

Four Year Undergraduate Course in Biomedical Science

**Four Year Undergraduate Course in
Biomedical Science
I Year
Semester I and II**

Semester I

BMS 101: Bio-Organic Chemistry (DC-I)

Preamble: Bio-organic 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 biomolecular reactions and metabolic processes.

THEORY

Total Lectures: 48

Unit I: Aqueous Solutions (Chapter 2: Campbell and Farrel) (04 Lectures)

Water, pH and buffers, 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 Bases. (Chapter 8: J. D. Lee) (04 Lectures)

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 (Chapter 2: J. D. Lee; Chapter 1: Morrison and Boyd) (06 Lectures)

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

Unit IV: Stereochemistry (Chapter 4 and 13: Morrison and Boyd) (08 Lectures)

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, Walden inversion, enantiotopic and diastereotopic hydrogens and prochiral centers.

Geometrical isomerism: Definition, nomenclature– E and Z.

Unit V: Introduction to Biomolecules and their Metabolism

Analogy between organic reactions and biochemical transformations.

(i) Carbohydrates **(10 Lectures)** **(Chapter 18: Finar, volume 1; Chapter 7, 14, 16 and 19: Nelson and Cox)**

Monosaccharides- cyclization of aldoses and ketoses, conformations, concept of mutarotation, anomers, epimers, derivatives-sugar phosphate, sugar alcohol, sugar acids, deoxy and amino sugars, ascorbic acid.

Disaccharides- structure, reducing and non-reducing sugars.

Polysaccharides- Starch, glycogen and cellulose.

Carbohydrate metabolism- Glycolysis, gluconeogenesis and their regulation, tricarboxylic acid cycle, electron transport chain, oxidative phosphorylation, hexose monophosphate shunt.

(ii) Lipids **(05 Lectures)** **(Chapter 10, 17 and 21: Nelson and Cox; Chapter 7 and 18: Campbell and Farrel)**

Fatty acids, triacylglycerols, glycerophospholipids, sphingolipids, steroids (cholesterol and its derivatives).

Lipid metabolism- Mobilization of triglycerides, metabolism of glycerol, β -oxidation of saturated fatty acids (palmitic acid), ketone bodies, biosynthesis of fatty acids and triglycerides.

(iii) Amino Acids **(02 Lectures)** **(Chapter 3: Nelson and Cox; Chapter 3: Campbell and Farrel)**

General structure, ionization, chemistry of peptide bond, non-ribosomal peptide bond formation, essential and non-essential amino acids, amino acids as precursors of other bioactive compounds.

(iv) Nucleotides **(05 Lectures)** **(Chapter 8 and 22: Nelson and Cox; Chapter 8 and 20: Campbell and Farrel)**

Sugars and Bases, conformation of sugar phosphate backbone, hydrogen bonding by bases, Types of DNA (A, B and Z DNA), tautomers of bases, nucleotide derivatives, nucleotides as regulating molecules, concept of anti-sense molecules.

Nucleotide metabolism-Outlines of purine and pyrimidine metabolism.

(v) Enzymes **(04 Lectures)** **(Chapter 6: Nelson and Cox; Chapter 5: Campbell and Farrel)**

Introduction to enzyme catalysis and kinetics, mechanism of enzyme action and inhibition using specific example.

PRACTICALS

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 $\text{Na}_2\text{S}_2\text{O}_3$.
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

ESSENTIAL BOOKS

1. Concise Inorganic Chemistry, 5th edition (1999), J. D. Lee; Wiley-Blackwell, ISBN-13: 9780632052936.
2. Organic Chemistry, 6th edition (1996), I L Finar; ELBS, Longman Higher Education. ISBN-13: 978-0582305601.
3. Lehninger: Principles of Biochemistry, 5th edition (2008), David L. Nelson and Michael M. Cox; Prentice Hall Publishers, ISBN-13: 978-0321707338
4. Biochemistry, 4th edition (2003), Campbell, M. K. and Farrel, S. O.; Brooks/Cole, Cengage Learning (Boston), ISBN: 0030348498

SUGGESTED READINGS

1. An Introduction to Practical Biochemistry, 3rd edition (1987), Plummer, McGraw-Hill College; ISBN-13: 978-0070841659
2. Organic Chemistry, 6th edition (1992), R. T. Morrison and R. N. Boyd; Pearson Education. ISBN-13: 9780136436690.
3. Biochemistry, J. M. Berg, J. L. Tymoczko and L. Stryer, 6th edition (2006), W. H. Freeman and Co., ISBN-13: 978-0716787242
4. Bioorganic Chemistry, 3rd edition (1999), Hermann Dugas; Springer Verlag. ISBN-13: 978-0387989105

Semester I

BMS 102: Cell and Radiation Biology (DC-I)

Preamble: Biology is essentially the study of life in all of its varied forms. Because cells are the 'basic unit of life', the study of cells can be considered one of the most important areas of biological research. This course will provide information about cells, including their composition, their function and cell-cycle checkpoints. The module on radiation biology will help to explore and gain insight into radiation-induced biological responses at molecular, cellular and tissue levels.

THEORY

Total Lectures: 48

Unit I: The Cell (02 Lectures) **(Chapter 1: Cooper; Chapter 1: Karp)**

Historical background, significant landmarks, cell theory, structure of prokaryotic and eukaryotic cells, mycoplasma, viruses, viroids, prions.

Unit II: Cell Fractionation (02 Lectures) **(Chapter 1: Cooper; Chapter 18: Karp; Chapter 11: Freifelder)**

Centrifugation: types of centrifuges, principle and different types of centrifugation- differential, density gradient and equilibrium.

Unit III: Cell Membrane (04 Lectures) **(Chapter 13: Cooper; Chapter 4: Karp)**

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.

Unit IV: Membrane Transport (05 Lectures) **(Chapter 13: Cooper; Chapter 4: Karp)**

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

Unit V: Cell Organelles (14 Lectures) **(Chapter 9, 10, 11: Cooper)**

Structure and functions of various organelles:

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

- B. *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.
- C. *Golgi Apparatus*: Golgi stack (cis, trans and medial cisternae), flow of proteins through GB. Glycosylation and protein sorting.
- D. *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).
- E. *Peroxisomes*: Assembly, functions- H_2O_2 metabolism, oxidation of fatty acids. Glyoxysomes.
- F. *Mitochondria*: Detailed structure, endosymbiotic theory, its genome, and functions in brief.
- G. *Chloroplast*: Detailed structure, its genome and functions in brief.

Unit VI: Cell Junctions
(Chapter 14: Cooper)

(02 Lectures)

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

Unit VII: Cytoskeletal Elements
(Chapter 12: Cooper)

(04 Lectures)

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 VIII: Cell Cycle
(Chapter 16: Cooper)

(03 Lectures)

Different phases of cell cycle and their significance. Checkpoints and regulation of cell cycle.

Unit IX: Radiation Biology
(Chapters 5, 6, 13 and 20: A. H. W. Nias; Chapter 5 and 6: Freifelder)

(12 Lectures)

Introduction of radiations, basic concept of radioisotopes, types of radioactive decay (gamma and beta emitter), half-life, detection and measurement of radioactivity methods based upon ionization (GM counter), methods based upon excitation (scintillation counter). Use of radioisotopes in cell biology in understanding of DNA replication (bidirectional and theta replication), transcription (labeling of RNA) and labeling of protein using labeled amino acid. Use of radioisotopes in biology: Autoradiography, radioisotopes in diagnosis (thyroid disorders, cancer) and therapy (radiotherapy). Effect of radiations (ionizing and non-ionizing) on living

systems, radiation induced damage to cell (chromosome and DNA damage), precautions and safety measures in handling radioisotopes.

PRACTICALS

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. To cytochemically demonstrate presence of proteins in cheek cells or onion peel using mercuric bromophenol blue or fast green.
5. To cytochemically demonstrate presence of carbohydrates in cheek cells or onion peel using periodic acid Schiff's reagent.
6. To cytochemically demonstrate presence of DNA in cheek cells or onion peel using Feulgen reagent.
7. To study the effect of isotonic, hypotonic and hypertonic solutions on cells.
8. To prepare polytene chromosomes.

ESSENTIAL BOOKS

1. The Cell: A Molecular Approach, 5th edition (2009), Cooper and Hausman. Sinauer Associates, Inc. ISBN-13: 978-0878933976.
2. Cell and Molecular Biology: Concepts and Experiments, 6th edition (2009), Gerald Karp, Wiley. ISBN-978-0470483374.
3. Physical Biochemistry: Applications to Biochemistry and Molecular Biology, David Freifelder, 2nd edition (1983), W. H. Freeman and Company. ISBN: 0716714442 / 0-7167-1444-2.
4. An Introduction to Radiobiology, 2nd edition (1998), A. H. W. Nias, Wiley Blackwell, ISBN-13: 978-0471975908.

SUGGESTED READINGS

1. The World of the Cell, 7th edition (2008), Becker, Kleinsmith, Hardin and Bertoni. Benjamin Cummings, ISBN-13: 978-0805393934.
2. The Cell: A Molecular Approach, 6th edition (2013), Cooper and Hausman; Sinauer Associates, Inc. ISBN-13: 978-1605351551.
3. Essential Cell Biology, 7th edition (2009), Alberts, Bray, Hopkin, Johnson, Lewis, Raff, Roberts and Walter. Garland Science. ISBN-13: 978-0815341291.
4. Molecular Cell Biology, 7th edition (2012), Lodish, Berk, Kaiser, Krieger, Bretscher, Ploegh, Amon and Scott. W. H. Freeman. ISBN-13: 978-1429234139.

Semester II

BMS 201: Principles of Genetics (DC-I)

Preamble: Genetics having its roots in mathematics thanks to Mendel, appeals to students as one of the analytical branches of biology even in senior school. Basic concepts that are essential to understand inheritance will be taught, starting from the abstract factors to physical basis of inheritance. The course aims to communicate the pivotal role of Mendelian concepts in the development of the science of genetics and also the fact that nature is full of examples that deviate from Mendelian laws starting from linkage groups. Introduction of models and the way they have contributed to our understanding of genetics will provide a perception of how forward genetics has been used to understand the basis of continuity of information transfer that is applicable to not only to the simple life forms but also to humans on one hand and to complex process of development on the other. Most of the topics will be at the introductory level, which would motivate the students to understand the molecular basis of genotype to phenotype correlation.

THEORY

Total Lectures: 48

Unit I: Overview of changing paradigms in genetics (Chapter 1: Snustad and Simmons)

(02 Lectures)

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. 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 (Chapter 3, 4: Snustad and Simmons)

(04 Lectures)

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.

Unit III: Physical basis of inheritance (Chapter 4, 5, 7: Snustad and Simmons)

(06 Lectures)

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 interaction.

Unit IV: Extra nuclear inheritance (Chapter 9: Klug and Cummings)

(03 Lectures)

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 V: Mutation (04 Lectures)
(Chapter 13: Snustad and Simmons; Chapter 11: Strachan and Read)

Concept of selection with examples from bacteria, prototrophy and auxotrophy, spontaneous and induced mutations, types of mutations- point, (non-sense, missense, frame shift, insertion, deletion), use of mutants to study gene functions, effects on the gene product- loss of the function and gain of function. Distinction between mutation and polymorphism.

Unit VI: Bacterial Genetics (04 Lectures)
(Chapter 8: Snustad and Simmons)

Introduction to genetic exchange in bacteria: conjugation; transformation; transduction.

Unit VII: Analysis of genetic inheritance in human (05 Lectures)
(Chapter 4: Strachan and Read)

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, variation in penetrance and expressivity.

Unit VIII: Cytogenetics (05 Lectures)
(Chapter 2: Strachan and Read; Chapter 6: Snustad and Simmons)

Karyotyping- banding pattern and nomenclature (G and Q banding), common syndromes due to numerical chromosome changes, common syndromes due to structural alterations (translocations, duplications, deletions)

Unit IX: Introduction to genetic basis of sex determination (04 Lectures)
(Chapter 5: Snustad and Simmons; Chapter 7: Klug and Cummings)

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

Unit X: Introduction to DNA structure and replication (04 Lectures)
(Chapter 9 and 10: Snustad and Simmons)

Basic structure of DNA, salient features of the double helix, semi-conservative replication—Messelson and Stahl experiment.

Unit XI: Introduction to developmental genetics (04 Lectures)
(Chapter 18: Klug and Cummings)

Study of model systems in developmental genetics- *Drosophila melanogaster* and zebrafish.

Unit XII: Basic population genetics

(03 Lectures)

(Chapter 23: Snustad and Simmons; Chapter 4: Strachan and Read)

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

PRACTICALS

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* – 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. Preparation of master and replica plates with wild type and some antibiotic sensitive strain.
8. Study of polyploidy in onion root tip by colchicine treatment.

ESSENTIAL BOOKS

1. Principles of Genetics, 6th edition (2011), Snustad DP and Simmons MJ, John Wiley and Sons, Inc; ISBN-13: 978-0470903599
2. Human Molecular Genetics, 3rd edition (2003) by Tom Strachan and Andrew Read; Garland Science Publishers, ISBN -13: 978-0815341826.
3. Concepts of Genetics, 10th edition, (2011). William S. Klug, Michael R. Cummings, Charlotte A. Spencer, Michael A. Palladino; Pearson Education, ISBN-13: 978-0321724120.

