B.Sc. (Hons) Course in Biomedical Science

Preamble

The B.Sc. (Hons) Biomedical Science started as an interdisciplinary course at University of Delhi. The course has been very successful in terms of the career options taken up by the students after graduation over the years. The course in its annual mode prior to 2009 and in the semester mode after 2009 has been structured to reinforce the basic exposure that students get in the higher secondary school and to gradually build on this knowledge-base. The proposed syllabus has taken advantage of the credit system to gradually make the transition from simple to complex concepts relevant to the interdisciplinary nature of undergraduate program in Biomedical Science.

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

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

The syllabus before you is the joint effort of all the teachers involved in teaching Biomedical Science in University of Delhi.

COURSE STRUCTURE

SEMESTER I		SEMESTER II	
C1	BMS-101: Bioorganic Chemistry	C3	BMS-201: Principles of Genetics
C2	BMS-102: Cell and Radiation Biology	C4	BMS-202: Human Physiology and Anatomy I
AECC1	English/MIL Communication or EVS	AECC2	EVS or English/MIL Communication
GE1	Generic Elective	GE2	Generic Elective

SEMESTER III		SEMESTER IV	
C5	BMS-301: Biochemistry	C8	BMS-401: Immunobiology
C6	BMS-302: Human Physiology and Anatomy II	C9	BMS-402: Molecular Biology
C7	BMS-303: Medical Microbiology	C10	BMS-403: Medicinal Chemistry
SEC1	Skill Enhancement Course	SEC2	Skill Enhancement Course
GE3	Generic Elective	GE4	Generic Elective

SEMESTER V		SEMESTER VI	
C11	BMS-501: Biophysics	C13	BMS-601: Human Pathology
C12	BMS-502: Pharmacology	C14	BMS-602: Toxicology
DSE1	Discipline Specific Elective	DSE3	Discipline Specific Elective
DSE2	Discipline Specific Elective	DSE4	Discipline Specific Elective

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

GE 1-4: Generic Electives (any one per semester in semesters 1-4)
BMS-G1: Basics of Immunology
BMS-G2: Biological Chemistry
BMS-G3: Biosafety and Bioethics
BMS-G4: Biostatistics
BMS-G5: Bridging Information Technology and Biotechnology
BMS-G6: Concepts in Biotechnology
BMS-G7: Concepts in Medicinal Chemistry and Drug Development
BMS-G8: Intellectual Property Rights (IPR) for Biologists
BMS-G9: Pathological Basis of Diseases
BMS-G10: Pharmacology and Toxicology
BMS-G11: Tools and Model Organisms in Biomedical Research

SEC 1-2: Skill Enhancement Courses (any one per semester in semesters 3-4)
BMS-S1: Methods in Epidemiological Data Analysis (EDA)
BMS-S2: Medical Laboratory Diagnostics (MLD)
BMS-S3: Techniques for Forensic Science
BMS-S4: Tools in Modern Biology

DSE 1-4: Discipline Specific Elective (any two per semester in semesters 5-6)
BMS-A: Computational Biology and Drug Discovery
BMS-B: Genome Organization and Function
BMS-C: Human Genetics
BMS-D: Medical Biochemistry
BMS-E: Medical Biotechnology
BMS-F: Project Work (can be chosen only in semester 6)

Core Courses (Theory + Practical*)

Semester I
BMS-101: Bioorganic Chemistry
BMS-102: Cell and Radiation Biology

Semester II
BMS-201: Principles of Genetics
BMS-202: Human Physiology and Anatomy I

Semester III
BMS-301: Biochemistry
BMS-302: Human Physiology and Anatomy II
BMS-303: Medical Microbiology

Semester IV
BMS-401: Immunobiology
BMS-402: Molecular Biology
BMS-403: Medicinal Chemistry

Semester V
BMS-501: Biophysics
BMS-502: Pharmacology

Semester VI
BMS-601: Human Pathology
BMS-602: Toxicology

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

B.Sc. (Hons) Course in

Biomedical Science

I Year

Semester I and II

Semester I

BMS 101: Bioorganic Chemistry

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

THEORY **Total Lectures: 48**

Unit I: Aqueous Solutions **(04 Lectures)**

Water, pH and buffers, concept of pKa (titration curves of amino acids), Henderson-Hasselbach equation, buffering zone, buffer index, concept of pI and zwitter ion.

