b) Hypersensitive Reactions:

Concepts of allergy, allergen and atopy. Type I-IV hypersensitive reactions and their molecular mechanisms with two examples each.

(c) Autoimmunity:

Organ specific autoimmune diseases (Myasthenia gravis), systemic autoimmune diseases (systemic lupus erythematosus and rheumatoid arthritis), mechanisms for induction of autoimmunity: Release of sequestered antigens and molecular mimicry.

(d) Cancer and the Immune System:

Immune responses to tumors: role of NK cells and macrophages, immune surveillance theory. Tumor evasion of the immune system: immunologic enhancement of tumor growth, modulation of tumor antigens, mechanism of immune evasion by tumors. Cancer immunotherapy

Practical (60 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 perform test for RA
2. Demonstration of immunoprecipitation
3. Analysis of antigen and antibody using immunoelectrophoresis
4. Perform quantitative precipitin assay
5. Demonstration of immunohistochemistry using kits
6. Identification and morphological characterization of various types of lymphocytes, macrophages, dendritic cells, neutrophils, basophils and mast cells using appropriate staining methods (Leishman staining, Giemsa staining etc.)
7. To perform Hemagglutination Reactions:
 - a. Rh Typing,
 - b. Coomb's test,
8. A visit to any regional vaccine/immunology institute to demonstrate the process of antisera production.

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
- 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.
- Cappuccino, J.G. and Sherman, N. (2013). 10th Edition. Microbiology: A laboratory manual. California, USA: Benjamin Cumming. ISBN-13: 978-0321840226.

Suggestive Readings:

- Willey, J. Sherwood, L and Woolverton, C.J. (2016). 10th Edition. *Prescott's Microbiology*. New York, USA: McGraw-Hill Education. ISBN-13: 978-1259281594.
- 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.
- 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.
- Tortora, G.J., Funke, B.R. and Case C.L. (2006). 9th Edition. Microbiology: An introduction. California, USA: Benjamin Cummings. ISBN-13: 978-0536292117.
- Hay, F.C. and Westwood, O.M.R. (2002). 4th Edition. *Practical Immunology*. New Jersey, USA: Blackwell Science. ISBN: 9780865429611.
- Pelczar, M.J (2001). 5th Edition. Microbiology. New York, USA: McGraw Hill International. ISBN-13: 9780074623206.

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

DISCIPLINE SPECIFIC ELECTIVE COURSE-17 (BIOMED-DSE-17)**MODEL ORGANISMS IN BIOMEDICAL RESEARCH**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Model Organisms in Biomedical Research BIOMED-DSE-17	4	2	0	2	XII Passed	Basic knowledge of Biological Science

Learning Objectives:

This course aims to give the students an introduction to different model organisms, fundamental discoveries made through these organisms, what they are used for, the techniques to modify their genome, and how the students may use these organisms employing modern technological approaches for research and understanding of biology.

Learning Outcomes:

After the completion of this course, students shall learn and appreciate:

1. The need to study model organisms ranging from unicellular to multicellular and complex higher order animals and their use in deciphering the mysteries of life.
2. Selection criteria of a model organism for any specific condition
3. Ethical issues related to studies on model organisms

SYLLABUS OF BIOMED -DSE- 17:**(30 hours)****Unit I: Introduction****(3 hours)**

Introduction to model organisms; need to study model organisms; criteria to choose appropriate model organisms for biomedical research; Ethical issues in using model organisms.

Unit II: Unicellular model organisms**(7 hours)**

Escherichia coli: Life cycle, Advantages and disadvantages as a model, It's use in understanding of the fundamental concepts of molecular biology such as replication, gene expression and protein synthesis through *E. coli*, Utilization in discovery of fundamental metabolic pathways and understanding of antibiotic resistance mechanisms.

Saccharomyces cerevisiae (Baker's yeast): Life cycle, Mating types and their inheritance, Culture conditions, Advantages and disadvantages as a model, Use of yeast in the discovery of cell cycle regulatory genes-*cdc* mutants, Yeast two hybrid systems for protein-protein interactions. Commonly used yeast assays, Overview of the Yeast Genome Deletion Collection.

Unit III: Invertebrate model organisms

(8 hours)

Caenorhabditis elegans (Nematode worm)

Life cycle, Maintenance, Advantages and disadvantages as a model, Overview of fundamental discoveries in programmed cell death (role of proteases- *ced* genes), Cell-fate mapping, lineage studies, Discovery of RNAi. Nobel prizes won by *C. elegans*. Use in study of ageing process. Genetic screening

Drosophila melanogaster (Fruit fly)

Life cycle, Maintenance, Advantages and disadvantages as a model, Overview of fundamental discoveries in genetics using fruit fly- TLR genes, development regulators, Nobel prizes won by *Drosophila*, Insights into forms of cancer and neurodegenerative diseases using *Drosophila*. The Gene disruption project, transgenic flies.

