दिल्ली विश्वविद्यालय
UNIVERSITY OF DELHI

Bachelor of Science (Hons) Biomedical Science

(Effective from Academic Year 2019-20)

Revised Syllabus as approved by

Academic Council

Date: No:

Executive Council

Date: No:

Applicable for students registered with Regular Colleges

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Preamble

The objective of any programme at Higher Education Institute is to prepare their students for the society at large. The University of Delhi envisions all its programmes in the best interest of their students and in this endeavour it offers a new vision to all its Under-Graduate courses. It imbibes a Learning Outcome-based Curriculum Framework (LOCF) for all its Under Graduate programmes.

The LOCF approach is envisioned to provide a focused, outcome-based syllabus at the undergraduate level with an agenda to structure the teaching-learning experiences in a more student-centric manner. The LOCF approach has been adopted to strengthen students' experiences as they engage themselves in the programme of their choice. The Under-Graduate Programmes will prepare the students for both, academia and employability.

Each programme vividly elaborates its nature and promises the outcomes that are to be accomplished by studying the courses. The programmes also state the attributes that it offers to inculcate at the graduation level. The graduate attributes encompass values related to well-being, emotional stability, critical thinking, social justice and also skills for employability. In short, each programme prepares students for sustainability and life-long learning.

The new curriculum of B. Sc. (Hons) Biomedical Science offers a comprehensive skill and the knowledge base for the students keeping in mind the employability of the students. The proposed syllabus has taken advantage of the credit system to gradually make the transition from simple to complex concepts relevant to the interdisciplinary nature of undergraduate program in Biomedical Science.

The University of Delhi hopes the LOCF approach of the B. Sc. (Hons) Biomedical Science programme will help students in making an informed decision regarding the goals that they wish to pursue in further education and life, at large.

1. Introduction to B.Sc. (Hons) Biomedical Science Programme

The B.Sc. (Hons) Biomedical Science was started as an interdisciplinary course at University of Delhi in 1999. The course has been very successful in terms of the career options taken up by the students after graduation over the years.

Over the years the course has been structured to reinforce the basic exposure that students get in the higher secondary school and to gradually build on this knowledge-base. The Core courses of the first two semesters are introductory courses in organic chemistry relevant to biology, biology of the cell, the basic building units of an organism, human physiology a glimpse at the orchestrated functioning of organ systems and the basic principles of genetics as seen in nature. In the second year the students would build on what is introduced in the I & II semesters; for instance, building on basic bioorganic chemistry the students will learn more about proteins, the work-horses of the cell running the biochemical factory. At the end of the second year, a student will have basic knowledge of cell biology, genetics, bioorganic chemistry, human physiology, biochemistry, medicinal chemistry, basic molecular and immunobiology. Along with this they will have hands-on training in medical lab techniques, epidemiological data analysis, tools used in forensic science and modern biology under the Skill enhancement courses (SEC). The concepts in pharmacology, toxicology, pathology and biophysics are vital to Biomedical Science and these are introduced in the final year of the course. In the third year, the courses include more complex concepts of mechanisms of achieving regulated functioning of the biological systems, biophysical principles of biological systems, human genetics, genome organization, medical biotechnology and biochemistry and some of the recent excitement in biology and the application of bioinformatics in Biomedical Science as part of Discipline specific elective (DSE) courses along with project work. One or two papers in the final year therefore have a longer list of learning material to be drawn from different sources; however, the actual length of the material for reading/teaching is minimal. This also introduces the students to resources for self-study.

The Generic elective (GE) courses are designed to give the essential exposure to the interdisciplinary nature of Biomedical Science. For example, biological chemistry, bioethics and biosafety, biostatistics, immunology, biotechnology, pharmacology and toxicology are combined into one paper, bioinformatics, IPR, pathophysiology combining human physiology in the context of diseases, tools and model organism in biomedical research are part of GE courses.

2. Learning Outcome-Based Approach to Curriculum Planning

2.1 Nature and Extent of the B.Sc. (Hons) Biomedical Science Programme

Learning outcomes-based curriculum framework for a B.Sc. degree in Biomedical Science is intended to provide a broad framework that responds to the needs of students and to the evolving nature of biology as a subject. The focus on outcomes creates a clear expectation of what needs to be accomplished by the end of the course. The present framework is intended to allow concept-based learning along with flexibility and innovation that enable transition towards application of the learnt concepts. The programme design and syllabi is abreast with the latest research and developments happening around the world. This helps the students to find a grip on the subject of his/ her choice and make dedicated efforts towards specific field of interest.

Biomedical Science focuses on how cells, organs and systems function in the human body; parameters governing them and attributes of gens and genetics. It is an exciting and dynamic area that is highly relevant to the understanding and treatment of human diseases and diagnostics. This course provides students with an intellectually stimulating education in modern molecular, cellular and systems biology along with Human Genetics, Medical Biotechnology, and a plethora of subjects like Biophysics, Toxicology, Human Pathology, Computational Biology and Drug Design, and Genome Organization and Function distributed over the three years of the course. The course structure essentially has varied components that play important role in an integrated understanding of biomedical science that allows students to subsequently shape their future studies towards the topics that interest them the most. Laboratory work forms an integral part of all the course offered in the programme.

2.2 Aims of the B.Sc. (Hons) Biomedical Science Programme

The overall aim(s) of the Bachelor's degree in Biomedical Science are:

(i) To help develop an inherent interest in the field of Biomedical Science. The course aims to enhance understanding of key concepts, theories and principles that will help them to find answers to challenges being faced today in Biomedical Science. The course will help the students develop a broad base understanding of various fields that the bachelor's degree opens up for them, so that they can take up their field of specialization in higher studies.

(ii) To help students to develop thinking and application skills to apply the knowledge thus gained in finding practical solutions to present day challenges.

(iii) To inculcate true scientific temperament in students, such that they apply their knowledge in interdisciplinary fields like Bioinformatics, Biophysics, and Data Science.

3. Graduate Attributes in Subject

Disciplinary knowledge

The course is an amalgamation of various fields of modern life science and provides basic knowledge of functioning of human body. The course also provides insights into mechanisms for normalizing altered functions of the body such as under pathological conditions by use of therapeutic xenobiotics or drugs. In addition, it also inculcates fundamentals of physics and chemistry necessary for development of a deeper understanding of molecular mystery of life.

Communication Skills

The course structure provides a systematic way of communicating scientific phenomena both oral and written, thereby facilitating expression skills. The precision in communication is instilled through seminars, presentations, viva and discussions.

Critical Thinking

The course curriculum indoctrinates the ability to critically evaluate the body of knowledge, formulate arguments, asses the present evidence, understand the implicit assumptions and then crystallize a concept or form an opinion.

Problem Solving

The curriculum would help students to get exposed to scientific skills, such as development of hypothesis and interpreting data. Helping students to acquire these skills would facilitate them to solve complex problems and generate innovative ideas.

Analytical Reasoning

The multidisciplinary design of the course enables learners to develop rational thinking with reference to the taught phenomena, life-process, etc. from various points of view. The interactive mode of teaching and hands-on sessions further refines their analytical skills.

Research-Related Skills

The course curriculum exposes students to basic disciplines as well as applied fields which gives a wholesome academic exposure. The inclusion of short-term research projects in the curriculum ensures students develop the capability to inquire, analyze, ask questions and identify cause and effect relationship, outline problem build hypothesis, collect data, infer, interpret and formulate an opinion. This sharpens their research skills and helps develop scientific temperament.

Cooperation/ Team Work

The course structure and its experimental curriculum ensure coordinated efforts amongst the students as a group. The co-action and synergism within the students for common goals builds a team spirit which nurtures tolerance and understanding.

Scientific Reasoning

After studying the course, students will be clear that most of the discoveries in the field are using well-structured protocols. Students would become more inquisitive, ready to do experimentation, collect evidences and draw inferences on a routine basis.

Reflective Thinking

Curriculum would promote emotionality supportive environment for students. Moreover, it would provide an environment that prompts students to explore what they think is important. Students will be able to develop strategies to apply new knowledge for complex situations. Ability of students to review their course work would substantially increase their problem-solving skills.

Information/ Digital Literacy

In addition to "Face-to-face" education, E-learning skills would help students understand concepts in a better way. These skills would help them with their own presentations and assignments and help them with their timelines. Peer learning using ICT skills would also make them connected with society. Considering the fact that ICT skills are now widespread in all fields, college graduates with these skills would be in great demand by employers in many sectors.

Self-Directed Learning

Students would be intrinsically motivated towards self-learning. This would help them cultivate their networks to learn effectively and would know how to be self-reliant. Students would readily embrace responsibility for doing good work and ready for growth mindset. Moreover, they would not be easily thwarted when their going gets tough.

Moral and Ethical Awareness/ Reasoning

The curriculum inculcates different aspects of moral and ethical values in students such as ethics in laboratories and animal- handling, and plagiarism related issues. Such training makes them responsible citizens and good human beings.

Lifelong Learning

The course curriculum teaches the students to keep themselves abreast with the current developments in different disciplines in order to have a comprehensive scientific knowledge which provides a base for all the future endeavours. The students thus develop a self-directed lifelong learning in conjunction with the contextual environment to remain relevant and progressive.

4. Qualification Descriptors for Graduates

Through the academic standards and generic outcomes for the award of B.Sc. (Hons) Biomedical Science, the student should be able to demonstrate:

i) an integrated grasp of the core and discipline specific subjects covered in Biomedical Science through stories of discovery and rigour of experiential learning;
ii) how to access, create and analyze knowledge and data, stitch diverse concepts and apply in the management of human diseases, public health and related areas;
iii) appreciation for interdisciplinary skills as the key theme in thinking, comprehending and solving the local and global issues in the area of biomedical research and development;
iv) extensive laboratory, analytical and problem-solving skills gained through elaborate and meticulously planned experiments;
v) an aptitude for research, academia and industry;
vi) how to do literature search, retrieve information on current research available online or in print, use and include open source tools for learning and in short-term projects relating to essential and advanced areas in Biomedical Science;
vii) experimental skills and their application required for identifying problems and issues relating to the disciplinary area and field of study;
viii) communication skills though making presentations (oral or written), writing reports and expressing their science ideas through a technical note/design or via an art form;
ix) confidence and a curiosity driven quest to work in large teams at national and international platforms and/or execute a research project/task independently and
x) the ability to extrapolate/draw inferences and direct the acquired knowledge and transferable skills to real-life research questions as well in areas such as industry, management, scientific communication etc.

5. Programme Learning Outcomes

The expected learning outcomes that an undergraduate student of B.Sc. (Hons) Biomedical Science should be able to demonstrate for the award of the qualification may include the following:

i) Demonstrate fundamental knowledge and understanding of the principles and processes underlying various inter-disciplinary subjects related to Biomedical Science, e.g. physiology, cell biology, biochemistry, biotechnology, computational biology, genetics, molecular biology, medicinal chemistry, toxicology, pharmacology, microbiology, etc.
ii) Apply appropriate methodologies for planning and executing experiments related to different aspects of life sciences. Also analyze and interpret the results of the experiments performed.
iii) Ability to reason scientifically and analytically.
iv) Undertake hands-on lab work and practical activities which develop problem solving abilities, required for careers in research.

6. Teaching-Learning Process

The programme of study in Biomedical Science is designed to encourage the acquisition of disciplinary/ subject (core, interdisciplinary) knowledge, understanding experimental research, academic and professional skills required for life sciences, biomedical science and biotechnology-based professions both in industry and academic jobs. Learning experiences both practical based and classroom teaching should be designed and implemented to foster active/ participative learning. Development of practical skills will constitute an important aspect of the teaching-learning process. A variety of approaches to teaching-learning process, including lectures by faculty, eminent scientists, student seminars, tutorials, workshops, peer teaching and learning, practicum and project-based learning, field-based learning, substantial laboratory-based practical component and experiments, open-ended project work, games, quizzes, technology-enabled learning, internship in industry and research establishments etc. will need to be adopted to achieve this. Problem-solving skills and higher-order skills of reasoning and analysis will be encouraged through teaching strategies.

7. Assessment Methods

Different assessment methods that are appropriate to Biomedical Science course will be used to assess progress towards the course/ programme learning outcomes. Progress towards achievement of learning outcomes will be assessed using the following:
Semester end examinations as conducted by the University; problem-based assignments; closed-book and open-book tests; observation of practical skills; laboratory records; project reports; case-study reports; oral presentations, including seminar presentation; viva-voce interviews; computerized adaptive testing; peer and self-assessment etc. and any other pedagogic approaches.

8. Structure of B.Sc. (Hons) Biomedical Science

8.1. Credit Distribution

The B.Sc. (Hons) in Biomedical Science programme is a three-year course divided into six-semesters. A student is required to complete 148 credits for the completion of course and the award of degree.

Course Credit Scheme

Semester	**Core Course (CC) (6 Credits/ Paper)**			**Skill-Enhancement Elective Course (SEC) (4 Credits/ Paper)**			**Discipline Specific Elective (DSE) Course (6 Credits/ Paper)**			**Generic Elective (GE) Course (6 Credits/ Paper)**			**Total credit/ Semester**
	No. of Papers	Credits (L+P)	Total Credits	No. of Papers	Credits (L+P)	Total Credits	No. of Papers	Credits (L+P)	Total Credits	No. of Papers	Credits (L+P)	Total Credits	
I*	2	8+4	12	0	-	-	0	-	-	1	4+2	6	**22***
II*	2	8+4	12	0	-	-	0	-	-	1	4+2	6	**22***
III	3	12+6	18	1	2+2	4	0	-	-	1	4+2	6	**28**
IV	3	12+6	18	1	2+2	4	0	-	-	1	4+2	6	**28**
V	2	8+4	12	0	-	-	2	8+4	12	0	-	-	**24**
VI	2	8+4	12	0	-	-	2	8+4	12	0	-	-	**24**
Total	14	56+28	**84**	2	4+4	**8**	4	16+8	**24**	4	16+8	**24**	**148***

*Students will have two papers of 4 credits each of Ability Enhancement Compulsory Course (AECC- English/ MIL and EVS) one in each semester.

For Theory (L): 1Credit = 1hour lecture and there will be 4 lectures/ week. For Practical (P): 1 Credit = 2 hours and there will be 4 hour-session/ week.

8.2 Semester-wise Distribution of Courses

SEMESTER I		SEMESTER II	
C1	Bioorganic Chemistry	**C3**	Principles of Genetics
C2	Cell and Radiation Biology	**C4**	Human Physiology and Anatomy I
AECC1	English/MIL Communication or EVS	**AECC2**	EVS or English/MIL Communication
GE1	Generic Elective	**GE2**	Generic Elective

SEMESTER III		SEMESTER IV	
C5	Biochemistry	**C8**	Immunobiology
C6	Human Physiology and Anatomy II	**C9**	Molecular Biology
C7	Medical Microbiology	**C10**	Medicinal Chemistry
SEC1	Skill-Enhancement Elective Course	**SEC2**	Skill-Enhancement Elective Course
GE3	Generic Elective	**GE4**	Generic Elective

SEMESTER V		SEMESTER VI	
C11	Biophysics	**C13**	Human Pathology
C12	Pharmacology	**C14**	Toxicology
DSE1	Discipline Specific Elective	**DSE3**	Discipline Specific Elective
DSE2	Discipline Specific Elective	**DSE4**	Discipline Specific Elective

C: Core Courses; **AECC:** Ability Enhancement Compulsory Course; **SEC:** Skill-Enhancement Elective Courses; **DSE:** Discipline Specific Elective; **GE:** Generic Elective

SEC 1-2: Skill-Enhancement Elective Courses (any one per semester in semesters 3-4)

1. Methods in Epidemiological Data Analysis (EDA)
2. Medical Laboratory Diagnostics (MLD)
3. Techniques for Forensic Science
4. Tools in Modern Biology

DSE 1-4: Discipline Specific Elective (any two per semester in semesters 5-6)

1. Computational Biology and Drug Design
2. Genome Organization and Function
3. Human Genetics
4. Medical Biochemistry
5. Medical Biotechnology
6. Project Work (can be chosen only in semester 6)

GE 1-4: Generic Electives (any one per semester in semesters 1-4)

1. Basics of Immunology
2. Biological Chemistry
3. Biosafety and Bioethics
4. Biostatistics
5. Bridging Information Technology and Biotechnology
6. Concepts in Biotechnology
7. Concepts in Medicinal Chemistry and Drug Development
8. Intellectual Property Rights (IPR) for Biologists
9. Pathological Basis of Diseases
10. Pharmacology and Toxicology
11. Tools and Model Organisms in Biomedical Research

9. Courses for Programme

Core Courses (CC) (Theory + Practical)

Semester I
Bioorganic Chemistry
Cell and Radiation Biology

Semester II
Principles of Genetics
Human Physiology and Anatomy I

Semester III
Biochemistry
Human Physiology and Anatomy II
Medical Microbiology

Semester IV
Immunobiology
Molecular Biology
Medicinal Chemistry

Semester V
Biophysics
Pharmacology

Semester VI
Human Pathology
Toxicology

B.Sc. (Hons) Course in
Biomedical Science
I Year
Semester I and II

Semester I
Bioorganic Chemistry
(Unique Paper Code: 32581101)
Core Course- (CC) Credit: 6

Theory **Total Lectures: 48**

Course Objective

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

Course Learning Outcomes

The student at the end of the course will be able to understand

Unit-I: Aqueous Solutions
The concept of pH and its effect on structure of biomolecule. The application of Henderson-Hasselbach equation. The structure and role of zwitter ion and isoelectric point of proteins.

Unit-II: Concept of Acids and Bases
Explain the different acid-base theories and concept of leveling solvent

Unit-III: Chemical Bonding and Molecular Forces
Describe chemical bonding and its role in biological systems. Identify and differentiate various inter and intra molecular forces and their effect on structure of different biomolecules.

Unit-IV: Stereochemistry
Identify, assess and analyze different types of stereoisomers and their properties in organic compounds and biomolecules

Unit-V: Introduction to Biomolecules
Explain the structures and function of biomolecules (carbohydrates, amino acids, lipids and nucleotide)

Unit-VI: Biologically significant name reactions
To understand the mechanism of biologically significant name reaction and their role in biological systems.

Course Content

Unit-I: Aqueous Solutions (L1-L6)
Water, pH and buffers, concept of pKa (titration curves of amino acids), Henderson-Hasselbach equation, buffering zone, buffer index, concept of pI and zwitter ion.

Unit-II: Concept of Acids and Base (L7-L8)

Arrhenius concept, Bronsted Lowry concept, Lewis concept, the levelling effect, effect of pH on the structure of biomolecules.

Unit-III: Chemical Bonding and Molecular Forces (L9-L14)

Introduction to ionic interactions and covalent bond, inter-molecular and intra-molecular forces, types of intermolecular forces and their characteristics: ion-dipole, dipole-dipole, dipole-induced dipole and dispersion (London) forces, hydrogen bond (intra-molecular and inter-molecular), effect of inter/intra-molecular forces on structure of different biomolecules.

Unit-IV: Stereochemistry (L15-L22)

Optical isomerism: Optical activity, specific rotation, enantiomerism, D and L designation, racemic modification, R and S sequence rules, diastereoisomers.

Conformational isomers: conformation of ethane and butane, interconversion of projection formula, cyclohexane (mono- and di-substituted), resolution, optical purity.

Geometrical isomerism: Definition, nomenclature– E and Z.

Unit-V: Introduction to Biomolecules

Carbohydrates: (L22-L27)

Monosaccharides- cyclization of aldoses and ketoses, conformations, concept of mutarotation, anomers, epimers.

Disaccharides- structure, reducing and non-reducing sugars.

Polysaccharides- Starch, glycogen and cellulose.

Lipids: (L28-L29)

Fatty acids, triacylglycerols, steroids (cholesterol)

Amino Acids: (L30-L35)

Structure and classification of amino acids, ionization, chemistry of peptide bond, non-ribosomal peptide bond formation, essential and non-essential amino acids, amino acids as precursors of other bioactive compounds, zwitterion, isoelectric point, optical properties of amino acids, Definition of a peptide, peptide unit, peptide group, bond length, cis and trans conformation, primary, secondary (alpha helix, beta sheet, beta turn, collagen helix), tertiary and quaternary structures (with examples).

Nucleotides: (L36- L40**)**

Sugars and Bases, conformation of sugar phosphate backbone, hydrogen bonding by bases, tautomers of bases

Unit-VI: Biologically significant name reactions (L41-L48)

Aldol (Glucogenesis), retro-aldol (Glycolysis), benzoin condensation (umpolung-decarboxylation of pyruvate in the presence of TPP), Claisen condensation (synthesis of fatty acids), Michael addition (Dehydrases), Cannizzaro (Sugar metabolism), Bayer Villiger reaction (FAD dependent ketone synthesis), Pinacol-pinacolone rearrangement (1,2-carbon carbon shift),

Practical

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

1. Preparation of solutions based on molarity, normality, percentage, dilutions etc.
2. Preparation of buffers.

3. Estimation of Mohr's salt/ oxalic acid by titrating with $KMNO_4$.
4. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.
5. Qualitative tests for carbohydrates to identify the given unknown carbohydrate solution: Mohlisch, Barfoed, Fehling/ Tollen/ Benedict, Selvinoff, Osazone, Bial's tests.
6. To determine the Iodine number of the given oil/ fat.
7. To find pKa value of given acetic acid/ amino acid.
8. Absorption spectrum of DNA/ Protein

References

Essential Readings for Theory and Practical

1. Eliel, L. (1975). 1st Edition. *Stereochemistry of carbon compounds*, New York, USA: Tata McGraw Hill. ISBN-13: 9780070992900.
2. Finar, I. L. (1996) 6th Edition (volume I and II). *Organic chemistry*. London, UK: ELBS, Longman Higher Education. ISBN-13: 978-0582305601.
3. Khosla, B.D. (2006). 12th Edition. *Senior practical physical chemistry*. R. Chand & Co. India. ISBN-13: 9788180450792.
4. Lee, J. D., (1999). 5th Edition. *Concise inorganic chemistry*, New Jersey, USA: Wiley-Blackwell. ISBN-13: 9780632052936.
5. Morrison, R. T. and Boyd R. N. (1992) 6th Edition. *Organic chemistry*. London, UK: Pearson Education. ISBN-13: 9780136436690.
6. Nelson, D. L. and Michael M. Cox (2008) 5th Edition. *Lehninger principles of biochemistry*. New Jersey, USA: Prentice Hall Publishers. ISBN-13:978-0321707338.
7. Plummer D.T. (1987). 3rd Edition. *An introduction to practical biochemistry*. New York, USA: McGraw-Hill College. ISBN-13: 978-0070841659.
8. Vogel A.I. (2000). 6th Edition. *Vogel's quantitative inorganic analysis*. New Jersey, USA: Prentice Hall. ISBN-13: 978-0582226289.

Suggested Readings

1. Berg, J. M., Tymoczko J. L. and Stryer L. (2006) 6th Edition. *Biochemistry*. New York, USA: W. H. Freeman and Co. ISBN-13: 978-0716787242.
2. Campbell, M. K. and Farrel, S. O. (2003) 4th Edition. *Biochemistry*. Boston, USA: Brooks/Cole Cengage Learning. ISBN: 0030348498.
3. Dugas, H. (1999) 3rd Edition. *Bioorganic chemistry*. New York, USA: Springer Verlag. ISBN-13: 978- 0387989105.

Teaching learning process

1. Use of blackboard and chalk method to communicate the concepts.
2. Use of Power Point presentations to visually explain various processes.
3. Verbal explanation, seminars, case studies, workshops and open discussions.
4. Quizzing and questioning.

Teaching learning Plan

Unit	Title	Lectures
I	Aqueous Solutions	(L1- L6)
II	Concept of Acids and Bases.	(L7-L8)
III	Chemical Bonding and Molecular Forces	(L9-L-14)
IV	Stereochemistry	(L15-L22)
V	Introduction to Biomolecules	(L23-L40)
VI	Biologically significant name reactions	(L41-L48)

Assessment Methods

1. Written class tests and assignments
2. Quizzing/ viva, Problem solving exercises
3. Seminar presentations
4. Final University Examination

Keywords

pH, Henderson Hasselbalch equation, zwitterion, isoelectric point, enantiomers, diastereoisomers, conformers, biomolecules, carbohydrates, amino acids, proteins, nucleotides, name reactions.

Semester I
Cell and Radiation Biology
(Unique Paper Code: 32581102)
Core Course (CC) - Credit: 6

Theory **Total Lectures: 48**

Course Objective

1. The objective is to offer detailed knowledge about the cell, including their composition, function, various cellular organelles, cell's cytoskeleton, cell division and cell-cycle checkpoints, and the signal transduction pathways associated with the cellular processes of the cells.
2. The course also aims to help the students to explore and gain insight into radiation induced biological responses at molecular, cellular and tissue levels.

Course Learning Outcomes

Unit-I: The Cell
Students will learn about cell theory, cell cycle mechanisms and role of Mitosis and Meiosis.

Unit-II: Cell Membrane and Membrane Transport
Students will acquire insight into the processes of transport across cell membranes, process of endocytosis and exocytosis.

Unit-III: Cell Organelles
Students will learn the structure and function of various cell organelles in detail and protein sorting and targeting.

Unit-IV: Cell Junctions and Cytoskeletal Elements
Students will understand cell junctions and cytoskeleton elements.

Unit-V: Cell Cycle and Overview Of Cell Signaling
Students will gain knowledge about an overview of cell signalling and various cellular signal transduction pathways.

Unit-VI: Radiation Biology
Students will also gain insight into radiation-induced biological responses at molecular, cellular and tissue levels. The course also covers knowledge of applications of radiations in biomedicine and radiation bio-safety.

Course Content

Unit-I: The Cell (L1- L2)
Historical background, significant landmarks, cell theory, structure of prokaryotic and eukaryotic cells, mycoplasma, viruses, viroids, prions.

Unit-II: Cell Membrane and Membrane Transport (L3– L11)

Functions, different models of membrane structure, types of membrane lipids, membrane proteins: types, methods to study membrane proteins (detergents, RBC ghosts), RBC membrane as a model, membrane carbohydrates, membrane asymmetry and fluidity, lipid rafts.

A. Transport of small molecules: Passive transport (simple diffusion and facilitated diffusion) and active transport and their types (P, V, F and ABC transporter) with example of Na+/K+ pump.

B. Transport of macromolecules: Endocytosis (pinocytosis, phagocytosis), exocytosis.

Unit-III: Cell Organelles (L12– L25)

Structure and functions of various organelles:

A. Nucleus: Different components, nuclear envelope- its structure, pore complex, nucleocytoplasmic interaction (NLS and NES), nucleolus- structure and functions.

B. Chromosome: Structure- centromere and telomere, types of chromosomes based on centromere, diversity in structure and significance of polytene and lampbrush chromosomes, mitosis and meiosis: different phases and their significance.

C. Endoplasmic reticulum: RER- Biosynthesis and processing of proteins, co-translational and post-translational transport of proteins, signal hypothesis, protein sorting. SER- detoxification, biosynthesis of membrane, carbohydrate metabolism, steroid synthesis.

D. Golgi apparatus: Golgi stack (cis, trans and medial cisternae), flow of proteins through Golgi body, glycosylation and protein sorting.

E. Lysosomes: Development of different forms of lysosomes, role in cellular digestion, lysosomal storage diseases- Hurler syndrome, Hunter syndrome, Tay-Sachs disease and Inclusion cell disease (I-cell disease).

F. Peroxisomes: Assembly, functions- H2O2 metabolism, oxidation of Fatty acids, glyoxysomes.

G. Mitochondria: Detailed structure, endosymbiotic theory, its genome and functions in brief.

H. Chloroplast: Detailed structure, its genome and functions in brief.

Unit-IV: Cell Junctions and Cytoskeletal Elements (L26– L31)

Basics concepts of anchoring junctions, tight junctions, communication junctions (gap junction and plasmodesmata).

Structure, assembly and functions of:

A. Microtubules: Axonemal and cytoplasmic microtubules (cilia, flagella, centrioles, basal bodies).

B. Microfilaments: Globular and filamentous actin, general idea about myosin.

C. Intermediate filaments: Different classes.

Unit-V: Cell Cycle and Overview of Cell Signaling (L32– L37)

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

Unit-VI: Radiation Biology (L38– L48)

A. Introduction to radiation biology: Introduction of radiations, basic concept of radioisotopes, types of radioactive decay (gamma and beta emitter), half-life.

B. Biological effects of radiation: Effects of Ionizing and non-ionizing radiation on cells, acute, delayed and late radiation effects (with particular reference to nervous system, gastrointestinal

and hematopoietic syndrome).
C. Application in biomedicine: Use of radioisotopes in biology, autoradiography, radioisotopes in diagnosis (thyroid disorders, cancer) and therapy (radiotherapy).
D. Radiation biosafety: Precautions and safety measures in handling radioisotopes.

Practical

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

1. Microscopy- Theoretical knowledge of Light and Electron microscope.
2. To study the following techniques through electron/ photomicrographs: fluorescence microscopy, autoradiography, positive staining, negative staining, freeze fracture, freeze etching shadow casting, endocytosis and phagocytosis.
3. To explain mitosis and meiosis using permanent slides.
4. Measurement of cell size using stage micrometer.
5. To cytochemically demonstrate presence of proteins in cheek cells or onion peel using mercuric bromophenol blue or fast green.
6. To cytochemically demonstrate presence of carbohydrates in cheek cells or onion peel using periodic acid Schiff's reagent.
7. To cytochemically demonstrate presence of DNA in cheek cells or onion peel using Feulgen reagent.
8. To study the effect of isotonic, hypotonic and hypertonic solutions on cells.
9. To prepare polytene chromosomes.

References

Essential Readings for Theory and Practical

1. Cooper, G. M. and Hausman, R. E. (2013). 6th Edition. *The cell: A molecular approach*. Massachusetts, USA: Sinauer Associates. ISBN-13:978-1605351551
2. Hardin, J. Bertoni, G. P. Kleinsmith, L.J. and Becker, W.M. (2008). 7th Edition. *The world of the cell*. San Francisco, USA: Benjamin Cummings Publishers, ISBN-13: 978 0805393934.
3. Karp, G. (2013). 7th Edition. *Cell and molecular biology: Concepts and experiments.* New Jersey, USA: Wiley Publishers. ISBN-978-0470483374.
4. Nias, A. H. W. (1998). 2nd Edition. *An introduction to radiobiology.* New Jersey, USA: Wiley Publishers, ISBN- 13: 978-0471975908.

Suggested Readings for Theory and Practical

Freifelder, D. (1982). 2nd Edition. *Physical biochemistry: Applications to biochemistry and molecular biology*. New York, USA: W.H. Freeman and Company. ISBN: 978-0716714446.

Teaching Learning Process

Cell biology course in biomedical science is designed to encourage the acquisition of disciplinary/ subject knowledge, understanding and developing academic and professional skills required for biomedical science-based professions, jobs and research. A variety of approaches to teaching-learning process, including lectures, seminars, tutorials, workshops,

peer teaching and learning, practicum and project-based learning, substantial laboratory-based practical component and experiments i.e. use of microscopes, preparation of slides, and various staining procedures, technology-enabled learning etc. will be adopted to achieve this. Development of practical skills will constitute an important aspect of the teaching-learning process. Some teaching strategies will be taken up to enhance the reasoning/ analytical problem-solving skills of students.