Unit II: Concept of Acids and Bases. **(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 **(06 Lectures)**

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

Unit IV: Stereochemistry **(08 Lectures)**

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

(i) Carbohydrates **(04 Lectures)**

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 (examples from biomolecules).
Disaccharides- structure, reducing and non-reducing sugars.
Polysaccharides- Starch, glycogen and cellulose.

(ii) Lipids (**02 Lectures)**

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

(iii) Amino Acids **(04 Lectures)**

Structure and classification of amino acids, ionization, chemistry of peptide bond, non-ribosomal peptide bond formation, essential and non-essential amino acids, amino acids as precursors of other bioactive compounds, zwitterion, isoelectric point, optical properties of amino acids, Lambert-Beer Law.

Peptide conformation **(04 Lectures)**

Definition of a peptide, peptide unit, peptide group, bond length, cis and trans conformation, Ramachandran Plot, primary, secondary (alpha helix, beta sheet, beta turn, collagen helix), tertiary and quaternary structures (with examples).

(iv) Nucleotides (**04 Lectures)**

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.

(v) Enzymes **(08 Lectures)**

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.

PRACTICALS

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

1. Preparation of solutions based on molarity, normality, percentage, dilutions etc.
2. Preparation of buffers.
3. Estimation of Mohr's salt/ oxalic acid by titrating with $KMNO_4$.
4. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.
5. Qualitative tests for carbohydrates to identify the given unknown carbohydrate solution: Mohlisch, Barfoed, Fehling/ Tollen/ Benedict, Selvinoff, Osazone, Bial'stests.
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

SUGGESTED READINGS

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

Semester I

BMS 102: Cell and Radiation Biology

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)**

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

Unit II: Cell Fractionation **(02 Lectures)**

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

Unit III: Cell Membrane **(04 Lectures)**

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)**

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)**

Structure and functions of various organelles:

A. *Nucleus*: Different components, nuclear envelope- its structure, pore complex, nucleo-cytoplasmic interaction (NLS and NES), nucleolus- structure and functions.
B. *Chromosome*: Structure- centromere and telomere, types of chromosomes based on centromere. Diversity in structure and significance of polytene and lampbrush chromosomes. *Mitosis and Meiosis:* Different phases and their significance.

C. *Endoplasmic Reticulum*: RER- biosynthesis and processing of proteins, co-translational and post-translational transport of proteins, signal hypothesis, protein sorting. SER- detoxification, biosynthesis of membrane, carbohydrate metabolism, steroid synthesis.
D. *Golgi Apparatus*: Golgi stack (cis, trans and medial cisternae), flow of proteins through GB. Glycosylation and protein sorting.
E. *Lysosomes*: Development of different forms of lysosomes, role in cellular digestion, lysosomal storage diseases- Hurler syndrome, Hunter syndrome, Tay-Sachs disease and Inclusion cell disease (I-cell disease).
F. *Peroxisomes*: Assembly, functions- H_2O_2 metabolism, oxidation of fatty acids. Glyoxysomes.
G. *Mitochondria*: Detailed structure, endosymbiotic theory, its genome, and functions in brief.
H. *Chloroplast*: Detailed structure, its genome and functions in brief.

Unit VI: Cell Junctions **(02 Lectures)**

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

Unit VII: Cytoskeletal Elements **(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 **(03 Lectures)**

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

Unit IX: Radiation Biology **(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

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

1. Microscopy- Theoretical knowledge of Light and Electron microscope.
2. To study the following techniques through electron/ photomicrographs: fluorescence microscopy, autoradiography, positive staining, negative staining, freeze fracture, freeze etching shadow casting, endocytosis and phagocytosis.
3. To explain mitosis and meiosis using permanent slides.
4. 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.