Unit IV: Vertebrate and Alternative Model Organisms in Biomedical Research (12 hours)

(a): Vertebrates model organisms

Danio rerio (Zebrafish): Life cycle, Maintenance, Advantages and disadvantages as a model, Overview of historical discovery of genetic control of early embryonic development, Zebrafish as a model for neurodevelopmental disorders and ecotoxicological studies, Introduction to tools for standard mutagenesis and Genetic screening.

Mus musculus (Mouse) and *Rattus norvegicus* (Rat)

Mouse vs rat w.r.t. physical features, age, size, weight, gestation period, weaning time and maintenance in animal house. Advantages and disadvantages of inbred and outbred species. “Premier” model organism for studying complex physiological processes and complex disorders such as infectious diseases (malaria) and non-infectious diseases (RA, diabetes, CVD, neurodegenerative disorders). Generation and application of knockout and transgenic mice as disease models. Applications in immunization, drug development and toxicology. Overview of the Knockout database.

Overview of other vertebrates model organisms commonly used in biomedical research- rabbit and guinea pig

(b): Introduction to other model organisms

Dictyostelium discoideum (Social amoeba) as a model for induced multicellularity and differentiation.

Daphnia (Water flea), ciliate and fish as models for ecotoxicological studies.

Practical

(60 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 induce artificial competence in *E.coli* and compare it with organisms having natural competence.
2. To explore Saccharomyces genome database (SGD)
3. To explore the Wormbase database to retrieve information for *ced9* for understanding *C. elegans* as a model organism
4. To investigate Flybase and retrieve information of any homologous gene for a Cancer to evaluate fruit fly as a suitable model organism.
5. To study SCN2A gene involved in neurodegenerative disorders through the MGI database (Mouse Genome Informatics).

6. To study genes involved in neurodevelopment using the Zebrafish Information Network.
7. To observe different mutants of Yeast
8. To observe different mutants of *Drosophila*
9. To observe different mutants of *C. elegans*
10. To select a suitable model organism for any given disease and design experiments to investigate the given hypothesis like deciphering the mechanism of a particular protein in the pathogenesis of a disease or progress of a disease, etc.

Essential Readings:

- Walz K et al. (2019), 1st edition, Cellular and Animal Models in Human Genomics Research. Elsevier, ISBN: 9780128165737
- Lodish H et al. (2021), 9th edition, Molecular Cell Biology. W H Freeman & Co., ISBN: 1319208525
- Experiments with *Drosophila* for Biology Courses: An e-resource book for laboratory experiments at under- and post-graduate levels and for research projects in Biology courses. Editor-in-Chief: S. C. Lakhota, Co-Editor: H. A. Ranganath. Indian Academy of Sciences, Bengaluru. March 2021, ISBN: 978-81-950664-2-1
- Tang, B., Wang, Y., Zhu, J., & Zhao, W. (2015). Web resources for model organism studies. *Genomics, proteomics & bioinformatics*, 13(1), 64–68. <https://doi.org/10.1016/j.gpb.2015.01.003>
- Westerfield, M. (2000). The zebrafish book. A guide for the laboratory use of zebrafish (*Danio rerio*). 4th ed., Univ. of Oregon Press, Eugene.

Suggested Readings:

- Hedrich, H., (2012) 2nd edition. The Laboratory Mouse, Elsevier, ISBN: 9780123820082.
- Wilson-Sanders, S.E. (2011), Invertebrate models for biomedical research, testing, and education). *ILAR J*, 52(2):126-52. doi: 10.1093/ilar.52.2.126.
- Yancheva et al. (2015), Fish in Ecotoxicological Studies, *Ecologia Balkanica*, Vol 7 (1), pp149
- Vilas-Boas, J.A., et al. (2020), Ciliates in ecotoxicological studies: A minireview, *Acta Limnol. Bras*, <https://doi.org/10.1590/S2179-975X6719>, Compendium of CCSEA
- Guide for the Care and Use of Laboratory Animals Paperback by National Research Council, National Academic Press; 8th edition (2010), ISBN-10: 0309154006, ISBN-13: 978-0309154000
- Eisenmann, D. M., Wnt signaling (June 25, 2005), *Worm Book*, ed. The *C. elegans* Research Community, WormBook, doi/10.1895/wormbook.1.7.1, <http://www.wormbook.org>.
- Handbook on Laboratory Animals by PV Desai and P Saravanan, Jaypee Brothers Medical Publishers (P) Ltd., 2nd edition (2015), ISBN 9789351529521
- Handbook of laboratory animal science: Essential principles and practices Hau, Jann; Schapiro, Steven Jay. 3rd edition (2011), CRC Press, ISBN:978-1-4200-8455-9