SUGGESTED READINGS

1. Principles of Genetics, 8th edition (2005), Gardner EJ, Simmons MJ, Snustad DP. John Wiley and Sons, Inc. ; ISBN-13: 978-9971513467.
2. An introduction to Genetic Analysis, 10th edition (2010), Griffith AJF, Miller JH, Suzuki DT, Lewontin RC, Gelbert WM., W. H. Freeman and Co. New York. ISBN-13: 978-429229432.
3. Principles of Genetics, 6th edition (1998), Robert H. Tamarin Publisher: William C Brown Pub; ISBN-13: 978-0697354624.

Semester II

BMS 202: Human Physiology and Anatomy-I (DC-I)

Preamble: The prime concern of this syllabus is to integrate the individual functions of all the cells and tissues and organs into functional whole, the human body. Since function is dependent on a structure, the curriculum lays stress on functional anatomy of the organs. It attempts to highlight the necessary bodily balances and internal bodily control so called homeostasis as well as present their abnormal function in disease. It provides a link between basic sciences and Medicine.

THEORY

Total Lectures: 48

Unit I: Body organization and Integumentary system (Chapter 1: Fox)

(04 Lectures)

General Anatomy of the body, Introduction to various kinds of body planes, Tissues level of organization (Types, origin, function and repair). Functional Anatomy and histology of human skin. Temperature regulation by skin.

Unit II: Blood (Chapter 13: Fox)

(08 Lectures)

Composition and Function of blood and its components: RBC, WBC, platelets, Hematopoiesis. Hemoglobin structure and function. Hemostasis and blood coagulation mechanism, blood groups and blood banking. An overview of lymphoid tissue and lymph. Basic concepts about Anemia, Abnormal hemoglobin, polycythemia, thalassemia and leukemia

Unit III: Nerve physiology (Chapter 7: Fox; Chapter 4: Guyton)

(07 Lectures)

Structure and function of neuron, Resting membrane potential, Action potential, electrophysiology of ion channels and conduction of nerve impulse, The Synapse, types of synapse, Synaptic Transmission, Neurotransmitters; types and function.

Unit IV: Nervous System I: Organization of nervous system (Chapter 8: Fox)

(07 Lectures)

Structure and function of Central nervous system, Peripheral nervous(spinal and cranial nerves) system and Autonomic nervous system. An overview of concepts on Sleep, memory and Pain. Reflexes: innate and acquired with suitable examples, reflex arch. Temperature regulation of the human body by hypothalamus.

Unit V: Nervous System II: Special senses (Chapter 10: Fox)

(07 Lectures)

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 system (07 Lectures)
(Chapter 12: Fox; Chapter 7: Guyton)

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, tetany, muscular dystrophy.

Unit VII: Gastrointestinal system (08 Lectures)
(Chapter 18: Fox)

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 and pancreas and their functions. An overview of vomiting, gastrointestinal dysfunction: nausea, mal-absorption, Constipation, Gastritis, Ulcer, Diarrhoea, jaundice and Cirrhosis.

PRACTICALS

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. Determination of reticulocyte count.
10. To study different human organs and their sections through permanent histological slides
T. S. of brain, spinal cord, skeletal fibres, various parts of GIT, different tissues

ESSENTIAL BOOKS

1. Guyton and Hall Textbook of Medical Physiology, 11th edition (2006), J. E. Hall; W B Saunders and Company, ISBN-13: 978-1416045748
2. Human Physiology, 9th edition (2006), Stuart I. Fox; Tata McGraw Hill, ISBN-13: 978-0077350062
3. Lab Manual on Blood Analysis and Medical Diagnostics, 1st edition (2012), Dr. Gayatri Prakash; S. Chand, ISBN: 81-219-3967

4. Manual of Practical Physiology, 4th edition (2012), A. K. Jain; Arya Publication, ISBN: 8178553155.

SUGGESTED READINGS

1. Principles of Anatomy and Physiology, 13th edition (2011), Gerard J. Tortora and Bryan H. Derrickson; Wiley and Sons, ISBN-13: 978-0470565100
2. Ganong's Review of Medical physiology, 24th edition (2012), K. E. Barrett, S. M. Barman, S. Boitano and H. Brooks; Tata McGraw Hill, ISBN-13: 978-0071780032
3. Textbook of Practical Physiology, 7th edition (2007), CL Ghai; Jaypee Publication, ISBN-13: 978-8184481419

**Four Year Undergraduate Course in
Biomedical Science
II Year
Semester III and IV**

Semester III

BMS 301: Protein Chemistry and Function (DC-I)

Preamble: Protein chemistry and function is a discipline, which aims at understanding the chemical properties of the amino acids, structural architecture of the proteins and how proteins fold to their native, functional forms. The defect in the folding of proteins and their link to various genetics/metabolic diseases is studied. This course includes various analytical techniques used in characterization of the proteins and a detailed account of how enzymes function: their kinetics, regulation and inhibition.

THEORY

Total Lectures: 48

Unit I: Properties of amino acids and metabolism: (04 Lectures)
(Chapter 3, 18: Nelson and Cox)

Structure and classification of amino acids, concept of pKa, zwitterion, isoelectric point, Optical properties, Lamberts-Beer Law, Molar ellipticities of chromophoric groups, overview of amino acid metabolism (phenylalanine and one branched chain amino acid).

Unit II: Peptide conformation (08 Lectures)
(Chapter 4: Nelson and Cox)

Definition of peptide, peptide unit, peptide group, bond length, cis and trans conformation, Ramachandran Plot, primary, secondary (alpha helix, beta sheet, beta turn, collagen helix and other non repetitive helices), tertiary structure (with examples), Motifs, super secondary structures, Domain and Quaternary structures (with examples).

Unit III: Protein stability and folding (08 Lectures)
(Chapter 4: Nelson and Cox)

Definition of native and denatured state, protein stability, forces that maintains the native state stability, Protein denaturation by chaotropic agents (urea, GdmCl), SDS and heat, Protein folding (hydrophobic collapse, Anfinsen Experiments, Levinthal Paradox), chaperone-assisted protein folding.

Unit IV: Analytical methods in protein characterization (12 Lectures)
(Chapter 3: Nelson and Cox)

Paper and Thin-layer chromatography, Ion exchange chromatography, Gel filtration and Affinity chromatography, SDS-PAGE, IEF, 2D-Gel electrophoresis, Dialysis, Mass Spectrometry, N-terminal and C-terminal sequencing.

Unit V: Enzymes (12 Lectures)
(Chapter 6: Nelson and Cox)

Introduction to enzyme, concept of lock and key and induced fit theory, concept of activation energy and binding energy. Enzyme kinetics, the Michaelis-Menten equation and its physiological significances, double reciprocal plots. Enzyme Inhibition, types of inhibitors of enzyme and their examples. Turnover Number.

Regulatory enzymes: General properties of allosteric enzymes, regulation by covalent modification (including co-enzymes), negative and positive cooperativity. Zymogens, Isoenzymes.

**Unit VI: Protein misfolding and diseases
(Chapter 4: Nelson and Cox)**

(04 Lectures)

How and why certain proteins misfold and how this misfolding is linked to many disease processes. Introduction to certain conformational diseases: Alzheimer's, Parkinson, Prion Diseases, p53 disorder in cancer.

PRACTICALS

1. Verification of Beer's Law
2. Protein estimation by any one method: Lowry's/Bradford method.
3. Separation of amino acids by thin layer chromatography.
4. To perform salting in and salting out by ammonium sulphate, using leaf extract or any other extract and to desalt by dialysis.
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.

ESSENTIAL BOOKS

1. Lehninger Principles of Biochemistry, 5th edition (2012), David L. Nelson and Michael M. Cox; W. H. Freeman, ISBN-13: 978-0716771081.
2. An Introduction to Practical Biochemistry, 3rd edition (1987), Plummer, McGraw-Hill College; ISBN-13: 978-0070841659.

SUGGESTED BOOKS

1. Introduction to Protein Structure, 2nd edition (1999), Carl Branden and John Tooze; Garland Science, ISBN-13: 978-0815323051.
2. Principles and Techniques of Practical Biochemistry, 5th edition (2000), Keith Wilson and John Walker; Cambridge University Press, ISBN -13: 978-0521799652.
3. Protein Folding, 1st edition (1992), Thomas E. Creighton; W. H. Freeman Company, ISBN-13: 978-0716770275.
4. Structure and Function of Intrinsically Disordered Proteins, 1st edition (2010), Peter Tompa; CRC Press, ISBN-13: 978-1420078923.

Semester III

BMS 302: Human Physiology and Anatomy-II (DC-I)

Preamble: This syllabus is extension of the part I. The syllabus justifiably divides the body systems into two semesters to ensure complete and comprehensive knowledge of all functionalities of the body. The course curriculum therefore emphasizes on the cardiovascular, respiratory, reproductive and endocrine system and their interrelatedness. The Laboratory exercises are designed to substantiate and clarify the theoretical concepts. Most of the topics are of introductory level and would stimulate the students to understand the basic functioning of every system and the resultant unified organization thereupon.

THEORY

Total Lectures: 48

Unit I: Cardiovascular system (Chapter 13 and 14: Fox)

(09 Lectures)

Structure and function of heart, Properties of cardiac muscle. The Cardiac Cycle, Electrocardiogram. Circulatory system: General principles of circulation and hemodynamics Cardiovascular regulatory mechanism, Lymphatic circulation and microcirculation. Basic concepts of angina, atherosclerosis and Cardiac failure

Unit II: Respiratory system (Chapter 16: Fox; Chapter 39: Guyton)

(07 Lectures)

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. An overview about cough, hypoxia, asthma and bronchitis. Basic concepts of physiology of exercise.

Unit III: Renal physiology: (Chapter 17: Fox; Chapter 27: Guyton)

(09 Lectures)

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

Unit IV: Reproductive system (Chapter 20: Fox; Chapter 81: Guyton)

(09 Lectures)

Structure and function of male and female reproductive organ and tract. Function and regulation of testicular and ovarian hormones. Gametogenesis (oogenesis and spermatogenesis), fertilization, implantation, pregnancy, parturition and lactation and neonatal physiology. Basic concepts of male and female infertility, menopause and various contraceptive measures.

Unit V: Endocrine system
(Chapter 11: Fox; Chapter 74: Guyton)

(09 Lectures)

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

Unit V: Skeletal System
(Chapter 6: Tortora)

(05 Lectures)

Cartilage: Structure, function and types. Bones: Structure, function, location and types. Joints: structure, function and types. An overview of disorders of skeletal system: arthritis, gout, fractures, osteoporosis.

PRACTICALS

1. To study the sperms and their motility (from different regions of epididymis).
2. Simple Reflex arc.
3. Physiological data acquisition based experiments. (ECG)
4. Physiological data acquisition based experiments. (EMG)
5. To prepare temporary slide of neuron from goat spinal cord.
6. To perform platelet count
7. To perform tests for sensations. (taste, touch and smell)
8. Blood Pressure recordings in humans.
9. Lung Function tests in humans.
10. Preparation of temporary slide of neuron from goat spinal cord.
11. To study various types of contraceptive (condoms, IUD's, oral and injectable contraceptives)
12. To study different human organs and their sections through permanent slides.
T. S. of thyroid, liver, thymus, spleen, ovary, artery, vein, capillaries, testis, pancreas, adrenal, kidney (cortex and medulla), urinary bladder, urethra, fallopian tubes, epididymis, prostate glands, lungs, trachea, bronchioles, pituitary, heart.

ESSENTIAL BOOKS

1. Guyton and Hall Textbook of Medical Physiology, 11th edition (2006), J. E. Hall; W B Saunders and Company, ISBN-13: 978-1416045748
2. Human Physiology, 9th edition (2006), Stuart I. Fox; Tata McGraw Hill, ISBN-13: 978-0077350062
3. Principles of Anatomy and Physiology, 13th edition (2011), Gerard J. Tortora and Bryan H. Derrickson; Wiley and Sons, ISBN-13: 978-0470565100

SUGGESTED READINGS

1. Lab Manual on Blood Analysis and Medical Diagnostics, 1st edition (2012), Dr. Gayatri Prakash; S. Chand, ISBN: 81-219-3967
2. Ganong's Review of Medical physiology, 24th Edition (2012), K. E. Barrett, S. M. Barman, S. Boitano and H. Brooks; Tata McGraw Hill, ISBN-13: 978-0071780032
3. Textbook of Practical Physiology, 7th Edition (2007), CL Ghai; Jaypee Publication, ISBN-13: 978-8184481419

Semester III
DC-II Courses

Semester III

BMS A: Biosafety and Bioethics (DC-II)

Preamble: The 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 will affect not only us but the plants, microorganisms, 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. The present course focus on the biosafety and bioethical issues the modern society confronts. 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.

THEORY

Total Lectures: 48

Unit I: Introduction (Chapter 1: Sateesh)

(03 Lectures)

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 (Chapter 7, 9, 20 and 21: Sateesh)

(10 Lectures)

Government of India definition of genetic modified organism (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.

Unit III: Handling and transportation of GM, infectious and radioactive materials (Chapter 7 and 10: Sateesh)

(05 Lectures)

Risk analysis, risk assessment, risk management and communication, overview of national regulations and relevant international agreements including Cartagena Protocol.