SUGGESTED READINGS

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.
5. The World of the Cell, 7th edition (2008), Becker, Kleinsmith, Hardin and Bertoni. Benjamin Cummings, ISBN-13: 978-0805393934.
6. The Cell: A Molecular Approach, 6th edition (2013), Cooper and Hausman; Sinauer Associates, Inc. ISBN-13:978-1605351551.
7. Essential Cell Biology, 7th edition (2009), Alberts, Bray, Hopkin, Johnson, Lewis, Raff, Roberts and Walter. Garland Science. ISBN-13:978-0815341291.
8. 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

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. 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 (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 (06 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 (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: Introduction to DNA structure and replication (04 Lectures)

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

Unit V: Extra nuclear inheritance (05 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 VI: Mutation (04 Lectures)

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 IV: Transposable genetic elements (03 Lectures)

Prokaryotic transposable elements- IS elements, Composite transposons; Eukaryotic transposable elements- Ac-Ds system in maize; Uses of transposons.

Unit VII: Analysis of genetic inheritance in human (04 Lectures)

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.

Unit VIII: Genome Organization and Cytogenetics (06 Lectures)

Organization of Genomes in Prokaryotes and Eukaryotes, Establishing the central Dogma, Nucleosomes organization and assembly, Regulation of chromatin structure. Euchromatin, Heterochromatin- constitutive and facultative heterochromatin.

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 chromosomal basis of sex determination (04 Lectures)

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

Unit X: Basic population genetics (04 Lectures)

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

PRACTICALS

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

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

SUGGESTED READINGS

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.
4. Principles of Genetics, 8th edition (2005), Gardner EJ, Simmons MJ, Snustad DP. John Wiley and Sons, Inc. ; ISBN-13: 978-9971513467.
5. 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.
6. 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

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 (04 lectures)

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

Unit II: Blood (08 lectures)

Composition and Function of blood and its components: WBC, RBC, platelets. Hematopoiesis, Hemoglobin structure and function. Hemostasis and blood coagulation mechanism, blood groups and blood banking. An overview of lymphoid tissue and Lymph. Basic concepts about Anemia, abnormal hemoglobin, Polycythemia, Thalassemia, Leukemia.

Unit III: Nerve physiology (07 lectures)

Resting membrane potential structure and function of neuron. 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 (08 lectures)

Structure and function of Central nervous system, Peripheral nervous system and Autonomic nervous system (spinal and cranial nerves). 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 (08 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 **(08 lectures)**

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: Skeletal System **(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 (any 8)

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

1. Estimation of hemoglobin (Sahli's method) and determination of blood group.
2. Determination of bleeding time and clotting time of blood.
3. Determination of total erythrocyte count.
4. Determination of total leukocyte count.
5. Preparation of blood smears and identifying various WBC
6. To perform differential leukocyte count of blood.
7. Determination of specific gravity of blood.
8. Determination of osmotic fragility of RBC.
9. To study various types of fractures from X ray films

*10. To study different human organs and their sections through permanent histological slides

T. S. of brain, spinal cord, skeletal fibers, cardiac muscles, skeletal muscles, cartilage joints and different tissues. (Minimum 8 slides covering the systems mentioned in theory.)

SUGGESTED READINGS

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.

5. Principles of Anatomy and Physiology, 13th edition (2011), Gerard J. Tortora and Bryan H. Derrickson; Wiley and Sons, ISBN-13: 978-0470565100.

6. Ganong's Review of Medical physiology, 24th edition (2012), K. E. Barett, S. M. Barman, S. Boitano and H. Brooks; Tata McGraw Hill, ISBN-13: 978-0071780032.

7. Textbook of Practical Physiology, 7th edition (2007), CL Ghai; Jaypee Publication, ISBN-13: 978-8184481419.

B.Sc. (Hons) Course in

Biomedical Science

II Year

Semester III and IV

Semester III

BMS 301: Biochemistry

Preamble: *Biochemistry is a discipline, which aims at understanding the chemical properties of the biomolecules, their structural architecture and how they fold to their native, functional forms. This course includes metabolic pathways and their regulation, protein stability, folding and mis-folding, 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: Metabolic Pathways and their regulation

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

(14 Lectures)

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

(04 Lectures)

Protein metabolism- General overview, transamination, deamination, glucose-alanine cycle, Urea cycle and it's regulation, metabolism of Phenylalanine and a branched chain amino acid.