DISCIPLINE SPECIFIC ELECTIVE COURSE-18 (BIOMED-DSE-18)
ADVANCED MOLECULAR BIOLOGY AND GENETIC ENGINEERING

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
		Lecture	Tutorial	Practical/ Practice		
Advanced Molecular Biology and Genetic Engineering BIOMED-DSE-18	4	2	-	2	XII Passed	Basic knowledge of Biological Science

Learning Objective:

- The course aims to teach an in-depth understanding of how those basic principles are applied in developing advanced techniques, enabling students to analyze the genomes and proteomes of any organism.
- The students would gain perspective on the transition of applications of molecular techniques performed in prokaryotes to the complex eukaryotes.
- As the course progresses, students will gain proficiency in gene editing tools such as CRISPR-Cas9 in creating transgenic organisms and in genetic engineering; they will learn the importance of molecular interactions, including protein-protein protein-DNA interactions.
- Finally, students will be primed to the significance of responsible molecular biology research practices and understand the ethical, regulatory and social aspects of RDT and genetic engineering.

Learning Outcomes:

- Based on this learning, they will appreciate how the recombinant DNA technology, which provides the ability to isolate, manipulate and express genes derived from any cell type, is helpful in creating therapeutic genes and recombinant proteins in human medicines.
- In-depth understanding of transcription, translation, and post-transcriptional modification process.
- Understanding the applications of these molecular processes and comprehending the next-generation techniques used in genome sequencing and analysis.
- Understand and apply molecular techniques in producing transgenic organisms and recombinant proteins as therapeutics.
- Students would appreciate the recent advances in Molecular Biology, Genetic Engineering and advanced high throughput sequencing methods that are leading to whole genome

sequencing of diverse organisms, and creating recombinant proteins in human medicine.

SYLLABUS OF BIOMED -DSE-18

30 hours

Unit-I: Basic Understanding of Molecular Biology

(3 Hours)

Structure of DNA and its forms (duplex, triplex, quadruplex); Structure and versatility of RNA; Structure of Proteins; Formation of nucleosome, chromatin and genome structure; Replication, Mutation and Repair of DNA. Mechanisms of Transcription, RNA-splicing and Translation. The Genetic Code, Transcriptional Regulation in Prokaryotes and Eukaryotes, Regulatory RNAs.

Unit II: Genome Dynamics- Recombination and Transposable Elements (9 Hours)

Homologous Recombination in DNA –Strand invasion, Holiday Junction model and Double strand break and repair and various enzymes involved; Homologous recombination in eukaryotes; genetic consequences of recombination.

Site-Specific Recombination in DNA- Role of enzymes in Site Specific recombination - Tyrosine recombinases, gamma integrase, Hin recombinase

Transposition- Prokaryotic transposable elements- IS elements, Composite transposons, Tn-3 elements; Eukaryotic transposable elements- Ac-Ds system in maize and P elements in Drosophila; Uses of transposons; Eukaryotic Viruses.

Unit-III: Enzymes and Vectors used in recombinant DNA Technology (8 Hours)

Restriction Modification system; Introduction to rDNA technology: Molecular gene cloning by Gibson Assembly; Restriction and modification enzymes used in rDNA technology. Reverse transcriptase for cDNA synthesis

Prokaryotic and Eukaryotic Vectors for cloning & expression with one example each: Expression and purification of recombinant proteins using a therapeutic gene of interest as an example; Importance of fusion proteins. Importance of genome organization of λ bacteriophage for understanding cloning vectors. Yeast vectors and expression system.

Unit-IV: Applications of rDNA Technology in Genetic Engineering

(10 Hours)

- a. Construction of cDNA library: Preparation and cloning of cDNA, Applications of cDNA library. A comparative analysis of Northern hybridization & Microarray methods for studying transcriptomes; Phage Display and Immunoprecipitation for protein-protein interactions; South-Western hybridization and DNase-foot printing for DNA-Protein interaction
- b. Basic concepts of transgenic organisms: Role of reporter genes, CRISPR-CAS; Functional analysis of cloned genes in transgenics; Production of transgenic plants, animals and microbes with one example of each; Applications of transgenic animals.
- c. Production of recombinant proteins for their application in human medicine: Three generations of recombinant hormones as therapeutics with one example of each; Recombinant enzymes - Streptokinase synthesis and application in myocardial infarction.
- d. Vaccines: DNA vaccines and Reverse Vaccinology

- e. Ethical and legal concerns in transgenics and recombinant therapeutics: Ethical issues in genetic engineering, patenting genes, cloning, genetic testing & screening; The legal & socio-economic impact of Biotechnology; Biosafety regulatory framework for the production of genetically modified organisms (GMOs) & their release in the environment. Cartagena Protocol on biosafety.