Unit IV: Biosafety management (Chapter 5 and 6: Sateesh)

(06 Lectures)

Key to the environmentally responsible use of biotechnology, ethical implications of biotechnological products and techniques, social and ethical implications of biological weapons.

Unit V: Concept of social science (02 Lectures)
(Chapter 1 and 40: Singer and Viens)

Reason to apply its principles to study cause of health problems and suggest appropriate intervention/ solution to problem.

Unit VI: Foundation of Bioethics (02 Lectures)
(Chapter 1: Tristram)

Definition, historic evolution, codes and guidelines, universal principles.

Unit VII: Codes, Covenants, Declarations and Guidelines (05 Lectures)
(Chapter 2 and 3: Tristram)

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.

Unit VIII: Clinical ethics (02 Lectures)
(Chapter 25, 27 and 28: Singer and Viens)

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.

Unit IX: Women health ethics (03 Lectures)
(Chapter 14 and 15: Singer and Viens)

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 X: Medical errors and Negligence (03 Lectures)
(Chapter 34: Singer and Viens)

Medical error and medical negligence difference, remedies against medical negligence, protection and compensation related to it.

Unit XI: Critical care ethics (04 Lectures)
(Chapter 58: Singer and Viens)

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.

Unit XII. Care in HIV and AIDS
(Chapter 61: Sateesh)

(02 Lectures)

Basics of HIV infection, identify ethical issues in clinical practice of HIV medicine and its prevention, research ethics related to HIV.

Unit XIII: Ethical use of animals in the laboratory
(Chapter 23: Sateesh)

(01 Lecture)

PRACTICALS

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 removal of selective marker in a DNA vaccine.
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.

ESSENTIAL BOOKS

1. Bioethics and Biosafety, 1st edition (2008), M. K Sateesh, I K International Pvt Ltd, ISBN-13: 978-8190675703.
2. The Cambridge Textbook of Bioethics, 1st edition (2008), Peter A. Singer and A. M. Viens; Cambridge University Press, ISBN-13: 978-0511545566.
3. Foundation of Bioethics, 2nd edition (1996), E. H Tristram; Oxford University Press, ISBN-13: 9780195057362.

SUGGESTED READINGS

1. Social science: An introduction to the study of society, 14th edition (2010), Hunt, E. F., and Colander, D. C. ; Peason/Allyn and Bacon, Boston, ISBN-13: 978-020570271.
2. Principles of Biomedical Ethics, 6th edition (2011), Beauchamp TI, Childress JF; Oxford University Press, 2001. ISBN-13: 978-0195143317.
3. A Companion to Bioethics, 2nd edition (2012), Helga Kuhse, Peter Singer; John Wiley and Sons, ISBN-13: 978-1444350845.
4. Bioethics: An Introduction to the History, Methods, and Practice, 1st edition (1997), Nancy Ann Silbergeld Jecker, Albert R. Jonsen, Robert A. Pearlman; Jones and Bartlett Learning, ISBN-13: 978-0763702281.

Four Year Undergraduate Course in Biomedical Science

5. Genetically Modified Organisms and biosafety, 1st edition (2004), Tomme Young. ISBN-13: 978-2831707983.
6. Environmental Safety of Genetically Engineered Crops, 1st edition (2011), Rebecca Grumet, James F. Hancock, Karim M. Maredia, Cholani Weebadde, Michigan State University Press ISBN-13: 978-1611860085.
7. Biosafety and Bioethics, 1st edition (2006), Rajmohan Joshi; Isha Books ISBN-13: 978-8182053779.
8. Bioethics and biosafety in biotechnology, 1st edition (2007), V. Sreekrishna; New Age International (P) Ltd., ISBN-13: 978-8122420852.

Four Year Undergraduate Course in Biomedical Science

Semester III
AC Course

Semester III

BMS 303: Medical Lab Diagnostics (MLD) (AC)

Preamble: Medical Lab Diagnostics would help students enhance their practical skills and would enable them work in a Hospital setup. The paper is divided into three modules. First of all the students would orient themselves to work in a proper diagnostic setting. Secondly students would be introduced to detection of diseases using microbiological and molecular methods. Finally they would enhance their skills by learning various cytogenetic disorders. By this time students would have been also exposed to various techniques used in Biochemistry. Therefore, after the exposure of the current paper they would find themselves equipped with a full package of skill development in order to work in a diagnostic setting.

**Number of Sessions: 12
(Each session has 3 Lectures)**

**Unit I: Fundamentals of Clinical Diagnostics (2 sessions)
(Chapter 2, 4, 9 and 11: Ramnik Sood)**

Laboratory 1: Sterilization Techniques: Physical methods and Chemical methods.

Laboratory 2: General overview of blood banking, blood typing, blood screening in transfusion medical lab.

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 hematology, 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: (4 sessions)
(Chapter 7, 8, 13, 14 and 15: Forbes, Sahm and Weissfeld)**

Laboratory 3: Isolation of bacteria from mixed culture. Study of morphological, cultural, biochemical characteristics of common bacterial pathogen

Laboratory 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)

Laboratory 5 and 6: Enumerate the microbial load on the selected fresh produce from major outlets. Isolate and identify the common microorganisms present on their surface using microbiological, biochemical and PCR techniques.

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).

Setting up “Gold Standard” method, concepts of accuracy (efficiency), Precision, sensitivity, specificity, Prevalence positive predictive value and negative predictive value.

Unit III: Immunoserology: Principles and Application. (3 sessions)
(Chapter 10: Forbes, Sahm and Weissfeld; Chapter 22 and 23: Ramnik Sood)

Laboratory 7, 8 and 9: 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).

Concepts of Immune response to be explained. Techniques to be discussed: ELISA - direct, indirect, competitive and sandwich ELISA, Co-immunoprecipitation for protein-protein interaction studies.

Unit IV: Medical Cytogenetics (3 sessions)
(Chapter 4: Dracopoli and Dracopoli)

Laboratory 10, 11 and 12: Become familiar with major techniques used in clinical cytogenetics, including culture of peripheral blood and preparation of metaphase chromosomes, chromosome banding and karyotyping.

Human cytogenetics and its application to medicine. cell culture and harvest, chromosome banding and staining, chromosome identification, cytogenetics nomenclature, chromosome abnormalities and aberrations, chromosomal syndromes, classification of genetic disorders, Disciplines within Clinical Genetics and integration of genetic diagnostic services with other healthcare services (Clinical Genetics, Prenatal Diagnosis, Infertility, Cancer Cytogenetics)

Students' Presentations:

Understand issues related to the interpretation of normal chromosomal variation (with the help of photographs), Examples like mosaicism, aneuploidy and other chromosomal rearrangements, ISCN nomenclature, Abnormalities of chromosome number (monosomy, trisomy, triploidy), Partial aneuploidy, microdeletion/contiguous gene syndromes, abnormal chromosomes

Skills that are developed at the end of this course:

1. The student will demonstrate knowledge of how to obtain reliable information from a variety of sources (e. g., web, popular media, and scientific publications).
2. Practical training to work in diagnostic setting increased.
3. The student will demonstrate knowledge of how to communicate the results of a scientific investigation.

ESSENTIAL BOOKS

1. Bailey and Scott's Diagnostic Microbiology, 12th edition (2007), Betty A. Forbes, Daniel F. Sahm and Alice S. Weissfeld; Mosby Elsevier Publishers, ISBN-13: 978-0808923640.
2. Medical Laboratory Technology Methods and Interpretations Volume 1 and 2, 6th edition (2009), Ramnik Sood; Jaypee Brothers Medical Publishers, ISBN-13: 978-8184484496.
3. Current Protocols in Human Genetics, 1st edition (1994), Dracopoli and Nicolas C. Dracopoli; John Wiley and Sons, Inc., ISBN-13: 978-0471034209.

SUGGESTIVE READINGS

1. Molecular Cloning: A Laboratory Manual, 4th edition (2012), Michael R. Green and Joseph Sambrook; Cold Spring Harbor Laboratory Press, ISBN-13: 978-1936113422.
2. Microbiology: A Laboratory Manual, 10th edition (2013), James Cappuccino and Natalie Sherman, Benjamin Cummings, ISBN-13: 978-0321840226.

Semester IV

BMS 401: Medical Biochemistry (DC-I)

Preamble: The Medical Biochemistry course has been formulated to impart medically relevant information on clinical 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 included to educate students on the clinical significance of 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 diseased state.

THEORY

Total Lectures = 48

Unit 1: Basic Concepts and Scope (Chapter 1: Harper) (02 Lectures)

Unit 2: Enzymes: Distribution and diagnostic significance (Chapter 1: Harper) (10 Lectures)

Properties of enzymes used in diagnosis of metabolic disorders, 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. A detailed account on: isoenzymes, their tissue distribution and clinical significance.

Unit 3: Hormones (Chapter 23: Nelson and Cox; Chapters 41 and 42: Harper) (08 Lectures)

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); functions.

Unit 4: Structural complexities and diseases associated with carbohydrates and lipids (Chapters 7, 10 and 21: Nelson and Cox; Chapters, 15 and 26: Harper) (10 Lectures)

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 fibers.

Lipids: Lipoproteins- types (chylomicron, VLDL, LDL, HDL); disorders associated with lipoprotein metabolism (hypercholesterolemia, Atherosclerosis). Metabolism of ketone bodies in diabetic patients. 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 mechanism of action).

Unit 5: Vitamins

(06 Lectures)

(Chapter 27: Tietz; Chapter 12: Chatterjea and Shinde)

Definition, classification, requirement and recommended allowances, and dietary precursors; diseases due to deficiency of water-soluble and fat-soluble vitamins: the symptoms and the clinical significance.

Unit 6: An overview of integrative metabolism

(12 Lectures)

(Chapter 19, 23: Nelson and Cox)

Local and global regulation in tissue specific metabolism, interplay of insulin and glucagon integration of various metabolic pathways of proteins, lipids, carbohydrates and nucleic acids, obesity and regulation of body mass, electron transport chain and inhibitors, oxidative phosphorylation: chemiosmotic theory, role of uncouplers and ionophores.

PRACTICALS

1. Preparation of serum and plasma from whole blood.
2. Quantitative determination of the following in the whole blood/plasma/serum:
 - a). **LFT:**
 - i) SGPT and SGOT
 - ii) Creatine kinase
 - iii) Albumin/total protein
 - b) **KFT:**
 - i) Urea
 - ii) Uric acid
 - c). **Metabolites:**
 - i) HDL/LDL and triglycerides
 - ii) Serum protein A: G ratio.
 - iii) Serum glucose.
3. Five case studies based on above quantitative studies performed.

ESSENTIAL BOOKS

1. Tietz Fundamentals of Clinical Chemistry, 6th edition (2007), Carl A. Burtis, Edward R. Ashwood, and David E. Bruns; WB Saunders Co, ISBN-13: 978-0721638652
2. Harpers Illustrated Biochemistry, 29th edition (2012), Robert Murray, David Bender, Kathleen M. Botham Peter J. Kennelly, Victor Rodwell, P. Anthony Weil; McGraw-Hill Medical, ISBN-13: 978-0071765763

Four Year Undergraduate Course in Biomedical Science

3. Lehninger's Principles of Biochemistry, David L. Nelson and Michael M. Cox, 5th edition (2008), ISBN-13: 978-0716771081
4. Textbook of Medical Biochemistry, 7th edition (2007), Chatterjea & Shinde, Jaypee Publications,. ISBN: 81-8448-134-9.

SUGGESTED BOOKS

1. Biochemistry, J. M. Berg, J. L. Tymoczko and L. Stryer, 6th edition (2006), W. H. Freeman and Co. ISBN-13: 978-0716787242
2. Fundamentals of Biochemistry: Life at the Molecular Level, 4th edition (2012), Donald Voet, Judith G. Voet, Charlotte W. Pratt; Wiley, ISBN-13: 978-0470547847

Semester IV

BMS 402: Genome Organization and Function –I (DC-I)

Preamble: The paper Genome Organization and Function –I encompasses the basic study and understanding of the central dogma. The paper starts with the basic organization of the genome in prokaryotes and eukaryotes along with their discerning features. This is followed by chapters on prokaryotic and eukaryotic replication, transcription and translation processes.

THEORY

Total Lectures = 48

Unit I: Genome structure, chromatin and nucleosome (Chapter 7: Watson; Chapter 10: Karp)

(8 Lectures)

Organization of Genomes in Prokaryotes and Eukaryotes, Chromosome sequence and diversity, Chromosome duplication and segregation, Establishing the central Dogma, Nucleosomes organization and assembly, Regulation of chromatin structure, DNA topology, Denaturation and renaturation of DNA, Cot curves, Euchromatin, Heterochromatin- constitutive and facultative heterochromatin.

Unit II: The replication of DNA in Prokaryotes and Eukaryotes (Chapter 8: Watson; Chapter 13: Karp)

(12 Lectures)

Chemistry of DNA synthesis, General principles - bidirectional replication, Semi-conservative, discontinuous. RNA priming, Various models of DNA replication including D-loop (mitochondrial), Theta mode of replication, rolling circle model, Replication of linear ds-DNA, Replicating the 5' end of linear chromosome, Enzyme involved in DNA replication – DNA polymerases, DNA ligase, primase, telomerase and other accessory proteins, DNA sequencing methods– Maxam Gilbert and Sanger method.