Teaching Learning Plan

Unit	Title	Lectures
I	The Cell	L1-L2
II	Cell Membrane and Membrane Transport	L3-L11
III	Cell Organelles	L12-L25
IV	Cell Junctions and Cytoskeletal Elements	L26-L31
V	Cell Cycle and Overview Of Cell Signaling	L32-L37
VI	Radiation Biology	L38-L48

Assessment Methods

The assessment of student's achievement in Cell and radiation biology will be aligned with the course learning outcomes and the academic and professional skills that the programme is designed to develop. A variety of assessment methods that are appropriate within the disciplinary area of biomedical science will be used. Learning outcomes will be assessed using the following: oral and written examinations, closed book and open-book tests, problem-solving exercises, seminar presentation, computerized adaptive testing, literature surveys and evaluations etc.

Keywords

Cell theory, RBC ghost, passive transport, active transport, cell organelles, cell junction, cytoskeleton elements, cell signaling, radiation biology.

Semester II

Principles of Genetics

(Unique Paper Code: 32581201)
Core Course (CC) - Credit: 6

Theory **Total Lectures: 48**

Course Objective

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

Course Learning Outcomes

Unit-I: Overview of Changing Paradigms in Genetics
The flavor of genomics as a progression from Mendelian genetics will be introduced, that can motivate the students to take up self-learning and Webinars. They should learn about classical experiments which led to discovery of genetic material. They should also learn structure of DNA, its replication and mutations.

Unit-II: Concept of Genetic Inheritance
Students should be able to explain Mendelian laws of inheritance, deviations from monohybrid ratio (incomplete dominance, codominance, multiple alleles and lethal genes) and deviations from dihybrid ratio (gene-gene interactions, linkage). They should be able to distinguish between sex-linked, sex-limited and sex-influenced traits. Students should also be able to interpret pattern of inheritance for autosomal and X-linked traits from pedigrees.

Unit-III: Extra Nuclear Inheritance
Students should learn the concept of extra-nuclear inheritance.

Unit-IV: Genome Organization and Cytogenetics
Students should learn the difference in genome organization between prokaryotes and eukaryotes. They should learn about transposable genetic elements with examples of prokaryotic IS-elements and composite transposons and eukaryotic Ac-Ds system.

Unit-V: Introduction to Mechanisms of Sex Determination
Students should gain insight into genetic and environmental sex determination mechanisms.

Unit-VI: Basic Population Genetics
Students should be introduced to basic population genetics. They should be able to understand Hardy-Weinberg Law and its relevance. They should be able to calculate allele and genotype frequencies using HW law. Students would be skilled with understanding of Binomial distribution and Chi-square test of goodness of fit.

Course Content

Unit-I: Overview of Changing Paradigms in Genetics (L1-L6)

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

Unit-II: Concept of Genetic Inheritance (L7-L24)

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

Unit-III: Extra Nuclear Inheritance (L25-L29)

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

Unit-IV: Genome Organization and Cytogenetics (L30-L40)

Organization of Genomes in prokaryotes and eukaryotes. Establishing the central Dogma. Nucleosomes organization and assembly. Euchromatin, heterochromatin- constitutive and facultative heterochromatin. Transposable genetic elements: Prokaryotic transposable elements- IS elements, Composite transposons; Eukaryotic transposable elements- Ac-Ds system in maize; Uses of transposons. Karyotyping- banding pattern and nomenclature (G and Q banding), Structural abnormalities (Duplication, Insertion, Deletion, Translocation – Reciprocal and Non-Reciprocal). Numerical abnormalities (Aneuploidy and Euploidy). Common syndromes due to numerical chromosome changes. Common syndromes due to structural alterations (translocations, duplications, deletions).

Unit-V: Introduction to Mechanisms of Sex Determination (L41-L44)

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

Unit-VI: Basic Population Genetics (L45-L48)

Gene pool and gene frequency, Hardy Weinberg law and its application for calculating allelic and genotype frequencies.

Practical

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

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

References

Essential Readings for Theory and Practical

1. Klug, W. S., Cummings, M. R., Spencer, C. A., Palladino, M. A. (2012*).* 10th Edition. *Concepts of genetics.* San Francisco, USA: Benjamin Cummings Publishers. ISBN-13: 9780321724120.
2. Snustad, D.P. and Simmons, M.J. (2015). 7th Edition. *Principles of genetics.* New York, USA: John Wiley and Sons. ISBN-13: 9780470903599.

Suggested Readings for Theory and Practical

1. Cooper, G. M. and Hausman, R. E. (2013). 6th Edition. *The cell: A molecular approach.* Massachusetts, USA: Sinauer Associates. ISBN-13:978-1605351551.
2. Hardin, J., Bertoni, G. P., Kleinsmith, L.J., Becker, W.M. (2008). 7th Edition. *The world of the cell.* San Francisco, USA: Benjamin Cummings Publishers. ISBN-13: 978-0805393934.
3. Karp, G. (2013). 7th Edition. *Cell and molecular biology: Concepts and experiments.* New Jersey, USA: Wiley Publishers. ISBN-13: 9781118206737.
4. Kornberg, A. (2005). 2nd Edition. *DNA replication.* California, USA: University Science Books. ISBN-13: 9781891389443.

Teaching Learning Process

1. Class lectures through chalk and board or through presentations.
2. Interactive learning by open discussions on certain topics.
3. Student presentations.
4. Assignments.
5. Numerical solving in class.
6. Monitoring in Practical sessions.
7. Sharing on-line video/animation links on relevant topics with students.

Teaching Learning Plan

Unit	Title	Lectures
I	Overview of changing paradigms in genetics	L1-L6
II	Concept of genetic inheritance	L7-L24
III	Extra nuclear inheritance	L25-L29
IV	Genome Organization and Cytogenetics	L30-L240
V	Introduction to mechanisms of sex determination	L41-L44
VI	Basic population genetics	L45-L48

Assessment Methods

1. Class tests
2. Written assignments
3. Student presentations
4. Oral questions for concepts taught in previous classes
5. End semester University examinations

Keywords

Genetics, Mendelian inheritance, linkage, mitochondrial inheritance, sex determination, cytogenetics, transposons, Hardy-Weinberg law, chromatin, gene-gene interactions, pedigree analysis

Semester II
Human Physiology and Anatomy I
(Unique Paper Code: 32581202)
Core Course - (CC) Credit:6

Theory **Total Lectures: 48**

Course Objective

The course curriculum is a systematic presentation of physiological concepts to ensure appropriate depth and breadth of basic physiology of the human body and its interrelations with respect to heart, lung, kidney, gonads, endocrine glands and digestive system. It would give sufficient exposure to the physiological concepts that provide the foundations needed for further studies in pharmacology, pathology and pathophysiology. The mechanisms of deranged function cannot be appreciated without an in-depth understanding of basic biophysical and physiological mechanisms. The purpose of curriculum is to provide guidelines for the breadth and depth of knowledge in the physiological principles and concepts that are considered minimal and essential for further progress in understanding mechanisms of disease and body defenses. The curricular objectives are focused primarily on normal body function. Accordingly, wherever possible clinical examples have been illustrated to the underlying physiological principles.

Course Learning Outcomes

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

Unit-I: Body Organization, Integumentary
The usefulness of dividing the human body in different anatomical planes and sections, cavities, along with the role of feedback system in maintaining homeostasis. Different cell junctions, functional anatomy of the epithelial and connective tissues while focussing on integumentary and skeletal system. Overview of structure, types and function of cartilage, bone and joints.

Unit-II: Blood
Structure, function and regulation of components/different formed elements of blood and the mechanism of clotting. Distinguish between blood groups, basis of their classification, their importance in blood transfusions and tissue grafting and basic concepts of blood and bleeding disorders

Unit-III: Nerve Physiology
Apply the basic concepts of action potential/ graded potential in the conduction of nerve impulse. Explain the action and significance of different neurotransmitters at the synapse along with the mechanism of synaptic transmission using different ligand gated ion channels, G protein coupled receptors and their ligands as example.

Unit-IV: Nervous System I: Organization of Nervous System
The organization of brain, with identification, structures and function of different brain regions. Identify different neural pathways and explain their significance. Demonstrate the basis of

division of autonomic nervous system and effect of its stimulation on different organs.

Unit- V: Nervous System II: Special Senses
Stimulus modality, sensory adaptation and the role of generator potential in the sensory physiology of touch, gustation, olfaction, hearing and vision. Recognize and explain the common disorders related to the senses.

Unit-VI: Muscular and Skeletal System
Describe and distinguish between the structure, mechanism and regulation of contraction of skeletal, cardiac and smooth muscles. Enlist the energy requirements, characteristic features of different muscle fibres and their role in generating muscle tension. Demonstrate the concept of muscle fatigue, adaptation to physical training, and muscle degeneration and associated disorders.

Course Content

Unit-I: Body Organization, Integumentary (L1-4)
General Anatomy of the body, Introduction to various kinds of body planes, cavities their membranes, Tissues level of organization (Types, origin, function & repair). Structure and functions of human skin.

Unit-II: Blood (L5-12)
Composition and Function of blood and its components: WBC, RBC, platelets. Hematopoiesis, Hemoglobin structure and function. Hemostasis and blood coagulation mechanism, blood groups and blood banking. Basic concepts about Anemia, abnormal hemoglobin, Polycythemia, Thalassemia, Leukemia.

Unit-III: Nerve Physiology (L13-19)
Resting membrane potential, structure and function of neuron. Action potential, electrophysiology of ion channels and conduction of nerve impulse, Synapse, and its types, Synaptic Transmission, Neurotransmitters; types and function.

Unit-IV: Nervous System I: Organization of Nervous System (L20-27)
Structure and function of Central nervous system, Peripheral nervous system and Autonomic nervous system (spinal and cranial nerves). Reflexes suitable examples, and reflex arch. Temperature regulation of the human body by hypothalamus. Overview of disorders associated with the nervous system

Unit-V: Nervous System II: Special Senses (L28-35)
Concept of receptors in the body and their types, Structure, Functional anatomy, regulation and common disorders of the following sensations: Vision, Hearing, Taste, Smell and Touch.

Unit-VI: Muscular and Skeletal System (L36-48)
Functional anatomy of muscular system, types of muscles, neuromuscular transmission, general and molecular mechanism of skeletal muscle excitation and contraction, energetics of muscle contraction and characteristics of whole muscle contraction. An overview of concepts of muscle fatigue, oxygen debt, shivering/tremor, muscle degeneration. Cartilage: structure, types and function. Bones: structure, function, location and types. Process of bone formation. Joints: structure, function and types. An overview of disorders of skeletal system

Practical (Any 8)

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

1. Estimation of hemoglobin (Sahli's method) and determination of blood group.
2. Determination of bleeding time and clotting time of blood.
3. Determination of total erythrocyte count.
4. Determination of total leukocyte count.
5. Preparation of blood smears and identifying various WBC
6. To perform differential leukocyte count of blood.
7. Determination of specific gravity of blood.
8. Determination of osmotic fragility of RBC.
9. To study different human organs and their sections through permanent histological slides- T.S. of brain, spinal cord, skeletal fibres, cardiac muscles, skeletal muscles, cartilage joints and different tissues. (Minimum 8 slides covering the systems mentioned in theory.)

References

Essential Readings for Theory and Practical

1. Ghai, C.L. (2012). 8th Edition. *Textbook of practical physiology.* India: Jaypee Publication. ISBN-13: 978-8184481419.
2. Hall, J.E. (2006) 13th Edition. *Guyton and Hall textbook of medical physiology*. Philadelphia, USA: W B Saunders and Company. ISBN-13: 978-1416045748.
3. Prakash, G. (2012). 1st Edition. *Lab manual on blood analysis and medical diagnostics.* India: S. Chand. ISBN: 81-219-3967.
4. Stuart I. and Fox, S.I. (2009). 12th Edition. *Human physiology*. New York, USA: Tata McGraw Hill. ISBN-13: 9780077350062.
5. Tortora, G.J. and Derrickson, B.H. (2011). 13th Edition. *Principles of anatomy and physiology*. New Jersey, USA: Wiley and Sons. ISBN-13: 978-0470565100.

Suggested Readings for Theory and Practical

Barett, K.E., Barman, S.M., Boitano, S., and Brooks, H. (2015). 25th Edition. *Ganong's review of medical physiology*. New York, USA: Tata McGraw Hill. ISBN-13:978-0071780032.

Teaching Learning Process

Teaching and learning process will extensively include classroom activities to encourage the acquisition of subject knowledge, understanding academic nuances through questions and queries of previous class before beginning of a new class. Teaching would include blackboard and chalk method to communicate the concepts together with use of Power Points presentations to visually explain various processes. The students would be encouraged to frame new questions on their subjects apart from the available ones to enable them to have better insight of the topic. Verbal explanation, seminars, case studies, workshops and Open discussions, Quizzing and questioning would be a regular exercise.

Teaching Learning Plan:

Unit	Title	Lectures
I	Body organization, Integumentary	L1-L8
II	Blood	L9-L16
III	Nerve Physiology	L17-L24
IV	Nervous System I: Organization of nervous system	L25-L30
V	Nervous System II: Special senses	L31-L38
VI	Muscular and Skeletal system	L39-L48

Assessment Methods

1. Written class tests and Assignments
2. Open and Closed Book Test
3. Quizzing/ viva, Problem solving exercises
4. Seminar presentations, Case Studies
5. Laboratory experiments and reports
6. Projects and Project Reports
7. Final University Examination

Keywords

Homeostasis, action potential, neurotransmission, blood, autonomic nervous system, gustation, olfaction, muscle contraction, neuron, organ of corti, sarcomere, joints, bone

B.Sc. (Hons) Course in
Biomedical Science
II Year
Semester III and IV

Semester III
Biochemistry
(Unique Paper Code: 32581301)
Core Course (CC) Credit: 6

Theory **Total Lectures: 48**

Course Objective

The objective of this course is to effectively incorporate the fundamentals of metabolism through key biochemical pathways and make learners appreciate the requirement for the stringency of their regulation; introduce various biochemical techniques used in characterization of the proteins and a detailed account on how enzymes function: their kinetics, regulation and inhibition.

Course Learning Outcomes

Unit-I: Metabolic Pathways and their Regulation

Students will gain understanding on fundamental biochemical principles of metabolism of biomolecules (Carbohydrates, Proteins, Lipids and Nucleic acids) and the associated bio-energetics. They will learn the biochemical reactions in metabolic pathways and understand their interrelations, logics and patterns. They will also understand the role of enzymes in the biochemical reactions and the connect between biochemical defects and metabolic disorders. Students would additionally gather a firm understanding and relevance of stringent regulation of metabolic pathways.

Unit-II: Analytical methods in protein characterization

Having understood the structural architecture of proteins in earlier semesters, students shall learn how biological molecules (especially proteins) are isolated and characterized through various analytical techniques such as types of column chromatography, PAGE, IEF that are used in contemporary biochemistry research laboratories. They will also learn to appreciate compare and contrast the analytical and preparative methods used in biochemistry for purification and characterization of biomolecules.

Unit-III: Enzymes

Students will get a grasp on central concepts underlying enzyme catalysis, kinetics and their mechanism of action. Effect of different kinds of enzyme-inhibitors will also be learnt.

Unit-IV: Coenzymes

Students would learn how coenzymes assist enzymes in catalyzing biochemical reactions and what are the criterion for their classification. Chemical structures of the key coenzymes would also be learnt.

Unit-V: Regulatory Enzymes

Having studied the role of enzymes which regulate metabolic pathways in the first Unit, students would learn the general properties of regulatory enzymes, their activity and kinetics.

Practical

The experiments are designed, so as to enable students to learn some of the techniques/methods covered in theory. Practical training shall help them in better understanding of how enzymes function under optimal and variant conditions. Also, how separation techniques are used in qualitative/quantitative analysis and purification of the biomolecules.

Course Content

Unit-I: Metabolic Pathways and their Regulation (L1-L28)

Carbohydrate metabolism- Glycolysis, Gluconeogenesis, Tricarboxylic acid cycle and their regulation, Cori cycle, Electron transport chain, Oxidative phosphorylation, Hexose monophosphate shunt, Glycogen metabolism and its regulation.

Lipid metabolism- Mobilization of triglycerides, Metabolism of glycerol, Biosynthesis and β-oxidation of saturated fatty acids (palmitic acid) and their regulation, Ketone bodies.

Protein metabolism- General overview, Transamination, Deamination, Glucose-Alanine cycle, Urea cycle and its regulation, Metabolism of phenylalanine and a branched chain amino acid.

Nucleic acid metabolism- General overview, outline of purine and pyrimidine metabolism, Gout and Lesch-Nyhan Syndrome.

Unit-II- Analytical methods in Protein Characterization (L29-L36)

Paper and Thin-layer chromatography, Ion exchange chromatography, Gel filtration and Affinity chromatography. SDS-PAGE, IEF.

Unit-III: Enzymes (L37-L44)

Introduction to enzymes, Concept of lock and key and induced fit theory, Concept of activation energy and binding energy. Enzyme kinetics: Michaelis-Menten equation and its physiological significance, double reciprocal plots. Enzyme Inhibition: types of inhibitors and their examples. Turnover number.

Unit-IV: Coenzymes (L45-L46)

Classification: various types, functions. Structures of NAD^+, $NADP^+$, FAD and FMN.

Unit-V: Regulatory Enzymes (L47-L48)

General properties of allosteric enzymes, Co-operativity. Regulation by covalent modification. Zymogens.

Practical

1. To perform dialysis
2. Protein estimation by any one method: Lowry's/Bradford.
3. Separation of sugars/amino acids by Thin Layer Chromatography.
4. To perform SDS-PAGE.
5. Calculation of Void Volume of Sephadex G -25 column, using Blue Dextran.
6. Assay of any one enzyme, under optimal conditions.
7. To study the effect of temperature on the activity of enzyme.
8. To study the effect pH on the activity of enzyme.

References

Essential Readings for Theory and Practical

1. Nelson, D.L. and Cox, M.M. (2017). *Lehninger principles of biochemistry*. New York, USA: W. H. Freeman.
2. Plummer, D.T. (2012). *An introduction to practical biochemistry.* New Delhi, India: McGraw-Hill College.
3. Sawhney, S.K. and Singh, R. (2005). *Introductory practical biochemistry*. Oxford, UK: Alpha Science International.

Suggested Readings for Theory and Practical

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

Teaching Learning Process

The teaching learning process will include lecture and interactive mode, where students would also get to actively participate in class-room activities. To enable students comprehend the logics and central themes in Biochemistry thoroughly, emphasis will be laid on enhancing their critical thinking through reasoning-based queries. To help students get a grasp on the subject, exercises such as building of metabolic pathways through team work; individual/team presentation on chosen topics, correlation of concepts learnt to real life situations are some of the ways active learning shall be encouraged. The hands-on performance of experiments will not only help them in understanding the concepts better, but will also develop their interest in a research career.

Teaching Learning Plan

Unit	Title	Lectures
I	Metabolic Pathways and their regulation	L1-L28
II	Analytical methods in protein characterization	L29-L36
III	Enzymes	L37-L44
IV	Coenzymes	L45-L46
V	Regulatory enzymes.	L47-L48

Assessment Methods

Learning outcomes will be assessed by written assignments, class tests, seminars/presentations by students; their practical skills shall be assessed while doing experiments and by thought-provoking viva-voce, where their ability to connect the learnt concepts to practical knowhow will be encouraged and assessed. Feedback on students' learning abilities shall also be taken.

Keywords

Metabolic pathways, enzymes, Michaelis-Menton equation, SDS-PAGE, chromatography, zymogens, coenzymes, metabolic disorders

Semester III
Human Physiology and Anatomy II
(Unique Paper Code: 32581302)
Core Course - (CC) Credit:6

Theory **Total Lectures: 48**

Course Objective

The course curriculum is a systematic presentation of physiological concepts to ensure appropriate depth and breadth of basic physiology of the human body and its interrelations with respect to heart, lung, kidney, gonads, endocrine glands and digestive system. It would give sufficient exposure to the physiological concepts that provide the foundations needed for further studies in pharmacology, pathology and pathophysiology. The mechanisms of deranged function cannot be appreciated without an in-depth understanding of basic biophysical and physiological mechanisms. The purpose of curriculum is to provide guidelines for the breadth and depth of knowledge in the physiological principles and concepts that are considered minimal and essential for further progress in understanding mechanisms of disease and body defenses. The curricular objectives are focused primarily on normal body function. Accordingly, wherever possible clinical examples have been illustrated to the underlying physiological principles.

Course Learning Outcomes

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

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

Unit-II: Respiratory system
The overall function of lung, its functional anatomy and blood flow pattern associated with it. The neural control and other regulators of respiration and to understand daily phenomenon like cough sneezing yawning etc.

Unit-III: Renal Physiology
Kidneys and the structures within the kidneys and their functions. Outline the process of micturition and abnormalities associated with it. Distinguish acidosis and alkalosis and appreciate its significance and control.

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

Unit-V: Endocrine system
The role of the endocrine system to maintain homeostasis Understand the chemical

composition and mechanisms of hormone action, their site of production, regulation, and effects of hormones of the pituitary, thyroid, parathyroid, adrenal, and pineal glands. Hormonal regulation of the reproductive system. The role of the pancreatic endocrine cells in the regulation of blood glucose In addition the contributions of hormones released by the heart, kidneys, and other organs with secondary endocrine functions. The student would be aware of several common diseases associated with endocrine system dysfunction.

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

Course Content

Unit-I: Cardiovascular system (L1-9)
Structure and function of heart, Properties of cardiac muscle, The Cardiac Cycle, Electrocardiogram. Circulatory system: General Principles of circulation and hemo-dynamics cardiovascular regulatory mechanism, Lymphatic circulation and micro-circulation.

Unit-II: Respiratory system (L10-16)
Functional Anatomy of the respiratory system. Mechanisms of pulmonary ventilation, alveolar ventilation, gaseous exchange, transport of gases, respiratory and nervous control and regulation of respiration**.**

Unit-III: Renal Physiology (L17-24)
Functional Anatomy of kidney, function and histology of nephron, Body fluid and electrolytes: their balances and imbalances. Urine formation (glomerular filtration and tubular reabsorption), renal regulation of urine volume and osmolarity, acid-base balance. Urinary bladder: structure, micturition and its regulation. Acidosis and alkalosis, basic concepts about kidney dysfunction.

Unit-IV: Reproductive system (L25-33)
Structure and function of male and female reproductive organ. Function and regulation of testicular and ovarian hormones. Gametogenesis (oogenesis and spermatogenesis), fertilization, implantation, pregnancy, parturition and lactation Basic concepts of male and female infertility, menopause and various contraceptive measures

Unit-V: Endocrine system (L34-41)
General mechanism of hormone action, Structure, function and regulation of the following glands and their secretions: Pituitary, Hypothalamus, Pineal, Thyroid, Parathyroid, Adrenal, and Pancreas. Basic concepts about hypo and hyper secretion of hormones and their diseases.

Unit-VI: Gastrointestinal system (L42-48)
Anatomy and histology of digestive tract, gastrointestinal physiology: General principles of gut motility secretion, digestion, absorption and assimilation. Gastrointestinal hormones, their formation, action and regulation. Physiological anatomy of liver, pancreas and their functions. An overview of gastrointestinal dysfunction

Practical (Any 8)

(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. Simple Reflex arc.
2. Physiological data acquisition based experiments (ECG).
3. Physiological data acquisition based experiments (EMG).
4. Physiological data acquisition based experiments (PFT).
5. To perform platelet count.
6. To determine the reticulocyte count.
7. To perform tests for sensations (taste, touch and smell.)
8. Blood Pressure recordings in humans.
9. To study various types of contraceptive (condoms, IUD‟s, oral and injectable contraceptives)
10. To study different human organs and their sections through permanent slides. T. S. of thyroid, liver, thymus, spleen, ovary, artery, vein, capillaries, testis, pancreas, esophagus, adrenal, kidney (cortex and medulla), urinary bladder, urethra, fallopian tubes, epididymis, prostate glands, lungs, trachea, bronchioles, pituitary, heart. (Minimum 8 slides covering the systems mentioned in theory.)

References

Essential Readings for Theory and Practical

1. Ghai, C.L. (2012). 8th Edition. *Textbook of practical physiology.* India: Jaypee Publication. ISBN-13: 978-8184481419.
2. Hall, J.E. (2006) 13th Edition. *Guyton and Hall textbook of medical physiology*. Philadelphia, USA: W B Saunders and Company. ISBN-13: 978-1416045748.
3. Prakash, G. (2012). 1st Edition. *Lab manual on blood analysis and medical diagnostics.* India: S. Chand. ISBN: 81-219-3967.
4. Stuart I. and Fox, S.I. (2009). 12th Edition. *Human physiology*. New York, USA: Tata McGraw Hill. ISBN-13: 9780077350062.
5. Tortora, G.J. and Derrickson, B.H. (2011). 13th Edition. *Principles of anatomy and physiology*. New Jersey, USA: Wiley and Sons. ISBN-13: 978-0470565100.

Suggested Readings for Theory and Practical

Barett, K.E., Barman, S.M., Boitano, S., and Brooks, H. (2015). 25th Edition. *Ganong's review of medical physiology*. New York, USA: Tata McGraw Hill. ISBN-13:978-0071780032.

Teaching Learning Process

Teaching and learning process will extensively include classroom activities to encourage the acquisition of subject knowledge, understanding academic nuances through questions and queries of previous class before beginning of a new class Teaching would include blackboard and chalk method to communicate the concepts together with use of Power Points presentations to visually explain various processes. The students would be encouraged to frame new questions on their subjects apart from the available one to enable them to have better insight of the topic. Verbal explanation, seminars, case studies, workshops and Open discussions, Quizzing and questioning would be a regular exercise.

Teaching Learning Plan

Unit	Title	Lectures
I	Cardiovascular system	L1-L9
II	Respiratory system	L10-L16
III	Renal Physiology	L17-L24
IV	Reproductive system	L25-L33
V	Endocrine system	L34-L41
VI	Gastrointestinal system	L42-L48

Assessment Methods

1. Written class tests and Assignments
2. Open and Closed Book Test
3. Quizzing/ viva, Problem solving exercises
4. Seminar presentations, Case Studies
5. Laboratory experiments and reports
6. Projects and Project Reports
7. Final University Examination

Keywords

Heart, ECG, cardiac cycle, lymph, ventilation, gametogenesis, nephron, acidosis, micturition, digestion assimilation absorption, endocrine, pancreas, thyroid, pituitary, contraceptive, fertility

Semester III
Medical Microbiology
(Unique Paper Code: 32581303)
Core Course - (CC) Credit: 6

Theory **Total Lectures: 48**

Course Objective

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

Course Learning Outcomes

Unit-I: Fundamental Concepts

Medical microbiology describes a broad perspective to study structure, classification, and disease caused by microbes including bacteria fungi, protozoa and viruses. The course helps to understand the nature of microorganism, their systematic classification and contribution of various scientists in the discovery of disease causing pathogens. Describes use of various culture media used for cultivation of microbes, their optimum physical and chemical cultural requirements and techniques for purification and preservation of microbes.

Unit-II: Bacterial Cells - Fine Structure and Function

Explain the various types of microbial cell, shape size, molecular structure and their role in pathogenesis. What are the basic nutrient requirements of microorganism and how they behave in variable atmospheric conditions? Analyzing optimum growth conditions helps in growth and cultivation of useful microorganism.

Unit-III: Microbial Genetics

The microbial genetics helps to understand the basic phenomenon of gene functioning and effects of various mutagens on microorganism. Elucidates different methods of gene transfer and causes of genetic variation.

Unit-IV: Host–Pathogen Relationship in The Infectious Diseases

Describe the interaction between host and their pathogens, mode of transmission of infectious disease and cure.

Unit-V: Microbial Diseases

Explains pathogenesis, etiology, clinical symptoms, control and cure of microbial diseases in addition to introducing antimicrobial action of antibiotics.

Unit-VI: Industrial Microbiology and Antimicrobial Chemotherapy

Fermentation tools give basic knowledge related to large scale cultivation of microbes for research, food, industry and improvising the existing strains for economic exploitation. Basic understanding about the action of common antimicrobial agents.

Course Content

Unit-I: Fundamental Concepts (L1-L8)

(a) History of microbiology with special emphasis on contribution of Louis Pasteur and Robert Koch in Medical Microbiology.
(b) Major Divisions of life- Domains, Kingdoms, Classical and Molecular methods of assessing microbial phylogeny- molecular chronometer, phylogenetic trees, rRNA, DNA and proteins as indicator of phylogeny.
(c) Requirements for microbial growth, growth factors, culture media- synthetic and complex, types of media. Obtaining Pure Cultures, Preserving Bacterial Cultures, Growth Curves and generation time, Control of microbial growth, general concept of effect of environmental factors on growth of microbes.

Unit-II: Bacterial Cells - Fine Structure and Function (L9-L12)

Size, shape and arrangement of bacterial cells; Cell membrane, cytoplasmic matrix, inclusion bodies (e.g magnetosomes), nucleoid, ultrastructure of Gram +ve and Gram –ve bacterial cell wall, pili, capsule, flagella and motility, endospore

Unit-III: Microbial Genetics (L13-L16)

Mutations, Bacterial recombination: general and site specific and replicative, bacterial plasmids fertility factor, col plasmid, bacterial conjugation (Hfr, F′, F+, F-), transformation, transduction- generalized and specialized.

Unit-IV: Host–Pathogen Relationship in The Infectious Diseases (L17-L19)

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

Unit-V: Microbial Diseases (L20-L33)

(a) Respiratory tract infections (Tuberculosis); Gastrointestinal tract infections including Diarrhea caused by Salmonella and *E.coli*, staphylococcal food poisoning. Clinical symptoms and life cycle of *Candida albicans* and *Plasmodium*.
(b) General life cycle of a virus, structure, enveloped and un-enveloped viruses, plaque assay, growth curve, classification based on genetic material and detail study of influenza and HIV virus with curative agent. Virods, virusoids and prions.

Unit-VI: Industrial Microbiology and Antimicrobial Chemotherapy (L34-L48)

(a) Industrial microbiological processes in industry, basic design of fermentation-continuous and discontinuous: Importance w.r.t medical microbiology like vaccine development and diagnostics.
(b) Range of activity and mechanism of action of antibiotics-sulfa drugs, penicillin, aminoglycosides, quinolones, cyclosporine, tetracycline and macrolides, their effectively and various test for antimicrobial activity.

Practical

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

1. Preparation of different media: synthetic media, Complex media-nutrient agar, Luria Agar.
2. Staining methods: Gram's staining, Acid fast staining (permanent slide only), Capsule staining and spore staining.
3. Study and plot the growth curve of E coli using turbidometric method and to calculate specific growth rate and generation time.
4. To perform antibacterial testing by Kirby-Bauer method.
5. Staining and morphological characterization of *Aspergillus* sp., *Pencillium* sp. and *Saccharomyces* sp.
6. Demonstration of PCR based method of detection.
7. Isolation of bacteriophages (any with a non-pathogenic host) and calculation of the plaque forming units (pfu).