Practical

60 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. Gene-specific Primer Designing for PCR-based cloning.
2. Based on the provided restriction map of a plasmid vector, selection of REs for restriction digestion experiment.
3. Double Restriction Digestion of a recombinant plasmid and analysis using agarose gel electrophoresis.
4. RNA isolation and gel electrophoresis.
5. Checking the methylation status of provided genomic DNA using isochizomers such as DpnI and DpnII.
6. Bacterial transformation with a yeast vector that serves as a shuttle vector.
7. To perform a zymogram to assay the activity of an enzyme using Native Gel Electrophoresis.
8. Application of PCR technique in Forensics
9. Mandatory Project on **anyone** of the following topics (group of 5 to 10 students):
 - 9a. PCR-based cloning of a prokaryotic gene and over-expression of the recombinant protein on SDS PAGE.
 - 9b. Construct the design of an experiment/flow chart of techniques and methods learnt in this paper (and previous papers, too) to find a solution in Gene Therapy/production of a recombinant protein/in forensic, etc.

Essential Readings:

- Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. (VI Edition); John Wiley & Sons. Inc.
- Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell.(VII Edition). San Francisco: Pearson Benjamin Cummings Publishing.
- Peter J. Russell. (2009). Genetics- A Molecular Approach. (III Edition). San Francisco, United States of America: Benjamin Cummings.
- 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: 978-0-321-76243-6.
- De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. (VIII Edition). Philadelphia: Lippincott Williams and Wilkins.
- Malacinski, George M.; Freifelder, David (1998). Essentials of Molecular Biology. (III Edition) Jones & Bartlett Pub.

- Brown, T. A. (2016). 7th Edition. Gene cloning and DNA analysis: An introduction. New York, 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.
- 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- 978168367368.

Suggested Readings:

- Kornberg, A. (2005). 2nd Edition. *DNA replication*. California, USA: University Science Books, ISBN-13: 978-1891389443.
- Cox, M. M. Doudna J. A. and Donnell, M. O. (2012). 1st Edition. *Molecular biology: Principles and practice*. London, UK: W H Freeman & Co Publishers, ISBN-13: 978-0-716-7998-8.
- 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.
- Winnaeker E. L. (1987). From Genes to Clones: Introduction to Gene Technology. Publisher VCH. ISBN - 0895734206, 9780895734204.
- D. M. Glower and B. D. Hames (1995). DNA cloning: A practical approach by IRL PRESS, Oxford. ISBN: 9780199634767.

**DISCIPLINE SPECIFIC ELECTIVE COURSE –19 (BIOMED-DSE-19) BRIDGING
ANCIENT MEDICINE AND PRACTICES WITH MODERN BIOMEDICAL RESEARCH**

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		
Bridging Ancient Medicine and Practices with Modern Biomedical Research BIOMED-DSE-19	4	2	-	2	XII Passed	Basic Knowledge of Biological Sciences

Learning Objectives

The Learning Objectives of this course are as follows:

- Students will be introduced to the field of ancient medicine including Ayurveda, Naturopathy and Yoga.
- Students will develop scientific and hands-on practical skills in investigating ancient medicine applications in modern biomedical research that will be useful for higher studies and research.

Learning Outcomes:

The Learning Outcomes of this course are as follows:

- Students will be introduced to the concept, scope and relevance of various ancient medical practices and the role of ancient medicine applications in modern biomedical research.
- Students will gain insights into the clinical applications of nutraceuticals, Yoga and basis of ethnopharmacological practices for drug development.
- Students will be able to appreciate the genomic context of ayurvedic classification.
- Students will learn to perform group project work to analyze the health benefits of Ancient traditional medicine

SYLLABUS OF BIOMED-DSE-19

(30 hours)

Unit I (a): Introduction to Ancient Medicine Knowledge

(4 hours)

Introduction and historical account of ancient medical practices including Ayurveda, Naturopathy and Yoga. Concept of Five elements (Pancha mahabhuta), Pancha kosha, Yoga sutras and Nature cure. Contribution of Charaka and Sushruta. Ayurvedic Pharmacopoeia of India, Traditional knowledge digital library, ICMR Research programmes on traditional medicine, WHO traditional medicine strategy.