Unit III: The mutability and Repair of DNA (Chapter 9: Watson; Chapter 13: Karp)

(6 Lectures)

Replication Errors (Transitions, transversion and thymine dimer), DNA Damage (deamination, depurination and dimerization) and their repair: mismatch repair, SOS response (recombination), Excision Repair, Photoreactivation.

Unit IV: Information Transfer –I: Mechanism of Transcription (Chapter 12: Watson; Chapter 11: Karp)

(10 Lectures)

Basic transcription apparatus, Initiation, elongation and termination of transcription, Eukaryotic transcription of mRNA, tRNA and rRNA, types of RNA polymerases, transcription factors, Inhibitors of transcription- rifampicin and α -amanitin.

UnitV: Information Transfer-II: Mechanism of Translation
(Chapter 14: Watson; Chapter 11: Karp)

(12 Lectures)

Features of genetic code and exceptions in some systems, Ribosome structure- rRNA and proteins, Charging of tRNA, aminoacyl tRNA synthetases, Proteins involved in initiation (both in prokaryotes and eukaryotes), elongation and termination of polypeptides, Fidelity of translation, Inhibitors of protein synthesis – tetracyclins, aminoglycosides, chloramphenicol and aminoglycosides.

PRACTICALS

1. Preparation of various stock solutions required for Molecular Biology Laboratory.
2. Preparation of culture medium (LB) for *E. coli* (both solid and liquid) and raise culture of *E. coli*.
3. Isolation of chromosomal DNA from bacterial cultures and visualization on Agarose Gel Electrophoresis.
4. Quantitative estimation of salmon sperm / calf thymus DNA using colorimeter (Diphenylamine reagent) and Spectrophotometer (A_{260} measurement).
5. Isolation of genomic DNA from blood / tissue.
6. Native PAGE for DNA
7. Demonstration of Polymerase Chain Reaction (PCR) technique
8. Demonstration of AMES test or reverse mutation for carcinogenicity

ESSENTIAL BOOKS

1. Molecular Biology of the Gene, 6th edition (2007), Watson, J. D., Baker T. A., Bell, S. P., Gann, A., Levine, M., and Losick, R; Benjamin Cummings Publishers, ISBN-13: 978-0805395921
2. Cell and Molecular Biology: Concepts and Experiments, 7th edition (2013), Gerald Karp. ; Wiley Publishers ISBN-13: 978-1118206737
3. Molecular Cloning: A Laboratory Manual, 4th edition (2012), Michael R. Green and Joseph Sambrook; Cold Spring Harbor Laboratory Press, ISBN-13: 978-1936113422

SUGGESTED READINGS

1. The World of the Cell, 7th edition (2008), Becker, Kleinsmith, Hardin and Bertoni. Benjamin Cummings, ISBN-13: 978-0805393934.
2. The Cell: A Molecular Approach, 6th edition (2013), Cooper and Hausman; Sinauer Associates, Inc. ISBN-13: 978-1605351551.
3. DNA Replication, 2nd edition (2005), Arthur Kornberg; University Science Books ISBN-13: 978-1891389443

Four Year Undergraduate Course in Biomedical Science

Semester IV
DC-II Courses

Semester IV

BMS B: Pathological basis of diseases (DC-II)

Preamble: Claude Bernad 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” Thus the syllabi of Pathology compliments and supplements the necessary knowledge students have gained in Physiology. Consequently it incorporates topics like cellular adaptations, inflammation, neoplasia, cellular ageing and other infectious diseases. 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 with basic concepts of pathology

THEORY

Total Lectures = 48

Unit I: Introduction (Chapter 1: Underwood and Underwood) (2 Lectures)

History of pathology, Basic definitions and common terms used in pathology, Survival mechanism and disease, microscopic and cellular pathology, scope and techniques used.

Unit II: Cell Injury and responses of cells: Cellular Adaptations, and Cell Death (Chapter 1: Robbins, Kumar and Cotran) (4 Lectures)

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

Unit III: Role of Inflammation in disease (with suitable examples) (Chapter 2: Robbins, Kumar and Cotran) (7 Lectures)

Basic concepts with suitable examples of general features of acute and chronic inflammation: Vascular Changes, cellular events, important chemical mediators of inflammation, Morphological effects inflammation response, Granulomatus Inflammation.

Unit IV: Role of Tissue repair Healing and Fibrosis (with suitable examples) (Chapter 3: Robbins, Kumar and Cotran) (5 Lectures)

Basic mechanism of tissue regeneration, and repair by healing, scar formation and fibrosis

Unit V: Common Hemodynamic Disorders in diseases (with suitable examples) (Chapter 4: Robbins, Kumar and Cotran) (6 Lectures)

An overview of Edema, hyperemia, congestion, hemorrhage, hemostasis and thrombosis, Embolism, Infarction and shock with suitable examples

Unit VI: Nutritional diseases (5 Lectures)
(Chapter 9: Robbins, Kumar and Cotran)

Protein energy malnutrition, deficiency diseases of vitamins, minerals, nutritional excess and imbalances. Role and effect of metals .

Unit VII: Cancer (7 Lectures)
(Chapter 7: Robbins, Kumar and Cotran)

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 VIII: Infectious diseases epidemiology (12 Lectures)
(Chapter 8: Robbins, Kumar and Cotran, Chapter 5 and 16: Park)

Modes of infections with suitable examples. Overview of cause, extent, prevention, treatment and control of the diseases: Respiratory infections, Intestinal infections, Arthropod-borne infections, Zoonosis and Surface infections

PRACTICALS

1. Urine analysis for abnormal constituents: protein, fats and glucose
2. Measuring Erythrocyte sedimentation rate.
3. Tissue Processing, embedding and sectioning.
4. Staining and preparation of permanent histological slide.
5. Diagnostic tests for detection of various Diseases – CRP, VDRL, RA, Pregnancy, Dengue and HIV (any four)
6. PCR based diagnostics (for any one disease)

ESSENTIAL BOOKS

1. Robbins and Cotran Pathologic Basis of Disease, 8th edition (2009), Vinay Kumar, Abul. K. Abbas, Jon C. Aster, Nelson Fausto; Saunders Publishers, ISBN-13: 978-1416031215
2. Robbins Basic Pathology, 9th edition (2012), Kumar, Abbas, Fausto and Mitchell; Saunders Publication, ISBN-13: 978-1437717815
3. General And Systematic Pathology, 2nd edition (1996) J., Ed. Underwood and J. C. E. Underwood; Churchill Livingstone, ISBN-13: 978-0443052828
4. Textbook of preventive and social medicine, 20th edition, J. E Park; Banarsi Das Bhanot. Publishers. ASIN B0007CBHKL.

SUGGESTED READING

1. Medical Laboratory Technology Methods and Interpretations, 6th edition (2009), Ramnik. Sood;. Jaypee Brothers Medical Publishers, ISBN-13: 978-8184484496.
2. Pathophysiology, 3rd edition (2012), Lee-Ellen C. Copstead-Kirkhorn and Publisher. Saunders. ISBN-13: 978-1455726509.

Four Year Undergraduate Course in Biomedical Science

Semester IV
AC Course

Semester IV

BMS 403: Techniques for Forensic Science (AC)

Preamble: 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. 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. This engage students in using a creative, problem solving and inquiry based approach to investigate the crime scene. It also explains the characteristics of a fingerprint collect, process, and analyze fingerprint evidence and explain DNA analysis.

**Number of Sessions: 12
(Each session has 3 Lectures)**

Unit I: Crime Scene Investigation (2 Sessions) **(Chapter 10 and 18 Nordby)**

Laboratory 1: Documentation of crime scene by photography, sketching and field notes.
Laboratory 2a: Simulation of a crime scene for training.
Laboratory 2b: To lift footprints from crime scene.

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 2: Types of injuries and death (1 session) **(Chapter 4: Nordby)**

Laboratory 3: Case studies to depict different types of injuries and death.

Classification of injuries and their medico-legal aspects, method of assessing various types of deaths.

Unit 3: Forensic chemistry and Ballistics (2 sessions) **(Chapter 4 and 5: Heard)**

Laboratory 4a: Comparison of bullets and cartridges in museum
Laboratory 4b: Separation of nitro compounds (explosives) by thin layer chromatography.
Laboratory 5: To perform the preliminary examination of blood in a given sample.

Classification of fire arms and explosives, introduction to internal, external and terminal ballistics. Chemical evidence for explosives.

Unit 4: Forensic Graphology (2 sessions) **(Chapter 2, 3, 4 and 15: Morris)**

Four Year Undergraduate Course in Biomedical Science

Laboratory 6: Identification and comparison of handwriting characters

Laboratory 7: To perform thin layer chromatography of ink samples.

General and individual characteristics of handwriting, examination and comparison of handwritings and analysis of ink various samples.

Unit 5: Forensic Toxicology (Chapter 5: Nordby)

(1 session)

Laboratory 8: Identification techniques of common toxins, drugs, pesticides, Volatile poisons, vegetable poisons etc. in given biological samples and crime scene.

Role of the toxicologist, significance of toxicological findings

Unit 6: Fingerprint analysis (Chapter 8: Wheeler)

(1 session)

Laboratory 9a: Investigate method for developing fingerprints by Iodine crystals.

Laboratory 9b: To observe the effects of surface temperature on fingerprints.

Fundamental principles of fingerprinting, classification of fingerprints, development of finger print as science for personal identification.

Unit 7: DNA Fingerprinting (Chapter 15: Nordby)

(2 sessions)

Laboratory 10: DNA isolation in minimal available biological samples

Laboratory 11: PCR amplification on target DNA and DNA profiling

Principle of DNA fingerprinting, application of DNA profiling in forensic medicine.

Unit 8: Cyber Forensic Investigation (Chapter 27: Nordby)

(1 session)

Laboratory 12a: Digital Evidence Collection

Laboratory 12b: E-Mail Investigation, E-Mail Tracking, IP Tracking, E-Mail Recovery, Recovering deleted evidences, Password Cracking

Investigation Tools, eDiscovery,, Evidence Preservation, Search and Seizure of Computers, Introduction to Cyber Security

ESSENTIAL BOOKS

1. Forensic Science – An introduction to Scientific and Investigative Techniques, 3rd edition (2009), James SH, Nordby JJ and Bell S; CRC Press, ISBN-13: 978-1420064933.
2. Practical Forensic Microscopy: A laboratory manual, 1st edition (2008), Barbara Wheeler and Lori J Wilson; Bios Scientific Publisher, ISBN-13: 978-0470031766.
3. Forensic Handwriting Identification: Fundamentals, Concepts and Principals 1st edition (2000) Ronald N. Morris, Academic press ISBN-13: 978-0125076401
4. Handbook of Firearms and Ballistics: Examining Interpreting Forensic Science by Brian J Heard 2nd edition (2008), John Wiley and Sons ISBN-13: 978-0470694602.

SUGGESTED READINGS

1. Principles of Forensic Medicine and Toxicology, 1st edition (2011) Rajesh Bardale; Jaypee Brothers Medical Pub, ISBN-13: 978-9350254936.
2. Practical Crime Scene Processing and Investigation, 2nd edition (2011), Ross M Gardner, CRC press ISBN-13: 978-1439853023.
3. Forensic Medicine and Toxicology: Oral, Practical And Mcq, 3rd edition (2006), Karmakar, Jaypee Brothers, ISBN-13: 978-8171797350.
4. Fundamentals of Forensic Science, 2nd edition (2010), Houck, M.M. and Siegel, JA; Academic Press, ISBN-13: 978-0123749895.
5. Criminalistics- An Introduction of Forensic Science, 10th edition (2010), Prentice Hall Inc; ISBN-13: 978-0135045206.

Four Year Undergraduate Course in Biomedical Science

**Four Year Undergraduate Course in
Biomedical Science
III Year
Semester V and VI**

Semester V

BMS 501: Introduction to Biopharmacology and Pharmacokinetics (DC-I)

Preamble: 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.

THEORY

Total Lectures: 48

Unit I: General Pharmacology

(08 Lectures)

(Chapter 1: Tripathi; Chapter 1, 2 and 3: Rang and Dale)

Nature and Source of drugs, Routes of drug administration and their advantages, receptor and receptor subtypes.

Unit II: Pharmacokinetics

(08 Lectures)

(Chapter 2 and 3: Tripathi)

Drug absorption, distribution, metabolism, and excretion, bioavailability, First Pass metabolism, excretion and kinetics of elimination, Bioavailability, Biological half life of drug and its significance, Drug-drug interactions.

Unit III: Pharmacodynamics

(06 Lectures)

(Chapter 4: Tripathi)

Principles and mechanism of drug action, Factors affecting drug action.

General considerations, pharmacological classification, mechanism of action and uses of following classes of drugs acting on various systems.

Unit IV: Drugs acting on CNS

(10 Lectures)

(Chapter 27, 29, 34 and 35: Tripathi)

(a) Mechanism of General anaesthesia, Stages of anaesthesia, General anaesthetics (Nitric oxide, halothane), (b) Principles of hypnosis and sedatives: sedative and hypnotics drugs (Phenobarbitone, diazepam), (c) Opioid analgesics (Morphine) (d) CNS stimulants (strychnine, amphetamine).

Unit V: Brief introduction to autocooids

(04 Lectures)

(Chapter 13 and 14: Tripathi)

Drug therapy of inflammation, NSAID and other drugs (aspirin, celecoxib).