(06 Lectures)

Nucleic acid metabolism-General overview, Outline of purine and pyrimidine metabolism, Gout and Lesch-Nyhan syndrome. **(04 Lectures)**

Unit II: Protein stability, folding and misfolding **(08 Lectures)**

Definition of native and denatured state, protein stability, forces that maintains the native state stability, Protein denaturation by chaotropic agents (urea, guanidinium HCl, SDS and heat), Protein folding (hydrophobic collapse, Anfinsen experiment, Levinthal Paradox), chaperone-assisted protein folding. Misfolding of proteins and its mechanism. Introduction to conformational diseases: Alzheimer's and Mad cow disease.

Unit III: Analytical methods in protein characterization **(08 Lectures)**

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

Unit IV: Coenzymes **(02 Lectures)**
Classification, various types, structure and function, structure of NAD^+, $NADP^+$, FAD and FMN.

Unit V: Regulatory enzymes **(02 Lectures)**
General properties of allosteric enzymes, regulation by covalent modification, Cooperativity. Zymogens.

PRACTICALS

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

1. To perform dialysis
2. Protein estimation by any one: Lowry's/Bradford method.
3. Separation of sugars/amino acids by thin layer chromatography.
4. To perform SDS-PAGE
5. Calculation of void volume of Sephadex G -25 column, using blue dextran
6. Assay of any one enzyme under optimal conditions.
7. To study the effect of temperature on the activity of enzyme.
8. To study the effect pH on the activity of enzyme.

SUGGESTED READINGS

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.
3. Introduction to Protein Structure, 2nd edition (1999), Carl Branden and John Tooze; Garland Science, ISBN-13: 978-0815323051.
4. Principles and Techniques of Practical Biochemistry, 5th edition (2000), Keith Wilson and John Walker; Cambridge University Press, ISBN -13: 978-0521799652.
5. Protein Folding, 1st edition (1992), Thomas E. Creighton; W. H. Freeman Company, ISBN-13: 978-0716770275.
6. 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

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 **(09 lectures)**

Structure and function of heart, Properties of cardiac muscle, The Cardiac Cycle, Electrocardiogram. Circulatory system: General Principles of circulation and hemo-dynamics cardiovascular regulatory mechanism, Lymphatic circulation and micro-circulation. Basic concepts of angina, atherosclerosis and Cardiac failure

Unit II: Respiratory system **(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 **(08 lectures)**

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

Unit IV: Reproductive system **(09 lectures)**

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

Unit V: Endocrine system **(08 lectures)**

General mechanism of hormone action, Structure, function and regulation of the following glands and their secretions: Pituitary, Hypothalamus, Pineal, Thyroid, Parathyroid, Adrenal,

Thymus and Pancreas. Basic concepts about hypo and hyper secretion of hormones and their diseases.

Unit V: Gastrointestinal system (07 lectures)

Anatomy and histology of digestive tract, gastrointestinal physiology: General principles of gut motility secretion, digestion, absorption and assimilation. Gastrointestinal hormones, their formation, action and regulation. Physiological anatomy of liver, pancreas and their functions. An overview of vomiting, gastrointestinal dysfunction: nausea, mal-absorption, constipation, Gastritis, Ulcer, Diarrhoea, Jaundice and Cirrhosis.

PRACTICALS

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

1. Simple Reflex arc.

2. Physiological data acquisition based experiments (ECG).

3. Physiological data acquisition based experiments (EMG).

4. Physiological data acquisition based experiments (PFT).

5. To perform platelet count.

6. To determine the reticulocyte count.

7. To perform tests for sensations (taste, touch and smell.)

8. Blood Pressure recordings in humans.

9.To study various types of contraceptive (condoms, IUD’s, oral and injectable contraceptives)

10. To study different human organs and their sections through permanent slides.

T. S. of thyroid, liver, thymus, spleen, ovary, artery, vein, capillaries, testis, pancreas, esophagus, adrenal, kidney (cortex and medulla), urinarybladder, urethra, fallopian tubes, epididymis, prostate glands, lungs, trachea, bronchioles, pititutory, heart. (Minimum 8 slides covering the systems mentioned in theory.)