Unit I (b): Ayurgenomics

(6 hours)

Tridosha theory of Ayurveda (Vata; Pitta; Kapha), Concept of Prakriti and Vikruti, Prakriti types (Vata; Pitta; Kapha; Vata/Pitta; Pitta/Kapha; Vata/Kapha; and Vata/Pitta/Kapha), Scientific explanation for Prakriti: Ayurgenomics (Integration of the principles of Ayurveda with the genomics), P4 medicine (four Ps are predictive, preventive, personalized, and participatory)

Case studies on expression levels of genes involved in immunity, cell division, blood coagulation, etc with respect to different Prakriti types, Studies on the Genetic Basis of Prakriti (high-altitude adaptation, rheumatoid arthritis, human leukocyte antigen), Studies on Physiology, Disease and Prakriti (Triglyceride, VLDL and LDL levels, Diabetes, Parkinson's disease), Epigenetics in Ayurveda.

Unit II: Health Benefits of Yoga

(6 hours)

Yoga Practices including postures (overview of asanas), breathing techniques (pranayama), meditation (dhyana/dharana), and relaxation for health promotion and therapeutics: Immune modulation (treating infectious diseases), headache, migraine, obesity, hyperthyroidism, diabetes, PCOD, hypertension (Savasana), anxiety and depression (Hatha Yoga), arthritis and cancer. Learning outcomes of experimental studies related to yoga in Mental Health, Stress, Cardiovascular Disease, Musco-skeletal disorders, Neurological Disorders, etc.

Unit III: Ethnopharmacology: Traditional medicine in modern drug discovery

(7 hours)

Introduction, scope and relevance. Quantitative and Comparative Methods in Ethnopharmacology (Materia medica and cultural consensus, Pharmacological research), Biodiversity, Conservation and Ethnopharmacology. Stages of ethnopharmacological research in drug discovery (ethnobotanical surveying and fieldwork/Screening and evaluation of traditional medicine, the pharmacological assessment of activity with diverse targets in the laboratory, and the transfer of results back to indigenous communities). Understanding the basis of ethnopharmacological practices for the development of early medicines using the examples of morphine, aspirin and digitalis. Recent drug discovery projects with ethnopharmacological association (Artemisinin for malaria, Prostratin as antiviral). Challenges in Ethnopharmacology (Biopiracy)

Unit IV: Nutraceuticals

(7 hours)

Introduction, scope and relevance. Difference Between Nutraceuticals, functional foods and Pharmaceuticals, Main categories of Nutraceuticals (Herbals, Nutrients and Dietary supplements), Ayurvedic Classification and Nutraceuticals- Classification of food according to the doshas (Vata, Pitta, and Kapha), Studying specific bioactive compounds in foods and herbs that target doshic imbalances (Ashwagandha for stress (Vata imbalance), Turmeric for inflammation (Pitta imbalance), Ginger for digestion and metabolism (Kapha imbalance). Research evidence based applications of nutraceuticals with examples related to neural (*Bacopa monnieri*, *Curcuma longa*), cardiovascular (flavanoid rich grapes, tea polyphenols), Diabetes (*Psyllium*, *Momordica charantia*) and renal disorders (*Tribulus terrestris*, Stevia). Nutraceuticals for health promotion, immune-boosting and protection. Adverse effects of Nutraceuticals.

Practical:

60 hours

Group project work to analyze the health benefits of Ancient traditional medicine

- Identification of Problem/Hypothesis through literature review (2 weeks)
- Questionnaire preparation (3 weeks)
- Survey after due ethical clearance/Data collection from published data or scientific literature (4 weeks)

- Data Analysis (4 weeks)
- Compilation and Presentation of results (2 weeks)

Essential Readings:

- Sebastian, T. (2024). Cell line studies in Ayurveda: Bridging ancient wisdom and modern science. *International Journal of Biological and Pharmaceutical Sciences Archive*, 7(1), 158-161. (DOI: 10.53771/ijbpsa.2024.7.1.0030)
- Mohan, S, Abdollahi, S, & Pathak, Y (Eds.). (2023). *Applications of Functional Foods and Nutraceuticals for Chronic Diseases: Volume I*. CRC Press. e-book ISBN: 9781003220053
- Heinrich, M, Jäger, AK (Eds.) (2015) *Ethnopharmacology*. Wiley. ISBN: 978-1-118-93074-8.
- Wiart, C (2007). *Ethnopharmacology of Medicinal Plants: Asia and the Pacific*. Netherlands: Humana Press. e-book ISBN: 9780429125263.
- Cosola C, Sabatino A, Di Bari I, *et al.* (2018) Nutrients, Nutraceuticals, and Xenobiotics Affecting Renal Health. *Nutrients*. (DOI: 10(7):808. (<https://doi.org/10.3390/nu10070808>))
- Huang Z, Chavda VP, Bezbaruah R, *et al.* (2022) An Ayurgenomics: A new approach in personalized and preventive medicine Development for Personalized Care. *Front Pharmacol*. 13:866827. (DOI: 10.36348/SIJB.2019.v02i10.001)
- Mukerji, M, & Prasher, B (2011). Ayurgenomics: A new approach in personalized and preventive medicine. *Sci Cult*, 77(1-2), 10-7.
- Khalsa, S B, Cohen, L, McCall, T, *et al.* (2016). *Principles and Practice of Yoga in Health Care*. United Kingdom: Jessica Kingsley Publishers. ISBN: 9781909141209.
- Basu-Ray I, Metri K, Khanra D, *et al.* (2022). A narrative review on yoga: a potential intervention for augmenting immunomodulation and mental health in COVID-19. *BMC Complement Med Ther.*, 22(1):191. doi: 10.1186/s12906-022-03666-2. PMID: 35850685; PMCID: PMC9289356.
- Bunn, M. (2010). *Ancient Wisdom for Modern Health: Rediscover the Simple, Timeless Secrets of Health and Happiness*. Australia: Enlightened Health Publishing.

Suggested Readings:

- Chakrabarti, D. (2024). *History of Ancient India (11 Volume Series)*. Sage Publications. New Delhi. ISBN: 9789353887009.
- PHOSP-COVID Collaborative Group (2022). Clinical characteristics with inflammation profiling of long COVID and association with 1-year recovery following hospitalisation in the UK: a prospective observational study. *The Lancet. Respiratory medicine*, 10(8), 761–775. (DOI: 10.1016/S2213-2600(22)00127-8)
- Wal P, Aziz N, Dash B *et al.* (2023) Neuro-nutraceuticals: Insights of experimental evidences and molecular mechanism in neurodegenerative disorders. *Futur J Pharm Sci*. 9, 31. (DOI: 10.1186/s43094-023-00480-6)
- Gupta R C, Doss R B, Garg R C, *et al.* (2021). Nutraceuticals for diabetes and glucose balance. In *Nutraceuticals* (pp. 83-100). Academic Press. ISBN: 9780128210383. (DOI: 10.1016/B978-0-12-821038-3.00006-9)
- Sosnowska B, Penson P, Banach M (2017) The role of nutraceuticals in the prevention of cardiovascular disease. *Cardiovasc Diagn Ther.* (Suppl 1):S21-S31. (DOI: 10.21037/cdt.2017.03.20)

- Ghani U, Naeem M, Rafeeq H, *et al.* (2019). A novel approach towards nutraceuticals and biomedical applications. Sch. Int. J. Biochem, 2, 245-252. (DOI: 10.36348/SIJB.2019.v02i10.001)
- Kim C H, Heinrich M, Yen H R, *et al.* (2023). Insights in ethnopharmacology: 2022. Frontiers in Pharmacology, 14. (DOI:[10.3389/fphar.2023.1264063](https://doi.org/10.3389/fphar.2023.1264063))
- Wallace R K (2020) Ayurgenomics and Modern Medicine. Medicina (Kaunas). 56(12):661. (DOI:[10.3390/medicina56120661](https://doi.org/10.3390/medicina56120661))
- McCall, T (2007). Yoga as Medicine: The Yogic Prescription for Health and Healing. United Kingdom: Random House Publishing Group.
- Pandomatti, S. C., Tyagi, I., Shrivastava, K. K., Mahajan, S., Patel, J., & Shinde, M. A. (2024). A Literature Review of the Integration of Ancient Indian Mythology in Clinical Medicine: A Holistic Approach to Health and Healing. Cureus, 16(7), e63779. (DOI: 10.7759/cureus.63779)
- Latest developments in associated fields through research articles. (https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=ayurveda+%2B+ayurgenomics+%2B+naturopathy+%2B+yoga+%2B+ethnopharmacology+%2B+nutraceuticals&btnG=)

B.Sc (Hons.) Biomedical Science
Pool of Generic Elective Papers

GENERIC ELECTIVE COURSE -05 (BIOMED-GE-05)

CONCEPTS IN 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		
Concepts in Medicinal Chemistry BIOMED-GE-05	4	3	-	1	XII Passed	Basic knowledge of Chemistry and Biology

Learning Objectives:

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

- Concepts of chemical science interlinked to other science disciplines such as chemistry, biology, biochemistry, pharmacology etc.
- Application of the area in revealing new drug design and targets through studying the drug-receptor interactions and lead discovery.
- Various drug targets in the body and drug development strategies.