Unit VI: Chemotherapy of microbial diseases (06 Lectures)
(Chapter 49, 50 and 57: Tripathi)

Antibacterial (sulfonamides), antifungal (amphotericin B).

Unit VII: Hormones and hormone antagonists (08 Lectures)
(Chapter 18, 19 and 20: Tripathi)

Insulin and oral hypoglycaemic agent (tolbutamide, rosiglitazone), thyroid and anti-thyroid drugs (eltroxin, carbimazole), estrogen and progestins (progesterone, hydroxyprogesterone caproate).

***PRACTICALS**

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.

*Experiments to be conducted in Virtual mode and through providing data.

ESSENTIAL BOOKS

1. Essentials of Medical Pharmacology, 7th edition (2010), K.D. Tripathi, Jaypee Brothers, ISBN: 9788184480856.
2. Pharmacology, 7th edition (2011), H.P. Rang, M.M. Dale, J.M. Ritter and P.K. Moore, Churchill Livingstone. ISBN: 9780702045042.
3. Hand book of Experimental Pharmacology, 4th edition (2012), S.K. Kulkarni, Vallabh Prakashan, 2012. ISBN 13: 9788185731124.

Semester V

BMS 502: Medical Microbiology (DC – I)

Preamble: 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. 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.

THEORY

Total Lectures = 48

Unit I: Fundamental Concepts (Chapter 1, 6, 7, 8 and 17: Willey)

(8 Lectures)

- a) History of microbiology, Discovery of microorganisms, Contributions of Louis Pasteur and Robert Koch in Medical Microbiology.
- b) Molecular methods of assessing microbial phylogeny- molecular chronometer, phylogenetic trees, rRNA, DNA and proteins as indicator of phylogeny. Major Divisions of life-Domains, Kingdoms.
- 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. (Chapter 3: Willey)

(5 Lectures)

Size, shape and arrangement of bacterial cells. Cell membrane, cytoplasmic matrix, inclusion bodies (eg magnetosomes), nucleoid, Ultrastructure of Gram +ve and Gram -ve bacterial cell wall, Pili, Capsule, Flagella and motility

Unit III: Microbial Genetics (Chapter 14: Willey)

(5 Lectures)

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: Principles of Diseases and Epidemiology (Chapter 14: Tortora)

(3 Lectures)

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

Unit V: Bacterial Diseases (with reference to etiology, clinical symptoms, virulence factors involved, detection and prevention) (7 Lectures)
(Chapter 38: Willey)

Respiratory tract infections: Diphtheria and Tuberculosis, Gastrointestinal tract infections, staphylococcal food poisoning and *E. coli* gastroenteritis, Urinary tract infections: gonorrhea and syphilis

Unit VI: Viruses, viroids, prions (5 Lectures)
(Chapter 25 and 37: Willey)

General characteristics of viruses, structure, isolation, cultivation and identification of viruses, viral multiplication, one step multiplication curve, lytic and lysogenic phages (lambda phage), concept of early and late proteins, clinical virology with reference to HIV virus and hepatitis virus (Life cycle and clinical symptoms), viroids and prions

Unit VII: Medical Mycology (with reference to Life Cycle and clinical symptoms) (5 Lectures)
(Chapter 50: Forbes, Sahm and Weissfeld)

General and detailed life cycle of *Aspergillus* and *Candida albicans* in relation to human diseases caused by them.

Unit VIII: Parasitology (with reference to Life Cycle and clinical symptoms) (3 Lectures)
(Chapter 49: Forbes, Sahm and Weissfeld)

Classification of medically important parasites. Common protozoan disease: Malaria, Infections caused by *Taenia solium* / *Taenia saginata*, *Fasciola hepatica* and *Ascaris lumbricoides*.

Unit IX: Antimicrobial chemotherapy and emerging antimicrobial resistance (7 Lectures)
(Chapter 34: Willey)

Spectrum of antimicrobial activity, action of antimicrobial drugs, inhibitors of cell wall synthesis, anti-mycobacterial antibiotics, inhibitors of protein synthesis and nucleic acid synthesis, competitive inhibitors of essential metabolites, antifungal, antiviral, anti-protozoan drugs; effectiveness of chemotherapeutic agents, concepts of antimicrobial resistance, novel methods to combat increasing antimicrobial resistance.

PRACTICALS

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).

ESSENTIAL BOOKS

1. Microbiology: An Introduction, 9th edition (2008), Gerard J. Tortora, Berdell R. Funke, Christine L. Case; Benjamin Cummings. ISBN-13: 978-0321733603.
2. Prescott, Harley, and Klein's Microbiology, 8th edition, (2011), Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton, McGraw Hill International. ISBN-13: 978-0071313674.
3. Bailey and Scott's Diagnostic Microbiology, 12th edition (2007), Betty A. Forbes, Daniel F. Sahm and Alice S. Weissfeld; Mosby Elsevier Publishers, ISBN-13: 978-0808923640.

SUGGESTED READINGS

1. Microbiology, 6th edition (1993), Pelczar, Chan and Krieg; McGraw Hill International, ISBN-13: 978-0070492585.
2. Brock Biology of Microorganisms, 13th edition (2010), Michael T. Madigan, John M. Martinko, David Stahl and David P. Clark, Pearsons, Benjamin Cummings, ISBN-13: 978-0321649638.
3. Microbiology: A Laboratory Manual, 10th edition, (2013), James Cappuccino and Natalie Sherman, Benjamin Cummings. ISBN-13: 978-0321840226.

Semester V

BMS 503: Immunobiology (DC-I)

Preamble: The immune system distinguishes between self and foreign molecules and thus alerts and mediates protection against attack by potentially infectious organisms. Malfunctioning of the immune system leads to a number of disorders and diseases. 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. This paper covers the structure, organization, function and regulation of and by the immune system keeping the above aspects in mind.

THEORY

Total Lectures: 48

Unit I: Introduction (Chapter 1 and 3: Kuby)

(2 Lectures)

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 (Chapter 2 and 7: Kuby)

(10 Lectures)

- (a) Hematopoiesis, 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 (Chapter 4, 8, 10, 11, and 12: Kuby)

(20 Lectures)

- (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 and functions of Interferon and Interleukins (IL1, IL2, IL4).

Unit IV: Immunological principles of various reactions and techniques (8 Lectures)
(Chapter 6: Kuby)

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 (4 Lectures)
(Chapter 19: Kuby)

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

Unit VI: Dysfunctions of immune system (4 Lectures)
(Chapter 15 and 16: Kuby)

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.

PRACTICALS

1. To perform immunodiffusion by Ouchterlony method.
2. Immunodiffusion 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 ELISA.
8. To perform Widal test.

ESSENTIAL BOOKS

1. Immunology, 6th edition, (2006), J. Kubly et al, W.H. Freeman and Company, New York. ISBN-13: 978-1429202114.

SUGGESTED READINGS

1. Microbiology, 7th edition, (2008), Prescott, L., John Ii Harley, Donald A. Klein, McGraw Hill. ISBN-13: 978-0071102315.
2. Roitt's Essential Immunology, 12th edition, (2011), Wiley-Blackwell Science. ISBN-13: 978-1405196833.
3. Immunology, 8th edition, (2012), Male, D., Brostoff, J., Roth, D.B. and Roitt, I., Elsevier-Saunders. ISBN-13: 978-0323080583.
4. An Introduction to Immunology, Immunochemistry and Immunobiology, 5th edition, (1988), Barrett, James T., Mosby Company, St. Louis. ISBN-13: 978-0801605307.
5. Immunology: An Introduction, 4th edition, (1994), Tizard, I.R., Saunders College Publishing, Philadelphia. ISBN-13: 978-0030041983.

Four Year Undergraduate Course in Biomedical Science

Semester V
DC-II Course

Semester V

BMS C: Concepts in Medicinal Chemistry and Drug Development (DC-II)

Preamble: The course emphasizes on various drug targets in the body and highlights the importance of drug-receptor interactions, lead discovery, drug design and drug development strategies.

THEORY

Total Lectures: 48

Unit I: General Introduction (Chapter 1: Silverman)

(2 Lectures)

Definition and scope of drug design.

Unit II: Drug target classification (Chapter 7-9: Patrick; Chapter 3, 4, and 6: Silverman)

(8 Lectures)

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 (Chapter 2: Silverman)

(8 Lectures)

Partition coefficient, drug dissolution, acid base properties, surface activity, bioavailability, stereochemical aspects of drug action.

Unit IV: Drug receptor interactions (Chapter 2 and 3: Nogrady)

(8 Lectures)

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 (Chapter 13, 14 and 15: Patrick)

(8 Lectures)

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 pharminformatics (Chapter 2: Silverman; Chapter 15, 17 and 18: Patrick)

(14 Lectures)

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, PubChem, 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.

PRACTICALS

1. Preparation of Benzocaine.
2. Preparation of Aspirin and determination of partition coefficient in octanol-water system.
3. Preparation of Paracetamol.
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.

ESSENTIAL BOOKS

1. Introduction to Medicinal Chemistry, 4th edition (2009), Graham I. Patrick, Oxford University Press. ISBN-13: 978-0199234479.
2. The Organic Chemistry of Drug Design and Drug Action, 2nd edition (2004), Richard B. Silvermann, Elsevier, Academic Press. ISBN-13: 978-0126437324.
3. Medicinal Chemistry: A Molecular and Biochemical Approach, 3rd edition (2005), Thomas Nogrady and Donal F. Weaver, Oxford University Press. ISBN-13: 978-0195104561.

Four Year Undergraduate Course in Biomedical Science

Semester V
AC Course

Semester V

BMS 504: Methods for Epidemiological Data Analysis (AC)

Preamble: In public health work, one may be concerned with planning of experiments and the analysis of their results. Therefore, one has to deal with statistical data analyses that come from no deliberate experiment but that arise because of the data collected from the population in the course of public health study and survey. This course therefore provides training to the students on how to conduct epidemiological surveys, design questionnaire and analyze the data. The students will get hands-on-training on 'R', a free software environment for statistical computing and graphics.

Total sessions: 12
(Each session of 3 Lectures)

Unit I: Understanding Epidemiological Data

(1 session)

(Chapter 2, 3, 9: Park; Chapter 7: Glantz; Website for NCRP: <http://www.ncrpindia.org/>)

1. Analysis of data from National Cancer Registry Program (NCRP)
2. Understanding incidence, mortality (rates, ratios and proportions)

Components of epidemiology: disease frequency, distribution of disease and determinants of disease. Epidemiological approach and measurements- vital statistics (rates, ratios and proportions), measurements of health indicators (morbidity, mortality and fertility rates).

Unit II: Epidemiologic Methods and Survey

(4 sessions)

(Chapter 3, 5, 6: Park)

1. Designing a questionnaire for survey of prevalence diabetes/ hypertension/ allergy/ respiratory disorders/etc.
2. Defining the parameters for ethical issues in a study
3. Determining the target and control populations
4. Surveying the population for the diseases mentioned above

Data collection: observational (descriptive and analytical) and experimental studies. Epidemiology study designs- case control and cohort studies (prospective and retrospective), techniques of sampling and matching, sources of bias.

Unit III: Data Organization and Presentation

(2 sessions)

(Chapter 19: Park; Chapter 2: Glantz; Website for 'R': www.r-project.org)

1. Introduction to 'R' software
2. Analysis of data from NCRP data and survey conducted by the students

Basic principles of 'R' software for tabulation and graphical representations (bar diagrams, histograms, pie charts, box plot, etc.), measures of central tendency (mean, mode, median and partition values), dispersion (range, standard deviation, coefficient of variance and covariance) and skewness.

Unit IV: Statistical Modeling and Analysis using 'R' on NCRP data and survey conducted by the students

(5 sessions)

(Chapter 19: Park; Chapter 3-10: Glantz; Website for 'R': www.r-project.org)

1. Correlation studies
2. Regression studies
3. Probabilistic distribution studies
4. Comparison of groups and ascertaining statistical significance of differences

Correlation analysis (scatter diagrams and Karl Pearsons coefficient of determination, standard and probable errors) and regression analysis. 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.

ESSENTIAL BOOKS

1. Park's Textbook of Preventive and Social Medicine, 21st edition (2011), K. Park, M/s Banarsi Das Bhanot Publishers.
2. Primer of Biostatistics, 7th edition (2011), Stanton Glantz, McGraw-Hill Medical. ISBN-13: 978-0071781503.

SUGGESTED READINGS

1. Basic epidemiology, 2nd edition (2006), R. Bonita, R. Beaglehole, TordKjellstrøm, Contributor; World Health Organization, illustrated, Publisher: World Health Organization, ISBN-13: 978-9241547079.
2. Biostatistics: A Foundation for Analysis in the Health Sciences, 10th edition (2013), Wayne W Daniel and Chad L. Cross, Wiley. ISBN-13: 978-1118302798.
3. Principles of Biostatistics, 2nd edition (2000), Marcello Pagano and Kimberlee Gauvreau, Thompson learning. ISBN-13: 978-0534229023.
4. Biostatistical Analysis, 5th edition (2009), Jerrold H. Zar, Pearson. ISBN-13: 978-0131008465.