SUGGESTED READINGS

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: 9780077350062.

3. Principles of Anatomy and Physiology, 13th edition (2011), Gerard J. Tortora and Bryan H.

Derrickson; Wiley and Sons, ISBN-13: 978-0470565100.

4. Lab Mannual on Blood Analysis and Medical Diagnostics, 1st edition (2012), Dr. GayatriPrakash; S. Chand, ISBN: 81-219-3967.

5. Ganong's Review of Medical physiology, 24th Edition (2012), K. E. Barett, S. M. Barman, S. Boitano and H. Brooks; Tata McGraw Hill, ISBN-13: 978-0071780032.

6. Textbook of Practical Physiology, 7th Edition (2007), CL Ghai; Jaypee Publication, ISBN-13:

978-8184481419.

Semester III

BMS 303: Medical Microbiology

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 **(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 **(5 Lectures)**

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

Unit III: Microbial Genetics **(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 **(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)

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)

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)

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)

Classification of medically important parasites. Common protozoan disease: Malaria, Infections caused by *Taeniasolium* / *Taeniasaginata*, *Fasciola hepatica and Ascarislumbricoides*.

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

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

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

1. Preparation of different media: synthetic media, Complex media-nutrient agar, Luria Agar.
2. Staining methods: Gram's staining, Acid fast staining (permanent slide only), Capsule staining and spore staining.
3. Study and plot the growth curve of *E coli* using turbidometric method and to calculate specific growth rate and generation time.
4. To perform antibacterial testing by Kirby-Bauer method.
5. Staining and morphological characterization of Aspergillus sp., Pencillium sp. and Saccharomyces sp.

6. Demonstration of PCR based method of detection.
7. Isolation of bacteriophages (any with a non-pathogenic host) and calculation of the plaque forming units (pfu).

SUGGESTED READINGS

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.
4. Microbiology, 6th edition (1993), Pelczar, Chan and Krieg; McGraw Hill International, ISBN-13: 978-0070492585.
5. 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.
6. Microbiology: A Laboratory Manual, 10th edition, (2013), James Cappuccino and Natalie Sherman, Benjamin Cummings. ISBN-13: 978-0321840226.

Semester IV

BMS 401: Immunobiology

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 **(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 **(10 Lectures)**

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

Unit III: Adaptive immune response **(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)

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)

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

Unit VI: Dysfunctions of immune system (4 Lectures)

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

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

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

SUGGESTED READINGS

1. Immunology, 6th edition, (2006), J. Kuby et al, W.H. Freeman and Company, New York. ISBN-13: 978-1429202114.
2. Microbiology, 7th edition, (2008), Prescott, L., John Ii Harley, Donald A. Klein, McGraw Hill. ISBN-13: 978-0071102315.
3. Roitt's Essential Immunology, 12th edition, (2011), Wiley-Blackwell Science. ISBN-13: 978-1405196833.
4. Immunology, 8th edition, (2012), Male, D., Brostoff, J., Roth, D.B. and Roitt, I., Elseivier-Sauders. ISBN-13: 978-0323080583.
5. An Introduction to Immunology, Immunochemistry and Immunobiology, 5th edition, (1988), Barrett, James T., Mosby Company, St. Louis. ISBN-13: 978-0801605307.
6. Immunology: An Introduction, 4th edition, (1994), Tizard, I.R., Saunders College Publishing, Philadelphia. ISBN-13: 978-0030041983.

Semester IV

BMS 402: Molecular Biology

Preamble: The paper Molecular Biology encompasses the basic study and understanding of the execution of 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: The replication of DNA in Prokaryotes and Eukaryotes (14 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.

Denaturation and renaturation of DNA, Cot curves.

Unit II: The mutability and Repair of DNA (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 III: Information Transfer –I: Mechanism of Transcription (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.