References

Essential Readings for Theory and Practical

1. Cappuccino, J.G. and Sherman, N. (2013). 10th Edition. *Microbiology: A laboratory manual*. California, USA: Benjamin Cumming. ISBN-13: 978-0321840226.
2. Tortora, G.J., Funke, B.R. and Case C.L. (2006). 9th Edition. *Microbiology: An introduction*. California, USA: Benjamin Cummings. ISBN-13: 978-0536292117.
3. Willey, J., Sherwood, L., and Woolverton, C.J. (2016). 10th Edition. *Prescott's microbiology*. New York, USA: McGraw-Hill Education. ISBN-13: 978-1259281594.

Suggested Readings for Theory and Practical

1. 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.
2. Pelczar, M.J (2001). 5th Edition. *Microbiology*. New York, USA: McGraw Hill International. ISBN-13: 9780074623206.
3. Tille, P. (2013). 13th Edition. *Bailey & Scott's diagnostic microbiology*. Missouri, USA: Mosby Publishers. ISBN-13: 978-0323083300.

Teaching Learning Process

The syllabus of Medical Microbiology is designed to encourage the acquisition of subject knowledge, skills required for biomedical science based professions and jobs. Learning experiences are aimed at developing practical skills which would prepare the students for industries and educational organizations. Various approaches to teaching-learning process, including lectures, seminars, tutorials, workshops, peer teaching, learning, project-based learning, field-based learning, substantial laboratory-based practical component and experiments, open-ended project work, technology-enabled learning, internship in industry and research establishments will be adopted to achieve this. Problem-solving skills and higher-order skills of reasoning and analysis will be encouraged through teaching strategies.

Teaching Learning Plan

Unit	Title	Lectures
I	Fundamental Concepts	L1-L8
II	Bacterial Cells - Fine Structure and Function	L9-L12
III	Microbial Genetics	L13-L16
IV	Host–Pathogen Relationship in The Infectious Diseases	L17-L19
V	Microbial Diseases	L20-L33
VI	Industrial Microbiology and Antimicrobial Chemotherapy	L34-L48

Assessment Methods

The assessment of students in Medical Microbiology will be done keeping in mind the skills acquired during the course. Students will be assessed using the following: oral and written examinations, closed-book and open-book tests; problem-solving exercises, assignments, observation of practical skills and seminar presentation.

Keywords

Bacteria, MIC, virus, cell wall, flagella, fermentation, lysogeny, antibiotics and antiviral agents

Semester IV
Immunobiology
(Unique Paper Code: 32581401)
Core Course - (CC) Credit: 6

Theory **Total Lectures: 48**

Course Objective

1. Immunobiology is a comprehensive study of the organization and functioning of the immune system with its network of cells and molecules. Understanding the biology of the immune system is, therefore, key to developing strategies towards prevention and cure to a number of disorders and diseases that result due to interference in the functioning and regulation of the immune system.
2. This paper covers the structure, organization, function and regulation of and by the immune system keeping the above aspects in mind.

Course Learning Outcomes

Unit-I: Introduction
Students learn various aspects of human immune system in normal and infectious stage which equips students to design better strategies for combating the immunological disorders.

Unit-II: Structure, Properties and Functions of the Immune System
Student will be familiarized with origin and maturation of all blood cell types in bone marrow and thymus. They will understand the functions of various types of cells and role played by them in immune response against pathogens.

Unit-III: Adaptive Immune Response
They will know the concept of antigen, antibody molecules and role of major histocompatibility complex and associated cells in the presentation of antigen. The students will also be able to understand the significance of various kinds of growth factors and cytokines in the activations of various lymphocytes

Unit-IV: Immunological Principles of Various Reactions and Techniques
Various techniques associated with immunological reaction will enhance the understanding students about common laboratory instruments.

Unit-V: Vaccines and Immunotherapeutics
Vaccine based immunotherapies and their designing will assist them to think about new path for combating with pathogens and working mechanism of immune system.

Unit-VI: Dysfunctions of Immune System
Student will also be sensitized with dysfunctions of immune system and autoimmune disorders.

Course Content

Unit-I: Introduction (L 1- L2)

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

Unit-II: Structure, Properties and Functions of the Immune System (L3-L11)

(a) Hematopoeisis, T and B lymphocyte, NK cells, monocytes and macrophages; neutrophils, eosinophils, basophils, mast cells and dendritic cells; thymus and bone marrow; lymph nodes, spleen, MALT, GALT and SALT; pattern recognition receptors.
(b) Mechanisms of pathogen killing by macrophages and neutrophils.
(c) Complement system: Components of the complement activation classical, alternative and lectin pathways; biological consequence of complement activation, methods to study complement fixation.
(d) Inflammation

Unit-III: Adaptive Immune Response (L12-L31)

(a) Antigens and haptens: Properties (foreignness, molecular size, heterogeneity); B and T cell epitopes; T dependent and T independent antigens.
(b) Major Histocompatibility Complex: Organization of MHC and inheritance in humans; concepts of polygeny and polymorphism with respect to MHC.
(c) Antigen presenting cells, antigen processing and presentation pathway (cytosolic and endocytic), MLRs.
(d) Humoral immune response: Concepts of B cell development in bone marrow, generation of plasma cells and memory B cells in lymphoid organs. Antibodies: Historical perspective of antibody structure; structure, function and properties of the antibodies; different classes and subclasses and biological activities of antibodies; concepts of antibody diversity and class switching. (isotype, allotype and idiotype); transport of IgA, Hybridoma technology, monoclonal antibodies; basic concepts of abzymes, immunotoxin, chimera, hybrid antibodies, antigen-antibody interactions.
(e) Cell mediated immune response: T cell maturation in thymus, thymic selection, self MHC restriction of T cells, T cell receptor complex. T cell sub-types and their effector function. Trimolecular complex formation between APC and Naïve T cells, clonal expansion. Cytokines properties of Interferon and Interleukins (IL1, IL2, IL4).

Unit-IV: Immunological Principles of Various Reactions and Techniques (L32-L39)

Affinity and avidity, cross reactivity, precipitation, agglutination, immunodiffusion, immunoelectrophoresis, ELISA (indirect, sandwich, competitive, chemiluminescence, and ELISPOT assay), western blotting, immunofluorescence, flow cytometry and fluorescence, and immunoelectron microscopy

Unit-V: Vaccines and Immunotherapeutics (L40-L43)

Types and their characteristics, adjuvants, overview of National Immunization Course

Unit-VI: Dysfunctions of immune system (L44-L48)

Types of hypersensitivity, overview of autoimmunity. Immunodeficiency disorders: Animal models of primary immunodeficiency (nude mouse and SCID mouse); specific impaired functions in lymphoid and myeloid lineage.

Practical

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

1. To perform immuno-diffusion by Ouchterlony method
2. Immuno-diffusion by Mancini method
3. Analysis of the ouchterlony and Mancini method
4. To perform ELISA checkerboard experiment
5. To perform Complement fixation assay
6. To perform Agglutination inhibition Assay
7. To perform sandwich dot ELISA
8. To perform Widal test

References

Essential Readings for Theory and Practical

1. 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.
2. Hay, F.C. and Westwood, O.M.R. (2002). 4th Edition. *Practical Immunology*. New Jersey, USA: Blackwell Science. ISBN: 9780865429611.
3. 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.

Suggested Reading for Theory and Practical

1. Owen, J. A. Punt, J. Stranford, S. A. Jones, P. P and Kuby, J. (2013). 7th Edition *Kuby Immunology*. New York, USA: W.H. Freeman and Company. ISBN-13: 97f8-1429219198.
2. Willey, J. Sherwood, L and Woolverton, C.J. (2016). 10th Edition. *Prescott's Microbiology*. New York, USA: McGraw-Hill Education. ISBN-13: 978-1259281594.

Teaching Learning Process

The programme of study in immunobiology is designed to encourage the acquisition of subject knowledge, skills required for biomedical science based professions and jobs.Learning experiences are aimed at developing practical skills which would prepare the students for industries. Various approaches to teaching-learning process, including lectures, seminars, tutorials, workshops, peer teaching, learning, project-based learning, field-based learning, substantial laboratory-based practical component and experiments, open-ended project work, technology-enabled learning, internship in industry and research establishments will be adopted to achieve this. Problem-solving skills and higher-order skills of reasoning and analysis will be encouraged through teaching strategies.

Teaching Learning Plan

Unit	Title	Lectures
I	Introduction	L1-L2
II	Structure, Properties and Functions of the Immune System	L3-L11
III	Adaptive Immune Response	L12-L31

IV	Immunological Principles of Various Reactions and Techniques	L32-L39
V	Vaccines and Immunotherapeutics	L40-L43
VI	Dysfunctions of Immune System	L44-L48

Assessment Methods

The assessment of students in Immunobiology will be done keeping in mind the skills acquired during the course. Students will be assessed using the following: oral and written examinations, closed-book and open-book tests; problem-solving exercises, assignments, observation of practical skills and seminar presentation.

Keywords

Innate immunity, adaptive immunity, B cell, T cell, antigen, antibody, major histocompatibility complex, autoimmunity, hypersensitive reaction, vaccine

Semester IV
Molecular Biology
(Unique Paper Code: 32581402)
Core Course (CC) - Credit: 6

Theory **Total Lectures: 48**

Course Objective

1. The paper of Molecular Biology encompasses basic study and understanding of the execution of central dogma.
2. The objective is to offer detailed and comprehensive knowledge about the mechanisms of DNA replication, repair, transcription and translation in prokaryotes and eukaryotes so that students can apply this knowledge in enhancing their analytical and research problem solving skills.

Course Learning Outcomes

Unit-I: The replication of DNA in Prokaryotes and Eukaryotes
Students will acquire basic concepts of central dogma. They will understand the concept of DNA replicated and repair and hence the consequences of improper processes.

Unit-II: The mutability and Repair of DNA
Students will learn about mutations, which are considered instrumental for species deviation and eventually diversity.

Unit-III: Information transfer-I: Mechanism of Transcription
Students will gain knowledge about basic transcription apparatus, mechanisms of transcription in bacteria and in eukaryotes and inhibitors of transcription.

Unit-IV: Post-Transcriptional Modifications
Students will learn about structure of gene, RNA splicing pathways, variants of splicing, mechanism of determining the sex of Drosophila and mRNA transport.

Unit-V: Information transfer-II: Mechanism of Translation
Students will gain knowledge about features of genetic code, types of RNA, ribosomal structure, process of translation in prokaryotes and eukaryotes and inhibitors of protein synthesis.

Course Content

Unit-I: The Replication of DNA in Prokaryotes and Eukaryotes (L1-L14)
Chemistry of DNA synthesis. Enzyme and proteins involved in DNA replication – helicase, topoisomerases, DNA polymerases, DNA ligase, primase, RNaseH, telomerase, sliding clamp, sliding clamp loader and SSBs. Mechanism of action of DNA polymerase, DNA transactions during replication - bidirectional replication, semi-conservative, discontinuous. Mechanics at the DNA replication fork: RNA priming, initiation and termination of DNA replication (comparing prokaryotes with eukaryotes), regulation of bacterial DNA replication, replicating

the 5' end of linear chromosome, replication coupled to chromatin synthesis in eukaryotes. Various models of DNA replication including Trombone model, D-loop (mitochondrial), Theta mode of replication, Rolling circle model, replication of linear ds-DNA. Denaturation and renaturation of DNA, Cot curves, Rot curves.

Unit-II: The Mutability and Repair of DNA (L15-L20)

Spontaneous and induced mutations. Types of mutations- point (non-sense, miss-sense, frame shift, insertion, deletion), use of mutants to study gene functions, effects on the gene product-loss of the function and gain of function. Replication Errors (transitions, transversion and thymine dimer), DNA Damage (deamination, depurination and dimerization). DNA repair: Direct repair, Mismatch repair, Excision Repair, Photoreactivation, Recombination Repair, SOS response. AMES test to identify DNA damaging chemicals. Detection of mutations: CLB method and attached X method.

Unit-III: Information Transfer –I: Mechanism of Transcription (L21-L30)

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

Unit-IV: Post-Transcriptional Modifications (L31-L36)

Split Genes, Concept of introns and exons, RNA splicing pathways: Spliceosomes and Self splicing introns (Group I and Group II introns), Ribozymes, Variants of splicing: alternative splicing, exon shuffling and RNA editing, Mutually exclusive splicing (example Drosophila Dscam gene), Mechanism determining the sex of Drosophila, mRNA transport.

Unit-V: Information Transfer-II: Mechanism of Translation (L3-L48)

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

Practical

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

1. Calculations and preparation of various stock and working solutions of molecular biology experiments (Number 2 to 8).
2. Isolation of genomic DNA from bacterial cells.
3. Fractionation of DNA by agarose gel electrophoresis.
4. Isolation of genomic DNA from blood/tissue.
5. Quantitative estimation of salmon sperm/ calf thymus DNA using colorimetric assay using Diphenylamine reagent.

6. Quantify and analyze the purity of DNA using spectrophotometer (estimating at 260nm, 280nm and 320nm).
7. In vitro gene amplification method of Polymerase Chain Reaction (PCR): Primer designing and setting up of the reaction.
8. Native-Polyacrylamide Gel Electrophoresis for DNA.

References

Essential Readings for Theory

1. 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.
2. Hardin, J. Bertoni, G. P. Kleinsmith, L.J. and Becker, W.M. (2008). 7th Edition. *The world of the cell.* San Francisco, USA: Benjamin Cummings Publishers, ISBN-13:978-0805393934.
3. Karp, G. (2013). 7th Edition. *Cell and molecular biology: Concepts and experiments.* New Jersey, USA: Wiley Publishers, ISBN-13:978-1118206737.
4. 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.

Essential Readings for Practical

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.

Suggested Readings

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

Teaching Learning Process

Teaching and learning activity will mainly include extensive class room discussions, Students will be asked to orally revise the previous class before every new class to helping them in the better understanding of the topics and clearing their doubts.
Teaching will be conducted through both regular chalk and board and power point presentation. There will be regular question and answer activities and consultation of relevant text books and research articles. Student queries will be entertained by the teachers.

Teaching Learning Plan

Unit	Title	Lectures
I	The replication of DNA in Prokaryotes and Eukaryotes	L1-L14
II	The mutability and Repair of DNA	L15-L20
III	Information transfer –I: Mechanism of transcription	L21-L30
IV	Post-transcriptional modifications	L31-L36
V	Information transfer-II: Mechanism of translation	L37-L48

Assessment Methods

Topic on current and important research area will be assigned individually to students and they will be asked to retrieve literature and show them to teachers for verification. They will be motivated to make short presentations. Class tests will be conducted for internal examinations. Students will be given home assignments from time to time to improve their writing skills. Finally, there will be end semester university examination

Keywords

Replication, mutation, repair, transcription, RNA splicing, translation

Semester IV
Medicinal Chemistry
(Unique Paper Code: 32581403)
Core Course (CC) - Credit: 6

Theory **Total Lectures: 48**

Course Objective

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

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

Course Learning Outcomes

After completing the course, students shall be able to:

Unit-I: General Introduction
Understand the various stages involved in drug development.

Unit-II: Drug Target Classification
Understand and explore various kinds of drug targets including protein, enzymes, nucleic acids etc.

Unit-III: How Drug Acts: Molecular Aspects
Understand drug-receptor interactions, identify association between chemical structure and its physicochemical properties.

Unit-IV: Physicochemical Principles of Drug Action and Measurement of Drug Effects
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.

Unit-V: Principles of Drug Design
Comprehend the physicochemical basis for the rational drug design, analogue synthesis, and mechanism of action of drugs.

Unit-VI: Introduction to Combinatorial Synthesis
Learn various methods of parallel/ mixed combinatorial synthesis (mix and split method) and also limitations of combinatorial synthesis.

Additionally, this course will involve extensive laboratory work. The students will be able to design and carry out small molecule (low molecular drug-relevant compounds) synthesis and natural product isolation along with their purification and characterization through

chromatography and spectroscopic methods. They will be able to analyze the results of such experiments. They will also actively participate in discussions during seminars and group exercises; communicate the results of experiments conducted in oral as well as written formats. Further, they will appreciate the central role of chemistry in our daily life and will also learn safe handling of hazardous chemicals and follow the SOP for chemical waste disposal.

Course Content

Unit-I: General Introduction (L1-L2)
Definition and scope of medicinal chemistry.

Unit-II: Drug Target Classification (L3-L16)
Proteins as drug targets. Receptors: the receptor role, ion channels, membrane bound enzyme activation, agonist and antagonists, concept of inverse agonist, desensitization and sensitization of receptors, affinity, efficacy and potency. Enzymes: Enzyme inhibitors (competitive, non-competitive, suicide inhibitors), medicinal use of enzyme inhibitors.
Nucleic acids as drug targets. Classes of drugs that interact with DNA: DNA intercalators (amsacrine), Groove binders (netropsin), DNA alkylators (amines: mechlorethamine; nitrosoureas: carmustine), concept of antisense therapy.

Unit-III: How Drug Acts: Molecular Aspects (L17-L24)
Structure and functions of cell surface receptors, Signal transduction mechanism (GPCRs, Tyrosine kinase, guanylate- cyclase linked receptors and intracellular receptors that regulate DNA transcription).

Unit-IV: Physicochemical Principles of Drug Action and Measurement of Drug Effects (L25-L38)
Partition coefficient, Drug dissolution, Acid-base properties, Surface activity, Bioavailability, Stereochemical aspects of drug action, Electronic structure (Hammett correlations) and determining relationship between chemical and biological data (Hansch approach).
Kinetic analysis of ligand receptor interactions using Scatchard plot, Double reciprocal plot, Hill plot, Forces involved, Relationship between dose and effect (graded and quantal response).

Unit-V: Principles of Drug Design (L39-L44)
Introduction to SAR, Strategies in the search for new lead compounds, Analogue synthesis versus Rational drug design, Concept of prodrugs.

Unit-VI: Introduction to Combinatorial Synthesis (L45-L48)
Methods of parallel synthesis, Methods in mixed combinatorial synthesis (mix and split method), Limitations of combinatorial synthesis.

Practical (Any 8)

(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 organic compound, determination of its melting point and TLC.
2. Preparation of Benzocaine.
3. Preparation of Benzoquinone.
4. Determination of partition coefficient of Aspirin in octanol-water system.
5. Preparation of Phenacetin.

6. Preparation of Hippuric acid.
7. Preparation of s-benzyl thiouronium salt.
8. Extraction of caffeine from tea leaves and study its absorption properties.
9. Phytochemical screening and qualitative chemical examination of various plant constituents by solvent extraction. (Detection of alkaloids, carbohydrates, glycosides, phytosterols, oils and fats, tannins, proteins, gums and mucilages).
10. Extraction of piperine from black pepper.

References

Essential Readings for Theory and Practical

1. Patrick G.I. (2017). 6th Edition. *Introduction to medicinal chemistry*. Oxford, UK: Oxford University Press. ISBN-13: 978-0198749691.
2. Silverman, R.B. and Holladay, M.W. (2014). 3rd Edition. *The organic chemistry of drug design and drug action*. San Diego, USA: Elsevier, Academic Press. ISBN-13: 9780123820303.

Suggested Readings for Theory and Practical

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

Teaching-Learning Process

The course in medicinal chemistry is designed to encourage the acquisition of subject knowledge, understanding academic and professional skills required for biological and medicinal chemistry-based professions and jobs, learning experiences should be designed and implemented to foster active/participative learning. Development of practical skills will constitute an important aspect of the teaching-learning process. A variety of approaches to teaching-learning process, including lectures, seminars, tutorials, workshops, peer teaching and learning and project-based learning, substantial laboratory-based practical component and experiments, open-ended project work, technology-enabled learning, internship in industry and research establishments etc. will need to be adopted to achieve this. Problem-solving skills and higher-order skills of reasoning and analysis will be encouraged through teaching strategies.

Teaching Learning Plan

Unit	Title	Lectures
I	General introduction	L1-L2
II	Drug target classification	L3-L16

III	How drug acts: Molecular aspects	L17-L24
IV	Physicochemical principles of drug action and Measurement of drug effects	L25-L38
V	Principles of drug design	L39-L44
VI	Introduction to combinatorial synthesis	L45-L48

Assessment Methods

Progress towards achievement of learning outcomes will be assessed using the following methods: time-constrained examinations; closed-book and open-book tests; problem-based assignments; practical assignment, laboratory reports; observation of practical skills; individual/team project reports; oral presentations, including seminar presentation; viva voce interviews; computerized adaptive testing; peer and self-assessment etc.

Keywords

Receptor, antisense, QSAR, enzyme inhibitor, DNA interacting agent, signal transduction, prodrug, combinatorial synthesis

Skill-Enhancement Elective Courses (SEC)
B.Sc. (Hons) Course in
Biomedical Science
Semester III and IV

Skill-Enhancement Elective Courses (SEC)

(Any one paper per semester in semesters III-IV)

1. Methods in Epidemiological Data Analysis (EDA)
2. Medical Laboratory Diagnostics (MLD)
3. Techniques for Forensic Science
4. Tools in Modern Biology

Semester III/ IV
Methods in Epidemiological Data Analysis
(Unique Paper Code: 32583901)
Skill-Enhancement Elective Course- (SEC) Credit: 4

Theory **Total Lectures: 24**

Course Objective

1. To help students in designing a hypothesis and statistical analysis of the data.
2. To provide training to the students on how to conduct epidemiological surveys, design questionnaire and analyze the data.
3. To develop practical skills by hands-on-training on 'R', a free software environment for statistical computing and graphics.

Course Learning Outcomes

Unit-I: Understanding Epidemiological Data
Students will have an enhanced knowledge and appreciation of the statistical analysis of data and epidemiological studies.

Unit-II: Epidemiologic Methods
Students will understand data collection, sampling and different epidemiological study designs.

Unit-III: Data Organization and Presentation
Students will be able to perform basic statistical analysis on 'R'.

Unit-IV: Statistical Modeling and Analysis
Students will be able to perform correlation and regression analyses and also will be able to make inferences from statistical analysis.

Course Content

Unit-I: Understanding Epidemiological Data (L1-L2)

(a) Epidemiology and its components: disease frequency, distribution of disease and determinants of disease.
(b) Epidemiological approach and measurements- vital statistics (rates, ratios and proportions)
(c) Measurements of health indicators (morbidity, mortality and fertility rates)

Unit-II: Epidemiologic Methods (L3-L10)

(a) Data collection: observational (descriptive and analytical) and experimental studies. Defining the target and control populations.
(b) Epidemiology study designs- case control and cohort studies (prospective and retrospective), Techniques of sampling and matching, sources of bias, ethical issues in a study.

Unit-III: Data Organization and Presentation (L11-L14)

(a) Basic principles of tabulation and graphical representations, measures of central tendency (mean, mode, median and partition values), dispersion (range, standard deviation, coefficient of variance and covariance) and skewness.
(b) Introduction to 'R' software.

Unit IV: Statistical Modeling and Analysis (L15-L24)

(a) Correlation analysis (scatter diagrams and Karl Pearson's coefficient of determination, standard and probable errors) and regression analysis.
(b) Inferential statistics: sampling distributions and standard error, null and alternate hypothesis, basic concept and illustrations of type I and type II errors, concept of confidence interval estimation, large sample tests for single mean and difference of means, single proportion and difference of proportions, students t-distribution (test for single mean, difference of means and paired t-test), chi-square distribution, F-distribution, one-way and two-way ANOVA, non-parametric analysis (sign and rank tests), p-value.

Practical

1. To explore the data from National Cancer Registry Program (NCRP)/ WHO/ any other public domain.
2. To calculate various epidemiological parameters like incidence, rates, ratios, and proportion.
3. To design a questionnaire for survey of prevalence of diabetes/ hypertension/ allergy/ respiratory disorders/ etc.
4. Hands-on training of R-software and to make bar diagrams, histograms, pie charts, box plot, etc. using 'R' software.
5. To calculate measures of central tendency and dispersion (mean, mode, median and partition values, range, standard deviation, coefficient of variance and covariance) using 'R' software.
6. To perform correlation and regression analysis using 'R' software.
7. To calculate probability and perform various hypothesis tests using 'R' software.

For practical 4-7, data used can be from the survey conducted, if any or extracted from any public domain.

References

Essential Readings for Theory and Practical

1. Daniel, W.W. and Cross, C.L. (2019). 11th Edition. *Biostatistics: A foundation for analysis in the health sciences*. New York, USA: John Wiley & Sons. ISBN-13: 978-1119588825.
2. Glantz, S. (2011). 7th Edition. *Primer of biostatistics*. New York, USA: McGraw-Hill Medical. ISBN-13: 978-0071781503.
3. Park, K. (2011). 25th Edition. *Park's textbook of preventive and social medicine*. India: Banarsi Das Bhanot Publishers. ISBN13: 9788190607995
4. Website for 'R': www.r-project.org
5. Website for NCRP: http://www.ncrpindia.org

Suggested Readings for Theory and Practical

1. Bonita, R., Beaglehole, R. and Kjellstrèom, T. (2006). 2nd Edition. *Basic epidemiology*. Geneva, Switzerland: World Health Organization. ISBN-13: 978-9241547079.
2. D'Agostino, R., Sullivan, L. and Beiser, A. (2005). 1st Edition. *Introductory applied biostatistics*. Boston, USA: Cengage Learning. ISBN: 978-0534423995.
3. Dawson, B., Trapp, R.G. (2004). 4th Edition. *Basic and clinical biostatistics*. New York, USA: Tata McGraw-Hill. ISBN: 978-0071410175.
4. Katz, D.L., Elmore, J.G., Wild, D. Lucan, S.C. (2013). 4th Edition. *Jekel's epidemiology, biostatistics, preventive medicine and public health*. Philadelphia, USA: Elsevier Saunders. ISBN: 978-1455706587.
5. Motulsky, H. (2013). 3rd Edition. *Intuitive biostatistics: A nonmathematical guide to statistical thinking*. New York, USA: Oxford University Press. ISBN: 978-0199946648.
6. Norman, G.R. and Streiner, D.L. (2008). 3rd Edition. *Biostatistics: The bare essentials*, New York, USA: McGraw-Hill Medical. ISBN: 978-1550093476.
7. Pagano M. and Gauvrean, K. (2000). 2nd Edition. *Principles of biostatistics*. California, USA: Duxbury Press. ISBN-13: 978-0534229023.
8. Zar, J.H. (2009). 5th Edition. *Biostatistical analysis*. USA: Pearson. ISBN-13: 978-0131008465.

Teaching Learning Process

Methods for Epidemiological Data Analysis course in biomedical science is designed to encourage the acquisition of subject knowledge, understanding and developing academic and professional skills required for statistical data analysis in biomedical science/ public health-based professions and research. A variety of approaches to teaching-learning process, including lectures, seminars, tutorials, workshops, peer teaching and learning etc. will be adopted to achieve this. Another important aspect of the teaching-learning process will be project-based learning comprising of designing of questionnaire, conducting a survey and data analysis using R-software. Teaching strategies will be taken up to enhance the reasoning/ analytical problem-solving skills of students.

Teaching Learning Plan

Unit	Title	Lectures
I	Understanding epidemiological data	L1-L2
II	Epidemiologic methods	L3-L10
III	Data organization and presentation	L11-L14
IV	Statistical modelling and analysis	L15-L24

Assessment Methods

The assessment of students' achievement in Methods for Epidemiological Data Analysis will be aligned with the course learning outcomes and the academic and professional skills that the programme is designed to develop. A variety of assessment methods like oral and written examinations, closed-book and open-book tests; problem-solving exercises, practical assignment laboratory reports, observation of practical skills, seminar, presentation; viva-voce interviews; computerized adaptive testing, literature surveys etc. Assessment of learning

outcomes will also include the evaluation of a short project involving designing of questionnaire for conducting a survey followed by data analysis.

Keywords

Epidemiology, NCRP, vital statistics, ‘R’ software, sampling, correlation, regression, probability, hypothesis testing

Semester III/ IV
Medical Laboratory Diagnostics (MLD)
(Unique Paper Code: 32583902)
Skill-Enhancement Elective Course- (SEC) Credit: 4

Theory **Total Lectures: 24**

Course Objectives

1. This course concerns the prevention, diagnosis, and treatment of disease through the clinical laboratory tests.
2. It helps students to learn how to diagnose, detect, and treat the diseases. In this course, students learn about sampling, reporting, testing, and documentation of the clinical tests.
3. Candidates learn the skills required to handle advanced equipment to perform accurate laboratory tests.
4. This course provides instruction about procedures to be followed for accurate diagnosis of the disease at the microbial and biochemical level.
5. The course aims at developing the laboratory based diagnostic skills of the students and is career oriented in nature.

Course Learning Outcomes

Unit-I: Fundamentals of Clinical Diagnostics

This course should help students to conduct research, finish tasks with accuracy and have interpreting technical skills. In addition, students should understand and explain concepts/ procedures related to laboratory tests: sampling and transport of biological/ infectious materials, biosafety, bio-hazard classifications, quality control for laboratory techniques and analyses in order to perform a proper risk assessment and plan for containment and transport.

Unit-II: Approaches to Diagnosis of Infectious Diseases

The course enables students to learn molecular detection test and techniques for culture, purification, long term preservation and storage of microbial cultures. Students also learn pathogens specificity and predictive value analysis.

Unit-III: Immunoserology: Principles and Application

Students learn serological (ELISA) pathogen detection tests and interpret output serological, bacteriological and parasitological and molecular diagnostic tests and explain how the pathogenesis of a disease can influence the interpretation of test results.

Unit-IV: Medical Cytogenetics

Students should learn fundamentals of human cytogenetics including techniques for identification of chromosome number and chromosomal aberrations leading to genetic disorders. They should understand scientific basis of genetic counselling with reference to prenatal diagnosis and cancer cytogenetics.

Course Content

Unit-I: Fundamentals of Clinical Diagnostics (L1-L7)

Introduction to clinical laboratory principles and procedures. Concept of GLP and ISO labs, quality control and laboratory safety. Regulation of diagnostic labs and accreditation methods. Guidelines for collection transport, preservation processing and analysis of specimen. Overview of phlebotomy, urinalysis, basic haematology, clinical biochemistry, immune-serology and clinical microbiology. Guidelines for proper discard of biological waste and chemical wastes. Principles and applications of important instruments used in the diagnostic laboratory: biological safety cabinets (Class I, II, III) autoclave, incubators, hot air oven, centrifuges, PCR machines, bright field microscope, fluorescence microscope, ELISA reader, Autoanalyser, Spectrophotometer Gel Electrophoresis System.

Unit-II: Approaches to Diagnosis of Infectious Diseases (L8-L13)

Classification of culture media and quality control of culture media. Inoculation, incubation and purification methods in bacteriology. Preservation of bacterial culture. Rapid identification system, Continuous monitoring culture systems: BacT/ESP/BACTEC. Use of conventional microbiological tools supplemented by most modern analytical techniques including PCR for enumeration, isolation and identification of microbes (mainly on fresh produce). To ascertain the pathogen specificity, Prevalence positive predictive value and negative predictive value.