Website for 'R': www.r-project.org

Website for NCRP: <http://www.ncrpindia.org/>

Semester VI

BMS 601: Human Pathology (DC-I)

Preamble: The curriculum of 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 work in altered and diseased stage under the influence of various internal and external stimuli Thus the syllabi of pathology compliments and supplements the necessary knowledge students have gained in Physiology. Consequently it incorporates topics like cellular adaptations, inflammation, neoplasia, cellular ageing and other infectious diseases. Laboratory exercises have been designed to substantiate and clarify the theoretical concepts.

THEORY

Total Lectures: 48

Unit I: Introduction (2 Lectures) **(Chapter 1: Underwood and Underwood)**

History of pathology, basic definitions and familiarization with the common terms used in pathology, techniques used in pathology.

Unit II: Cellular Adaptations, Cell Injury and Cell Death (6 Lectures) **(Chapter 1: Robbins, Kumar and Cotran)**

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), Cellular ageing.

Unit III: Role of Inflammation in diseases (with suitable examples) (8 Lectures) **(Chapter 2: Robbins, Kumar and Cotran)**

General features of acute and chronic inflammation: Vascular changes, cellular events, termination of acute inflammatory response. Cells and molecular mediators of inflammation, morphological effects and outcome of acute inflammation., systemic effects of chronic inflammation, granulomatous inflammation.

Unit IV: Tissue Renewal And Repair, Healing And Fibrosis (6 Lectures) **(Chapter 3: Robbins, Kumar and Cotran)**

Mechanism of tissue regeneration, role of ECM, repair by healing, scar formation and fibrosis, cutaneous wound healing, tissue remodeling in liver (mechanism of fibrosis and cirrhosis).

Unit V: Hemodynamic Pathology (5 Lectures) **(Chapter 4: Robbins, Kumar and Cotran)**

Edema, hyperemia, congestion, hemorrhage, hemostasis and thrombosis, Embolism, Infarction and shock and hypertension.

Unit VI: Nutritional diseases in disease conditions (5 Lectures)
(Chapter 9: Robbins, Kumar and Cotran)

Protein energy malnutrition, deficiency diseases of vitamins and minerals, nutritional excess and imbalances. Role and effect of metals (Zinc Iron and Calcium) in pathogenesis of cardiovascular and neurodegenerative diseases.

Unit VII: Cell proliferation: Cancer (6 Lectures)
(Chapter 7: Robbins, Kumar and Cotran)

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 VIII: Pathophysiology diseases (10 Lectures)
(Chapters 17, 11 and 15: Robbins, Kumar and Cotran)

Diaorrhea, typhoid, arteriosclerosis, restrictive and obstructive respiratory diseases (COPD), silicosis.

PRACTICALS

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. Physiological data acquisition like EMG, PFT, Temperature EEG (any two)
6. PCR based diagnostics (for any one disease)
7. Measurement of Erythrocyte Sedimentation Rate.

ESSENTIAL BOOKS

1. Robbins and Cotran Pathologic Basis of Disease, 8th edition (2009), Vinay Kumar, Abul K. Abbas, Jon C. Aster, Nelson Fausto; Saunders Publishers, ISBN-13: 978-1416031215

Four Year Undergraduate Course in Biomedical Science

2. General And Systematic Pathology, 2nd edition (1996), J., Ed. Underwood and J. C. E. Underwood; Churchill Livingstone, ISBN-13: 978-0443052828.
3. Robbins Basic Pathology, 9th edition (2012), Kumar, Abbas, Fausto and Mitchell; Saunders Publication, ISBN-13: 978-1437717815.

SUGGESTED READINGS

1. Medical Laboratory Technology Methods and Interpretations Volume 1 and 2, 6th edition (2009), Ramnik Sood; Jaypee Brothers Medical Publishers, ISBN-13: 978-8184484496.
2. Pathophysiology, 3rd edition (2012), Lee-Ellen C. Copstead-Kirkhorn and Publisher Saunders, ISBN-13: 978-1455726509.

Semester VI

BMS 602: Medicinal Chemistry (DC-I)

Preamble: The course highlights the importance of Medicinal Chemistry in all our lives and the fascination of working in a field that overlaps the disciplines of chemistry, biology, biochemistry, pharmacology etc. It gives brief understanding about drug-receptor interactions, lead discovery, drug design and molecular mechanism by which drug act in the body. The course emphasizes on various drug targets in the body and drug development strategies with mechanism of action of antibacterial agents and concept of drug resistance.

THEORY

Total Lectures: 48

Unit I: General Introduction (Chapter 1: Silverman)

(2 Lectures)

Definition and scope of medicinal chemistry

Unit II: Drug target classification (Chapter 7-9: Patrick; Chapter 3-6: Silverman)

(12 Lectures)

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 (Chapter 5: Patrick; Chapter 3: Silverman)

(6 Lectures)

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 (Chapter 2: Silverman)

(8 Lectures)

Partition coefficient, drug dissolution, acid-base properties, surface activity, bioavailability, stereochemical aspects of drug action, electronic structure (Hammett correlations), determining relationship between chemical and biological data (Hansch approach)

Unit V: Measurement of drug effects (8 Lectures)
(Chapter 2 and 3: Nogrady)

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 VI: Principles of drug design (8 Lectures)
(Chapter 12-14: Patrick)

Introduction to SAR, strategies in the search for new lead compounds, analogue synthesis versus rational drug design, concept of prodrugs.

Unit VII: Antibacterial agents (4 Lectures)
(Chapter 19: Patrick)

Mechanism of action, antimetabolites (sulphonamides), cell wall synthesis inhibitors (penicillins), agents that act on plasma membrane (valinomycin), protein synthesis inhibitors (streptomycin and chloramphenicol), nucleic acids transcription and replication inhibitors (quinolones and fluoroquinolones), drug resistance.

PRACTICALS

1. Preparation of Benzocaine.
2. Preparation of Benzoquinone.
3. Preparation of Aspirin and determination of partition coefficient in octanol-water system.
4. Preparation of Paracetamol.
5. Preparation of Phenacetin.
6. Preparation of Hippuric acid.
7. Preparation of s-benzyl thiuronium 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).

ESSENTIAL BOOKS

1. Introduction to Medicinal Chemistry, 4th edition (2009), Graham I. Patrick, Oxford University Press. ISBN-13: 978-0199234479.
2. The Organic Chemistry of Drug Design and Drug Action, 2nd edition (2004), Richard B. Silvermann, Elsevier, Academic Press. ISBN: 978-0126437324.
3. Medicinal Chemistry: A Molecular and Biochemical Approach, 3rd edition (2005), Thomas Nogrady and Donal F. Weaver, Oxford University Press. ISBN-13: 978-0195104561.

SUGGESTED READINGS

1. Wilson Gisvold textbook of Organic Medicinal and Pharmaceutical Chemistry, 11th edition (2003), edited by Block and Beale, Baltimore, Lippincot. ISBN-13: 978-0781734813.
2. The Practice of Medicinal Chemistry, 2nd edition (2003), Camille G. Wermuth, Academic Press. ISBN-13: 978-0127444819.
3. Principles and Practice of Medicinal Chemistry, 2nd edition (2003), Frank. D. King. The Royal Society of Chemistry. ISBN-13: 978-0854046317.
4. Introduction to Medicinal Chemistry: How Drugs Act and Why, 1st edition (1996), Alex Gringauz, Wiley VCH. ISBN-13: 978-0471185451.

Semester VI

BMS 603: Toxicology (DC – I)

Preamble: 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. 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.

THEORY

Total Lectures 48

Unit I: Introduction (Chapter 2: Cassarett)

(2 Lectures)

Brief history, Different areas of modern toxicology, classification of toxic substances, various definitions of toxicological significance.

Unit II: Toxic exposure and response (Chapter 2: Cassarett)

(5 Lectures)

Effect of duration, frequency, route and site of exposure of xenobiotics on its toxicity. Characteristic and types of toxic response. Types of interactions between two and more xenobiotics exposure in humans. Tolerance and addiction.

Unit III: Evaluation of toxicity (Chapter 3: Cassarett; Chapter 1: Timbrell)

(2 Lectures)

Various types of dose response relationships, assumptions in deriving dose response, LD50, LC50, TD50 and therapeutic index.

Unit IV: Mechanism of toxicity (Chapter 3: Cassarett)

(10 Lectures)

Delivery of the toxicant, mechanisms involved in formation of ultimate toxicant, detoxification of ultimate toxicant.

Unit V: Fate of xenobiotics in human body (Chapter 5 and 6: Cassarett; Chapter 2: Timbrell)

(10 Lectures)

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 VI: Toxic agents (8 Lectures)
(Chapter 22 and 23: Cassarett; Chapter 8: Timbrell)

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 VII: Eco-toxicology (7 Lectures)
(Chapter 29: Cassarett; Chapter 8 and 9: Timbrell)

Brief introduction to avian and aquatic toxicology, movement and effect of toxic compounds in food chain (DDT, mercury), bioaccumulation, biomagnification, acid rain and its effect on ecosystems, concept of BOD and COD.

Unit VIII: Clinical toxicology (4 Lectures)
(Chapter 22: Cassarett)

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

PRACTICALS

1. Separation of a mixture of benzoic acid, beta- naphthol and naphthelene by solvent extraction and identification of their functional Groups.
2. Determination of Dissolved oxygen (DO) using Winkler's 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.

ESSENTIAL BOOKS

1. Cassarett and Doull's Toxicology "The Basic Science of The Poisons" 7th edition (2008), Curtis D. Klaassen Editor, Mc GrawHill Medical. ISBN: 9780071470513.

Four Year Undergraduate Course in Biomedical Science

2. Cassarett and Doull's "Essentials of Toxicology" 2nd edition (2010), Klaassen and Whatkins, Mc Graw Hill Publisher. ISBN-13: 978-0071622400.
3. Introduction to Toxicology, 3rd edition (2001), John Timbrell, Taylor and Francis Publishers. ISBN 13: 9780415247627.

SUGGESTED READINGS

1. Principles of Toxicology, 2nd edition (2006), Stine Karen and Thomas M Brown, CRC press. ISBN-13: 978-0849328565.
2. Lu's basic toxicology: Fundamentals target organ and risk assessment, 5th edition (2009), Frank C Lu and Sam Kacow, Informa Health care. ISBN: 9781420093117.

Four Year Undergraduate Course in Biomedical Science

Semester VI
DC-II Courses

Semester VI

BMS D: Pharmacology and Toxicology (DC-II)

Preamble: The course provides basic insight into principles of pharmacology and toxicology. It also highlights the pharmacodynamics and pharmacokinetics aspect of drugs in general. The emphasis will be on evaluation of toxicity and mechanism of toxicity of xenobiotics.

THEORY

Total Lectures: 48

Unit I: General pharmacology and toxicology (6 Lectures)

(Chapter 1: Tripathi; Chapter 1-3: Rang and Dale; Chapter 2, 29: Casarett)

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 (6 Lectures)

(Chapter 3: Casarett)

Formation of ultimate toxicant of xenobiotics and its interaction with target molecules.

Unit III: Pharmacokinetics (6 Lectures)

(Chapter 5 and 6: Casarett; Chapter 2: Timbrell)

Membrane transport, absorption, distribution of xenobiotics. Brief introduction to biotransformation, Phase- I reactions including oxidations, hydrolysis, reductions and phase II conjugation reactions and excretion of drugs.

Unit IV: Pharmacodynamics (6 Lectures)

(Chapter 2: Rang and Dale; Chapter 2: Casarett)

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 the drugs acting on:

a. Central and autonomic nervous system, neurotoxic agents. **(6 Lectures)**

(Chapter 29, 32 and 33: Tripathi; Chapter 16: Casarett)

b. Cardiovascular system and cardiotoxic agents. **(6 Lectures)**

(Chapter 37-40: Tripathi; Chapter 18: Casarett)

c. Kidney and nephrotoxic agents. **(4 Lectures)**

(Chapter 41 and 42: Tripathi; Chapter 14: Casarett)

Unit VI: Introduction and classification

- a. Anti-inflammatory and analgesic drugs and their related toxicity. **(4 Lectures)**
(Chapter 14 and 15: Tripathi; Chapter 13 and 14: Casarett)
- b. Endocrine drugs (Tripathi, Chapter 18, 19, 20) **(2 Lectures)**
(Chapter 18-20: Tripathi)
- c. Antimicrobial chemotherapeutic drugs (Tripathi, Chapter 49) **(2 Lectures)**
(Chapter 49: Tripathi)

PRACTICALS

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- naphthol and naphthelene by solvent extraction and identification of their functional groups.
4. Determination of Dissolved water (DO) using Winkler's 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.

ESSENTIAL BOOKS

1. Essentials of Medical Pharmacology, 7th edition (2010), K.D. Tripathi, Jaypee Brothers, ISBN-13: 978-8184480856.
2. Pharmacology, 7th edition (2011), H.P. Rang, M.M. Dale, J.M. Ritter and P.K. Moore, Churchill Livingstone, ISBN-13: 978-0702045042
3. Cassarett and Doull's Toxicology "The Basic Science of The Poisons" 7th edition (2008), Curtis D. Klaassen Editor, Mc GrawHill Medical. ISBN-13: 978-0071470513.
4. Introduction to Toxicology, 3rd edition (2001), John Timbrell, Taylor and Francis Publishers. ISBN-13: 978-0415247627.