Learning Outcomes:

- After completing the course, students shall be able to understand the structure and function of biomolecules, chemistry of stereoisomers and its importance in process of drug designing. 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.
- The students will be able to design and carry out small molecule (low molecular drug-relevant compounds) synthesis. They will understand the natural product isolation along with identification of their phytochemical constituents. They will also learn to identify biomolecules.

SYLLABUS OF BIOMED-GE-05

(45 hours)

Unit I: Introduction and Stereoisomerism

(16 Hours)

Importance of water as solvent, Partition coefficient, Drug dissolution, Acid-base properties, Henderson Hasselbach equation, Surface activity, Bio-availability, Hammett equation. Physicochemical Interactions-bonding and non-bonding interactions, Rational drug design and Introduction to SAR, Concept of prodrugs and Stereochemical aspects of drug action.

Optical isomerism: Optical activity, enantiomerism, D and L designation, racemic modification, R and S sequence rules, diastereoisomers, (2L), Geometrical isomerism: Definition, nomenclature– E and Z isomerism, Walden inversion, Conformational isomers: conformation of ethane and butane, Specific rotation, optical purity.

Unit II: Biomolecules

(8 Hours)

Amino Acids: Structure and classification of amino acids, ionization & titration curves and formation of peptide bond, cis and trans conformation and planarity. Ramachandran Plots (ϕ , ψ and ω), Secondary structure of proteins (α -helical, β -pleated sheet). Nucleotides: structure and numbering, Tautomerism in nucleic acid bases, pH and properties; Sugars and conformation of sugar phosphate backbone. Monosaccharides- cyclization of aldoses and ketoses, concept of mutarotation, anomers, epimers.

Unit III : Principles of Drug Action: Receptor Interactions & Target Classification

(a): Drug-Receptor Interaction

(8 Hours)

Kinetic analysis of ligand receptor interactions using Scatchard plot, Double reciprocal plot, Hill plot, Forces involved, Affinity, Efficacy and potency, Relationship between dose and effect (graded and quantal response). Concept of Enzyme inhibition and Michaelis equation. Drug distribution and Zero & First order kinetics, half life, Microsomes and drug metabolism-Phase I and Phase II enzyme

(b): Drug Target Classification

(8 Hours)

Drug Target Classification: Proteins as target: a) Classification of receptors and their functions and their activation/inhibition (such as Agonist, antagonists and inverse agonist) , Desensitization and sensitization of receptors. b) Enzymes as targets: Enzyme inhibitors (competitive, non-competitive, suicide inhibitors) Nucleic acids as drug targets: Classes of drugs that interact with DNA: DNA intercalators (amracrine) and DNA alkylators (amine: mechlorethamine, nitrosoureas: carmustine).

Unit IV: New Drug Approval Process and regulatory affairs

(5 Hours)

Investigational New Drug Applications (INDs): Approval processes and timelines involved, Preclinical testing, Clinical testing - Phase I, II, III and IV, Developing clinical trial protocols, Institutional Review Board / Independent Ethics committee - formation and working procedures, Informed consent process and procedures. Pharmacovigilance - Safety monitoring in clinical trials, Introduction of Drugs and Cosmetics Act (1940 and 1945) and patent act 1970. Process of drug patent filing- specifications, framing of claims and various forms.

Practical:**(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. Recrystallization of an organic compound (e.g., benzoic acid) and determination of its melting point.
2. Preparation of Hippuric acid/s-benzyl thiuronium salt/ Benzoquinone, recrystallization and characterization.
3. Phytochemical qualitative examination of *Curcuma Longa* constituents by solvent extraction (Tannins, Saponins, Flavanoids, Alkaloids, Polyphenols)
4. Conduct qualitative tests for amino acids/proteins: Ninhydrin, Xanthoproteic, Million's, Lead Acetate, Biuret test.
5. Prepare the titration curve of acetic acid/glycine.
6. Measure absorption spectrum of protein and DNA and calculate the purity of protein
7. Measure protein concentration using absorption spectrum (BSA)
8. Extraction of caffeine from tea leaves.
9. Study absorption property of caffeine using absorption spectroscopy.

Essential Readings:

- 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.
- Nelson, D. L. and Michael M. Cox (2021) 8th Edition. Lehninger Principles of Biochemistry. New Jersey, USA: Prentice Hall Publishers.
- Nasipuri, D. (2020), Stereochemistry of Organic Compounds: Principles and Applications, 4 th Edition, New Age International.
- Plummer, D. (2017) An Introduction to Practical Biochemistry, 3rd edition. McGraw-Hill College.