Unit-III: Immunoserology: Principles and Application (L14-L18)

To understand the concept of Immune response and to learn important techniques ELISA - direct, Indirect, competitive and sandwich ELISA. To study and understand Co-immunoprecipitation for protein-protein interaction studies.

Unit-IV: Medical Cytogenetics (L19-L24)

Human cytogenetics and its application to medicine and cell culture. Chromosome identification by chromosome banding and staining, cytogenetics nomenclature. Classification of genetic disorders, chromosome abnormalities & aberrations, chromosomal syndromes. To understand the basics of Clinical Genetics, Prenatal Diagnosis, Infertility and Cancer Cytogenetics.

Practical

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

1. Sterilization Techniques: Physical methods and Chemical methods.
2. General overview of blood banking, blood typing, blood screening in transfusion medical lab.
3. Isolation of bacteria from mixed culture. Study of morphological, cultural, biochemical characteristics of common bacterial pathogen.
4. To study composition and use of important differential media for identification of pathogenic bacteria EMB agar, McConkey agar, TCBS agar and Salmonella-Shigella agar and blood culture media (any two).
5. Enumerate the microbial load on the selected fresh produce from major outlets.

6. Isolate and identify the common microorganisms present on their surface using microbiological, biochemical and PCR techniques.
7. Antigen-antibody interaction and its use in diagnosis: Detection and diagnosis of common diseases: Widal and typhi dot for typhoid, Acylated haemoglobin in Diabetes, TSH levels in Thyroid condition, Malaria antigen in Malaria, NS1 antigen in Dengue (any three immune diagnostic tests).
8. To culture peripheral blood and preparation of metaphase chromosomes, chromosome banding and karyotyping.

References

Essential Readings for Theory and Practical

1. Cappuccino, J. G. and Welsh, C. D. (2017). 11th Edition. *Microbiology: a laboratory manual*. Chennai, India: Pearson India Education Services Pvt. Ltd. ISBN-13: 978-0134098630.
2. Dracopoli, N. C., Haines, J. L., Korf, B. R., Morton, C. C., Seidman, C. E., Seidman J. G., Smith, D. R. (1994). 1st Edition. *Current protocols in human genetics.* New Jersey, USA: John Wiley and Sons. ISBN-13: 978-0471034209.
3. Green, M. R. and Sambrook, J. (2012). 4th Edition. *Molecular cloning: A laboratory manual*. New York, USA: Cold Spring Harbor Laboratory Press. ISBN 978-1-936113-42-2
4. Sood, R. (2009*).* 6th Edition. *Medical laboratory technology methods and interpretations (Volume 1 and 2).* New Delhi, India: Jaypee Brothers Medical Publishers (P) Ltd. ISBN-13: 978-8184484496.
5. Tille, P. T. (2017). 14th Edition. *Bailey and Scott's diagnostic microbiolog*y. St. Louis, Missouri, USA: Elsevier. ISBN-13: 978-0323354820.

Suggested Readings for Theory

Mukherjee, K.L. and Chakravarthy, A. (2017). 3rd Edition. *Medical laboratory technology procedure: Manual for routine diagnostic tests. Volume 1-3.* Delhi, India: Mc Graw Hill Education (India) Pvt. Ltd Publishers, ISBN-13: 978-93-5260-680-1.

Teaching Learning Process

The syllabus of medical lab diagnostics is designed to encourage the acquisition of subject knowledge and skills required for biomedical based professions and jobs. Learning experiences are aimed at developing practical skills which would prepare the student for research in educational institutions and biomedical science-based jobs both teaching and industry. Various approaches to teaching learning process, including lectures, seminars, tutorials, workshops, peer teaching, learning, project-based learning, field-based learning, substantial laboratory based practical component and experiment will be adopted to achieve this.

Teaching Learning Plan

Unit	Title	Lectures
I	Fundamentals of clinical diagnosis	L1-L14
II	Approaches to diagnosis of infectious diseases	L15-L26
III	Immunoserology- Principles and applications	L27-L36
IV	Medical Cytogenetics	L37-L48

Assessment Methods

1. Class tests
2. Written assignments
3. Student presentations
4. Oral questions for concepts taught in previous classes
5. End semester University examination

Keywords

Clinical diagnostics, biosafety, biohazard, host pathogen interface, diagnostic immunoserology, blood banking, karyotyping

Semester III/ IV
Techniques for Forensic Science
(Unique Paper Code: 32583903)
Skill-Enhancement Elective Course- (SEC) Credit: 4

Theory **Total Lectures: 24**

Course Objective

1. Forensic science is the application of scientific knowledge to questions of civil and criminal law. Interest in forensic science has grown considerably in recent years. The forensic science plays very important role in crime investigation as governed by the legal standards.
2. Keeping this in view, the 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.
3. This engage students in using a creative, problem solving and inquiry-based approach to investigate the crime scene and criminal profiling.
4. It also explains the characteristics of a fingerprint collect, process, and analyze fingerprint evidence and explain DNA analysis.

Course Learning Outcomes

Unit-I: Crime Scene Investigation

After completion of course in Techniques for Forensic Science, students are expected to be familiar with key concepts of crime scene investigation and cybercrimes. The students are expected to learn the management and documentation of indoors and outdoor crime scene. Simulation of crime scene will familiarize them with situations during a crime scene investigation.

Unit-II: Examination of Security Documents

Students will be able identify major security features in various educational documents, bank notes, cheques and other essential documents of identification.

Unit-III: Forensic Chemistry and Ballistics

Providing information about ballistics will help them to compare with different types of cartridges, handguns and assault rifles.

Unit-IV: Forensic Graphology and Cyber Forensic Investigation

Forensic graphology sensitization will assist students in the identification of forge and original handwritings. It will also help to understand the chemical nature of pen ink and methods of their identification. Cyber forensic will give them exposure to understand cyber vulnerability and protective measure during online surfing

Unit-V: Forensic Toxicology

The methods for identification and characterization of toxins, drugs, pesticides and poisonous substance in forensic toxicology will assist students to understand their impact on human body

Unit-VI: Fingerprint Analysis
They will know the extensive usage of DNA fingerprinting and dactyloscopy (pattern on fingerprints) in identification and individualization of human beings.

Course Content

Unit-I: Crime Scene Investigation (L1-L5)
Introduction and principles of forensic science, Forensic science laboratory and its organization and service, tools and techniques in forensic science, branches of forensic science, causes of crime, role of modus operandi in criminal investigation

Unit-II: Examination of Security Documents (L6-L8)
Introduction to various security features in documents, methods of security document examinations. Examination of documents (Indian Passports/Visas, Stamp Papers, Postal Stamps etc.) with important security features, Physical matching of documents

Unit-III: Forensic Chemistry and Ballistics (L9-L11)
Classification of fire arms and explosives, introduction to internal, external and terminal ballistics, Chemical evidence for explosives

Unit-IV: Forensic Graphology and Cyber Forensic Investigation (L12-17)
General and individual characteristics of handwriting, examination and comparison of handwritings and analysis of ink various samples.
Investigation Tools, eDiscovery, Evidence Preservation, Search and Seizure of Computers, Introduction to Cyber Security, Digital Evidence Collection: E-Mail Investigation, E-Mail Tracking, IP Tracking, E-Mail Recovery, Recovering deleted evidences, Password Cracking

Unit-V: Forensic Toxicology (L18-21)
Role of the toxicologist and significance of toxicological findings, techniques for analyzing common toxins, drugs, pesticides, Volatile poisons, vegetable poisons etc. in given biological samples and crime scene.

Unit-VI: Fingerprint Analysis (L22-L24)
Fundamental principles of fingerprinting, classification of fingerprints, development of finger print as science for personal identification. Principle of DNA fingerprinting, application of DNA profiling in forensic medicine.

Practical

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

1. Simulation and documentation of crime scene by photography, sketching and field notes for training.
2. To lift footprints from crime scene.
3. Comparison of bullets and cartridges in museum**.**
4. Separation of nitro compounds (explosives) by thin layer chromatography.
5. To perform the preliminary examination of blood in a given sample.
6. Identification and comparison of handwriting characters.
7. To perform thin layer chromatography of ink samples.

8. Investigate method for developing fingerprints by iodine crystals and observe the effects of surface temperature on fingerprints.
9. DNA isolation in minimal available biological samples and PCR amplification of target DNA followed by DNA profiling.

References

Essential Readings for Theory and Practical

1. Barbara, W. and Lori, J. W. (2008). 1st Edition. *Practical forensic microscopy: a laboratory manual.* Oxford, England: Bios Scientific Publisher. ISBN-13**:** 9780470031766
2. James, S.H. Nordby, J.J. and Bell, S. (2014). 4th Edition. *Forensic science: An introduction to scientific and investigative techniques*. Florida, USA: CRC Press. ISBN-13: 978-1439853832
3. 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.

Suggested Readings for Theory and Practical

1. Bardale, R. (2011). 1st Edition. *Principles of forensic medicine and toxicology*. New Delhi: Jaypee Brothers Medical Publishers. ISBN-13**:** 978-9350254936.
2. Brian, J. H. (2008). 2nd Edition. *Handbook of firearms and ballistics: Examining interpreting forensic science*. New Jersey, USA: John Wiley and Sons. ISBN: 978-0-470-69460-2.

Teaching Learning Process

The syllabus of Techniques for Forensic Science is designed to encourage the acquisition of subject knowledge, skills required to understand the basics in professions and jobs. Learning experiences are aimed at developing practical skills which would prepare the students for day to day general activities and educational organizations. Various approaches to teaching-learning process, including lectures, seminars, tutorials, workshops, peer teaching, learning, project-based learning, field-based learning, substantial laboratory-based practical component and experiments, open-ended project work, technology-enabled learning, internship in industry and research establishments will be adopted to achieve this. Problem-solving skills and higher-order skills of reasoning and analysis will be encouraged through teaching strategies.

Teaching Learning Plan

Unit	Title	Lecture
I	Crime Scene Investigation	L1-L5
II	Examination of Security documents	L6-L8
III	Forensic Chemistry and Ballistics	L9-L11
IV	Forensic Graphology and Cyber Forensic Investigation	L12-L17
V	Forensic Toxicology	L18-L21
VI	Fingerprint analysis	L22-L24

Assessment Methods

1. Class tests
2. Written assignments
3. Student presentations
4. Oral questions for concepts taught in previous classes
5. End semester University examination

.

Keywords

Crime scene, graphology, security documents, toxicology, fingerprinting, DNA profiling, evidence, chromatography

Semester III/ IV
Tools in Modern Biology
(Unique Paper Code: 32583904)
Skill-Enhancement Elective Course- (SEC) Credit: 4

Theory **Total Lectures: 24**

Course Objective

The objective of this course is to provide hand-on skills to students for tools and techniques in modern era of biology and biotechnology. It focuses on the principles of amplification, purification and analysis of DNA sequences by the means of plasmids, PCR and mapping. It also accounts for purification and study of protein-protein interactions besides giving an overview of cell culture. This course is primarily practical based.

Course Learning Outcomes

Unit-I: Plasmids and Biotechnology
Students will be able to isolate and handle plasmids for recombinant DNA technology and will also learn to construct restriction maps.

Unit-II: Amplification and Analysis of DNA Sequences
They will be able to design primers and PCR amplify target sequences. They will also learn analysis of sequencing data.

Unit-III: Purification and Analysis of Proteins
They will be able to analyze proteins by PAGE and purify them based on their affinity and charge.

Unit-IV: Cell Culture and Imaging
They will learn basic principles of cell culture handling and fluorescence microscopy.

Course Content

Unit-I: Plasmids and Biotechnology L1-L6
Significance of plasmids in biotechnology; different methods of plasmid isolation; types and relevance of restriction sites and their potential in mapping.

Unit-II: Amplification and Analysis of DNA Sequences L7-L12
Principle, applications and modifications of PCR; essentials for a primer; concept of DNA sequencing and analysis of electropherograms.

Unit-III: Purification and Analysis of Proteins L13-L20
Concept of protein structure and denaturation with relevance to its resolution on gel; principle of chromatography and its application in purification and studying interactions.

Unit-IV: Cell Culture and Imaging L21-L24
Essentials of cell culture, composition of media and the variations therein, analysis of the cell

phenotype using fluorescence microscopy.

Practical (Any 8)

(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. Isolation of Plasmid (mini-prep) from *E. coli* culture.
2. Restriction digestion of plasmid and its analysis.
3. Extraction of DNA from agarose gel.
4. Construction of restriction maps from the data provided.
5. Primer designing.
6. Optimization of PCR conditions for temperature (gradient PCR) and Magnesium concentration.
7. Detection of bacteria specific genes using colony PCR.
8. Analysis of DNA sequences with electropherograms.
9. Comparative analysis of protein on native and denaturing gels.
10. Protein purification by affinity chromatography.
11. Separation of proteins by ion exchange chromatography.
12. Preparation of media and culturing of cells. Fluorescence imaging demonstration in *E coli* with GFP and mammalian cells with PI/DAPI.

References

Essential Readings for Theory and Practical

1. Brown, T.A. (2016). 7th Edition. *Gene cloning and DNA analysis*. New Jersey, USA: Wiley-Blackwell. ISBN: 978-1-119-07256-0.
2. Glick, B.R. and Patten, C.L. (2017). 5th Edition. *Molecular biotechnology: Principles and applications of recombinant DNA*. Washington DC, USA: ASM Press. ISBN: 978-1555819361
3. Green, M.R. and Sambrook, J. (2012). 4th Edition. *Molecular cloning: A laboratory manual*. New York, USA: Cold Spring Harbor Laboratory Press. ISBN: 978-1936113422.
4. Hofmann, A. and Clokie, S. (2018). 8th Edition. *Wilson and Walker's principles and techniques of biochemistry and molecular biology*. Cambridge, UK: Cambridge University Press. ISBN: 978-1108716987.

Suggested Readings for Theory and Practical

1. Freifelder, D. (1982). 2nd Edition. *Physical biochemistry: Applications to biochemistry and molecular biology*. New York, USA: W.H. Freeman and Company. ISBN: 978-0716714446.
2. Freshney, R.I. (2016). 7th Edition. *Culture of animal cells: A manual of basic technique and specialized applications*. New Jersey, USA: Wiley-Blackwell. ISBN: 978-1-118-87365-6.
3. Primrose, S.B. and Twyman, R.M. 7th Edition. (2013). *Principles of gene manipulation and genomics*. Massachusetts, USA: Blackwell Publishing. ISBN: 978-1405135443.
4. Strachan, T. and Read, A. (2018). 5th Edition. *Human molecular genetics*. Florida, USA: CRC Press, Garland Science. ISBN: 978-0815345893.

Teaching Learning Process

Class lectures through chalk and board or through presentations, interactive learning by open discussions on certain topics, assignments and hands on training during practical session.

Teaching Learning Plan

Unit	Title	Lectures
I	Plasmids and Biotechnology	L1-L6
II	Amplification and Analysis of DNA Sequences	L7-L12
III	Purification and Analysis of Proteins	L13-L20
IV	Cell Culture and Imaging	L21-L24

Assessment Methods

1. Class tests
2. Written assignments
3. Seminar/ presentations/ quizzes
4. Monitoring in practical sessions
5. End semester University examination.

Keywords

Biotechnology, plasmids, restriction endonucleases, PCR, primer designing, DNA sequencing, protein purification and analysis, cell culture, fluorescence microscopy

B.Sc. (Hons) Course in
Biomedical Science
III Year
Semester V and VI

Semester V
Biophysics
(Unique Paper Code: 32581501)
Core Course- (CC) Credit: 6

Theory **Total Lectures: 48**

Course Objective

1. Biological phenomena cannot be understood fully without physical insight. The course will demonstrate the role of fundamentals of chemistry and physics in understanding the biological processes including the methods to study the structure and functions of macromolecules and the chemical reactions occurring in living cells.
2. The students will be able to learn theoretical basis of various analytical and biomedical techniques including various spectroscopic techniques, hydrodynamic methods, molecular biophysics.
3. The students will be introduced to various physical principles responsible for maintaining the basic cellular function and integrity of biological membranes including transport across them.

Course Learning Outcomes

After completing the course, students shall be able to:

Unit-I: Biophysical Techniques
Appreciate the interdisciplinary frontier of science in which the principles and techniques of physics are applied to understand biological problems at every level, from atoms and molecules to cells, organisms and environment and analyze the data generated through spectroscopic techniques such as UV-Visible, Infrared, Mass spectroscopy, NMR, etc.

Unit-II: Hydrodynamic Methods
Understand the concepts of viscosity and sedimentation methods and their biological applications.

Unit-III: Molecular Biophysics
Comprehend the thermodynamics of the structure of biomolecules and consequences of their structural instability and apply their biophysics knowledge to analyze the known experiments and to develop newer experimental methods for new biophysical applications.

Unit-IV: Biological Membranes
Understand the physical basis of transport across biological membranes.

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

Course Content

Unit-I: Biophysical Techniques (L1-L20)

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

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

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

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

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

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

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

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

Unit-II: Hydrodynamic Methods (L21-L30)

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

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

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

Unit-III: Molecular Biophysics (L31-L42)

Basic thermodynamics: Concept of entropy, enthalpy, free energy change, heat capacity.

Forces involved in biomolecular interactions with examples: Configuration versus conformation, Van der Waals interactions, Electrostatic interactions, Stacking interactions, Hydrogen bond and hydrophobic effect, Ramachandran plot.

Supercoiling of DNA: Linking number, twist and writhe.

Protein folding: Marginal stability of proteins, Thermodynamic and kinetic basis of protein folding, Protein folding problem (Levinthal's paradox) and role of molecular chaperones in cellular protein folding, Basics of molecular and chemical chaperones, Protein misfolding and aggregation, Diseases associated with protein misfolding.

Unit-IV: Biological Membranes (L43-L48)

Transport of solutes and ions, Fick's laws of diffusion, Ionophores, Transport equation, Membrane potential.

Practical

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

1. Effect of different solvents on UV absorption spectra of proteins.

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

References

Essential Readings for Theory and Practical

1. Freifelder, D. (1982). 2nd Edition. *Physical biochemistry: Applications to biochemistry and molecular biology*. New York, USA: W.H. Freeman and Company. ISBN-13: 978-0716714446.
2. Sheehan, D. (2009). 2nd Edition. *Physical biochemistry: Principles and* applications. Oxford, UK: John Wiley. ISBN-13: 978-0470856031.
3. Skoog D.A., Holler, F.J. and Crouch, S.R. (2017). 7th Edition. *Principles of Instrumental Analysis*. Boston, USA: Cengage Learning. ISBN-13: 978-1305577213.

Suggested Readings for Theory and Practical

1. Branden, C. and Tooze, J. (1999). 2nd Edition. *Introduction to protein structure*. New York, USA: Garland Science, ISBN-13: 978-0815323051.
2. Cantor, C.R. Schimmel, P.R. (1980). 1st Edition. *Biophysical Chemistry*. New York, USA: W.H. Freeman and Company. ISBN-13: 9780716711889.
3. Frauenfelder, H., Chan, S.S. and Chan, W.S. (2010). 1st Edition. *The physics of proteins: An introduction to biological physics and molecular biophysics*. New York, USA: Springer, ISBN-13: 978- 1441910431.
4. Hofmann, A. and Clokie, S. (2018). 8th Edition. *Wilson and Walker's principles and techniques of biochemistry and molecular biology*. Cambridge, UK: Cambridge University Press. ISBN: 978-1108716987.
5. Hoppe, W., Lohmann, W., Markl, H. and Ziegler, H. (1983). 1st Edition. *Biophysics*. Berlin, Germany: Springer-Verlag and Heidelberg GmbH & Co., ISBN-13: 978-3540120834.
6. Kuriyan, J., Konforti, B. and Wemmer, D. (2012). 1st Edition. *The molecules of life: Physical and chemical principles*. New York, USA: Garland Science. ISBN-13: 978-0815341888.
7. Rhodes, G. (2006). 3rd Edition. *Crystallography made crystal clear: Guide for users of macromolecular models.* Massachusetts, USA: Academic Press. ISBN-13: 978-0125870733.
8. Tinoco I., Sauer, K. Wang, J.C., Puglisi, J.D., Harbison, G. and Rovnyak, D. (2013). 5th Edition. *Physical chemistry: Principles and applications in biological sciences* Pearson, Prentice Hall. ISBN-13: 978-0136056065.
9. Van Holde, K.E., Jhonson, W.C. and Shing Ho, P. (2005). 2nd Edition. *Principles of physical biochemistry*. New Jersey, USA: Prentice Hall Inc. ISBN-13: 978-0130464279.
10. Watson, J. D., Baker T. A., Bell, S. P., Gann, A., Levine, M., Losick, R. (2013). 7th Edition. *Molecular Biology of the Gene*. New York, USA: Cold Spring Harbor Laboratory Press, ISBN-13: 978-0-321-76243-6.

Teaching-Learning Process

The course in biophysics is designed to encourage the acquisition of subject knowledge, understanding and skills and academic and professional skills required for biological physics-based professions and jobs, learning experiences should be designed and implemented to foster active/participative learning. Development of practical skills will constitute an important aspect of the teaching-learning process. A variety of approaches to teaching-learning process, including lectures, seminars, tutorials, workshops, peer teaching and learning and project-based learning, substantial laboratory-based practical component and experiments, open-ended project work, games, technology-enabled learning, internship in industry and research establishments etc. will need to be adopted to achieve this. Problem-solving skills and higher-order skills of reasoning and analysis will be encouraged through teaching strategies.

Teaching Learning Plan

Unit	Title	Lectures
I	Biophysical Techniques	L1-L20
II	Hydrodynamic Methods	L21-L30
III	Molecular Biophysics	L31-L42
IV	Biological Membranes	L43-L48

Assessment Methods

Progress towards achievement of learning outcomes will be assessed using the following methods: time-constrained examinations; closed-book and open-book tests; problem based assignments; practical assignment laboratory reports; observation of practical skills; individual/ team project reports; oral presentations, including seminar presentation; viva voce interviews; computerized adaptive testing; peer and self-assessment etc.

Keywords

Spectroscopy, UV, NMR, IR, CD, fluorescence, x-ray, viscosity, centrifugation, flow cytometry, supercoiling, protein folding, membrane transport, Fick’s law

SEMESTER V
Pharmacology
(Unique Paper Code: 32581502)
Core Course- (CC) Credit: 6

Theory **Total Lectures: 48**

Course Objective

Pharmacology is the science concerned with the study of drugs and how they can best be used in the treatment of disease in both humans and animals. The course starts with the general considerations and lead to understanding of various drugs acting on different body systems. It is a very important biomedical discipline, with roots both in basic biology and chemistry, and plays a vital role in helping to safeguard our health and welfare.

Course Learning Outcomes

Unit-I: Introduction to Pharmacology
Broad range of chemicals that act as medicine for humans and their various sources. How drugs are administered in the body i.e. routes; and under which conditions is one route preferred over another in patients, various types of drug receptors in the body and their functioning.

Unit-II: Pharmacokinetics and Pharmacokinetics
Basics of absorption, transport, excretion of drugs and effects of metabolism on drug action. Basics of quantification of half-life, bio-availability and elimination of drugs in the body and factors affecting them. The action effect sequence, how response changes with dose of drug administered, basics of measurement of response, efficacy and potency of drug. Different factors affecting action of the drug.

Unit-III: Brief Introduction to Autacoids
The concept, mechanism of suppression of pain, fever and inflammation by NSAIDS

Unit-IV: Mechanism of Action of Different Classes of Drugs
The concept, mechanism, classification, use and contraindication of drugs of various classes.

Unit-V: Chemotherapy of Microbial Diseases
Assessment of the choice and role of antibiotics in drug therapy and the problems arising from their indiscriminate use.

Unit-VI: Hormones and Hormone Antagonists
The importance and use of hormones and hormone antagonists as drugs in endocrine system related disorders. Hormone replacement therapy and its application.

Course Content

Unit-I: Introduction to Pharmacology (L1-L4)
Nature and source of drugs, routes of drug administration, their advantages and disadvantages, receptor and receptor subtypes.

Unit-II: Pharmacokinetics and Pharmacokinetics (L5-L18)
Drug absorption, distribution, metabolism, and excretion, bio-availability, first pass metabolism, excretion and kinetics of elimination, bio-availability, biological half-life of drug and its significance, drug-drug interactions.

Unit-III: Brief Introduction to Autacoids (L19-L22)
Drug therapy of inflammation, NSAIDs and other drugs (aspirin, celecoxib).

Unit-IV: Mechanism of Action of Different Classes of Drugs (L23-L34)
General aspects, classification and mechanism of action of following classes of drugs along with side effects and contraindication of the drugs mentioned against each class should also be covered.

(a) General Anesthetics:	Halothane
(b) Sedatives and Hypnotics:	Diazepam
(c) Cholinergics:	Bethanechol, Rivastigmine
(d) Skeletal Muscle Relaxants:	Succinylcholine
(e) Adrenergics:	Isoprenaline, Propranolol, Salbutamol
(f) Dopaminergics:	Dopamine, Syndopa
(g) Diuretics:	Furosemide

Unit-V: Chemotherapy of Microbial Diseases (L35-L40)
Antibacterial (sulfonamides), Antifungal (amphotericin B)

Unit-VI: Hormones and Hormone Antagonists (L41-L48)
Insulin and oral hypoglycemic agent (tolbutamide, rosiglitazone), thyroid and anti-thyroid drugs (eltroxin, carbimazole), HRT estrogen and progestins (progesterone, hydroxyprogesteronecaproate).

Practical

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

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

References

Essential Readings for Theory and Practical

1. Kulkarni, S.K. (2012). 4th Edition. *Hand book of experimental pharmacology*. Delhi, India: Vallabh Prakashan, ISBN-13: 97881857311.
2. Tripathi, K.D. (2010). 7th Edition. *Essentials of medical pharmacology*. Delhi, India: Jaypee Brothers. ISBN-13:9788184480856.

Suggested Reading

Rang, H.P., Dale, M.M., Ritter, J.M., Moore, P.K. (2011). 7th Edition. *Rang and Dale's pharmacology*. New York, USA: Elsevier Churchill Livingstone. ISBN-13: 978-0702034718.

Teaching Learning Process

1. Use of blackboard and chalk method to communicate the concepts.
2. Use of Power Points presentations to visually explain various processes.
3. Verbal explanation.
4. Open discussions.
5. Quizzing and questioning.

Teaching and Learning Plan

Unit	Title	Lectures
I	Introduction to Pharmacology	L1-L4
II	Pharmacokinetics and Pharmacokinetics	L5-l8
III	Brief introduction to autacoids	L19-L22
IV	Mechanism of action of different classes of drugs	L23-L34
V	Chemotherapy of microbial diseases	L35-L40
VI	Hormones and hormone antagonists	L41-L48

Assessment Methods

1. Written class test
2. Written assignments
3. Quizzing/ viva
4. Presentations
5. Final University Examination

Keywords

Drugs, medicine, pharmacokinetics, pharmacodynamics, therapeutics, mechanism of action, classification, clinical uses, anti-microbial, hormone, hormone analogues

Semester VI
Human Pathology
(Unique Paper Code: 32581601)
Core Course- (CC) Credit:6

Theory **Total Lectures: 48**

Course Objective

The course of Human Pathology aims at preparing the students in basic understanding of diseases and their pathogenesis. The topics are of introductory nature and build the concepts of how human system works in altered and diseased states under the influence of various internal and external stimuli Thus the pathology syllabus builds on the existing knowledge that the students have gained in Physiology, cell and tissue biology. Consequently, it incorporates topics like cellular adaptations, inflammation, neoplasia, cellular ageing and other infectious and non-infectious diseases. Laboratory exercises have been designed to substantiate and clarify the theoretical concepts.

Course Learning Outcomes

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

Unit-I: Introduction, Cellular Adaptations, Cell Injury and Cell
Differentiate and assess the role and importance of apoptosis and necrosis along with the concept of ageing. Describe the causes and mechanism of various cellular adaptations, cell injury and concepts of dysplasia.

Unit-II: Inflammation and its Role in Diseases
Describe the cardinal signs and basic pathophysiology of inflammation. Explain associated events, vascular changes, molecular mediators, morphological effects, outcomes and systemic effects.

Unit-III: Tissue Renewal & Repair, Healing and Fibrosis
Describe the basic concept and mechanism of healing responses after acute and chronic injury using examples of tissue remodelling in liver and rheumatoid arthritis

Unit-IV: Hemodynamic Pathology
Discuss disorders of hemodynamics (edema, congestion, and shock) and hemostasis (hemorrhage and thrombosis), as well as various forms of embolism. Conceptualize infarction, hypertension along with pathogenesis, stages and clinical consequences of shock.

Unit- V: Tumor Pathology and Pathogenesis
Describe the definition and concepts of dysplasia, oncogenes, tumor suppressor genes, neoplasia, tumour classification, staging and grading. Differentiate benign and malignant neoplasia and recognize clinical complications of tumors. Conceptualize cancer stem cells.

Unit-VI: Pathophysiology of Diseases
Define and conceptualize various aspects of disease. Understand and integrate the general

principles, terminology, and modes of spread of disease (Neoplastic and Non- neoplastic). Demonstrate an understanding of predisposing factors, etiology, pathogenesis, morphology, sequalae and potential complications of some lifestyle and infectious diseases

Course Content

Unit-I: Introduction, Cellular Adaptations, Cell Injury and Cell responses (L1-8)
History of pathology, basic definitions and familiarization with the common terms used in pathology, techniques used in pathology. Basic Concepts in cell and Tissue remodelling. Causes and mechanisms of cell injury: reversible and irreversible injury, Cellular responses: Hyperplasia, Hypertrophy, Atrophy, Metaplasia, Necrosis, Apoptosis, subcellular and intracellular response, (with suitable examples of diseases), Concepts and mechanisms of Cell ageing.

Unit-II: Inflammation and its Role in Diseases (L9-16)
General features of acute and chronic inflammation: Vascular changes, cellular events, termination of acute inflammatory response, Molecular mediators of inflammation, morphological effects and outcome of acute inflammation. Systemic effects of chronic inflammation, granulomatous inflammation.

Unit-III: Tissue Renewal & Repair, Healing and Fibrosis (L17-24)
Mechanism of tissue regeneration, role of ECM, repair by healing, scar formation and fibrosis, cutaneous wound healing, fractures and healing, tissue remodeling in liver (mechanism of fibrosis and cirrhosis) and rheumatoid arthritis.

Unit-IV: Hemodynamic Pathology (L25-30)
Edema, hyperaemia, congestion, haemorrhage, haemostasis and thrombosis, Embolism, Infarction and shock and hypertension.

Unit-V**:** Tumor Pathology and Pathogenesis (L31-38)
Definitions, nomenclature, characteristics of benign and malignant neoplasms, grading and staging of cancer, biology of tumor growth, mechanism of tumor invasion and metastasis, carcinogens and cancer, concept of oncogenes, tumor suppressor genes, DNA repair genes and cancer stem cells.