SUGGESTED READINGS

1. Cassarett and Doull's "Essentials of Toxicology", 2nd edition (2010), Klaassen and Whatkins, Mc Graw Hill Publisher. ISBN-13: 978-0071622400.
2. Principles of Toxicology, 2nd edition (2006), Stine Karen and Thomas M Brown, CRC press. ISBN-13: 978-0849328565.
3. Lu's basic toxicology: Fundamentals target organ and risk assessment, 5th edition (2009), Frank C Lu and Sam kacow, Informa Health care. ISBN: 9781420093117.

Four Year Undergraduate Course in Biomedical Science

Semester VI

AC Course

Semester VI

BMS 604: Tools in Modern Biology (AC)

Preamble: This course has been designed to introduce the various tools and techniques in modern era of biology and biotechnology. The philosophy behind this course is to make the students appreciate various processes and techniques they learn in other courses with hands-on training and experience. The emphasis is laid on techniques and tools in understanding DNA and proteins- the building blocks of life. 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.

Total sessions: 12
(Each session of 3 Lectures)

Unit I: Plasmids and Biotechnology (3 sessions)

(Chapter 2, 3 and 4: T. A. Brown; Chapter 5: Strachan and Read)

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

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 (3 sessions)

(Chapter 9 and 10: T. A. Brown; Chapter 5: Strachan and Read)

1. Primer designing
2. Optimization of PCR conditions for temperature (gradient PCR) and Mg^{2+} concentration
3. Detection of bacteria specific genes using colony PCR
4. Analysis of DNA sequences with electropherograms

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 (4 sessions)

(Chapter 8 and 9: Freifelder)

1. Comparative analysis of protein on native and denaturing gels
2. Protein purification by affinity chromatography
3. Separation of proteins by ion exchange chromatography

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
(Chapter 2: Wilson and Walker)**

(2 sessions)

1. Preparation of media and culturing of cells
2. Fluorescence imaging demonstration in *E coli* with GFP and mammalian cells with PI/DAPI.

Essentials of cell culture, composition of media and the variations therein, analysis of the status within using fluorescence microscopy.

ESSENTIAL BOOKS

1. Gene cloning and DNA analysis, 6th edition (2010), T.A. Brown. Wiley-Blackwell ISBN-13: 978-1405181730.
2. Human Molecular Genetics, 3rd edition (2003), Tom Strachan and Andrew Read; Garland Science Publishers, ISBN -13: 978-0815341826.
3. Physical Biochemistry: Applications to Biochemistry and Molecular Biology, 2nd edition (1982), David Freifelder, W.H. Freeman and Company. ISBN-13: 978-0716714446.
4. Principles and Techniques of Biochemistry and Molecular Biology 7th edition (2010), Wilson K and Walker J. Cambridge University Press, 2010. ISBN-13: 9780521516358.

SUGGESTED READINGS

1. Principles of Gene Manipulation and Genomics, 7th edition (2006), S.B. Primrose and R.M. Twyman. Blackwell Scientific ISBN-13: 978-1405135443.
2. Molecular Biotechnology: Principles and Applications of Recombinant DNA, 4th edition (2009), Bernard R. Glick, Jack J. Paternack, Cheryl I. Patten. ASM press, ISBN-13: 9781555814984.
3. Molecular Cloning: A Laboratory Manual, 4th edition (2012), Three-volume set by Michael R. Green, Joseph Sambrook; Cold Spring Harbor Laboratory Press, ISBN-13: 978-1936113422.
4. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, 6th edition (2010), ISBN-13: 978-0470528129.

**Four Year Undergraduate Course in
Biomedical Science
IV Year
Semester VII and VIII**

VII Semester

BMS 701: Genome Organization and Function –II (DC-I)

Preamble: The paper Genome Organization and Function –II deals with the more intriguing concepts of gene regulation (transcriptional, translation and genomic), gene silencing, RNAi and forms and mechanisms of regulatory RNAs. The organization of the genome from overlapping genes in bacteria and DNA of cell organelles to the abundance of repetitive DNA in higher organisms will be discussed. Jumping Genes will also be introduced to students here. The paper concludes with view to various genomes and their sequencing, special emphasis on the Human genome project, its goals and features.

THEORY

Total Lectures = 48

Unit I: Gene Architecture (Chapter 13: Watson)

(5 Lectures)

Split Genes, Concept of introns and exons, RNA splicing, Spliceosomes and Self splicing introns, alternative splicing and exon shuffling, RNA editing, mRNA transport and metabolism.

Unit II: Gene Regulation in Prokaryotes and Eukaryotes (Chapter 16 and 17: Watson; Chapter 23: Becker)

(15 Lectures)

- 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, changes in histone and chromosome remodeling proteins.

Unit III: Regulatory RNAs (Chapter 18: Watson)

(4 Lectures)

Riboswitches, RNA interference, miRNA, siRNA, Regulatory RNA and X-inactivation (reference of calico cats)

**Unit IV: Transposable genetic elements
(Chapter 18: Snustad and Simmons)**

(4 Lectures)

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

**Unit V: Human Genome Project
(Chapter 5, 8 and 18: Strachan and Read)**

(8 Lectures)

Introduction to Genome Projects, organization and goals of human genome project, Tools (Vectors- BAC, PAC, YAC and sequencing techniques) and approaches (Hierarchical and shotgun sequencing), Outcomes and ethical issues, Applications in human diseases with an example of CFTR

**Unit VI: Organization of the Human Genome
(Chapter 9 and 13: Strachan and Read)**

(12 Lectures)

General features: Gene density, CpG islands, RNA-encoding genes, Gene clusters, Diversity in size and organization of genes, Types of repetitive DNA, Pseudogenes, gene families, Genetic markers and their applications

PRACTICALS

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. Preparation of human metaphase chromosome and Giemsa Staining
4. Perform Southern Hybridization.
5. Isolation of RNA from *E. coli* or mammalian cells and cDNA preparation
6. Perform RT-PCR of the cDNA prepared
7. Demonstration of Northern Blotting
8. Demonstration of Western Blotting

ESSENTIAL BOOKS

1. Molecular Biology of the Gene, 6th edition (2007), Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R; Benjamin Cummings Publishers, ISBN-13: 978-0805395921.
2. Principles of Genetics, 6th edition (2011), D. Peter Snustad, Michael J. Simmons; John Wiley and Sons, ISBN-13: 978-0470903599.
3. The World of the Cell, 7th edition (2008), Becker, Kleinsmith, Hardin and Bertoni. Benjamin Cummings, ISBN-13: 978-0805393934.

4. Human Molecular Genetics, 3rd edition (2003), Tom Strachan and Andrew Read; Garland Science Publishers, ISBN -13: 978-0815341826.

SUGGESTED READINGS

1. The Cell: A Molecular Approach, 6th edition (2013), Cooper and Hausman; Sinauer Associates, Inc. ISBN-13: 978-1605351551.
2. DNA Replication, 2nd edition (2005), Arthur Kornberg; University Science Books ISBN-13: 978-1891389443
3. Cell and Molecular Biology: Concepts and Experiments, 7th edition (2013), Gerald Karp; Wiley Publishers, ISBN-13: 978-1118206737.
4. Gene cloning and DNA Analysis: An Introduction, 6th edition (2010) T.A. Brown; Wiley - Blackwell Publishing, ISBN-13: 978-1405181730.
5. Genomics: The Science and Technology behind the Human Genome Project, 1st edition (1999), Cantor and Smith; John Wiley and Sons, ISBN-13: 978-0471599081.
6. Molecular Cloning: A Laboratory Manual, 4th edition (2012), Michael R. Green and Joseph Sambrook; Cold Spring Harbor Laboratory Press, ISBN-13: 978-1936113422.
7. Concepts of Genetics, 10th edition, (2012). William S. Klug, Michael R. Cummings, Charlotte A. Spencer, Michael A. Palladino. ISBN-13: 978-0321724120.

VII Semester

BMS 702: Medical Biotechnology (DC-I)

Preamble: The unique preposition of this paper is that the students learn the basic techniques and methods used in the diagnosis and therapy of various human diseases and in the production of biopharmaceuticals. The concepts of cloning and expression of the desired gene is explored. This paper aims to train students to understand how biological systems are applied in the advancement of medical biotechnology.

THEORY

Total No of Lectures = 48

Unit I: Introduction to Biotechnology (1 Lecture)
(Chapter 1: T. A. Brown; Chapter 1: Primrose)

Brief history and Importance

Unit II: Basic techniques (4 Lectures)
(Chapter 2: Primrose)

Agarose gel electrophoresis, Southern, Northern and Western blotting and hybridization, use of enzymatic and chemiluminiscent methods for detection of proteins, detection of nuclei acids by radioactive and fluorescent probes.

Unit III: Manipulation of DNA (5 Lectures)
(Chapter 3, 4 and 5: T. A. Brown; Chapter 3 and 4: Primrose)

Isolation and purification of genomic and plasmid DNA, Restriction and modification systems, type I-IV restriction endonucleases, nomenclature and sequence recognition, restriction mapping. Joining of DNA molecules: role of DNA ligase, adaptors, linkers, homopolymer tailing

Unit IV: Cloning Vectors (8 Lectures)
(Chapter 2, 6 and 7: T. A. Brown; Chapter 5: Primrose)

Basic biology of plasmids, brief life cycle of phages (lambda and M13), Plasmid vectors (pBR322 and pUC vectors, T-vectors) and phage vectors (Bacteriophage vectors- replacement and insertion vectors), cosmids, phasmids, *in vitro* packaging, expression vectors, example of prokaryotic and eukaryotic expression vectors, inducible and constitutive expression vectors with one example each.

Unit V: Cloning and expression of cloned genes in prokaryotic and eukaryotic Cells (6 Lectures)
(Chapter 6, 7 and 11: T. A. Brown)

Challenges in expression of foreign proteins in heterologous host, factors affecting the expression host cell physiology, promoters, codon choice, plasmid copy no. etc., expression in eukaryotic cells (yeast and mammalian expression system, Baculovirus system), Shuttle vectors,

Bacterial transformation and selection and screening of transformants (blue/white and antibiotic selection methods).

Unit VI: Polymerase chain reaction (PCR) (4 Lectures)
(Chapter 9: T. A. Brown)

Principle and applications, primer-design, detailed understanding of PCR and RT- (Reverse transcription) PCR.

Unit VII. Construction of genomic and cDNA libraries, screening and selection of recombinants (6 Lectures)
(Chapter 5 and 6: Primrose; Chapter 8: T. A. Brown)

Immunochemical methods of screening, nuclei acid hybridization (Colony and Plaque hybridization), different methods of preparation of gene probe. Hybrid Release Translation and Hybrid Arrest Translation.

Unit VIII. Random and site-directed mutagenesis (4 Lectures)
(Chapter 8: Primrose)

Methods in Random mutagenesis: any two, methods in Site-directed mutagenesis: oilgonucleotide-directed mutagenesis, PCR-based method, screening and identification of mutants. Protein engineering concept and examples of Subtilisin, and alpha-Antitrypsin (AAT)

Unit IX: Application of Medical Biotechnology (8 Lectures)
(Chapter 26: T. A. Brown)

- (a) Production of recombinant biomolecules: Insulin, somatostatin, Factor VIII and interferons.
- (b) DNA Profiling: Introduction, DNA profiling based on STRs, minisatellites, RFLP, AFLP, VNTRs, SNPs and their applications.
- (c) Gene Therapy: Strategies and limitations, somatic and germline gene therapy, different vectors (viral and non viral) and their comparison, treatment for genetic and infectious diseases.

Unit X: Biosafety and ethical issues in biotechnology (2 Lectures)
(Chapter 13 and 14: T. A. Brown)

PRACTICALS

1. To understand the method of digesting DNA with different restriction enzymes.
2. To maintain and store the *E.coli* DH5 alpha cells.
3. Preparation of Competent Cell (Calcium Chloride Treatment).
4. To prepare insert and vector for ligation.
5. To perform ligation reaction using T4 DNA ligase.
6. Transform competent bacterial cells with foreign DNA.

7. To identify recombinants by blue-white screening and PCR.

ESSENTIAL BOOKS

1. Gene cloning and DNA analysis, 6th edition (2010), T.A. Brown. Wiley-Blackwell ISBN-13: 978-1405181730.
2. Principles of Gene Manipulation and Genomics, 7th edition (2006), S.B. Primrose and R.M. Twyman. Blackwell Scientific ISBN: 978-1405135443.

SUGGESTED READINGS

1. Molecular Biotechnology: Principles and Applications of Recombinant DNA, 4th edition (2009), Bernard R. Glick, Jack J. Paternack, Cheryl I. Patten. ASM press, ISBN-13: 9781555814984.
2. DNA Replication, 2nd edition (1992), Arthur Kornberg; University Science Books, ISBN - 13: 978- 0716720034.
3. Genomics: The Science and Technology behind the Human Genome Project, 1st edition (1999), Cantor and Smith; John Wiley and Sons, ISBN-13: 978-0471599081.
4. Molecular Cloning: A Laboratory Manual, 4th edition (2012), Three-volume set by Michael R. Green, Joseph Sambrook; Cold Spring Harbor Laboratory Press, ISBN-13: 978-1936113422.

Four Year Undergraduate Course in Biomedical Science

Semester VII
DC-II Course

VII Semester

BMS E: Bridging Information Technology and Biotechnology (DC-II)

Preamble: 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 etc.