Unit IV: Post-Transcriptional Modifications (6 Lectures)

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

Unit V: Information Transfer-II: Mechanism of Translation (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

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

1. Preparation of various stock solutions 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. Demonstration of Polymerase Chain Reaction (PCR) technique
7. Demonstration of AMES test or reverse mutation for carcinogenicity

SUGGESTED READINGS

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

Semester IV

BMS 403: Medicinal Chemistry

Preamble: The course highlights the importance of Medicinal Chemistry in all our lives and the fascination of working in a field that overlaps the disciples 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 **(2 Lectures)**

Definition and scope of medicinal chemistry

Unit II: Drug target classification **(14 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 **(8 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 **(8 Lectures)**

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

Unit V: Measurement of drug effects (6 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 VI: Principles of drug design (6 Lectures)

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

Unit VII: Introduction to Combinatorial Synthesis (4 Lectures)

Methods of parallel synthesis, methods in mixed combinatorial synthesis (mix and split method), limitations of combinatorial synthesis.

PRACTICALS

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

1. Preparation of 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 thiouronium salt.
8. Extraction of caffeine from tea leaves and study its absorption properties.
9. Phytochemical screening and qualitative chemical examination of various plant constituents by Solvent extraction. (Detection of alkaloids, carbohydrates, glycosides, phytosterols, oils and fats, tannins, proteins, gums and mucilages).

SUGGESTED READINGS

1. Introduction to Medicinal Chemistry, 4th edition (2009), Graham l. 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.
4. Wilson Gisvold textbook of Organic Medicinal and Pharmaceutical Chemistry, 11th edition (2003), edited by Block and Beale, Baltimore, Lippincot. ISBN-13: 978-0781734813.
5. The Practice of Medicinal Chemistry, 2nd edition (2003), Camille G. Wermuth, Academic Press. ISBN-13: 978-0127444819.
6. Principles and Practice of Medicinal Chemistry, 2nd edition (2003), Frank. D. King. The Royal Society of Chemistry.ISBN-13: 978-0854046317.
7. Introduction to Medicinal Chemistry: How Drugs Act and Why, 1st edition (1996), Alex Gringauz, Wiley VCH. ISBN-13: 978-0471185451.

B.Sc. (Hons) Course in

Biomedical Science

III Year

Semester V and VI

V Semester

BMS-501: Biophysics

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)**

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)**

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)

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), and role of molecular chaperones in cellular protein folding, basics of molecular and chemical chaperones, protein misfolding and aggregation, diseases associated with protein misfolding.

Unit IV: Biological membranes (08 Lectures)

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

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

1. Effect of different solvents on UV absorption spectra of proteins.
2. Study of structural changes of proteins at different pH using UV spectrophotometry.
3. Study of structural changes of proteins at different temperature using UV spectrophotometry.
4. Determination of melting temperature of DNA.
5. Study the effect of temperature on the viscosity of a macromolecule (Protein/DNA).
6. Use of 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.

SUGGESTED READINGS

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.
6. 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.
7. Principles of Instrumental Analysis, 6th edition (2006), D.A. Skooget. al., Saunders College Publishing. ISBN-13: 978-0495012016.
8. 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.
9. Biophysical Chemistry, 1st edition (1980), C.R. Cantor, P.R. Schimmel, W.H. Freeman and Company. ISBN-13: 9780716711889.
10. Crystallography Made Crystal Clear: Guide for Users of Macromolecular Models, 3rd edition (2010), Gale Rhodes, Academic Press. ISBN: 9780080455549.
11. Introduction to Protein Structure, 2nd edition (1999), C. Branden and J. Tooze, Garland Publishing, ISBN-13: 978-0815323051.

Semester V

BMS 502: Pharmacology

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)**

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

Unit II: Pharmacokinetics **(08 Lectures)**

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)**

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)**

(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 autocoids **(04 Lectures)**

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

Unit VI: Chemotherapy of microbial diseases **(06 Lectures)**

Antibacterial (sulfonamides), antifungal (amphotericin B).