Unit-VI: Pathophysiology of Diseases (L39-48)

a. Etiology and Pathophysiology of lifestyle Diseases: Diabetes, Atherosclerosis and Myocardial infarction and Asthma
b. Etiology and Pathophysiology of infectious Diseases: Diarrheal diseases like cholera, Tuberculosis

Practical

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

1. Urine Analysis: Gross examination of urine for colour, odour etc. Abnormal constituents like protein, ketone bodies, glucose, blood, urea (any three)
2. Tissue Processing, embedding, sectioning. Staining and preparation of permanent histological slide.
3. Study of histological slides showing hypertrophy, hyperplasia, dysplasia, leukemia,

cirrhosis and any common cancer.
4. Diagnostic tests for detection of various Diseases – CRP, VDRL, RA, Pregnancy, Dengue and HIV (any four)
5. PCR based diagnostics (for any one disease)
6. Measurement of Erythrocyte Sedimentation Rate.

References

Essential Readings for Theory and Practical

1. Kumar, V., Abbas, A.K., Aster, J.C. and Fausto, N. (2009). 8th Edition. *Robbins and Cotran Pathologic basis of disease*. Philadelphia, USA: Saunders Publishers. ISBN-13:978-1416031215.
2. Sood, R. (2009). 6th Edition Volume 1 and 2. *Medical laboratory technology methods and interpretations.* India: Jaypee Brothers Medical Publishers. ISBN-13:978-8184484496.
3. Underwood, J. C. E. and Cross, S.S. (2009). 5th Edition. *General and systematic pathology*. London, UK: Churchill Livingstone. ISBN-13: 978-0443068881.

Suggested Readings for Theory and Practical

Copstead-Kirkhorn, L. C. (2012). 3rd Edition. *Pathophysiology*. Philadelphia, USA: Saunders. ISBN-13:978-1455726509.

Teaching Learning Process

Teaching and learning process will extensively include classroom activities to encourage the acquisition of subject knowledge, understanding academic nuances through questions and queries of previous class before beginning of a new class. Teaching would include blackboard and chalk method to communicate the concepts together with use of Power Points presentations to visually explain various processes. The students would be encouraged to frame new questions on their subjects apart from the available ones to enable them to have better insight of the topic. Verbal explanation, seminars, workshops, open discussions, quizzing and questioning would be a regular exercise. Cases studies on various diseases would be discussed to give firm grip on concepts of classical pathology. This would be supported by visit to a nearby laboratory.

Teaching Learning Plan

Unit	Title	Lectures
I	Introduction, Cellular Adaptations, Cell Injury and Cell injury and cell responses	L1-L4
II	Inflammation and its role in diseases	L5-L12
III	Tissue Renewal & Repair, Healing and Fibrosis	L13-L19
IV	Hemodynamic Pathology	L20-L27
V	Tumor Pathology and Pathogenesis	L28-L35
VI	Pathophysiology of diseases	L36-L48

Assessment Methods

1. Written class tests and assignments
2. Open and Closed Book Test
3. Quizzing/ viva, problem solving exercises
4. Seminar presentations, case studies
5. Laboratory experiments and reports
6. Projects and project reports
7. Final University examination

Keywords

Etiology, pathogenesis, necrosis, apoptosis, inflammation, tissue injury, tissue repair, fibrosis, neoplasia, oncogenes, edema, congestion, shock, dengue, tuberculosis, myocardial infarction

SEMESTER VI
Toxicology
(Unique Paper Code: 32581602)
Core Course- (CC) Credit: 6

Theory **Total Lectures: 48**

Course Objective

Different types of poisons have been known to humans since ages. Even in early times when science was in its infancy, curious people such as "Paracelsus" could predict "Every substance is a poison and, it is the right dose of the substance which differentiates remedy from poisons". This thought is fundamental even to modern toxicology and pharmacology. There is an increasing use of chemicals in the modern society and hence, toxicology is becoming a more important subject to study with the passage of time. Modern toxicology is a vast, multidisciplinary subject encompassing various other basic fields of science. The present course content is designed to provide the basics of toxicology. It provides insight into measurement of toxicity, principles of exposure, molecular mechanism of toxicity and toxicants that harm our environment. Relevant importance has been given to those topics which can build a strong foundation in the subject, based on which, facts can be assimilated during subsequent higher studies.

Course Learning Outcomes

Unit-I: Introduction
Form of toxicology practiced during antiquities across the world; and how the modern form of toxicology emerged. Nature of toxic substances and how humans are exposed to them. Spectrum of toxic responses. Types of toxicity and factors affecting the toxicity by a chemical.

Unit-II: Toxic Exposure, Response, Evaluation of Toxicity and Mechanism of Toxicity
Basics methods and biological parameters used to measure toxicity of a chemical. General mechanisms whereby toxicants cause toxicity; interaction of toxicants with target bio-molecules in the body and resultant toxicity. Basics of safety evaluation of toxicants.

Unit-III: Fate of Xenobiotics in Human Body
Mechanisms/processes involved in absorption, transport, chemical modification and excretion of toxicants from the body.

Unit-IV: Toxic Agents
Through examples of two common classes of toxicants such as pesticides and metals, students are able to learn; how humans are exposed to them, their mechanism of action and symptoms of toxicity.

Unit-V: Eco-toxicology
The process by which certain anthropogenic chemicals cause harm to wildlife/ ecosystem.

Unit-VI: Clinical Toxicology
Basics of management, clinical evaluation of toxic patients, methods used to prevent further toxicity, and use of antidotes.

Course Content

Unit-I: Introduction (L1-L5)
Brief history, Different areas of modern toxicology, Classification of toxic substances, various definitions of toxicological significance, characteristic and types of toxic responses and tolerance to toxicants.

Unit-II: Toxic Exposure, Response, Evaluation of Toxicity and Mechanism of Toxicity (L6-20)
Effect of duration, frequency, route and site of exposure of xenobiotics on its toxicity, **v**arious types of dose response relationships, assumptions in deriving dose response, LD50, LC50, TD50 and therapeutic index, Delivery of the toxicant, general mechanisms involved in formation of ultimate toxicants and toxicities by them, Detoxification of ultimate toxicants.

Unit-III: Fate of Xenobiotics in Human Body (L21-L30)
Absorption, distribution, excretion and metabolism of xenobiotics (biotransformation, Phase-I reactions including oxidations, hydrolysis, reductions and phase II conjugation reactions). Toxic insult to liver, its susceptibility to toxicants with reference to any two hepatotoxicants.

Unit-IV: Toxic Agents (L31-L38)
Human exposure, mechanism of action and resultant toxicities of the following xenobiotics: Metals: lead, arsenic, Pesticides: organophosphates, carbamates, organochlorine, bipyridyl compounds and anticoagulant pesticides.

Unit-V: Eco-toxicology (L39-L43)
Brief introduction to avian and aquatic toxicology, movement and effect of toxic compounds in food chain (DDT, mercury), bio-accumulation, bio-magnification, acid rain and its effect on ecosystems, concept of BOD and COD.

Unit-VI: Clinical Toxicology (L44-L48)
Management of poisoned patients, clinical methods to decrease absorption and enhance excretion of toxicants from the body, use of antidotes.

Practical

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

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

References

Essential Reading for Theory and Practical

1. Klaassen, C.D and Watkins, J.B. (2010). 2nd Edition. *Cassarett and Doull's essentials of toxicology*. New York, USA: McGraw Hill. ISBN-13: 978-0071622400.
2. Timbrell. J. (2001). 3rd Edition. *Introduction to toxicology*. Florida, USA: CRC Press. ISBN-13: 9780415247627.

Suggested Reading

1. Klaassen, C.D. (2008). 7th Edition. *Cassarett and Doull's toxicology, the basic science of the poisons*. New York, USA: McGraw Hill. ISBN-13: 9780071470513.
2. Lu, F.C. and Kacow, S. (2009).5th Edition. *Lu's basic toxicology: fundamentals target organ and risk assessment*. New York, USA: Informa Health Care. ISBN-13: 9781420093117.
3. Stine, K.E. and Brown T.M (2015). 3rd Edition. *Principles of toxicology*. Florida, USA: CRC Press. ISBN-13: 9781466503434.

Teaching Learning Process

1. Use of blackboard and chalk method to communicate the concepts.
2. Use of Power Point presentations to visually explain various processes.
3. Verbal explanations.
4. Open discussions.
5. Quizzing and questioning.

Teaching Learning Plan

Unit	Title	Lectures
I	Introduction	L1-L5
II	Toxic exposure, Response, Evaluation of Toxicity and Mechanism of Toxicity	L6-L20
III	Fate of Xenobiotics in Human Body	L21-L30
IV	Toxic Agents	L31-L38
V	Eco-toxicology	L39-L43
VI	Clinical Toxicology	L44-L48

Assessment Methods

1. Written class test
2. Written assignments
3. Quizzing in classes/viva
4. Presentations
5. Final University Examination

Keywords

Toxicology, toxicants, poison, xenobiotics, toxic agents, toxicokinetics, toxicodynamics, ecotoxicology, clinical toxicology, pesticides, metal toxicity, toxic exposure

Discipline Specific Elective (DSE) Courses
B.Sc. (Hons) Course in
Biomedical Science
Semester V and VI

Discipline Specific Elective (DSE) Courses

(Any two papers per semester in semesters V-VI)

1. Computational Biology and Drug Design
2. Genome Organization and Function
3. Human Genetics
4. Medical Biochemistry
5. Medical Biotechnology
6. Project Work (can be chosen only in semester VI)

Semester V/ VI
Computational Biology and Drug Design
(Unique Paper Code: 32587901)
Discipline Specific Elective- (DSE) Credit: 6

Theory **Total Lectures: 48**

Course Objective

1. This course will introduce the discipline of computational biology and drug design. It has been designed to explain different aspects of nucleotide and protein sequence analyses, sequence alignments and their applications in understanding biology.
2. The course will also emphasize on the strategic issues in rational drug discovery and development, principles of computational methods involved in lead generation, virtual screening, quantitative structure-activity relationship and molecular docking.

Course Learning Outcomes

Unit-I: Introduction to Computational Biology
Students will be able to understand the importance and basic applications of bioinformatics and computational biology.

Unit-II: Biological Databases and Genome Browsers
Students will be able to explore publicly available databases and other online resources to critically assess biological and medicinal information.

Unit-III: Sequence Alignment and Phylogenetic Analysis
They will be able to retrieve sequence information, perform sequence alignments and phylogenetic analysis.

Unit-IV: Microarray Analysis
Students will be introduced to genome wide gene expression methods and will understand microarray data analysis.

Unit-V: Drug Discovery Pipeline and Lead Generation
Learn various aspects of protein structure and their visualization, appreciate the role of modern computational techniques in the drug design, including virtual screening, de novo design, quantitative-structure activity relationships and molecular docking.

Unit-VI: Overview of Drug Development
Design and conduct computational biology and drug design-based project for the purpose of solving a scientific problem. They will be able to record and analyze the complex results in a clear and concise manner.

Course Content

Unit-I: Introduction to Computational Biology (L1-L2)
What is computational biology and bioinformatics, internet and bioinformatics, chemoinformatics. Introduction to Linux and common terminal commands.

Unit-II: Biological Databases and Genome Browsers (L3-L12)
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-III: Sequence Alignment and Phylogenetic Analysis (L13-L24)
Local and global sequence alignments (Needleman-Wunsch and Smith-Waterman algorithms), pair-wise (BLAST and FASTA algorithms) and multiple sequence alignment (Clustal W) and its importance. Theory behind BLAST- how Hidden Markov Model (HMM) can be used to model a family of unaligned sequences or a common motif within a set of unaligned sequences and further be used for discrimination and multiple alignment, BLAST score, amino acid substitution matrices, s-value and e-value, calculating the alignment score and significance of e and p value. Basics and tools for phylogenetic analysis, cladistics, tree-building methods (character and distance-based methods), construction of phylogenetic trees and identifying homologs.

Unit-IV: Microarray Analysis (L25-L27)
Introduction and use of DNA microarray to assay gene expression. Designing of the experiment, analysis and biological interpretation, principle and applications of protein microarray.

Unit-V: Drug Discovery Pipeline and Lead Generation (L28-L36)
Drug life cycle, stages of drug discovery and strategic issues in drug discovery. 2D and 3D molecular structures, molecular descriptors and fingerprints, molecular similarity and diversity, topological descriptors, quantitative structure-property relationships.

Unit-VI: Overview of Drug Development (L37-L48)
HTS, clinical trials, Applications of chemoinformatics in drug research, chemical libraries, Protein 3D modeling, characterization of binding site, virtual screening, protein-ligand interactions, prediction of pharmacological properties, introduction to drug databases, PubChem and their use in drug development, Lipinski's rule of five, concept of energy minimization and force fields, introduction to rational drug design using example.

Practical

1. Retrieval of information from databases.
2. Sequence alignment using BLAST and Clustal W.
3. Phylogenetic analysis.
4. Microarray data analysis.
5. Molecular format conversion and hands-on molecular visualization program for displaying, animating and analyzing large bio-molecular systems using 3-D graphics.
6. Homology Modeling using SPDBV, model structure refinement using SPDBV and model validation.

7. Comparing structures, mutations, studying interactions creating electrostatic potential diagrams.
8. Virtual screening and molecular docking.

References

Essential Readings for Theory and Practical

1. Baxevanis, A.D. and Ouellette, B.F.F. (2004). 3rd Edition. *Bioinformatics: A practical guide to the analysis of genes and proteins*. New Jersey, USA: John Wiley and Sons. ISBN-13: 978-0471478782.
2. Mount, D.W. (2004). 2nd Edition. *Bioinformatics: Sequence and genome analysis*. New York, USA: Cold Spring Harbour Laboratory Press. ISBN-13: 978-0879697129.
3. Patrick G.I. (2017). 6th Edition. *Introduction to medicinal chemistry*. Oxford, UK: Oxford University Press. ISBN-13: 978-0198749691.

Suggested Readings for Theory and Practical

1. Attwood, T.K. and Parry-Smith D.J. (1999). 1st Edition. *Introduction to bioinformatics*. London, UK: Prentice Hall. ISBN-13: 9780582327887.
2. Campbell, A.M. & Heyer, L.J. (2006). 2nd Edition. *Discovering genomics, proteomics and bioinformatics*. San Francisco, USA: Benjamin Cummings. ISBN-13: 978-0805382198.
3. Gasteiger, J. and Engel T. (2003). 1st Edition. *Cheminformatics*. Weinheim, Germany: Wiley-VCH. ISBN-13: 978-3527306817.
4. Ghosh, Z. and Mallick, B. (2015). 1st Edition. *Bioinformatics: Principles and applications*. Oxford, UK: Oxford University Press. ISBN-13: 978-0195692303.
5. Leach, A.R. (2009). 2nd Edition. *Molecular modeling: Principles and applications*. Pearson India. ISBN 13: 9780582382107.
6. Pevsner, J. (2015) 3rd Edition. *Bioinformatics and functional genomics*. New Jersey, USA: Wiley-Blackwell. ISBN-13: 978-1118581780.
7. Smith C.G. and O'Donnell, J.T. (2006). 2nd Edition. *The Process of New Drug Discovery and Development*. New York, USA: Informa Healthcare Inc. ISBN-13: 978-0849327797.
8. Young, D.C. (2009). 1st Edition. *Computational drug design: A guide for computational and medicinal chemists*. New Jersey, USA: John Wiley and Sons. ISBN-13: 978-0470126851.

Teaching Learning Process

This course is designed to encourage the acquisition of subject knowledge, understanding academic and professional skills required for computational data analysis-based professions and jobs, learning experiences should be designed and implemented to foster active/participative learning. Development of practical skills will constitute an important aspect of the teaching-learning process. A variety of approaches to teaching-learning process, including lectures, seminars, tutorials, workshops, peer teaching and learning and project-based learning, substantial laboratory-based practical component, open-ended project work, games, technology-enabled learning, internship in industry and research establishments etc. will need to be adopted to achieve this. Problem-solving skills and higher-order skills of reasoning and analysis will be encouraged through teaching strategies.

Teaching Learning Plan

Unit	Title	Lectures
I	Introduction to computational biology	L1-L2
II	Biological databases and genome browsers	L3-L12
III	Sequence alignment and phylogenetic analysis	L13-L24
IV	Microarray analysis	L25-L27
V	Drug discovery pipeline and lead generation	L28-L36
VI	Overview of drug development	L37-L48

Assessment Methods

Progress towards achievement of learning outcomes will be assessed using the following methods: time-constrained examinations; closed-book and open-book tests; problem based assignments; practical assignment, laboratory reports; observation of practical skills; individual/team project reports; oral presentations, including seminar presentation; viva voce interviews; computerized adaptive testing; peer and self-assessment etc.

Keywords

Databases, NCBI, BLAST, sequence alignment, phylogeny, microarray, drug design, QSAR, modeling, virtual screening, docking

Semester V/ VI
Genome Organization and Function
(Unique Paper Code: 32587902)
Discipline Specific Elective- (DSE) Credit: 6

Theory **Total Lectures: 48**

Course Objective

1. The paper Genome Organization and Function deals with the more intriguing concepts of genome packing within the nucleus, the regulatory strategies either at transcriptional or translational level, gene silencing, RNAi and mechanisms of regulatory effects of non-coding RNA.
2. This course will review the basic concepts of organization and architecture of human genome.
3. The paper concludes with an introduction to the different model organisms and explains their importance in investigations of basic principles in genetics.

Course Learning Outcomes

Unit-I: Organization of Human Genome
Students will acquire basic concepts of genome, its organization and maintenance, DNA methylation and CpG islands. Students will learn about packaging of DNA into chromosome structure, changes in histone and chromosome remodelling proteins.

Unit-II: Gene Regulation in Prokaryotes and Eukaryotes
Students will learn the concept of regulatory mechanisms governing over-expression and under-expression of genes. They will understand transcriptional control in prokaryotes (operons) and in eukaryotes (signal integration, combinatorial control, transcriptional activators and repressors, signal transduction). Students will also learn about translation-dependent regulation of mRNA and protein stability and post-translational control.

Unit-III: Regulatory RNAs
Students will understand regulatory RNA (RNA interference, riboswitches, miRNA and siRNA) and X-inactivation.

Unit-IV: Understanding Gene Function through Model Organisms
Students will gain knowledge about the need of model organisms and functioning of genes through these model organisms.

Course Content

Unit-I: Organization of Human Genome (L1-L8)
General features: Genome size, gene density and diversity. Types of repetitive DNA. Gene families and super families. Pseudogenes and processed Pseudogenes. RNA encoding genes. Nucleosomes: Basic unit of DNA condensation, packaging of DNA into chromosome structure, nucleosome assembly.

Unit-II: Gene Regulation in Prokaryotes and Eukaryotes (L9-L33)

a) Transcriptional regulation in prokaryotes: Principles of transcriptional regulation. Bacterial gene regulation with reference to lactose, tryptophan and arabinose operon. Role of sigma factors in gene expression.
b) Eukaryotic gene regulation: Transcriptional control - Conserved mechanism of regulation, activators, signal integration, combinatorial control, transcriptional repressors, signal transduction and control of transcriptional regulators, examples of steroid receptors, MAP kinase and STATs pathways.
c) Eukaryotic gene regulation: Post-transcriptional control. Regulation of translation, translation-dependent regulation of mRNA and protein stability. Post-translational control and role of ubiquitin.
d) Eukaryotic gene regulation: Genomic control – gene amplification and deletions, DNA rearrangements, chromosome puffs, DNA methylation, CpG islands. Changes in histone and chromosome remodeling proteins, nucleosome modifications and nucleosomes positioning.

Unit-III: Regulatory RNAs (L34-L 38)

Riboswitches, RNA interference, miRNA, siRNA, Piwi-interacting RNA, regulatory RNA and X-inactivation (reference of calico cats).

Unit-IV: Understanding Gene Function through Model Organisms (L39-L48)

Model organisms and the need to study them. Mechanism of choosing the right model organism. Advantages and disadvantages of the organism as a model. Study of model systems in developmental genetics. Early studies of the organism as a Model organism, life cycle, genetic techniques and use of the organism as model organism today.
Different types of model organisms: *Escherichia coli*, *Saccharomyces cerevisiae* (Baker's yeast), *Drosophila melanogaster* (Fruit fly), *Mus musculus* (Mouse), *Danio rerio* (Zebra fish).

Practical

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

1. Preparation of various stock solutions for mentioned experiments.
2. Comparative analysis of genomic DNA and plasmid DNA by restriction enzyme digestion and estimation of size of a DNA fragment after electrophoresis using DNA markers.
3. Quantification of unknown DNA using Lambda-HindIII marker.
4. Perform Southern Hybridization.
5. Perform Western Blotting.
6. Drosophila as a model system for studying *toll-9* gene for asthma using bioinformatics tools.
7. Isolation and Identification of Auxotrophic and Drug Resistant Mutants of *E. coli*.

References

Essential Readings for Theory

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

2. 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.
2. Klug, W. S. Cummings, M. R. Spencer, C. A. and Palladino, M. A. (2012*).* 10th Edition. *Concepts of genetics.* San Francisco, USA: Benjamin Cummings Publishers. ISBN-13: 978-0321724120.
3. Snustad, D. P. and Simmons, M. J. (2011). 6th Edition. *Principles of genetics.* New York, USA: John Wiley and Sons. ISBN-13: 978-0470903599
4. Strachan, T. and Read, A. (2018). 5th Edition. *Human molecular genetics*. Florida, USA: CRC Press, Garland Science. ISBN: 978-0815345893.
5. Watson, J. D. Baker T. A. Bell, S. P. Gann, A. Levine, M. and Losick, R. (2013). 7th Edition. *Molecular biology of the gene.* New York, USA: Cold Spring Harbor Laboratory Press. ISBN-13: 9780321762436.

Essential Readings for Practical

Green M. R. and Sambrook J. (2012). 4th Edition, (three-volume set). *Molecular cloning: A laboratory manual.* Cold Spring Harbor Laboratory Press. ISBN-13: 978-1936113422.

Suggested Readings for Theory and Practical

1. Cooper, G. M. and Hausman, R. E. (2013). 6th Edition. *The cell: A molecular approach.* Massachusetts, USA: Sinauer Associates. ISBN-13:978-1605351551.
2. Hardin, J. Bertoni, G. P. Kleinsmith, L.J. and Becker, W.M. (2008). 7th Edition. *The world of the cell.* San Francisco, USA: Benjamin Cummings Publishers. ISBN-13: 978-0805393934.
3. Karp, G. (2013). 7th Edition. *Cell and molecular biology: Concepts and experiments.* New Jersey, USA: Wiley Publishers. ISBN-13: 9781118206737.
4. Kornberg, A. (2005). 2nd Edition. *DNA replication.* California, USA: University Science Books. ISBN-13: 9781891389443.

Teaching Learning Process

Teaching and learning activity will mainly include extensive class room discussions. Students will be asked questions and queries of the previous class before every new class to helping them in the better understanding of the topics and clearing their doubts. Teaching will be conducted through both regular chalk and board and power point presentation. There will be regular question and answer activities and consultation of relevant text books and research articles. Development of practical skills will constitute an important aspect of the teaching-learning process.

Teaching Learning Plan

Unit	Title	Lectures
I	Organization of Human genome	L1-L8
II	Gene regulation in Prokaryotes and Eukaryotes	L9-L33
III	Regulatory RNAs	L34-L38
IV	Understanding gene function through model organisms	L39-L48

Assessment Methods

Topic on current and important research area will be assigned individually to students and they will be asked to retrieve literature and show them to teachers for verification. They will be motivated to make short presentations. Class tests will be conducted for internal examinations. Students will be given home assignments from time to time to improve their writing skills. Finally, there will be end semester university examination.

Keywords

Human genome, repeats, nucleosome, gene regulation, MAP kinase, STAT pathway, post-translational control, DNA methylation, miRNA, siRNA, X-inactivation, model organism

Semester V/ VI
Human Genetics
(Unique Paper Code: 32587903)
Discipline Specific Elective- (DSE) Credit: 6

Theory **Total Lectures: 48**

Course Objective

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

Course Learning Outcomes

Unit-I: Inheritance for Monogenic Traits
Students will understand the patterns of inheritance of monogenic traits from pedigree data for both Mendelian and non-Mendelian traits.

Unit-II: Techniques for Genomics
They will comprehend the techniques and advances in the analysis of DNA and protein expression, identification of genes involved in diseases, and gene/sequence mapping strategies.

Unit-III: Human Genome Project
Students will be able to describe objectives, tools, approaches and outcomes of Human Genome Project (HGP). They will be aware of the ethical and societal issues raised by the new knowledge derived by using new technologies.

Unit-IV: Population Genetics
Students will be able to apply principles of genetics at population level.

Unit-V: Clinical Genetics
They will understand genetic basis of common diseases and methods of prenatal diagnosis.

Unit-VI: Guided short project
Students will be able to proficiently explore relevant literature, web sites and databases for research into human genetics.

Course Content

Unit-I: Inheritance for Monogenic Traits (L1-L7)
History of Human Genetics: Early Greek concepts about inheritance, Cytogenetics history (the works of Winiwater, Painter and Tjio and Levan), Landmark achievements of Galton, Garrod etc.

Patterns of Inheritance: Recapitulation of principles of human inheritance pattern through pedigree analysis: Autosomal inheritance-dominant, recessive, sex-linked inheritance, sex-limited and sex- influenced traits and mitochondrial inheritance. Deviations from the basic pedigree patterns- non-penetrance, variable expressivity, pleiotropy, late onset, dominance problems, anticipation, genetic heterogeneity and uniparental disomy, mosaicism and chimerism, consanguinity and its effects, epigenetic modifications and imprinting.

Unit-II: Techniques for Genomics (L8-L21)
DNA sequencing (Maxam-Gilbert and Sanger Method, introduction to NGS), DNA fingerprinting, polymorphism screening (genotyping of SNPs and microsatellite markers), expression and proteome analysis (microarray, 2-D analysis, pull down assays).
Physical maps (different types- restriction, cytogenetic maps, use of FISH in physical mapping, radiation hybrids and clone libraries in STS mapping) and genetic maps. Genetic markers and their applications.
Principles and strategies, positional and candidate gene approaches, positional- cloning approach (examples- HD, CFTR), concept of twin and adoption studies.

Unit-III: Human Genome Project (L22-L25)
History, organization and goals of human genome project, Tools (Vectors- BAC, PAC, YAC and sequencing techniques) and approaches (Hierarchical and shotgun sequencing), outcomes ethical issues and applications in human diseases

Unit-IV: Population Genetics (L26-L28)
Genotypic and allelic frequencies, linkage disequilibrium, haplotype construction (two loci using SNPs and/or microsatellites).

Unit-V: Clinical Genetics (L29-L38)
Inborn errors of metabolism and their genetic basis (example- phenylketonuria), genetic disorders of haemopoietic systems (examples- sickle cell anemia and thalassemia), genetic basis of color blindness, genetic basis of familial cancers (example- retinoblastoma), genetics of mental retardation.
Diagnosis and screening of genetic disorders, prenatal genotyping for mutations in β- globin gene and sickle cell anemia, DNA profiling: establishing identity and relationships, applications in personalized medicine (genetic polymorphism in drug metabolism genes e.g. cytP450 and GST and their effect on drug metabolism and drug response), genetic counseling.
Prenatal Diagnosis: Brief introduction, methods of prenatal diagnosis and its application with example of Aneuploidy and Thalassemia.

Unit-VI: Guided short project (L39-L48)
Short project involving, data analysis/*in silico* analysis of genomes/ literature-based project; guiding the students through identification of the project, discussions on approach and methodology, and strategies for data analysis.

Practical

(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. PTC testing to prove monogenic inheritance.
2. Demonstration of DNA fingerprinting.
3. Polymorphism analysis using PCR.

4. Mapping of clones/STS on plasmids or BACs.
5. Video based demonstration of tools for prenatal diagnosis.
6. Haplotype construction.
7. Web based analysis: retrieval of a desired human sequence from NCBI database and sequence alignment using BLAST.
8. Preparation of human metaphase chromosomes and Giemsa staining.

References

Essential Readings for Theory and Practical

1. Cantor, C.R. and Smith, C.L. (1999). 1st Edition. *Genomics: The science and technology behind the human genome project*. New York, USA: Wiley-Interscience. ISBN: 9780471599081.
2. Speicher, M.R., Antonarakis, S.E. and Motulsky, A.G. (2010). 4th Edition. *Vogel and Motulsky's Human genetics: Problems and approaches*. Berlin, Germany: Springer Verlag. ISBN: 978-3540376538.
3. Strachan, T. and Read, A. (2018). 5th Edition. *Human molecular genetics*. Florida, USA: CRC Press, Garland Science. ISBN: 978-0815345893.

Suggested Readings for Theory and Practical

1. Brown, T.A. (2017). 4th Edition. *Genomes 4*. New York, USA: Garland Science. ISBN-13: 978-0815345084.
2. Pasternak, J.N. (2005). 2nd Edition. *An introduction to human molecular genetics*. New York, USA: Wiley-Liss. ISBN: 978-0-471-47426-5.
3. Wilson, G.N. (2000). 1st Edition. *Clinical genetics: A short course*. New York, USA: Wiley-Liss, ISBN: 978-0471298069.

Teaching Learning Process

The teaching process will create learning environments where students are active participants as individuals and as members of teams. A wide range of learning resources incorporating student experiences, interests and real-life situations will be integrated with classroom instruction. Multiple representations, examples, explanations and variety of technology that support student learning will be used. Students will be effectively engaged in hands-on sessions and discussions to promote higher-order thinking skills. Project work emphasizing on literature and database survey for human genetic diseases will also form an important part of teaching-learning process.

Teaching Learning Plan

Unit	Title	Lectures
I	Inheritance for Monogenic Traits	L1-L7
II	Techniques for Genomics	L8-L21
III	Human Genome Project	L22-L25
IV	Population Genetics	L26-L28
V	Clinical Genetics	L29-L38
VI	Guided short project	L39-L48

Assessment Methods

Progress towards achievement of learning outcomes will be assessed using the following methods: semester end examinations; closed-book and open-book tests; problem-based assignments; practical assignment laboratory reports; observation of practical skills; individual/ team project reports; oral presentations, including seminar presentation; viva voce; peer and self-assessment etc.

Keywords

Mendelian Inheritance, pedigree, human genome, genetic mapping, sequencing, ELSI, prenatal diagnosis, haplotype, linkage disequilibrium

Semester V/VI
Medical Biochemistry
(Unique Paper Code: 32587904)
Discipline Specific Elective- (DSE) Credit: 6

Theory **Total Lectures: 48**

Course Objective

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

Course Learning Outcomes

Unit-I: Enzymes- Distribution and Diagnostic Significance
Students will be able to understand the diagnostic significance of enzymes and isoenzymes as diagnostic markers in clinical tests. They will learn to assess how biochemical tools accomplish diagnostic and therapeutic intervention on metabolic and genetic disorders. They will also learn to correlate the tissue/organ-specific metabolic indicators with the physiological and clinical state of a patient.

Unit-II: Hormones
An insight in to the classification and mechanisms that hormones adopt to regulate metabolic pathways shall be gained by the students. Also, interplay of hormones in disorders such as obesity and diabetes will be learnt.