Total Lectures: 48

Unit I: Convergence of biotechnology and information technology (2 Lectures)
(Chapter 1: Mount)

Introduction to bioinformatics and its applications, Internet and bioinformatics.

Unit II: Databases and genome browsers (8 Lectures)
(Chapters 2 and 6: Mount)

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 visualization (8 Lectures)
(Chapters 3 and 4: Mount)

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.

Unit IV: Theory behind BLAST (4 Lectures)
(Chapter 4: Mount)

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.

Unit V: Phylogenetic analysis (5 Lectures)
(Chapter 14: Baxevanis and Ouellette)

Basics and tools for phylogenetic analysis, cladistics and its assumptions, tree-building methods (Character and distance based methods), construction of phylogenetic trees (PHYLIP).

Unit VI: Gene ontology (3 Lectures)
(Chapter 9: Baxevanis and Ouellette)

The Ontologies: cellular component, biological process and molecular function.

Unit VII: Genome analysis (5 Lectures)
(Chapter 11: Mount)

Features of DNA sequence analysis, gene prediction methods, SNP analysis (dbSNP), sequence assembly and genome annotation.

Unit VIII: Restriction site mapping and primer design (6 Lectures)
(Chapter 13: Baxevanis and Ouellette)

In silico restriction mapping, cloning and expression, identification of cDNA from databases, design of primers for standard and real time PCR, e-PCR.

Unit IX: Introduction to machine learning (4 Lectures)
(Chapter 12: Mount)

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.

Unit X: Application of bioinformatics in biotechnology (3 Lectures)
PCR diagnostic design, design strategy for over-expression of a therapeutic protein using specific examples to illustrate the strategy.

PRACTICALS

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.

ESSENTIAL BOOKS

1. Bioinformatics: Sequence and Genome analysis, 2nd edition (2004), David W. Mount, Cold Spring Harbour Laboratory Press. ISBN-13: 978-0879697129.
2. Bioinformatics: A practical guide to the analysis of genes and proteins, 3rd edition (2004), Andreas D. Baxevanis and B.F. Francis Ouellette, John Wiley and Sons. ISBN: 978-0471478782.

VIII Semester

BMS-801: Computational Biology and Drug Design (DC-I)

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

THEORY

Total Lectures: 48

Unit I: Introduction to computational biology (Chapter 1: Mount)

(2 Lectures)

What is computational biology and bioinformatics, internet and bioinformatics, cheminformatics. Introduction to linux and common terminal commands.

Unit II: Biological databases and genome browsers (Chapter 2 and 6: Mount)

(10 Lectures)

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 visualization (Chapters 3, 4 and 5: Mount)

(8 Lectures)

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.

Unit IV: Phylogenetic analysis (Chapter 14: Baxevanis and Ouellette)

(4 Lectures)

Basics and tools for phylogenetic analysis, cladistics, tree-building methods (character and distance based methods), construction of phylogenetic trees (PHYLIP) and identifying homologs.

Unit V: Microarray analysis (Chapter 13: Mount; Chapter 9 and 16: Baxevanis and Ouellette)

(3 Lectures)

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 VI: Drug discovery pipeline (3 Lectures)

(Chapter 1, 2: Smith and O'Donnell)

Drug life cycle, stages of drug discovery and strategic issues in drug discovery.

Unit VII: Lead generation (6 Lectures)

(Chapter 12, 18: Patrick)

2D and 3D molecular structures, molecular descriptors and fingerprints, molecular similarity and diversity, topological descriptors, quantitative structure-property relationships.

Unit VIII: Overview of drug development (12 Lectures)

(Chapter 15, 17, 18: Patrick)

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 forcefields, introduction to rational drug design using example.

PRACTICALS

1. Retrieval of information from databases.
2. Sequence alignment using BLAST and Clustal W.
3. Phylogenetic analysis using PHYLIP.
4. Microarray analysis using Bioconductor.
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 using What Check and Pro Check.
7. Comparing structures, mutations, studying interactions creating electrostatic potential diagrams.
8. Virtual screening and molecular docking using AUTODOCK.

ESSENTIAL BOOKS

1. Bioinformatics: Sequence and Genome analysis, 2nd edition (2004), David W. Mount, Cold Spring Harbour Laboratory Press. ISBN-13: 978-0879697129.
2. Bioinformatics: A practical guide to the analysis of genes and proteins, 3rd edition (2004), Andreas D. Baxevanis and B.F. Francis Ouellette, John Wiley and Sons. ISBN-13: 978-0471478782.
3. Introduction to Medicinal Chemistry, 4th edition (2009), Graham I. Patrick, Oxford University Press. ISBN-13: 978-0199234479.

4. The Process of New Drug Discovery and Development, 2nd edition (2006), C.G. Smith and J.T. O'Donnell, Informa Healthcare, ISBN-13: 978-0849327797.

SUGGESTED READINGS

1. Cheminformatics (2003), J. Gasteiger, Thomas Engel; Wiley-VCH . ISBN: 9783527618279.
2. Molecular modeling - Principles and Applications, 2nd edition (2003), A. R. Leach, Pearson Education Limited, UK. ISBN 13: 9780582382107.
3. Cheminformatics in Drug Discovery (2006), edited by. T.I. Opera; Wiley Publishers, ISBN: 9783527604203.
4. Molecular dynamics simulation: elementary methods (1992), J. M. Haile, Wiley-Interscience, New York. ISBN-13: 978-0471184393.

VIII Semester

BMS-802: Biophysics (DC-I)

Preamble: Biological phenomena cannot be understood fully without physical insight. Biophysics is an 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. The work always aims to find out how biological systems work. This paper covers various spectroscopic techniques, hydrodynamic methods, molecular biophysics and introduction to various physical principles responsible for maintaining the basic cellular function and integrity of biological membranes including transport across them.

THEORY

Total Lectures: 48

Unit I: Biophysical techniques

(20 Lectures)

(Chapter 3, 4 and 6: Sheehan; Chapter 14-17: Freifelder)

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

(10 Lectures)

(Chapter 7: Sheehan; Chapter 11, 13: Freifelder)

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 (10 Lectures)
(Chapter 6: Sheehan; Chapter 1: Freifelder; Chapter 2 and 3: Tinoco; Chapter 6: Watson)

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.

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), 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 (08 Lectures)
(Chapter 12: Hoppe)

Colloidal solution, Micelles, reverse micelles, bilayers, liposomes, phase transitions of lipids, transport of solutes and ions, Fick's laws of diffusion, ionophores, transport equation, membrane potential.

PRACTICALS

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 viscometry in the study of ligand binding to DNA/protein.
7. Crystallization of enzyme lysozyme using hanging drop method.
8. Analysis, identification and comparison of various spectra (UV, NMR, MS, IR) of simple organic compounds.

ESSENTIAL BOOKS

1. Physical Biochemistry: Principles and Applications, 2nd edition (2009), David Sheehan, John Wiley. ISBN-13: 978-0470856031.
2. Physical Biochemistry: Applications to Biochemistry and Molecular Biology, 2nd edition (1982), David Freifelder, W.H. Freeman and Company. ISBN-13: 978-0716714446.
3. Physical Chemistry: Principles and Applications in Biological Sciences, 4th edition (2001), I. Tinoco, K. Sauer, J.C. Wang and J.D. Puglisi, Prentice Hall, ISBN-13: 978-0130959430.

4. Molecular Biology of the Gene, 7th edition (2007), Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R, Benjamin Cummings Publishers, ISBN-13: 978-0805395921.
5. Biophysics, 1st edition (1983), W. Hoppe, W. Lohmann, H. Markl and H. Ziegler, Springer-Verlag, ISBN-13: 978-3540120834.

SUGGESTED READINGS

1. The Physics of Proteins: An introduction to Biological Physics and Molecular Biophysics, 1st edition (2010), H. Frauenfelder, S.S. Chan and W.S. Chan, Springer, ISBN-13: 978-1441910431.
2. Principles of Instrumental Analysis, 6th edition (2006), D.A. Skoog et. al., Saunders College Publishing. ISBN-13: 978-0495012016.
3. Principles of Physical Biochemistry, 2nd edition (2005), K.E. Van Holde, W.C. Jhonson and P. Shing Ho, Prentice Hall Inc. ISBN-13: 978-0130464279.
4. Biophysical Chemistry, 1st edition (1980), C.R. Cantor, P.R. Schimmel, W.H. Freeman and Company. ISBN-13: 9780716711889.
5. Crystallography Made Crystal Clear: Guide for Users of Macromolecular Models, 3rd edition (2010), Gale Rhodes, Academic Press. ISBN: 9780080455549.
6. Introduction to Protein Structure, 2nd edition (1999), C. Branden and J. Tooze, Garland Publishing, ISBN-13: 978-0815323051.

Four Year Undergraduate Course in Biomedical Science

Semester VIII
DC-II Course

VIII Semester

BMS F: Tools and Model Organisms in Biomedical Research (DC-II)

Preamble: This course has been designed to introduce the various tools and techniques in modern era of biology. It focuses on the principles of microscopy, spectroscopy, chromatography, various molecular biology and immunological techniques. This course also aims to give the students an introduction to different model organisms, what they are used for, which techniques that can be applied to modify their genome, and how the students may use these organisms employing modern technological approaches for research and understanding of biology.

It's a motley collection of creatures: They fly, swim, wiggle, scurry, or just blow in the wind. But to the scientific community, this compilation has been elevated above all other species. They are the model organisms.- The Scientist, June 2, 2003

THEORY

Total Lectures: 48

Unit I: Spectroscopy (5 Lectures)

(Chapter 3, 4 and 6: Sheehan)

Principles and biological applications of UV, visible spectroscopy, Fluorescence spectroscopy, Infrared spectroscopy, NMR and Mass spectroscopy

Unit II: Microscopy (3 Lectures)

(Chapter 18: Karp)

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 (5 Lectures)

(Chapter 18: Karp)

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: Fluorochromes, fluorescent probe and principle, application in biomedical science.

Unit IV: Molecular Biology Methods (8 Lectures)

(Chapter 2, 3, 4, 9 and 10: T. A. Brown; Chapter 2: Primrose; Chapter 5: Strachan and Read)

Isolation, purification and quantification of nucleic acids; Agarose 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 (3 Lectures)

(Chapter 6: Kuby)

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-immunoprecipitation for protein-protein interaction studies.

Unit VI: Introduction to model organisms (2 Lectures)
(Chapter 1: Pierce; Chapter 8: Strachan and Read)

What are model organisms? Why there is a need to study model organisms? How to choose a model organism?

Unit VII: Different model organisms
(Chapter 1: Pierce; Chapter 8: Strachan and Read)

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* (2 Lectures)**

Utilization in discovery of fundamental metabolic pathways.

***Saccharomyces cerevisiae* (Baker's yeast) (6 Lectures)**

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) (2 Lectures)**

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) (4 Lectures)**

Insights into forms of cancer and neurodegenerative diseases. Flybase, the Gene disruption project, transgenic flies.

***Mus musculus* (Mouse) (4 Lectures)**

“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 (4 Lectures)

***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.

PRACTICALS

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 Mg²⁺ concentration.
3. Restriction digestion of DNA for RFLP and DNA fingerprinting.
4. To perform Southern hybridisation.
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*.

ESSENTIAL BOOKS

1. Physical Biochemistry: Principles and Applications, 2nd edition (2009), David Sheehan, John Wiley. ISBN-13: 978-0470856031.
2. Cell and Molecular Biology: Concepts and Experiments, 6th edition (2009), Gerald Karp, Wiley. ISBN-978-0470483374.
3. Gene cloning and DNA analysis, 6th edition (2010), T.A. Brown. Wiley-Blackwell ISBN-13: 978-1405181730.
4. Principles of Gene Manipulation and Genomics, 7th edition (2006), S.B. Primrose and R.M. Twyman. Blackwell Scientific ISBN: 978-1405135443.
5. Human Molecular Genetics, 3rd edition (2003), Tom Strachan and Andrew Read; Garland Science Publishers, ISBN -13: 978-0815341826.
6. Immunology, 6th edition, (2006), J. Kuby, W.H. Freeman and Company, New York. ISBN-13: 978-1429202114.
7. Genetics: A Conceptual Approach, 4th edition (2010), Benjamin A. Pierce, W. H. Freeman, ISBN-13: 978-1429232524.

SUGGESTED READINGS

1. Molecular Cloning: A Laboratory Manual, 4th edition (2012), Three-volume set by Michael R. Green, Joseph Sambrook; Cold Spring Harbor Laboratory Press, ISBN-13: 978-1936113422.
2. Concepts of Genetics, 10th edition, (2012). William S. Klug, Michael R. Cummings, Charlotte A. Spencer, Michael A. Palladino. ISBN-13: 978-0321724120.
3. Physical Biochemistry: Applications to Biochemistry and Molecular Biology, 2nd edition (1982), David Freifelder, W.H. Freeman and Company. ISBN-13: 978-0716714446.
4. Principles and Techniques of Biochemistry and Molecular Biology, 7th edition (2010), Wilson K and Walker J., Cambridge University Press, 2010. ISBN-13: 978-0521516358.
5. Emerging Model Organisms: A Laboratory Manual, Volume 2, Lab manual edition (2010), Cold Spring Harbor Laboratory Press, ISBN-13: 978-0879698652.