Unit VII: Horomones and hormone antagonists (08 Lectures)

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

PRACTICALS

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

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

SUGGESTED READINGS

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 VI

BMS 601: Human Pathology

***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)**

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)**

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)**

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)**

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

Unit V: Hemodynamic Pathology **(5 Lectures)**

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

Unit VI: Nutritional diseases (5 Lectures)

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

Unit VII: Cell proliferation: Cancer (6 Lectures)

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)

A. Aetiology and Pathophysiology of:
Diabetes, Arteriosclerosis, Myocardial infarction, restrictive and obstructive respiratory diseases (COPD), Parkinson, Schizophrenia, Silicosis
B. Infectious Diseases: Pathogenesis of diseases and overview of modes of infections, prevention and control with suitable examples like Typhoid, Dengue

PRACTICALS

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

1. Urine Analysis: Gross examination of urine for colour, odour etc. Abnormal constituents like protein, ketone bodies, glucose, blood, urea (any three)
2. Tissue Processing, embedding, sectioning. Staining and preparation of permanent histological slide.
3. Study of histological slides showing hypertrophy, hyperplasia, dysplasia, leukemia, cirrhosis and any common cancer.
4. Diagnostic tests for detection of various Diseases – CRP, VDRL, RA, Pregnancy, Dengue and HIV (any four)
5. Physiological data acquisition like Temperature EEG
6. PCR based diagnostics (for any one disease)
7. Measurement of Erythrocyte Sedimentation Rate.

SUGGESTED READINGS

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

Semester VI

BMS 602: Toxicology

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 **(2 Lectures)**

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

Unit II: Toxic exposure and response **(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 **(2 Lectures)**

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

Unit IV: Mechanism of toxicity **(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 **(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)

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)

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)

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

PRACTICALS

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

1. Separation of a mixture of benzoic acid, beta- napthol and napthelene 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.

SUGGESTED READINGS

1. Cassarett and Doull's Toxicology "The Basic Science of The Poisons" 7th edition (2008), Curtis D. Klaassen Editor, McGrawHill Medical. ISBN: 9780071470513.
2. Cassarett and Doull's "Essentials of Toxicology" 2nd edition (2010), Klaassen and Whatkins, McGraw Hill Publisher. ISBN-13: 978-0071622400.
3. Introduction to Toxicology, 3rd edition (2001), John Timbrell, Taylor and Francis Publishers. ISBN 13: 9780415247627.
4. Principles of Toxicology, 2nd edition (2006), Stine Karen and Thomas M Brown, CRC press. ISBN-13: 978-0849328565.
5. Lu's basic toxicology: Fundamentals target organ and risk assessment, 5th edition (2009), Frank C Lu and Sam Kacow, Informa Health care. ISBN: 9781420093117.

Skill Enhancement Courses (SEC)

B.Sc. (Hons) Course in Biomedical Science

SEC: Skill Enhancement Courses

BMS-S1: Methods in Epidemiological Data Analysis (EDA)

BMS-S2: Medical Laboratory Diagnostics (MLD)

BMS-S3: Techniques for Forensic Science

BMS-S4: Tools in Modern Biology

In alphabetical order

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

BMS-S1: Methods for Epidemiological Data Analysis

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 4 Lectures)

Unit I: Understanding Epidemiological Data (1 session)

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)

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)

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)**

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.

SUGGESTED READINGS

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.
3. Basic epidemiology,2nd edition (2006), R. Bonita, R. Beaglehole, TordKjellstrèom, Contributor; World Health Organization, illustrated, Publisher: World Health Organization, ISBN-13: 978-9241547079.
4. Biostatistics: A Foundation for Analysis in the Health Sciences, 10th edition (2013), Wayne W Daniel and Chad L. Cross, Wiley. ISBN-13: 978-1118302798.
5. Principles of Biostatistics,2nd edition (2000), Marcello Pagano and KimberleeGauvrean, Thompson learning. ISBN-13: 978-0534229023.
6. 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/

BMS-S2: Medical Lab Diagnostics (MLD)

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 4 Lectures)

Unit I: Fundamentals of Clinical Diagnostics (2 sessions)

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)**

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. Innoculation, 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)

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, Acylatedhaemoglobin 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)

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.