Unit-III: Structural Complexities and Diseases Associated with Carbohydrates and Lipids
In this unit students would know about several bimolecular conjugates, their structural complexities, physiological significance and clinical correlations, especially the disorders related to lipid metabolism.

Unit-IV: Vitamins
Students will learn about recommended daily allowance for vitamins, their role as dietary precursors and clinical significance of deficiency diseases.

Unit-V: An Overview of Integrative Metabolism
Students will learn to integrate the biochemical pathways of different biomolecules; the point of divergence and convergence and will have a comprehensive overview of the metabolic and hormonal regulation of pathways and cycles. Students will understand how disruptions in intermediary metabolism can lead to manifestations of diseases. Additionally, hormonal actions in maintaining body mass shall be understood and factors leading to disorders such as obesity and diabetes will also be learnt.

Practical
With the help of diagnostic kits that are used in clinical laboratories, students will learn to do qualitative and quantitative analyses of specimen. Through the presentations made on the known case studies, students will learn how to apply the gained knowledge in diagnosis and prognosis of a disease and know the relevance of preventive measures taken in healthcare. Also, they will be introduced to quantitative analysis of biomolecules in clinical biochemistry.

Course Content

Unit-I: Enzymes - Distribution and Diagnostic Significance (L1-L11)
Basic Concepts and Scope of Medical Biochemistry, Properties of enzymes used in diagnosis. Factors affecting levels of diagnostic enzymes in blood and the selection of a test.

Clinical significance of diagnostically important enzymes: creatine kinase, lactate dehydrogenase, alanine- and aspartate aminotransferases, with a detailed account of the biochemical reactions catalysed by these enzymes and of their clinical assays.

Kinetic assay and end point assay for the enzymes.
Isoenzymes: types of isoenzymes, allozymes, hybrid isoenzymes, isoforms, macrocomplexes, their tissue distribution, clinical and diagnostic significance.

Unit-II: Hormones (L12-L17)
Classification (with reference to their biochemical nature).
Mechanism of action - one example from each class of hormones, with special reference to epinephrine and thyroid hormones (T3 and T4) and their functions.

Unit-III: Structural Complexities and Diseases Associated with Carbohydrates and Lipids (L18-L29)
Carbohydrates: Sugars as information molecules. Detailed account on Lectins: their role in physiological functions and their potential as drug targets in various infectious diseases. Dietary fibres
Lipids: Glycerophospholipids, Spingolipids, Types of Lipoproteins (chylomicrons, VLDL, LDL, HDL). Disorders associated with lipid metabolism (hyperlipidemia). Prostaglandins: classification, biosynthesis, role of COX-1, COX-2, NSAIDS in synthesis, functions. Steroids: Cholesterol- biosynthesis and regulation, inhibitors of cholesterol biosynthesis (Statins - structure and biochemical basis).

Unit-IV: Vitamins (L30-L37)
Definition, classification, functions, recommended dietary allowances, and dietary precursors. Diseases due to deficiency of water-soluble and fat-soluble vitamins: symptoms and clinical significance.

Unit-V: An Overview of Integrative Metabolism (L38-L48)
Local and global regulation in tissue specific metabolism. Interplay of insulin and glucagon hormones. Integration of various metabolic pathways of proteins, lipids, carbohydrates and nucleic acids. Obesity, role of leptin, ghrelin and other hormones in regulation of body mass.

Practical

1. Preparation of serum or plasma from whole blood.
2. Quantitative determination of the following in the whole blood/plasma/serum:
   i) SGPT or SGOT
   ii) Albumin/Total protein and A:G ratio
   iii) Urea
   iv) Uric acid
   v) Total cholesterol, HDL, LDL and triglycerides
   vi) Glucose
3. Five case studies

References

Essential Readings for Theory

1. Burtis, C.A., Ashwood, E.R. and Bruns, D.E. (2007). *Tietz Fundamentals of Clinical Chemistry*. United States Of America:WB Saunders Co.
2. Chatterjea & Shinde (2011). *Textbook of Medical Biochemistry*. New Delhi,India: Jaypee Publications.
3. Nelson, D.L. and Cox, M.M. (2017). *Lehninger Principles of Biochemistry*. United States of America:W. H. Freeman.

Essential Readings for Practical

1. Burtis, C.A., Ashwood, E.R. and Bruns, D.E. (2007). *Tietz Fundamentals of Clinical Chemistry*. United States of America:WB Saunders Co.
2. Literature provided by Diagnostic Kit's manufacturer.

Suggested Readings for Theory and Practical

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

Teaching Learning Process

The teaching learning process will encompass interactive mode. Students will be given opportunity to revisit the concepts of biochemistry and gain deeper understanding of the significance its clinical applications. Emphasis will be laid on presentations by the students on actual case studies, followed by Question and Answer sessions., which will enable them to develop a comprehensive understanding of the clinical cases. Practical training with respect to quantitative determination of the analytes shall give them exposure to skills required in medical laboratories and initiate them into research on development of diagnostic tests.

Teaching-Learning Plan:

Unit	Title	Lectures
I	Unit I: Enzymes- Distribution and Diagnostic Significance	L1-L11
II	Unit II: Hormones	L12-L17
III	Unit III: Structural Complexities and Diseases Associated with Carbohydrates and Lipids	L18-L29
IV	Vitamins	L30-L37
V	An Overview of Integrative Metabolism	L38-L48

Assessment Methods

Learning outcomes will be assessed, using the class-assignments, closed-book and open-book tests; problem-solving exercises, observation of students' practical skills, case studies, seminar presentations and viva-voce.

Keywords

Diagnostic enzymology, isoenzyme, lectins, lipoproteins, hormones, vitamins, integrative metabolism.

Semester V/ VI
Medical Biotechnology
(Unique Paper Code: 32587905)
Discipline Specific Elective- (DSE) Credit: 6

Theory **Total Lectures: 48**

Course Objective

1. To enable the students to comprehend the concepts of gene cloning and DNA analysis.
2. To explore and understand the origin of basic techniques and methods used in the diagnosis and treatment of various diseases.
3. To provide insight into the cutting-edge technology used in biological systems to augment understanding of human diseases, genome and other related areas
4. To provide them with basic platform to understand production of Biopharmaceuticals and other recombinant Products.
5. To make them understand basic techniques that enhance knowledge about various fields where Biotechnology is widely being used: Forensics, Paternity disputes, DNA testing, Genome Analysis etc.

Course Learning Outcomes

Unit-I: Introduction to Biotechnology and Various Techniques Used

To stay abreast with the fast-emerging innovative processes practiced in medical biotechnology, a detailed knowledge of several techniques and methods such as PCR, Microarray, Northern hybridization shall be gained by the students.

Unit-II: Manipulation of the Purified DNA and Process of Gene Cloning

An in-depth understanding of how to manipulate DNA and create recombinant proteins by learning gene cloning, expression and purification methods will prepare students to apply the gained knowledge on other organisms as well.

Unit-III: Expression and Purification of Recombinant Proteins in Prokaryotic and Eukaryotic Cells

Concept of applications and the challenges of use of biotechnology in human medicine shall be discerned by the students, imbued with deeper understanding of genetic & protein engineering and several advanced techniques in molecular analysis.

Unit-IV: Studying Gene Expression and Functions

Laboratory experience in techniques such as DNA foot-printing, Deletion Assays, studying interactions between two or more proteins shall equip students with technical skills that are coherent with the learnt concepts and help them in applying these skills towards formulating new solutions to impending challenges in healthcare.

Unit-V: Application of Medical Biotechnology

Molecular tools used in engineering of proteins, in the diagnosis and therapy of various human diseases and in the production of biopharmaceuticals shall be learnt by the students, enabling them to fathom the drivers of innovation in medical biotechnology.

Unit -VI: Biosafety and Ethical Issues in Biotechnology
Students shall gain sensitivity to safe and ethical practices related to genetically modified organisms/genome editing and how these issues shape the public opinion of medical biotechnology.

Additional Note: Through class practical (which are designed to help students connect the gained knowledge and give exposure to some of the techniques and methods used in research and industrial laboratories), they will gain laboratory skills, learn to build and interpret data (on DNA & proteins) and develop analytical skills. Scientific writing skills will also be strengthened through maintenance of lab record book.

Course Content

Unit-I: Introduction to Biotechnology and various Techniques used (L1-L9)
Brief history and Importance, Emergence of molecular biotechnology, Concept of in vivo and in vitro gene cloning.
Polymerase chain reaction (PCR): Principle and applications, Primer-designing, different types of PCR: Hot start, Reverse transcription, Real time and multiplex PCR.
Northern hybridization, Microarray concept for studying transcriptomes, Electroporation, Transformation, Use of enzymatic and chemiluminescent methods for detection of proteins, Preparation of labelled probes.

Unit-II: Manipulation of the Purified DNA and Process of Gene Cloning (L10-L20)
Restriction and modification system: Type I-IV restriction endonucleases, nomenclature and sequence recognition, isochizomers, blunt end and sticky ends, restriction mapping. Joining of DNA molecules: role of DNA ligase enzymes, adaptors, linkers, homopolymer tailing.
Basic biology of plasmids, Cloning vectors (pUC vectors, T-vectors), Lambda phage-derived vectors (replacement and insertion vectors), Cosmids, in vitro packaging, Cloning vectors for eukaryotic system, Expression vectors, Prokaryotic and Eukaryotic expression vectors with one example each, Shuttle vectors, Inducible and Constitutive expression.
Entire process of gene cloning (Blunt end and directional).

Unit-III: Expression and Purification of Recombinant Proteins in Prokaryotic and Eukaryotic Cells (L21-L28)
Expression and Purification: Methods for clone identification, Selection (antibiotic selection) and Screening (blue/white & by colony PCR) of bacterial transformants. Challenges in expression of foreign proteins in heterologous host, Factors affecting the expression host cell physiology. Promoters, Codon usage, Plasmid copy number. Expression in eukaryotic cells (yeast), Fusion proteins and tags, Fusion and tagged protein cleavage system, Manipulations to improve the yield of recombinant protein.

Unit-IV: Studying Gene Expression and Functions (L29 -L34)
RNA transcript of the gene analysis by primer extension and PCR, Identification of protein binding sites: gel retardation, foot printing and modification interference assays. Deletion assays, Phage display and Yeast two hybrid system for studying protein-protein interaction.

Unit-V: Application of Medical Biotechnology (L35-L46)
(a) Production of recombinant biomolecules: Insulin, Adenosine deaminase (ADA), Factor VIII and Interferons.

(b) Oligonucleotide-directed mutagenesis, PCR-based method of mutagenesis, Screening and identification of mutants.
(c) Protein engineering: addition of disulphide bonds, amino acid substitution. Subtilisin and alpha-Antitrypsin (AAT) as the examples of mutant enzymes and their applications.
(d) DNA Profiling: Introduction, DNA profiling based on STRs, minisatellites, RFLP, AFLP, VNTRs, SNPs and their applications.
(e) Gene Therapy: Strategies and limitations, Somatic and Germline gene therapy, Vectors used in gene therapy (viral and non-viral) and their comparison. Treatment for genetic and infectious diseases (one example each).

Unit-VI: Biosafety and Ethical Issues in Biotechnology (L47-L48)
Safe handling and disposal of GMOs and toxic reagents. Concerns about gene editing, gene therapy and impact of GMOs on the environment.

Practical

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

1. Regular maintenance and storage of *E. coli* DH5 alpha cells.
2. Preparation of competent cells (*E.coli*) by Calcium chloride method.
3. Digestion of plasmid DNA with different Type II restriction endonucleases.
4. PCR amplification of the desired gene, followed by restriction digestion.
5. DNA extraction from gel
6. Ligation of the insert to the vector using T4 DNA ligase
7. Agarose gel analysis of restricted and ligated DNA.
8. Transform competent bacterial cells with recombinant DNA.
9. Identification of recombinants by blue-white screening and PCR.
10. Over-expression of recombinant proteins in bacteria, followed by detection by SDS-PAGE.

References

Essential Readings for Theory

1. Bernard, R. G. Jack, J. P. and Cheryl, I. P. (2009). 4th Edition. *Molecular biotechnology: Principles and applications of recombinant DNA.* USA: ASM press, ISBN-13:9781555814984.
2. 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.
3. Cantor, C. R. and Smith, C. L. (1999). 1st Edition. *Genomics: The science and technology behind the human genome project*, New York, USA: John Wiley and Sons. ISBN-13:978-0471599081.
4. Kornberg, A. (2005). 2nd Edition. *DNA Replication.* California, USA: University Science Books., ISBN -13: 9780716720034
5. Primrose, S. B. and Twyman, R. B. (2006). 7th Edition. *Principles of gene manipulation and genomics.* Oxford, UK: Blackwell Scientific Publishers. ISBN: 978-1405135443.

Essential Readings for Practical

1. Different Journal papers and review articles along with.

2. Green, M. R. and Sambrook, J. (2012). 4th Edition, (three-volume set). *Molecular cloning: A laboratory manual.* New York, USA: Cold Spring Harbor Laboratory Press ISBN-13: 978-1936113422.

Suggested Readings for Theory and Practicals

1. Green, M. R. and Sambrook, J. (2012). 4th Edition, (three-volume set). *Molecular Cloning: A Laboratory Manual.* Cold Spring Harbor Laboratory Press. ISBN-13: 978-1936113422.
2. Karp, G. (2013). 7th Edition. *Cell and molecular biology: Concepts and experiments.* New Jersey, USA: Wiley Publishers. ISBN-978-0470483374.

Teaching Learning Process

The teaching learning process will be highly interactive and student-centric with an aim to prepare students to apply current biotechnology techniques in real-world settings in healthcare (diagnostics, therapeutics and molecular medicine). Teaching would include lectures, seminars, short animation films and laboratory-based practicals with an emphasis to instil qualitative analysis and quantitative estimations. Learning would be through active participation of students in classroom; by using library and web resources, computer-assisted learning, handouts and by acquiring hands on training in the molecular techniques.

Teaching Learning Plan

Unit	Title	Lectures
I	Introduction to Biotechnology and various techniques used	L1-L9
II	Manipulation of the purified DNA and process of gene cloning	L10-L20
III	Expression and purification of recombinant proteins in prokaryotic and eukaryotic cells	L21-L28
IV	Studying gene expression and functions	L29-L34
V	Application of Medical Biotechnology	L35-L46
VI	Biosafety and ethical issues in Biotechnology	L47-L48

Assessment Methods

Learning outcomes will be assessed through open/closed-book tests; problem-solving exercises, seminar presentations; viva-voce, literature surveys. Evaluation of practical skills would be based on how experiments are performed and results interpreted and communicated.

Keywords

Restriction endonucleases, cloning vectors, recombinant DNA, PCR, mutagenesis, DNA profiling, gene therapy, protein engineering

Generic Elective (GE) Courses

Generic Elective (GE) Courses

1. Basics of Immunology
2. Biological Chemistry
3. Biosafety and Bioethics
4. Biostatistics
5. Bridging Information Technology and Biotechnology
6. Concepts in Biotechnology
7. Concepts in Medicinal Chemistry and Drug Development
8. Intellectual Property Rights (IPR) for Biologists
9. Pathological Basis of Diseases
10. Pharmacology and Toxicology
11. Tools and Model Organisms in Biomedical Research

Semester I/ II/ III/ IV
Basics of Immunology
(Unique Paper Code: 32585901)
Generic Elective - (GE) Credit: 6

Theory **Total Lectures: 48**

Course Objective

1. Basics of immunology is a comprehensive study of the organization and functioning of the immune system with its network of cells and molecules. Understanding the biology of the immune system is, therefore, key to developing strategies towards prevention and cure to a number of disorders and diseases that result due to interference in the functioning and regulation of the immune system.
2. This paper covers the structure, organization, function and regulation of and by the immune system keeping the above aspects in mind.

Course Learning Outcomes

Unit-I: Overview
Students learn various aspects of human immune system in normal and infectious stage which equips students to design better strategies for combating the immunological disorders.

Unit-II: Our Immune System
Students will be familiarized with origin and maturation of all blood cell types in bone marrow and thymus. They will understand the functions of various types of cells and role played by them in immune response against pathogens.

Unit-III: Immune Response
They will know the concept of antigen, antibody molecules and role of major histocompatibility complex and associated cells in the presentation of antigen. The students will also be able to understand the significance of various kinds of growth factors and cytokines in the activations of various lymphocytes.

Unit-IV: Antigen-Antibody Interactions Based Immunological Techniques
Various techniques associated with immunological reaction will enhance the understanding students about common laboratory instruments.

Unit-V: Vaccines
Vaccine based immunotherapies and their designing will assist them to think about new path for combating with pathogens and working mechanism of immune system.

Unit-VI: Dysfunctions of Immune System
Students will also be sensitized with dysfunctions of immune system and autoimmune disorders.

Course Content

Unit-I: Overview (L1- L2)
Historical background, general concepts of the immune system, innate and adaptive immunity; active and passive immunity; primary and secondary immune response.

Unit-II: Our Immune System (L3- L11)
(a) T and B lymphocyte, NK cells, monocytes and macrophages; neutrophils, eosinophils, basophils, mast cells and dendritic cells; thymus and bone marrow; lymph nodes, spleen.
(b) General overview of the Complement System: Components of the complement activation (classical pathway); biological consequence of complement activation.

Unit-III: Immune Response (L12- L31)
(a) Antigens and haptens: Properties (foreignness, molecular size) and their importance in cell mediated and humoral immune response.
(b) Humoral immune response: Concepts of B cell development in bone marrow, generation of plasma cells and memory B cells in lymphoid organs. Antibodies: Historical perspective of antibody structure; structure, function and properties of the antibodies; different classes and subclasses and biological activities of antibodies, hybridoma technology and monoclonal antibodies.
(c) Cell mediated immune response: T cell maturation in thymus (in brief), thymic selection, self MHC restriction of T cells, T cell sub-types and their effector functions. Molecules involved in functioning of T cells-Trimolecular complex formation between APC and Naïve T cells, Properties and functions of Interferon (IFN-γ) and Interleukins (IL4).
(d) Basic introduction to Major Histocompatibility Complex: Organization of MHC and inheritance in human

Unit-IV: Antigen-Antibody Interactions Based Immunological Techniques (L32- L39)
Concept of affinity and avidity, cross reactivity, precipitation, agglutination, immunodiffusion, ELISA.

Unit-V: Vaccines (L40- L43)

Concept and history of vaccines, contribution of Edward Jenner, components of vaccines (e.g. BCG vaccine), overview of National Immunization Course

Unit-VI: Dysfunctions of Immune System (L44-L48)
Types of hypersensitivity, overview of autoimmunity, Immunodeficiency disorders: Animal models of primary immunodeficiency (nude mouse and SCID mouse).

Practical

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

1. To perform immuno-diffusion by Ouchterlony method.
2. Immuno-diffusion by Mancini method
3. To perform ELISA experiment.
4. To perform Agglutination inhibition Assay
5. To perform sandwich dot ELISA.
6. To perform blood grouping (direct agglutination) or Widal test (indirect agglutination).

References

Essential Readings for Theory and Practical

1. 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.
2. Hay, F.C. and Westwood, O.M.R. (2002). 4th Edition. *Practical Immunology*. New Jersey, USA: Blackwell Science. ISBN: 9780865429611.
3. 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.

Suggested Readings for Theory and Practical

1. Owen, J. A. Punt, J. Stranford, S. A. Jones, P. P and Kuby, J. (2013). 7th Edition *Kuby Immunology*. New York, USA: W.H. Freeman and Company. ISBN-13: 97f8-1429219198.
2. Willey, J. Sherwood, L and Woolverton, C.J. (2016). 10th Edition. *Prescott's Microbiology*. New York, USA: McGraw-Hill Education. ISBN-13: 978-1259281594.

Teaching Learning Process

Basics of Immunology is designed to encourage the acquisition of subject knowledge, skills required for biomedical science-based professions and jobs. Learning experiences are aimed at developing practical skills which would prepare the students for industries. Various approaches to teaching-learning process, including lectures, seminars, tutorials, workshops, peer teaching, learning, project-based learning, field-based learning, substantial laboratory-based practical component and experiments, open-ended project work, technology-enabled learning, internship in industry and research establishments will be adopted to achieve this. Problem-solving skills and higher-order skills of reasoning and analysis will be encouraged through teaching strategies.

Teaching Learning Plan

Unit	Title	Lectures
I	Overview	L1-L2
II	Our Immune System	L3-L11
III	Immune Response	L12-L31
IV	Antigen-Antibody Interactions Based Immunological Techniques	L32-L39
V	Vaccines	L40-L43
VI	Dysfunctions of Immune System	L44-L48

Assessment Methods

The assessment of students in Basics of immunology will be done keeping in mind the skills acquired during the course. Students will be assessed using the following: oral and written examinations, closed-book and open-book tests; problem-solving exercises, assignments, observation of practical skills and seminar presentation.

Keywords

Innate immunity, adaptive immunity, B cell, T cell, antigen, antibody, major histocompatibility complex, autoimmunity, hypersensitive reaction, vaccine

Semester I/ II/ III/ IV
Biological Chemistry
(Unique Paper Code: 32585902)
Generic Elective- (GE) Credit: 6

Theory **Total Lectures: 48**

Course Objective

Biological Chemistry integrates the fundamental principles of chemistry with biology. It aims to apply the tools of chemistry in understanding the molecular structure of biomolecules and the chemical reactions occurring in biological processes. It has been structured to understand the significance of acids and bases in the formation of the buffers and maintenance of pH in the cell. The course helps to understand the interaction of various organic and inorganic biomolecules to form ionic and covalent bonds. The inclusion of stereochemistry and molecular interactions explains the 3D structure and stability of biomolecules.

Course Learning Outcomes

Some course level outcome that a student is required to demonstrate is indicated below:

Unit-I: Ionic Equilibria
To conceptualize ionization and effectively explain ionization of different molecules, ionic product. Explain pH, buffer and buffer action and titration curve of simple molecules.

Unit-II: Application of Chemical Bonding and Molecular Structure in Biomolecules
To understand various types of bonding. Draw the structure of various molecule-using concept of hybridization and VSPER theory.

Unit-III: Fundamentals of Organic Chemistry
Role of the various electronic effect to explain the stability of various reaction intermediates, explain acidity and basicity of different molecules and its role in different biomolecule function

Unit-IV: Stereochemistry
To identify, classify and write various types of stereoisomers, chiral centers, configuration and projection formulae of different molecules. To able to use the concept for describing properties of different biomolecules and their role in biological systems.

Unit-V: Reaction Mechanism and Name Reactions
To describe the mechanism for addition and substitution reaction and understand the mechanism of biologically significant name reactions.

Course Content

Unit-I: Ionic Equilibria (L1-L12)
Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases (concept of pKa), pH scale and effect of pH on the structure of biomolecules. Common ion

effect. Buffer solutions and its action, Henderson-Hasselbach equation, buffering zone, buffer index. Qualitative treatment of acid base titration curves (NaOH vs HCl, mono amino acid), isoelectric point, concept of pI and zwitter ion.

Unit-II: Application of Chemical Bonding and Molecular Structure in Biomolecules (L13-L20)

Ionic Bonding: General characteristics of ionic bonding. Lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Polarizing power and polarizability, Fajan's rules, ionic character in covalent compounds.
Covalent bonding: Shapes of some inorganic molecules and ions on the basis of VSEPR with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Hybridization (concept only).
Coordinate bonding: introduction, structure of biomolecules- Haemoglobin.

Unit-III: Fundamentals of Organic Chemistry (L21-L30)

Concept of hybridization of carbon. Cleavage of a covalent bond: hemolysis and heterolysis. Electronic effects and their applications (inductive, electromeric, hyperconjugation and resonance). Structure and stability of reactive intermediates (carbocations, carbanions and free radicals). Relative acid strength: carboxylic acids (aliphatic, aromatic and halo-substituted aliphatic). Relative basic strength of amines (aliphatic).
Intermolecular and intramolecular forces, Types of intermolecular forces and their characteristics-ion-dipole, dipole-dipole, dipole-induced dipole and dispersion forces. Intermolecular and intramolecular hydrogen bonding. Effect of intermolecular and intramolecular forces on properties such as solubility, vapour pressure, melting and boiling points of organic compounds and effect of inter/intra-molecular forces on structure of different biomolecules-peptides and nucleotides.

Unit-IV: Stereochemistry (L31-L40)

Conformations w.r.t. ethane, butane, angle strain, Interconversion of Wedge Formula, Newman, Sawhorse and Fischer representations. Concept of chirality (up to two carbon atoms).
Configuration: Geometrical- *cis* - *trans* nomenclature; CIP Rules and E/ Z Nomenclature (for up to two C=C systems), Threo and erythro.
Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds), R/ S (for up to 2 chiral carbon atoms).
D and L nomenclature, General Properties of Glucose and Fructose (open chain and cyclic structure- Haworth projection), configuration and absolute configuration of Glucose and Fructose, Mutarotation, epimers, anomers (Glycosidic linkage, reducing and non-reducing sugars).

Unit-V: Reaction Mechanism and Name Reactions (L41-48)

Addition Reactions: Hydrohalogenation (Markovnikov's and Anti- Markovnikov's addition)
Nucleophilic substitution reactions: mechanism of SN_1 and SN_2 reactions, Walden inversion.
Electrophilic Substitution Reactions (aromatic compounds): General mechanism of electrophilic substitution reactions (nitration, halogenation, sulphonation,).
Biologically significant name reactions: Aldol (Glucogenesis), retro-aldol (Glycolysis), Benzoin condesation (umpolung-decarboxylation of pyruvate in the presence of TPP), Knoevenagel (Application in drug synthesis), Cannizzaro and Cross Cannizzaro (Sugar metabolism), Bayer Villiger reaction (FAD dependent ketone synthesis), Pinacol-pinacolone rearrangement (1,2-carbon carbon shift).

Practical (Any 8)

(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 solutions based on molarity, normality, percentage, dilutions etc.
2. Preparation of buffers.
3. Estimation of Mohr's salt/ oxalic acid by titrating with $KMNO_4$.
4. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.
5. Qualitative tests for carbohydrates to identify the given unknown carbohydrate solution: Mohlisch, Barfoed, Fehling/ Tollen/ Benedict, Selvinoff, Osazone, Bial's tests.
6. To determine the optical rotation of a biomolecule.
7. To find pKa value of given acetic acid/ amino acid.
8. Absorption spectrum of DNA/ Protein.
9. Estimation of (i) Mg2+ or (ii) Zn2+ by complexometric titration using EDTA.

References

Essential Readings for Theory

1. Eliel, L. (1975). 1st Edition. *Stereochemistry of carbon compounds*, New York, USA: Tata McGraw Hill. ISBN-13: 9780070992900.
2. Finar, I. L. (1996) 6th Edition (volume I and II). *Organic chemistry*. London, UK: ELBS, Longman Higher Education. ISBN-13: 978-0582305601.
3. Lee, J. D., (1999). 5th Edition. *Concise inorganic chemistry*, New Jersey, USA: Wiley-Blackwell. ISBN-13: 9780632052936.
4. Morrison, R. T. and Boyd R. N. (1992) 6th Edition. *Organic chemistry*. London, UK: Pearson Education. ISBN-13: 9780136436690.
5. Nelson, D. L. and Michael M. Cox (2008) 5th Edition. *Lehninger principles of biochemistry*. New Jersey, USA: Prentice Hall Publishers. ISBN-13:978-0321707338.

Essential Readings for Practical

1. Khosla, B.D. (2006). 12th Edition. *Senior practical physical chemistry*. R. Chand & Co. India. ISBN-13: 9788180450792.
2. Plummer D.T. (1987). 3rd Edition. *An introduction to practical biochemistry*. New York, USA: McGraw-Hill College. ISBN-13: 978-0070841659.
3. Vogel A.I. (2000). 6th Edition. *Vogel's quantitative inorganic analysis*. New Jersey, USA: Prentice Hall. ISBN-13: 978-0582226289.

Suggested Readings for Theory and Practical

1. Atkins, P.W. and Paula, J. (2014). 10th Edition. *Physical chemistry*. New York, USA: W. H. Freeman. ISBN-13: 978-1429290197
2. Barrow, G. M. (2008). 6th Edition. *Physical chemistry*. New York, USA: Tata McGraw-Hill. ISBN 13: 9780071140485.
3. Castellan, G. W. (2004). 4th Edition. *Physical chemistry.* Narosa Publications, India. ISBN: 978-81-85015-59-0.
4. Dugas, H. (1999). 3rd Edition. *Bioorganic chemistry.* New York, USA: Springer Verlag. ISBN-13: 978- 0387989105
5. Huheey, J.E. (1997). 4th Edition. *Inorganic chemistry*. New Jersey, USA: Prentice Hall.

ISBN-13: 978-0060429959.
6. Solomons Graham, T. W. (2016). 12th Edition. *Organic chemistry*. New Jersey, USA: John Wiley and Sons. ISBN-13: 978-1118875766.

Teaching Learning Process

This course is designed to encourage the acquisition of subject knowledge, understanding the relevance of biological processes using the fundamental concepts of organic chemistry. Learning experiences should be designed and implemented to foster active/ participative learning. Development of practical skills will constitute an important aspect of the teaching-learning process. A variety of approaches to teaching-learning process, including lectures, seminars, tutorials, workshops, peer teaching and learning and project-based learning, substantial laboratory-based practical component, open-ended project work, games, technology-enabled learning, internship in industry and research establishments etc. will need to be adopted to achieve this. Problem-solving skills and higher-order skills of reasoning and analysis will be encouraged through teaching strategies.

Teaching Learning Plan

Unit	Title	Lectures
I	Ionic Equilibria	L1- L12
II	Application of Chemical Bonding and Molecular Structure in Biomolecules	L13-L20
III	Fundamentals of Organic Chemistry	L21-L30
IV	Stereochemistry	L31-L40
V	Reaction Mechanism and Name Reactions	L41-L48

Assessment Methods

Progress towards achievement of learning outcomes will be assessed using the following methods: time-constrained examinations; closed-book and open-book tests; problem based assignments; practical assignment, laboratory reports; observation of practical skills; individual/team project reports; oral presentations, including seminar presentation; viva voce interviews; computerized adaptive testing; peer and self-assessment etc.

Keywords

Henderson Hasselbalch equation, pH, zwitterion, isoelectric point, electronic effect intermolecular forces, nucleophilic substitution, electrophilic substitution, enantiomers, diastereoisomers, conformers, mutarotation, glycosidic linkage, biomolecules, name reactions

Semester I/ II/ III/ IV
Biosafety and Bioethics
(Unique Paper Code -32585903)
General Elective - (GE) Credit: 6

Theory **Total Lectures: 48**

Course Objective

Recent advances in the field of biotechnology have brought into focus several safety and ethical issues. The inventions in the field of genetic engineering and related fields of molecular biology not only affect us but also the plants, microflora, animals and the entire environment and the way we practice agriculture, medicine and food processing. An increase in our ability to change life forms in recent years has given rise to the new science of bioethics.

1. The present paper focuses on the biosafety and bioethical issues the modern society confronts.

2. Topics such as biosafety levels, GM food debate, impact of biotechnology on biosafety, biotech products and ethical issues, governance of biosafety, environmentally responsible use of biotechnology, clinical ethics will be discussed in the curriculum.