Suggested Readings:

- Wermuth, C. G., Aldous, D., Raboisson, P., & Rognan, D. (2015). *The Practice of Medicinal Chemistry* (4th ed.). Elsevier, Academic Press.
- King, F. D. (2003). *Principles and Practice of Medicinal Chemistry* (2nd ed.). The Royal Society of Chemistry
- Nogrady, T., & Weaver, D. F. (2005). *Medicinal Chemistry: A Molecular and Biochemical Approach* (3rd ed.). Oxford University Press

GENERIC ELECTIVE COURSE -14 (BIOMED-GE-14) PHARMACOLOGICAL 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 (if any)
		Lecture	Tutorial	Practical/ Practice		
Pharmacological Science BIOMED-GE-14	4	3	-	1	XII Passed	Basic knowledge of human physiology

Learning Objectives:

- This course focuses on the study of drugs and their application in treating various diseases. Students will gain knowledge about different drug formulations and their methods of administration within the body.
- The course covers the fundamental mechanisms through which drugs influence or modify physiological processes to achieve therapeutic effects.
- Additionally, students will develop an understanding of selecting and utilizing drugs to manage microbial infections and address diseases resulting from hormonal imbalances.

Learning Outcomes:

- Students will be introduced to the naming and formulation of drugs, the routes of drug administration, and the factors influencing the choice of one route over another in specific patient conditions.
- The course will cover fundamental concepts of drug absorption, transport, excretion, and the effects of metabolism on drug activity. Topics will include the quantification of drug half-life, bioavailability, and elimination, along with the factors that influence these processes. Students will also explore the primary macromolecular targets of drugs in the body, such as receptors and enzymes and gain insight into measuring drug response, efficacy, potency, and the variables affecting drug action.
- Additionally, students will learn about the mechanisms of action, side-effects and contraindications of various drug classes.
- The course will also address the selection and use of antimicrobial drugs, the challenges associated with their indiscriminate or inadequate use, and the therapeutic applications of hormones and hormone antagonists.

SYLLABUS OF BIOMED-GE-14

Unit I: Introduction to pharmacology

(10 hours)

Nomenclature of drugs (Generic, IUPAC and Proprietary name); Drug formulations- Powders, Liquids, Emulsions, Semisolid, Solid dosage forms and Aerosols; Routes of drug administration, their advantages and disadvantages, drug adverse effects.

Unit II: Pharmacokinetics and pharmacodynamics

(12 hours)

Pharmacokinetics: Drug absorption, distribution, metabolism, and excretion, bio-availability, Therapeutic window, Kinetics of elimination, biological half-life of drug.

Pharmacodynamics: Various macromolecular targets of drugs (membrane receptor, transporters, enzymes, channels etc.). Dose response curve, Therapeutic Index, Affinity, Efficacy, Potency, Agonist and Antagonist.

Unit III: Mechanism of action of different classes of drugs

(15 hours)

Mechanism of action, main side-effects and contraindications of the following drugs-

1. Antipyretics and Analgesics (Paracetamol and Ibuprofen)
2. Anti-inflammatory drugs (Aspirin, Celecoxib)
3. Sedatives (Diazepam)
4. Cholinergics (Bethanechol)
5. Adrenergics (Isoprenaline)
6. Oral hypoglycemic agent (Tolbutamide)

Unit IV : Pharmacotherapy: Antimicrobials and Hormonal Agents

(8 Hours)

(a): Anti-microbial therapy

General aspects of anti-microbial therapy, Antibacterial drugs (Ciprofloxacin), Antifungal drugs (Amphotericin B).

(b): Hormones as drugs

Brief introduction; Insulin and Insulin Analogues, Hormone Replacement Therapy (HRT), Estrogen and Progestins.

Practical:**(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. Handling and housing of laboratory animals.
2. Demonstration of different routes of drug administration using rat/mice.
3. Fixing of organ bath and kymograph
4. To record CRC of acetylcholine using guinea pig ileum/ rat intestine (virtually)
5. Study of competitive antagonism using acetylcholine and atropine.
6. Determination of dose ratio.
7. Study the effect of an analgesic by Tail-flick test.
8. Study of effect of an anti-anxiety drug using Plus Maze test.

Essential Readings:

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

Suggestive Readings:

- Katzung, B. G., (2021) Basic and Clinical Pharmacology, 15th Edition, McGraw-Hill Education, ISBN: 978-1260452310.
- 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.