Course Learning Outcomes

Unit-I: Introduction
This should enable students to understand various hazardous biological substance they can come across while working in laboratory or day today life, and what are the steps to minimize the risk.

Unit-II: Biosafety Guidelines and Management
The course should kindle the inquisitiveness in students about genetically modified and living modified organisms (GMO & LMO) and their impact on environment.

Unit-III: Handling and Transportation of GM, Infectious and Radioactive Materials
This course should give students idea of different regulation for handling biohazard and radioactive material.

Unit-IV: Codes, Covenants, Declarations and Guidelines
The students should be familiar with various aspects of bioethics followed in day to day life as well as while handling animals in laboratory during their further studies or research career.

Unit-V: Clinical Ethics
Student should understand their ethical and social, rights and responsibilities for medical care

Unit-VI: Critical Care Ethics
This course should familiarise students with concepts of medical negligence, protection and compensation related issues. They should also understand moral and ethical conflicts related to ICU care and HIV infection.

Course Content

Unit-I: Introduction (L1-L3)
Historical background, introduction to biological safety cabinets, primary containment for biohazards, biosafety levels of specific microorganisms, recommended biosafety levels for infectious agents and infected animals.

Unit-II: Biosafety Guidelines and Management (L4-L17))
Government of India definition of genetically modified organisms (GMOs) and living modified organisms (LMOs), roles of institutional biosafety committee, review committee on genetic manipulation (RCGM), genetic engineering approval committee (GEAC) for GMO applications in food and agriculture, environmental release of GMOs. The GM-food debate and biosafety assessment procedures for biotech foods and related products, including transgenic food crops, case studies of relevance. Biosafety assessment of pharmaceutical products such as drugs/vaccines etc. Key to the environmentally responsible use of biotechnology and its ethical implications.

Unit-III: Handling and Transportation of GM, Infectious and Radioactive Materials (L18-L22)
Risk analysis, risk assessment, risk management and communication, overview of national regulations and relevant international agreements including Cartagena Protocol.

Unit-IV: Codes, Covenants, Declarations and Guidelines (L23-L33)
Reason to apply its principles to study cause of health problems and suggest appropriate intervention/ solution to problem. Definition, historic evolution, codes and guidelines, universal principles. Define the term “Bioethics” in relation to profession, society, and biomedicine, learn about gradation of moral and ethical norms from simpler to higher levels for initiating right actions to "first do no harm‟ and learn about prayers, oaths, covenants, declarations, guidelines and codes which have relevance to bioethics. Ethical use of animals in the laboratory.

Unit-V: Clinical Ethics (L34-L38)
Describe the sanctity of human life and the need to preserve human life, explain about issues related to prenatal screening, clinical trials (Phase I/II/III/IV) studies. Vulnerability of women with respect to health care, examination and screening of women for disease, social issues like domestic violence and female genital mutilation and abortion.

Unit-VI: Critical Care Ethics (L39-L48)
Medical error and medical negligence difference, remedies against medical negligence, protection and compensation related to it. History and need for ICU care, functioning and ethical principles of an ICU care, triage and futility, end of life care, ethical principles related to withholding treatment and withdrawing treatment (euthanasia), legal position regarding policies in ICU and handling of conflicts in the ICU. Basics of HIV infection, identify ethical issues in clinical practice of HIV medicine and its prevention, research ethics related to HIV.

Practical

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

1. A case study based on genetic modified organism (Bt-Cotton).

2. A case study based on genetic modified organism (Bt-Brinjal).
3. A case study based on terminator seeds.
4. A case study based on clinical trials of vaccines with emphasis on ethical issues.
5. A case study on clinical trials of drugs in India with emphasis on ethical issues.
6. A case study on women health ethics.
7. A case study on medical errors and negligence.
8. A case study on critical care ethics.
9. A case study on ethical issues in clinical practice of AIDS.
10. A case study on handling and disposal of radioactive waste.

References

Essential Readings for Theory and Practical

1. Beauchamp, T.L and Childress, J.F. (2011). 6th edition. *Principles of biomedical ethics*. Oxford, UK: Oxford University Press.
2. Helga, K. and Peter, S. (2012). 2nd edition. *A companion to bioethics*. New Jersey, USA: John Wiley and Sons.
3. Hunt, E. F. and Colander, D. C. (2010). 14th edition. *Social science: An introduction to the study of society*. Boston, USA: Pearson/Allyn and Bacon.
4. Peter, A. S. and Viens, A. M. (2008). 1st edition. *The Cambridge textbook of bioethics*. Cambridge, UK: Cambridge University Press.
5. Sateesh, M.K. (2008). 1st edition. *Bioethics and Biosafety*. New Delhi, India: I K International Pvt Ltd.
6. Tristram, E.H. (1996). 2nd edition. *Foundation of Bioethics*. Oxford, UK: Oxford University Press.

Suggested Readings for Theory and Practical

1. Nancy, S. J.; Albert, R. J.; Robert A. Pearlman (1997). 1st edition. *Bioethics: An introduction to the history, methods, and practice*. Massachusetts, USA: Jones and Bartlett Learning.
2. Rajmohan, J. (2006). 1st edition. *Biosafety and bioethics.* New Delhi, India: Isha Books.
3. Rebecca, G.; James, F. H.; Karim, M. M.; Cholani,W. (2011). 1st edition. *Environmental safety of genetically engineered crops*. Michigan, USA: Michigan State University Press.
4. Sreekrishna, V. (2007). 1st edition. *Bioethics and biosafety in biotechnology*. New Delhi, India: New Age International (P) Ltd.
5. Tomme, Y. (2004). 1st edition. *Genetically modified organisms and biosafety*. Gland, Switzerland: World Conservation Union publications.

Teaching Learning Process

The syllabus of biosafety and bioethics is designed to encourage the acquisition of subject knowledge and skills required for biomedical based professions and jobs. Learning experiences are aimed at developing practical skills which would prepare the student for research in educational institutions and biomedical science-based jobs. Various approaches to teaching learning process, including lectures, seminars, tutorials, workshops, peer teaching, learning, project-based learning, field-based learning, substantial laboratory based practical component and experiments, open ended project work, technology enabled learning, internship in industry and research establishment will be adopted to achieve this. Problem solving skills and higher

order skills of reasoning and analysis will be encouraged through teaching strategies.

Teaching Learning Plan

Units	Title	Lectures
I	Introduction	L1-L3
II	Biosafety Guidelines and Management	L4-L17
III	Handling and Transportation of GM, Infectious and Radioactive Materials	L18-L22
IV	Codes, Covenants, Declarations and Guidelines	L23-L33
V	Clinical Ethics	L34-L38
VI	Critical Care Ethics	L39-L48

Assessment Methods

Topic on current and important research areas will be assigned individually to students and they will be asked to retrieve literature and discuss the same with teachers for verification. Progress will be assessed using the following methods: tests; problem-based assignments; practical assignment; laboratory reports; team project reports; oral presentations, including seminar presentation; computerized adaptive testing; peer and self-assessment etc. Students will be given home assignments from time to time to improve their writing skills. Finally, there will be end semester university examination.

Keywords

Genetically modified and living modified organisms (GMO & LMO)

Semester I/ II/ III/ IV
Biostatistics
(Unique Paper Code-32585904)
Generic Elective-(GE) Credit: 6

Theory **Total Lectures: 48**

Course Objective

1. The objective of this course is to acknowledge, appreciate and effectively incorporate the basic statistical concepts indispensable for carrying out and understanding biological hypothesis, experimentation as well as validations.
2. The course is aimed to create awareness about the applications of statistics in biological sciences along with building confidence in students to logically test their experimental data with an appropriate test of significance.
3. Use of open source software and web material is encouraged as the course intends to give wings to the students and not just the height for their soaring potentials.

Course Learning Outcomes

Unit-I: Descriptive Statistics
Students will be able to recognise the importance of statistics in biological sciences, understand population and sample, sampling techniques; qualitative and quantitative variables, and differentiate discrete and continuous variables. Students will learn the measures of central tendency like mean, median and mode, understand the importance of measures of dispersion-range, mean deviation, standard deviation, variance etc. The unit will also expose the students to symmetric and asymmetric distributions, skewness and Kurtosis of distributions.

Unit-II: Probability and Probability Distributions
This will help the student in recognizing the degree of uncertainty in making important decisions, learning joint probability, conditional probability, Bayes' theorem and solve its application level problems. The students will also learn Binomial, Poisson and Normal distributions.

Unit-III: Correlation and Linear Regression
The student will be able to calculate the correlation between two variables and simple linear regression equation for a set of data

Unit-IV: Hypothesis Testing
The student will be able to learn the process of hypothesis testing, determine one or two tailed tests, understand level of significance, critical region and distinguish between Type I and Type II error.

Course Content

Unit-I: Descriptive Statistics (L1-L13)
Data in biology: Development in biostatistics, Samples and Populations, Techniques of sampling (random and stratified), Sampling and non-sampling errors, Variables in biology,

Univariate and bivariate frequency distributions and their graphical representations.
Measures of central tendency: Arithmetic mean, mode, median and partition values.
Measures of dispersion: Range, standard deviation, coefficient of variance and covariance.
Measures of skewness: Pearson's coefficient of skewness.
Kurtosis

Unit-II: Probability and Probability Distributions (L14-L28)
Probability: Basic concepts, Addition and Multiplication rules of probability, Conditional probability, Bayes' theorem and its applications in biostatistics.
Random variables: Discrete and Continuous.
Mathematical Expectation and Variance: Definition and Properties
Probability Distributions: Binomial distribution, Poisson distribution and Normal distribution along with their properties and relationships

Unit-III: Correlation and Linear Regression (L29-L33)
Correlation Analysis: Scatter diagrams, Pearson's and Spearman's coefficients of correlation, Coefficient of determination.
Regression Analysis: Method of least squares, Equations of lines of regression and their applications in biostatistics.

Unit-IV: Hypothesis Testing (L34-L48)
Sampling distributions and standard error, Null and Alternate hypothesis, Basic concept and illustrations of type I and type II errors, Concept of confidence interval estimation.
Large sample tests for single mean and difference of means.
Student's t-distribution: test for single mean, difference of means and paired t-test. Chi- square distribution: tests for goodness of fit, independence of attributes and homogeneity. F-distribution, one-way and two-way analysis of variance (ANOVA).
Non-parametric analysis: Sign and run tests.

Practical

The experiments are designed for students to use spreadsheet/ R/ SPSS for doing biostatistics problem. All theoretical concepts would be covered in the practical using software which includes performing descriptive statistics, probability and probability distribution and inferential statistics.

Computer-based practical using any statistical software like 'R', MATLAB, SPSS, Spreadsheets, etc. to understand the following concepts:

1. Graphical data representation
2. Measures of central tendency and dispersion
3. Probability and probability distributions: Binomial, Poisson and Normal distribution
4. Correlation and linear regression analysis
5. Student's t- test
6. Chi-square test
7. ANOVA

Reference

Essential Reading for Theory and Practical

1. Daniel, W.W. and Cross, C.L. (2019). 11th Edition. *Biostatistics: A foundation for analysis in the health sciences*. New York, USA: John Wiley & Sons. ISBN-13: 978-1119588825.
2. Pagano M. and Gauvrean, K. (2000). 2nd Edition. *Principles of biostatistics*. California, USA: Duxbury Press. ISBN-13: 978-0534229023.

Suggested Reading for Theory and Practical

1. Glantz, S. (2011). 7th Edition. *Primer of biostatistics*. New York, USA: McGraw-Hill Medical. ISBN-13: 978-0071781503.
2. Gupta S.P (2018) *Statistical methods*. Delhi, India: Sultan Chand and Sons.
3. Triola M.M., Triola M.F., Roy J. (2019). *Biostatistics for biological and health sciences*. Harlow, UK: Pearson Education Ltd.
4. Zar, J.H. (2010). *Biostatistical analysis*. Harlow, UK: Pearson Education Limited.

Teaching Learning Plan

The teaching learning process will make use of problem-based learning methods which give undergraduate students direct practice in the statistical reasoning skills needed to choose appropriate procedures for analyzing data.

Unit	Title	Lectures
I	Descriptive Statistics	L1-L13
II	Probability and Probability Distributions	L14-L28
III	Correlation and Linear Regression	L29-L33
IV	Hypothesis Testing	L34-L48

Assessment Methods

Learning outcomes will be assessed using the following assignments written examinations, closed-book and open-book tests; problem-solving exercises, observation of practical skills, seminar, presentation; viva-voce interviews; computerized adaptive testing, literature surveys and evaluations etc.

Keywords

Probability distribution, hypothesis testing, correlation, kurtosis, regression, mean, standard deviation, mode, variance, non-parametric tests, dispersion, chi-square test, ANOVA

Semester I/ II/ III/ IV
Bridging Information Technology and Biotechnology
(Unique Paper Code: 32585905)
Generic Elective- (GE) Credit: 6

Theory **Total Lectures: 48**

Course Objective

1. This course has been designed to reflect how information technology synergizes biotechnology. The course will focus on information retrieval from various databases, the basis of sequence data analysis, use of Hidden Markov Model to solve various sequence analysis problems, such as pairwise and multiple sequence alignments, gene annotation, phylogenetic analysis etc.
2. This course also covers *in silico* restriction site mapping and primer design, introduction to machine learning and applications to bioinformatics in biotechnology.

Course learning Outcomes

After completing the course, students shall be able to:

Unit-I: Convergence of Biotechnology and Information Technology
Appreciate the pivotal role of information technology in critically assessing the biological information.

Unit-II: Databases and Genome Browsers
Use one or several computer programs to extract and conduct comparative critical analyses of different types of biological and medicinal information from publicly available databases.

Unit-III: Sequence Alignment and Phylogenetic Analysis
Learn the use of various tools for sequence alignment and phylogenetic analysis.

Unit-IV: Gene Ontology and Genome Analysis
Learn biological interpretation of computationally and statistically derived results. They will also appreciate the application of computational biology at the whole genome level.

Unit-V: Restriction Site Mapping and Primer Design
Learn the *in silico* tools used for restriction digestion, primer designing, PCR, cloning and expression.

Unit-VI: Introduction to Machine Learning
Recognize the importance of mathematical modeling and computing, and the role of approximation and mathematical approaches in describing the biological processes.

Additionally, they will be able to define biological problems, formulate hypotheses, test hypotheses, analyze, interpret and draw conclusions from biological data, and report the results of an experiment or investigation verbally and in writing. They will also actively participate in discussions during seminars and group exercises.

Course Content

Unit-I: Convergence of Biotechnology and Information Technology (L1-L2)
Introduction to bioinformatics and its applications, Internet and bioinformatics.

Unit-II: Databases and Genome Browsers (L3-L10)
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 pathway databases.

Unit-III: Sequence Alignment and Phylogenetic Analysis (L11-L28)
Local and global sequence alignments (Needleman-Wunsch and Smith-Waterman algorithms), pair-wise (BLAST and FASTA algorithms) and multiple sequence alignment (Clustal W) and its importance. Theory behind BLAST: How Hidden Markov Model (HMM) can be used to model a family of unaligned sequences or a common motif within a set of unaligned sequences and further be used for discrimination and multiple alignment. Basics and tools for phylogenetic analysis, Cladistics and its assumptions, Tree-building methods (Character and distance-based methods), Construction of phylogenetic trees (PHYLIP).

Unit-IV: Gene Ontology and Genome Analysis (L29-L36)
The Ontologies: Cellular component, Biological process and Molecular function. Features of DNA sequence analysis, Gene prediction methods, SNP analysis (dbSNP), Sequence assembly and genome annotation.

Unit-V: Restriction Site Mapping and Primer Design (L37-L44)
In silico restriction mapping, Cloning and expression, Identification of cDNA from databases, Design of primers for standard and real time PCR, e-PCR. PCR diagnostic design, Design strategy for over-expression of a therapeutic protein using specific examples to illustrate the strategy.

Unit-VI: Introduction to Machine Learning (L45-L48)
Learning from data, how can we extract knowledge from data to take decisions and program the computer to be able to learn from examples and adapt systems dynamically to enable better user experiences.

Practical

1. Retrieval of information from nucleotide databases.
2. Sequence alignment using BLAST.
3. Multiple sequence alignment using Clustal W.
4. Phylogenetic analysis using PHYLIP.
5. Gene Ontology.
6. Gene prediction and ORF finding.
7. *In silico* primer designing for standard and real time PCR and performing e-PCR.

References

Essential Readings for Theory and Practical

1. Baxevanis, A.D. and Ouellette, B.F.F. (2004). 3rd Edition. *Bioinformatics: A practical guide to the analysis of genes and proteins*. New Jersey, USA: John Wiley and Sons. ISBN-13: 978-0471478782.
2. Brown, T.A. (2017). 4th Edition. *Genomes 4*. New York, USA: Garland Science. ISBN-13: 978-0815345084.
3. Mount, D.W. (2004). 2nd Edition. *Bioinformatics: sequence and genome analysis*. New York, USA: Cold Spring Harbour Laboratory Press. ISBN-13: 978-0879697129.

Suggested Readings for Theory and Practical

1. Kellehar, J.D., Namee, B.M. and D'Arcy, A. (2015). 1st Edition. *Fundamentals of machine learning for predictive data analytics: algorithms, worked examples, and case studies*. Boston, USA: The MIT Press. ISBN-13: 978-0262029445.
2. Leach, A.R. (2009). 2nd Edition. *Molecular modeling: Principles and applications*. Pearson India. ISBN 13: 9780582382107.
3. Smith C.G. and O'Donnell, J.T. (2006). 2nd Edition. *The Process of New Drug Discovery and Development*. New York, USA: Informa Healthcare Inc. ISBN-13: 978-0849327797.
4. Theobald, O. (2018). *Machine learning for absolute beginners: A plain English introduction (Machine learning for beginners)*. Independently published. ISBN-13: 978-1549617218.
5. Young, D.C. (2009). 1st Edition. *Computational drug design: A guide for computational and medicinal chemists*. New Jersey, USA: John Wiley and Sons. ISBN-13: ISBN-13: 978-0470126851.

Teaching-learning processes

This course is designed to encourage the acquisition of subject knowledge, understanding academic and professional skills required for use of information technology in biotechnology-based professions and jobs. A variety of approaches to teaching-learning process, including lectures, tutorials, workshops, seminars, peer teaching and learning, and project-based learning, substantial computer based practical component, open-ended project work, games, technology-enabled learning, internship in industry and research establishments etc. will need to be adopted to achieve this. Problem-solving skills and higher-order skills of reasoning and analysis will be encouraged through teaching strategies.

Teaching Learning Plan

Unit	Title	Lectures
I	Convergence of Biotechnology and Information Technology	L1-L2
II	Databases and Genome Browsers	L3-L10
III	Sequence Alignment and Phylogenetic Analysis	L11-L28
IV	Gene Ontology and Genome Analysis	L29-L36
V	Restriction Site Mapping and Primer Design	L37-L44
VI	Introduction to Machine Learning	L45-L48

Assessment Methods

Progress towards achievement of learning outcomes will be assessed using the following methods: time-constrained examinations; closed-book and open-book tests; problem-based assignments; practical assignment reports; observation of computer-based skills; individual/team project reports; oral presentations, including seminar presentation; viva voce interviews; computerized adaptive testing; peer and self-assessment etc.

Keywords

Databases, NCBI, BLAST, sequence alignment, phylogeny, ontology, primer, ePCR, restriction map, machine learning

Semester I/ II/ III/ IV
Concepts in Biotechnology
(Unique Paper Code: 32585906)
Generic Elective- (GE) Credit: 6

Theory **Total Lectures: 48**

Course Objective

1. To introduce importance of Biotechnology in allied fields.
2. To enable students from diverse backgrounds to understand basic concepts in Gene Cloning and DNA Analysis.
3. To provide them an insight into various molecular techniques commonly used in Biotechnology.
4. To enable them to appreciate applications of Biotechnology in everyday life.

Course Learning Outcomes

Unit-I: Techniques Used in Biotechnology
Students shall learn basic biotechnology techniques and key concepts that are used in isolation and characterization of biomolecules (DNA and proteins). They will also develop basic understanding of the robust techniques with wide applications (such as PCR, DNA sequencing) and appreciate their contribution in biotechnology.

Unit-II: Process of Gene Cloning, Expression and Protein Purification
They will comprehend the importance of gene cloning in biotechnology and learn the intricacies of gene cloning using plasmids and bacteriophages as cloning vectors.

Unit-III: Process and Challenges of Heterologous Gene Expression
Students shall learn the challenges (and troubleshooting) of heterologous expression and also learn about cDNA cloning and its significance.

Unit-IV: Genomic and cDNA Libraries
Students shall be able to understand the importance of construction of genomic libraries and their specialized screening methods to identify gene of interest.

Unit-V: Applications of Biotechnology
Through protein engineering, gene therapy, DNA profiling and biopharmaceutical production, students shall learn the importance of various applications of biotechnology.

Unit-VI: Biosafety and Ethical Issues
They shall gain an insight of safe and ethical practices required in medical biotechnology.

Course Content

Unit-I: Techniques Used in Biotechnology (L1-L17)
Brief history of biotechnology and its importance.
Isolation and purification of genomic and plasmid DNA, Agarose and polyacrylamide gel

electrophoresis, Southern and Western hybridization (probes and labels used in the preparation of probes- radioactive, fluorescent, enzymatic and chemiluminescent).
Polymerase Chain Reaction (PCR): Principle, types of DNA polymerases, primer designing, types of PCR: hot start, multiplex, inverse, reverse transcription and touchdown PCR and their applications.
Sequencing: Chemical (Maxam Gilbert) and Enzymatic (Sanger's dideoxy) method, automated DNA sequencing concept.

Unit-II: Process of Gene Cloning, Expression and Protein Purification (L18-L27)
Restriction endonucleases: Restriction and modification systems, nomenclature and types of restriction enzymes (type I-IV), recognition of restriction sites, restriction mapping.
Joining of DNA molecules: sticky end and blunt end ligations, role of DNA ligase, reaction mechanism of ligation in viruses and bacteria, adaptors, linkers, homopolymer tailing.
Vectors: Plasmids (pUC vectors), Bacteriophage (lambda phage-derived replacement and insertion vectors), cosmids, in vitro packaging; expression vectors (one example each of prokaryotic and eukaryotic expression vectors); shuttle vectors.
Bacterial transformation, selection (antibiotic selection methods) and screening (blue/white) of transformants. Challenges in expression of eukaryotic proteins in prokaryotic hosts, factors affecting the expression, expression in eukaryotic cells, cDNA cloning.

Unit-III: Process and Challenges of Heterologous Gene Expression (L28-L32)
Challenges in expression of eukaryotic proteins in prokaryotic hosts, factors affecting the expression, expression in eukaryotic cells, cDNA cloning.

Unit-IV: Genomic and cDNA Libraries (L33-L37)
Construction of genomic and cDNA libraries, their screening by nucleic acid hybridization (Colony and Plaque hybridization) and immunochemical methods.

Unit-V: Applications of Biotechnology (L38-L46)
Through protein engineering, gene therapy, DNA profiling and biopharmaceutical production, students shall learn the importance of various applications of biotechnology.

Unit-VI: Biosafety and Ethical Issues (L47-L48)
Safe handling and disposal of GMOs and toxic reagents. Concerns about gene editing, gene therapy and impact of GMOs on the environment

Practical

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

1. To prepare general media and reagents.
2. To perform genomic DNA isolation.
3. To perform plasmid DNA isolation.
4. To perform agarose gel electrophoresis.
5. To amplify DNA using PCR.
6. To perform restriction digestion of plasmid DNA
7. To analyze DNA sequence from autoradiogram/ electrophoretogram.

References

Essential Reading for Theory

1. Bernard, R. G. Jack, J. P. and Cheryl, I. P. (2009). 4th Edition. *Molecular biotechnology: principles and applications of recombinant DNA.* USA: ASM press, ISBN-13:9781555814984.
2. 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.
3. Cantor, C. R. and Smith, C. L. (1999). 1st Edition. *Genomics: The science and technology behind the human genome project.* New York, USA: John Wiley and Sons. ISBN-13:978-0471599081.
4. Kornberg, A. (2005). 2nd Edition. *DNA Replication.* California, USA: University Science Books, ISBN -13:978- 0716720034.
5. Primrose, S. B. and Twyman, R. B. (2006). 7th Edition. *Principles of gene manipulation and genomics.* Oxford, UK, Blackwell Scientific Publishers. ISBN: 978-1405135443.

Essential Reading for Practical

Different Journal papers and review articles along with:
Green, M. R. and Sambrook, J. (2012). 4th Edition, (three-volume set). *Molecular Cloning: A Laboratory Manual.* New York, USA: Cold Spring Harbor Laboratory Press ISBN-13: 978-1936113422.

Suggested Reading for Theory and Practical

Karp, G. (2013). 7th Edition. *Cell and Molecular Biology: Concepts and Experiments* New Jersey, USA: Wiley Publishers. ISBN-978-0470483374.

Teaching Learning Process

The teaching learning process will be interactive through chalk and board, power point presentations and inclusions of short animation films available on the topics being covered to help students grasp the basic concepts in biotechnology. Suitable examples shall be taken to engage students from different disciplines to appreciate the role of various tools and techniques used in creating desired biotechnological applications in the field of medicine and industry etc. To enable active participation, students would be encouraged to make brief presentations on chosen topics related to the curriculum. Experiments would help students learn the basic methods and techniques used in isolation, manipulation and analysis of DNA.

Teaching Learning Plan

Unit	Title	Lectures
I	Techniques used in Biotechnology	L1-L17
II	Process of Gene Cloning, Expression and Protein Purification	L18-L27
III	Process and Challenges of Heterologous Gene Expression	L28-L32
IV	Genomic and cDNA Libraries	L33-L37
V	Applications of Biotechnology	L38-L46
VI	Biosafety and Ethical Issues	L47-L48

Assessment Methods

Learning outcomes will be assessed through written & oral examinations, problem-solving exercises, class presentations and evaluation of the acquired practical skills.

Keywords

Recombinant DNA, PCR, gene cloning, RFLP, SNP, DNA sequencing

Semester I/ II/ III/ IV
Concepts in Medicinal Chemistry and Drug Development
(Unique Paper Code: 32585907)
Generic Elective - (GE) Credit: 6

Theory **Total Lectures: 48**

Course Objective

1. This course introduces principles that are required to understand the action, behavior and nature of drug compounds on different drug targets. This encompasses different approaches to drug discovery and design, including development of drugs from natural products, in silico approaches and rational drug design.
2. The course highlights physico-chemical considerations in structure activity relationships, drug receptor interactions and drug development strategies.

Course Learning Outcomes

Unit-I: General Introduction
Having successfully completed this course, students shall be able to describe the overall process of drug discovery, and the role played by medicinal chemistry

Unit-II: Drug Target Classification
Explain the relationship between drug's chemical structure and its interaction with the drug target i.e., Proteins, Enzymes, Receptors and Nucleic acids

Unit-III: Physicochemical Principles of Drug Action
Assess relevant physic-chemical properties and their influences on mechanism of pharmacologic actions (Structure activity relationship)

Unit-IV: Drug Receptor Interactions
Describe the kinetics of drug receptor interactions and relationship between the dose and response of drug

Unit-V: Principles of Drug Design
Explain strategies in finding hit to lead, lead modification and identification of drug candidate

Unit-VI: Drug Discovery and Pharmainformatics
Explain the various strategies in finding the lead, lead modification, identification of drug candidate and discuss the concept of prodrugs. Appreciate the role of modern computational techniques in drug designing, target identification and validation.

Course Content

Unit-I: General Introduction (L1-L2)
Definition and scope of drug design.

Unit-II: Drug Target Classification (L3-L10)

Proteins as drug targets: Receptors - receptor role, Ion channels, Membrane bound enzyme activation, Agonist and antagonists, Concept of inverse agonist, Desensitization and sensitization of receptors, Affinity, Efficacy and potency. Enzymes: Enzyme inhibitors (competitive, non- competitive, suicide inhibitors), Medicinal use of enzyme inhibitors. Nucleic acids as drug targets: Classes of drugs that interact with DNA: DNA intercalators and DNA alkylators.

Unit- III: Physicochemical Principles of Drug Action **(**L11-L19)
Partition coefficient, Drug dissolution, Acid-base properties, Surface activity, Bioavailablity, Stereochemical aspects of drug action

Unit-IV: Drug Receptor Interactions (L20-L27)
Kinetic analysis of ligand receptor interactions using Scatchard plot, Double reciprocal plot, Hill plot, Forces involved, Relationship between dose and effect (graded and quantal response).

Unit-V: Principles of Drug Design (L28-L35)
Introduction to SAR, Strategies in the search for new lead compounds, Analogue synthesis versus rational drug design, Concept of prodrugs.

Unit-VI: Drug Discovery and Pharmainformatics (L36-48)
Drug discovery pipeline, Drug target identification and validation for microbial pathogen, Selection of gene unique to the pathogen, screening for its presence in other microbes and human host. Drug Databases, Pub Chem, calculating drug-like properties, Introduction to rational drug design methods, Optimization of lead compounds, Protein 3D structure and binding site analysis, Similarity based virtual screening using online tools.

Practical

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

1. Recrystallization of organic compound, determination of its melting point and TLC.
2. Preparation of Benzocaine.
3. Determination of partition coefficient of Aspirin in octanol-water system.
4. Preparation of Phenacetin.
5. Visualization and analysis of 3D structures of proteins.
6. Finding the active sites in a receptor.
7. Molecular docking using AutoDock or HEX.
8. Searching databases for drug like compounds and computing drug like properties of small molecules.
9. Extraction of piperine from black pepper.

References

Essential Readings for Theory and Practical

1. Ashutosh, K. (2004). *Advanced practical medicinal chemistry*. New Delhi, India: New Age International (P) Ltd. ISBN-13: 978-8122415391.
2. Patrick, G.L. (2009). 4th Edition. *Introduction to medicinal chemistry*. Oxford, UK: Oxford University Press. ISBN-13: 978-0199234479.

3. Silverman, R.B. (2012). 2nd Edition. *The organic chemistry of drug design and drug action.* Massachusetts, USA: Academic Press. ISBN-13: 978-0126437324.

Suggested Readings for Theory and Practical

Nogrady, T. and Weaver, D.F. (2005). 3rd Edition. *Medicinal chemistry: A molecular and biochemical approach*. Oxford, UK: Oxford University Press. ISBN-13: 978-0195104561.

Teaching Learning Process

The syllabus of Concepts in Medicinal Chemistry and Drug Development is designed to encourage the acquisition of subject knowledge, skills required for biomedical science-based professions and jobs. Learning experiences are aimed at developing practical skills which would prepare the students for industries and educational organizations. Various approaches to teaching-learning process, including lectures, seminars, tutorials, workshops, peer teaching, learning, project-based learning, field-based learning, substantial laboratory-based practical component and experiments, open-ended project work, technology-enabled learning, internship in industry and research establishments will be adopted to achieve this. Problem-solving skills and higher-order skills of reasoning and analysis will be encouraged through teaching strategies.

Teaching Learning Plan

Units	Title	Lectures
I	General Introduction	L1-L2
II	Drug Target Classification	L3-L10
III	Physicochemical Principles of Drug Action	L11-L19
IV	Drug Receptor Interactions	L20-L27
V	Principles of Drug Design	L28-L35
VI	Drug Discovery and Pharmainformatics	L36-L48

Assessment Methods

The assessment of students in Concepts in Medicinal Chemistry and Drug Development will be done keeping in mind the skills acquired during the course. Students will be assessed using the following: oral and written examinations, closed-book and open-book tests; problem-solving exercises, assignments, observation of practical skills and seminar presentation.

Keywords

Drug discovery, drug targets, lead molecules, pharmacophore, physico-chemical properties, drug design

Semester I/ II/ III/ IV
Intellectual Property Rights (IPR) for Biologists
(Unique Paper Code: 32585908)
Generic Elective- (GE) Credit: 6

Theory **Total Lectures: 48**

Course Objective

Developments in the recent years has increased the knowledge acquisition process, which is considered to have commercial value as well. The knowledge pool so generated can be considered as intellectual property which has grown tremendously in academic community and society at large. The pace with which our modern science is progressing today, various new and useful inventions take place.

1. Students are made aware to understand the need for creation, protection, commercialization of intellectual property in the area.
2. Various forms of Intellectual Property Rights are also explained.
3. Paper also deals with the entire process of patent filling, taking some case studies.

Course Learning Outcomes

Unit-I: Introduction to IPR and Types of IPR
Students should be able to apply intellectual property law principles (including copyright, patents, designs and trademarks) to real problems and analyze the social impact of intellectual property law and policies.

Unit-II: Biotechnology and Expanding Boundaries of IP Protection
Students should be able to decipher IP law in relation to biotechnology and life-science based industries and would be well versed with patenting law of biological products.

Unit-III: Highlights of Indian Patent Law and Patent Filing
Students would be encouraged to work in teams, analyze case studies, solve problems and manage time in context with biological patent filing both in India and abroad. They should be familiar with both National and International laws of patent filing and their financial implications.

Unit-IV: Intellectual Property Exploitation and Management
Students should be able to analyze ethical and professional issues which arise in intellectual property law context.

Unit-V: Forums, Processes and Initiatives and International Treaties
Students should be equipped to write reports on project work that critically reflects their learning of regulatory framework.

Unit-VI: Future Developments of Intellectual Property Rights
Students should be fully conversant with tools and techniques to detect plagiarism in innovation which can be questioned legally.

Course Content

Unit-I: Introduction to IPR and Types of IPR (L1-L13)

Importance of IPR, advantages of IP protection, relationship with trade, Product/ design, patent and Terminologies. Copyrights, Trademarks, Trade Secrets, Patents, Industrial Design, Geographical indicators, plant variety protection.

Copyrights- Nature of Copyright, Author & ownership of Copyright, Rights Conferred by Copyright, Assignment, Transmission, Licensing of Copyrights, Copyright Societies, Office, Board, Registration of Copyrights & Appeals, International Conventions, Copyright pertaining to Software/Internet, Database, Copyright Protection/Database Protection, IP issues in cyber space, Legal Position in USA/Indian. Law/WIPO Copyright Treaty.

Trademarks- Meaning of Trademarks, Different kinds of marks (brand names, logos, signatures, symbols), Use of a Mark, Registration of Trademarks- Procedure, Opposition to Registration-Procedure, What Marks are Registrable/Not Registrable, Concurrent Registration, Similarity of Marks, Assignment/Transmission/Licensing of Trademarks, Infringement of Trademarks, Passing off Action.

Patents- Definition of patents, Elements of patentability - Patentable subject matter, Utility, novelty and non-obviousness, Patentability of Biotechnological inventions, biochemicals and software. Concept and patenting of bio-equivalence and biosimilars. General Introduction: Product/ Process/ Design, Patents claims, Dates associated with patent, Patent Life and Geographical Boundaries, Patent Infringement, Utilization of Intellectual Assets, Ownership of Patents, Deposition of microorganisms, NBA permission when biological material is used, Disclosure of origin on biological material.

i. Patent Search, Patent Databases & Library (INPASS, USPTO, WIPO, EPO), Practical Search Training.
ii. Patent Terminology: (Abstract, Summary, Background, Drawings, Description, Claims).

Geographical Indications- Nature of Geographical Indications, Conditions & Procedure for Registration, Offences, Penalties.

Industrial Design- Need for Protection of Industrial Designs, Subject Matter of Protection and Requirements, The Designs Act 2000, Procedure for obtaining Design Protection, Revocation, Infringement and Remedies

Plant Variety Protection (PVP)- The Protection of Plant Varieties and Farmer's Rights Act 2001, Registration of Plant Varieties and Essentially derived variety, Duration, Effect of Registration and Benefit Sharing, Farmers right.

Trade Secrets- Protectable Subject Matter, Secrets versus Public Knowledge Economic Value, Reasonable Effort to Maintain Secrecy.

Unit-II: Biotechnology and Expanding Boundaries of IP Protection (L14-L16)

Biotechnology and Life Science Industries, Commercial importance of biogenetic resources. Concepts and patenting of Bio-equivalence products and biosimilars

Unit-III: Highlights of Indian Patent Law and Patent Filing (L17-L25)

General outline of 1970 Indian Patent Act and as amended further, Total sections, briefly discuss the sections for filing of application, sections related to infringement offence. Relevant application Forms, timelines, fee, patent search and patent drafting. Patent filing in India and abroad, Preparation of patent documents, Process for examination of patents, Patent Evaluation and Economics of patenting.

Unit-IV: Intellectual Property Exploitation and Management (L26 -L33)

a) Licensing and Technology: Know-how transfer.

b) Key Business concerns in commercializing Intellectual Property Rights Competition and Confidentiality issues, competition law and competition commission; Employee Confidentiality; Assignment of Intellectual Property Rights; Material Transfer Agreements, Non-disclosure agreements, Transfer of technology/ knowhow Agreements; Intellectual Property Issues in the Sale of Business.

Unit-V: Forums, Processes and Initiatives and International Treaties (L34-L42)

(a) Forums, Processes and Initiatives:
International: Conference of the parties to the convention on Biological diversity. INDIA: Biodiversity conservation, Trade and development, India's Bio-scientific and Technological capacities, implementing TRIPS, Regulatory Framework in Biotech Industry and Pharma setup in India, Clinical trials.

(b) International Treaties:
Paris Convention, World Trade Organization, World Intellectual Property organization, TRIPS Agreement, PCT, UPOV convention, Convention on Biological Diversity, Biopiracy, Traditional knowledge and benefit sharing, Budapest Treaty, Madrid Agreement/protocol, Hauge Agreement, Strasbourg Agreement, Lacarno Agreement.

Unit-VI: Future Developments of Intellectual Property Rights (L43-48)

Artificial Intelligence and IP, 3D printing and IPR, Indian Traditional Medicine & IP Protection, Folklore, Patenting of Life Forms, International-Traditional Medicines & Health Foods.

Practical

A) Case Studies to be carried out:
1. Infringement cases
2. Biopiracy cases (Hoodia case, the Quinoa case, the Enola bean case, The neem patents)
3. Traditional knowledge and IP system
4. Patents as assets
5. Trade secrets
6. Drug pricing as a result of patent filing
7. Patenting of genetically-engineered micro-organism (Diamond Vs Chakravarthy)
8. Recent cases related to the provisions of Section 3(d) of The Patents Act (Novartis vs Generic Manufacturers, Roche vs Cipla, Astra Zeneca Vs Natco Pharma).

B) Write the provisional and complete specifications of the above mentioned case studies.

References

Essential Readings for Theory

1. Ahuja, V. K. (2015). 2nd Edition. *Intellectual property rights in india*. Delhi, India: Lexis Nexis. ISBN-13: 9789351433880
2. Ganguli, P. (2001). 1st Edition. *Intellectual property rights: Unleashing the knowledge economy*. Delhi, India: Tata McGraw Hill Publishing. ISBN: 9780070077171.
3. Narayanan, P. (2017). 4th Edition. *Patent law*. Kolkata, India: Eastern Law House (ELH). ISBN-13**:** 9788171773190.
4. Wadhera, B. L. (2004). 1st Edition. *Law relating to patents, trademarks, copyright, designs and geographical indications.* Delhi, India: Universal Law Publishing Co. Ltd. ISBN-13: 978-8175343825.

Essential Reading for Case Studies

Gupta, O. P. (2019). Version 3.0. *Manual of patent office practice and procedure.* Mumbai, India: The office of Controller General of patents, designs & trademarks.

Suggested Readings for Theory and Case Studies

1. The Patents Act (1970), with latest Amendments. (http://www.ipindia.gov.in).
2. Venkataraman, M. (2014*).* 1st Edition. *An introduction to intellectual property rights,* Bangalore, India: M. Venkataraman. ISBN: 9788191045741.

Teaching Learning Process

Teaching and learning activity will extensively include classroom activities. Students will be regularly asked questions and queries of previous class before beginning of a new class Teaching would include both blackboard and chalk method to communicate the concepts. Use of Power Points presentations to visually explain various processes. Verbal explanation, seminars, case studies, workshops and Open discussions. Quizzing and questioning would be a regular exercise. Drafting of patent would be given as an assignment.

Teaching Learning Plan:

Unit	Title	Lectures
I	Introduction to IPR and Types of IP	L1-L13
II	Biotechnology and the expanding boundaries of IP protection	L14-L16
III	Highlights of Indian patent Law	L17-L25
IV	Intellectual property exploitation and management	L26-L33
V	Forums, Processes and Initiatives and International Treaties	L34-L42
VI	Future Developments of Intellectual Property Rights	L43-L48

Assessment Methods

1. Written class tests and assignments
2. Quizzing/ viva, Problem solving exercises
3. Seminar presentations
4. Final University Examination
5. Study of exiting patents and suggestions for improvements

Keywords

Intellectual property rights, WIPO, patents, trademarks, industrial designs, geographic indications, copyright and related rights.

Semester I/ II/ III/ IV
Pathological Basis of Diseases
(Unique Paper Code: 32585909)
Core Course - (GE) Credit:4

Theory **Total Lectures: 48**

Course Objective

Claude Bernard once said "Effects vary with the conditions which bring them to pass, but laws do not vary. Physiology and pathology states are ruled by the same forces; they differ only because of the special conditions under which the vital laws manifest themselves". The syllabus of "Pathological Basis of Diseases" compliments and supplements the knowledge of Human Physiology. It incorporates basic topics like cellular adaptations, inflammation, repair, disruption of homeostasis which form the basis of pathogenesis of many diseases. Concepts of neoplasia, cellular ageing and features other infectious diseases are also included for in-depth understanding. Pathology also provides the necessary inputs for the other disciplines like Pharmacology, social and preventive medicine, medicinal biochemistry etc. all the topics and experiments are introductory in nature and lay stress on introducing students to the basic concepts of pathology.

Course Learning Outcomes

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

Unit-I: Introduction
History and importance of study of pathology in understanding the diseases. Concepts and important terminology.

Unit-II: Basis of Pathogenesis: Cell Injury and Responses of Cells to Injury
Basic knowledge of cellular responses to changing physiological stimuli, stress and injury. Understanding of molecular, structural and metabolic changes associated with cellular adaptation to physiological stimuli, stress and injury.

Unit-III: Basis of Pathogenesis: Inflammation, Tissue Regeneration and Repair
Understanding of the basis of pathogenesis of a disease: inflammation and repair mechanisms and how alterations in them may be the reason for disease.

Unit-IV: Basis of Pathogenesis: Hemodynamic Derangements
Understand that disruption of homeostasis and hemostasis are contributing factors for progression of a disease.

Unit-V: Tumor Pathology
Describe how pathological analysis is used to recognize, classify, grade and stage the major types of malignancy and how pathological analysis contributes to disease surveillance and the evaluation of therapeutic interventions.

Unit-VI: Infectious Diseases Pathology
Discussion of specific diseases as examples to describe and recognize the major cell and tissue

alterations associated with these diseases and how they contribute to organ dysfunction or clinical signs and symptoms.

Course Content

Unit-I: Introduction (L1-5)
History of pathology, Basic definitions and common terms used in pathology. Basic Concepts in Cell and Tissue Organization.

Unit-II: Basis of Pathogenesis: Cell Injury and Responses of Cells to Injury (L6-13)
An overview of cellular adaptation: Hyperplasia, Hypertrophy, Atrophy, Metaplasia; Causes and mechanisms of cell injury, reversible and irreversible injury, Necrosis, Apoptosis, Types of apoptosis, Intracellular accumulations, Cellular ageing and its mechanisms, Fibrosis.

Unit-III: Basis of Pathogenesis: Inflammation, Tissue Regeneration and Repair (L14-25)
Basic concepts of acute and chronic inflammation: Vascular Changes, cellular events, important chemical mediators of inflammation, Morphological effects inflammation response, Granulomatous Inflammation. Mechanism of tissue regeneration, role of ECM, repair by healing, scar formation, cutaneous wound healing, tissue remodeling in liver (mechanism of fibrosis and cirrhosis).

Unit-IV: Basis of pathogenesis: Hemodynamic Derangements (L26-31)
An overview of Edema, hyperemia, congestion, hemorrhage, hemostasis and thrombosis, Embolism, Infarction and shock with suitable examples.

Unit-V**:** Tumor Pathology (L32-38)
Definitions, Nomenclature, characteristics of benign and malignant neoplasms, grading and staging of cancer, biology of tumor growth, invasion and metastasis, carcinogens and cancer, concept of oncogenes, tumor suppressor genes, DNA repair genes and cancer stem cells.

Unit-VI: Infectious Diseases Pathology (L39-48)
Etiology and Pathophysiology of Cholera (Diarrheal Disease), Etiology and Pathophysiology of Tuberculosis (Respiratory Disease), Etiology and Pathophysiology of Leprosy (Skin Disease).

Practical

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

1. Urine analysis for abnormal constituents: protein, fats and glucose.
2. Measurement of erythrocyte sedimentation rate.
3. Tissue Processing, embedding and sectioning. Staining and preparation of permanent histological slides.
4. Diagnostic tests for detection of various Diseases – CRP, VDRL, RA, Pregnancy, Dengue and HIV (any four).
5. PCR based diagnostics (for any one disease).

References

Essential Readings for Theory and Practical

1. Kumar, V., Abbas, A.K., Aster, J.C. and Fausto, N. (2009). 8th Edition. *Robbins and Cotran pathologic basis of disease*. Philadelphia, USA: Saunders Publishers. ISBN-13:978-1416031215.
2. Sood, R. (2009). 6th Edition Volume 1 and 2. *Medical laboratory technology methods and interpretations.* India: Jaypee Brothers Medical Publishers. ISBN-13:978-8184484496.
3. Underwood, J. C. E. and Cross, S.S. (2009). 5th Edition. *General and systematic pathology*. London, UK: Churchill Livingstone. ISBN-13: 978-0443068881.

Suggested Readings for Theory and Practical

Copstead-Kirkhorn, L. C. (2012). 3rd Edition. *Pathophysiology*. Philadelphia, USA: Saunders. ISBN-13:978-1455726509.

Teaching Learning Process

Teaching and learning process will extensively include classroom activities to encourage the acquisition of subject knowledge, understanding academic nuances through questions and queries of previous class before beginning of a new class. Teaching would include blackboard and chalk method to communicate the concepts together with use of Power Points presentations to visually explain various processes. The students would be encouraged to frame new questions on their subjects apart from the available ones to enable them to have better insight of the topic. Verbal explanation, seminars, workshops, open discussions, quizzing and questioning would be a regular exercise. Cases studies on various diseases would be discussed to give firm grip on concepts of classical pathology. This would be supported by visit to a nearby laboratory.

Teaching Learning Plan

Unit	Title	Lectures
I	Introduction	L1-L5
II	Basis of Pathogenesis: Cell Injury and responses of cells to injury	L6-L13
III	Basis of Pathogenesis: Inflammation, Tissue Regeneration and Repair	L14-L24
IV	Basis of pathogenesis: Hemodynamic Derangements	L25-L31
V	Tumor Pathology	L32-L38
VI	Infectious diseases Pathology	L39-L48

Assessment Methods

1. Written class tests and Assignments
2. Open and Closed Book Test
3. Quizzing/ viva, Problem solving exercises
4. Seminar presentations, Case Studies
5. Laboratory experiments and reports
6. Projects and Project Reports
7. Final University Examination

Keywords

Etiology, pathogenesis, necrosis, apoptosis, inflammation, tissue injury, tissue repair, fibrosis, neoplasia, oncogenes, edema, congestion, shock, dengue, tuberculosis, myocardial infarction

Semester I/ II/ III/ IV
Pharmacology and Toxicology
(Unique Paper Code: 32585910)
Generic Elective-(GE) Credit: 6

Theory **Total Lectures: 48**

Course Objective

The course provides basic insight into principles of pharmacology and toxicology. It also highlights the pharmacodynamics and pharmacokinetics aspect of drugs in general. The course will emphasize on evaluation of toxicity and mechanism of toxicity by xenobiotics on various systems of the body. The course also introduces with mechanism of action of drugs acting on various systems of the body and their clinical uses. The course also gives an insight into the ways whereby various anthropogenic chemicals cause toxicity to ecosystems.

Course Learning Outcomes

Unit-I: General Pharmacology and Toxicology
Concept of various sources of drugs and different routes of drug administration, Types of toxic substances to which humans are exposed. Basics of how various chemical compounds cause adverse effects to the ecosystem.

Unit-II: Mechanism of Toxicity
Various mechanism by which toxicants interact with biomolecules, alter their function and manifest toxicity or effect.

Unit-III: Pharmacokinetics
Various mechanisms by which xenobiotics are absorbed, distributed, metabolized and excreted from the body.

Unit-IV: Pharmacodynamics
Interaction of xenobiotics with biomolecules such as various types of receptors, that results in the effect. Concept of dose response relationship and various parameters used to assess therapeutic potential and toxicity of a chemical compound.

Unit-V: Introduction and Classification of Drugs and Toxic Agents acting on following Systems/ Organs
Classification, mechanism of action and clinical uses of drugs and effects of a few toxicants on systems/organs such as: CNS, Cardiovascular system, Kidney and Respiratory system.

Unit-VI: Introduction and Classification Following Drugs
Pharmacological action, mechanism of action and clinical uses of Anti-inflammatory drugs, Endocrine drugs and Antimicrobial drugs; and major toxicities associated with these classes of drugs.

Course Content

Unit-I: General Pharmacology and Toxicology (L1-L6)
Nature and source of drugs, routes of drug administration and their advantages, definitions and scope of toxicology. Introduction to ecotoxicology.

Unit-II: Mechanism of Toxicity (L7-L12)
Formation of ultimate toxicant of xenobiotics and its interaction with target molecules.

Unit-III: Pharmacokinetics (L13-L18)
Membrane transport, Absorption, concepts of bio-availability and half- life of the drug, distribution of xenobiotics. Brief introduction to bio-transformation, phase-I reactions including oxidations, hydrolysis, reductions and phase II conjugation reactions and excretion of drugs.

Unit-IV: Pharmacodynamics (Ll9-L24)
Mechanism of drug action, receptors and receptors subtypes, Dose response relationship and combined effect of drugs. Concept of LD50, LC50, TD50 and therapeutic index.

Unit-V: Introduction and Classification of Drugs and Toxic Agents acting on following Systems/ Organs (L25-L-40)
Central and autonomic nervous system, neurotoxic agents. Cardiovascular system and cardiotoxic agents. Kidney and nephrotoxic agents. Drugs/Toxicants acting on Respiratory System.

Unit-VI: Introduction and Classification Following Drugs (L41-L48)
Anti-inflammatory drugs their related toxicity. Endocrine drugs. Antimicrobial drugs and their related toxicities.

Practical

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

1. Handling of laboratory animals and various routes of drug administration.
2. To study presence of paracetamol/aspirin in the given sample.
3. Separation of a mixture of benzoic acid, beta- napthol and napthelene by solvent extraction and identification of their functional groups.
4. Determination of Dissolved water (DO) using Winkler method.
5. To determine the total hardness of water by complexometric method Using EDTA.
6. To determine Acid value of the given oil sample.
7. Calculation of LD50 value of an insecticide from the data provided.

References

Essential Readings for Theory and Practical

1. Klaassen, C.D and Watkins, J.B. (2010). 2nd Edition. *Cassarett and Doull's essentials of toxicology*. New York, USA: McGraw Hill. ISBN-13: 978-0071622400.
2. Tripathi, K.D. (2010). 7th Edition. *Essentials of medical pharmacology*. New Delhi, India: Jaypee Brothers. ISBN-13:9788184480856.

Suggested Readings for Theory and Practical

1. Klaassen, C.D. (2008). 7th Edition. *Cassarett and Doull's toxicology, the basic science of the poisons*. New York, USA: McGraw Hill. ISBN-13: 9780071470513.
2. Lu, F.C. and Kacow, S. (2009). 5th Edition. *Lu's basic toxicology: Fundamentals target organ and risk assessment.* New York, USA: Informa Health Care. ISBN-13: 9781420093117.
3. Rang, H.P., Dale, M.M., Ritter, J.M. Moore, P.K. (2011). 7th Edition. *Rang and Dale's pharmacology*. New York, USA: Elsevier Churchill Livingstone. ISBN-13: 978-0702034718.
4. Stine, K.E. and Brown T.M (2015). 3rd Edition. *Principles of toxicology*. Florida, USA: CRC Press. ISBN-13: 9781466503434.
5. Timbrell. J. (2001). 3rd Edition. *Introduction to toxicology*. Florida, USA: CRC Press. ISBN-13: 9780415247627.

Teaching Learning Process

1. Use of blackboard and chalk method to communicate the concepts.
2. Use of Power Points presentations to visually explain various processes.
3. Verbal explanations.
4. Open discussions.
5. Quizzing and questioning.

Teaching and Learning Plan:

Unit	Title	Lectures
I	General Pharmacology and Toxicology	L1-L6
II	Mechanism of Toxicity	L7-L12
III	Pharmacokinetics	L13-18
IV	Pharmacodynamics	L19-L24
V	Introduction and Classification of Drugs and Toxic Agents acting on following Systems/ Organs	L25-L40
VI	Introduction and Classification Following Drugs:	L41-L48

Assessment Methods

1. Written class test
2. Written assignments
3. Quizzing/ viva
4. Presentations
5. Final University Examination

Keywords

Toxicology, toxicants, poison, xenobiotics, toxic agents, toxicokinetics, toxicodynamics, ecotoxicology, clinical toxicology, pesticides, metal toxicity, toxic exposure, pharmacology, pharmacokinetics, medicine, drugs, pharmacodynamics, eco-toxicity, mechanism of action

Semester I/ II/ III/ IV
Tools and Model Organisms in Biomedical Research
(Unique Paper Code: 32585911)
Generic Elective- (GE) Credit: 6

Theory **Total Lectures: 48**

Course Objective

1. This course has been designed to introduce various tools and techniques in modern era of biology. It focuses on the principles of microscopy, spectroscopy, chromatography, various molecular biology and immunological techniques.
2. This course also aims to give the students an introduction to different model 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.

Course Learning Outcomes

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

Unit I: Spectroscopy
The principles underlying the use of absorption of electromagnetic spectrum in various range of wavelength (U.V, Visible, I.R.,) and also NMR and MS to elucidate structural details.

Unit II: Microscopy
The principle underlying different types of microscopy used to visualize sub-micron sized biological structures such as cells, arrangement of various cells in tissues etc.

Unit III: Analytical Methods
Physicochemical properties of biomolecules such as charge, size, molecular weight by chromatography and different types of centrifugation methods.

Unit IV: Molecular Biology Methods
Methods used for manipulation of genetic material (DNA and RNA), their purification, characterization and amplification of minute quantity of genetic material for analysis.
understand the nature of antibody-antigen interactions and its use in techniques for qualitative and quantitative analysis of bio-molecules.

Unit V: Immunological Methods
Basics of methods for isolation of various immune cells and generation of immune-deficient laboratory mice used in immunological studies.

Unit VI: Introduction to Different Model Organisms
The need to study model organisms and their use in deciphering the mysteries of life.

Course Content

Unit I: Spectroscopy (L1-L5)
Principles and biological applications of UV, visible spectroscopy, Fluorescence spectroscopy, Infrared spectroscopy, NMR and Mass spectroscopy.

Unit II: Microscopy (L6-L8)
Principles of Light microscopy, Phase contrast microscopy, Electron microscopy (EM)- scanning EM, transmission EM and scanning transmission EM (STEM); Fluorescence microscopy.

Unit III: Analytical Methods (L9-L13)
Chromatography: Principle and applications of affinity, gel filtration and ion exchange chromatography, HPLC.
Centrifugation: Principle and different types of centrifugation- differential, density gradient and equilibrium.
Flow cytometry: Flurochromes, fluorescent probe and principle, application in biomedical science.

Unit IV: Molecular Biology Methods (L14-L21)
Isolation, purification and quantification of nucleic acids. Agarose gel *electrophoresis* and PAGE. Hybridization techniques- Southern, Northern and Western. Restriction enzymes, Gene cloning and RFLP. Principles of PCR, RT PCR, Real time PCR. DNA sequencing- Maxam Gilbert and Sanger methods.

Unit V: Immunological Methods (L22-L24)
Monoclonal antibody generation, Isolation of various immune cells and their functional assays, Generation and applications of nude mice. ELISA - direct, indirect, competitive and sandwich ELISA, Co-immuno-precipitation for protein-protein interaction studies.

Unit VI: Introduction to Different Model Organisms (L25-L48)
What are model organisms? Why there is a need to study model organisms? How to choose a model organism?
The following aspects will be discussed under each model organism listed below.
Brief history of model organisms, Life cycle, Culture conditions/maintenance, Advantages and disadvantages of the organism as a model, Fundamental discoveries made so far using these organisms, Discussion on suitability of each for genetic, Developmental biology and as disease models:
Escherichia coli: Utilization in discovery of fundamental metabolic pathways.
Saccharomyces cerevisiae (Baker's yeast): Mating types and their inheritance. Discovery of cell division cycle genes-*cdc* mutants,Yeast two hybrid system for protein-protein interactions. Overview of saccharomyces genome database (SGD), Commonly used yeast assays, the 'Yeast Genome Deletion Collection.
Caenorhabditis elegans (Nematode worm): Insights into the role of proteases (*ced* genes) in Coursed cell death, Cell-fate mapping and lineage studies. Discovery of RNAi in *C. elegans*, Overview of Wormbase database.
Drosophila melanogaster (Fruit fly): Insights into forms of cancer and neurodegenerative diseases. Flybase, the Gene disruption project, transgenic flies.
Mus musculus (Mouse): "Premier" model organism for studying complex physiological processes. Generation and application of knock out and transgenic mice as disease models.

Knockout database.
Introduction to other model organisms:
Dictyostelium discoideum (Social amoeba) as a model for induced multicellularity and differentiation.
Danio rerio (Zebra fish) as a model for human disease (any 2). Introduction to tools for Standard mutagenesis and Genetic screening.
Daphnia (Water flea) as a model for ecotoxicological studies.

Practical

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

1. Isolation and spectroscopic quantification of genomic DNA from blood/ tissue/ *E. coli*, determination of melting temperature of DNA.
2. Optimization of PCR conditions for temperature (gradient PCR) and Mg^{2+} concentration.
3. Restriction digestion of DNA for RFLP and DNA fingerprinting.
4. To perform Southern hybridization.
5. Protein purification by affinity/ ion exchange/ gel filtration chromatography.
6. To perform sandwich ELISA.
7. Preparation of culture media for *Drosophila* and study different stages of life cycle of *Drosophila*.
8. Study of life cycle of *Dictyostelium discoideum*.

References

Essential Readings for Theory and Practical

1. Brown, T.A. (2016). 7th Edition. *Gene cloning and DNA analysis*. New Jersey, USA: Wiley-Blackwell. ISBN: 978-1-119-07256-0.
2. Freifelder, D. (1982). 2nd Edition. *Physical biochemistry: Applications to biochemistry and molecular biology*. New York, USA: W.H. Freeman and Company. ISBN-13: 978-0716714446.
3. Hofmann, A. and Clokie, S. (2018). 8th Edition. *Wilson and Walker's principles and techniques of biochemistry and molecular biology*. Cambridge, UK: Cambridge University Press. ISBN: 978-1108716987.
4. Primrose, S.B. and Twyman, R.M. (2013). 7th Edition. *Principles of gene manipulation and genomics*. Massachusetts, USA: Blackwell Publishing. ISBN: 978-1405135443.
5. Sheehan, D. (2009). 2nd Edition. *Physical biochemistry: principles and applications*. Oxford, UK: John Wiley. ISBN-13: 978-0470856031.
6. *Emerging model organisms: A laboratory manual*, Volume 2, lab manual edition (2010), New York, USA: Cold Spring Harbor Laboratory Press, ISBN-13: 978-0879698652.

Suggested Readings for Theory and Practical

1. Green, M. R., Sambrook, J. (2012). 4th Edition. *Molecular Cloning: A laboratory manual*. New York, USA: Cold Spring Harbor Laboratory Press, ISBN-13:978-1936113422.
2. Karp, G. (2013). 7th Edition. *Cell and molecular biology: Concepts and experiments*. New Jersey, USA: Wiley Publishers. ISBN-978-0470483374.

3. Klug, W. S., Cummings, M. R., Spencer, C. A., Palladino, M. A. (2015). 11th edition. *Concepts of genetics*. San Francisco, USA: Pearson Education Limited. ISBN-13: 9780134832227.
4. Pierce, B.A. (2016). 6th Edition. *Genetics: A conceptual approach*. New York, USA: W. H. Freeman, ISBN-13: 978-1319050962.
5. Punt, J., Stranford, S. Jones, P. and Owen, J. (2019). 9th Edition. *Kuby Immunology*. New York, USA: W.H. Freeman and Company. ISBN-13: 978-1464189784.
6. Strachan, T. and Read, A.P. (2010). 5th Edition. *Human molecular genetics*. Florida, USA: CRC Press, Garland Science. ISBN: 978-0815345893.

Teaching Learning Process

A variety of approaches to teaching-learning process, including lectures, seminars, tutorials, workshops, peer teaching and learning and project-based learning, substantial laboratory-based practical component and experiments, open-ended project work, games, technology-enabled learning, etc. will need to be adopted to achieve outcomes of this course. The teaching process will create learning environments where students are active participants as individuals and as members of teams. Multiple representations, examples, explanations and variety of technology that support student learning will be used. Development of practical skills will constitute an important aspect of the teaching-learning process. Students will be effectively engaged in hands-on sessions and discussions to promote higher-order thinking skills.

Assessment Methods

Progress towards achievement of learning outcomes will be assessed using the following methods: time-constrained examinations; closed-book and open-book tests; problem-based assignments; practical assignment laboratory reports; observation of practical skills; individual/ team project reports; oral presentations, including seminar presentation; viva voce; peer and self-assessment etc.

Keywords

Spectroscopy, microscopy, chromatography, centrifugation, flow cytometry, electrophoresis, hybridization, PCR, sequencing, ELISA, antibody, model organism, *E. coli*, yeast, *C. elegans*, fruit fly, mouse, zebra fish