SUGGESTED READINGS

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

BMS-S3 Techniques for Forensic Science

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 4 Lectures)

Unit I: Crime Scene Investigation (2 Sessions)

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)

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)

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)

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 (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 (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 (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 (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.

SUGGESTED READINGS

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

BMS-S4: Tools in Modern Biology

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 4 Lectures)

Unit I: Plasmids and Biotechnology (3 sessions)

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)

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)

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 (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.

SUGGESTED READINGS

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.
5. Principles of Gene Manipulation and Genomics, 7th edition (2006), S.B. Primrose and R.M. Twyman. Blackwell Scientific ISBN-13: 978-1405135443.
6. 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.
7. 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.
8. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, 6th edition (2010), ISBN-13: 978-0470528129.

Discipline Specific Elective (DSE) Courses

B.Sc. (Hons) Course in Biomedical Science

DSE: Discipline Specific Elective (Theory + Practical*)

BMS-A: Computational Biology and Drug Discovery
BMS-B: Genome Organization and Function
BMS-C: Human Genetics
BMS-D: Medical Biochemistry
BMS-E: Medical Biotechnology
BMS-F: Project Work
In alphabetical order

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

BMS-A: Computational Biology and Drug Design

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 **(2 Lectures)**
What is computational biology and bioinformatics, internet and bioinformatics, chemoinformatics. Introduction to linux and common terminal commands.

Unit II: Biological databases and genome browsers **(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 **(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 **(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 **(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)**
Drug life cycle, stages of drug discovery and strategic issues in drug discovery.

Unit VII: Lead generation (6 Lectures)

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)

HTS, clinical trials, applications of chemoinformatics in drug research (chemical libraries, protein 3D modeling, characterization of binding site, virtual screening, protein-ligand interactions, prediction of pharmacological properties, Introduction to drug databases, PubChem and their use in drug development, Lipinski's rule of five, concept of energy minimization and force fields, introduction to rational drug design using example.

PRACTICALS

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

1. Retrieval of information from databases.
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.

SUGGESTED READINGS

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

BMS B: Genome Organization and Function

Preamble: The paper Genome Organization and Function 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 gens in bacteria and DNA of cell organelles to the abundance of repetitive DNA in higher organisms will be discussed. The paper concludes with an introduction to the Human genome project, its goals and features.

THEORY **Total Lectures: 48**

Unit I: Gene Regulation in Prokaryotes and Eukaryotes (20 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 II: Regulatory RNAs (08 Lectures)

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

Unit III: Human Genome Project (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 IV: Organization of the Human Genome (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

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

1. Preparation of various stock solutions for mentioned experiments.
2. Comparative analysis of genomic DNA and plasmid DNA by restriction enzyme digestion and estimation of size of a DNA fragment after electrophoresis using DNA markers
3. Quantification of unknown DNA using Lambda-HindIII marker
4. Preparation of human metaphase chromosome and Giemsa Staining
5. Perform Southern Hybridization.
6. SDS-Polyacrylamide Gel Electrophoresis for proteins
7. Demonstration of Western Blotting

SUGGESTED READINGS

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

BMS-C: Human Genetics

Preamble: This course is designed to develop an appreciation for the groundwork carried out so far in order to gain an insight into mechanisms of human genetic diseases, relate to how it has been built on the numerous genetic studies carried out over decades to contribute to the understanding of relationship between genotype and phenotype. The time is poised for understanding human as a model organism. The course will also introduce the methods for whole genome analysis and the genome sequencing.

THEORY **Total Lectures: 48**

Unit I: History of Human Genetics **(1 Lecture)**

Early Greek concepts about inheritance, Cytogenetics history (the works of Winiwater, Painter and Tjio and Levan), Landmark achievements of Galton, Garrod etc.

Unit II: Patterns of Inheritance for Monogenic Traits **(5 Lectures)**

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

Unit III: Human Genome Project **(4 Lectures)**

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

Unit IV: Organization of the Human Genome **(3 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

Unit V: Techniques for Genomics **(6 Lectures)**

DNA sequencing (Maxam-Gilbert and Sanger Method, introduction to NGS), DNA fingerprinting, polymorphism screening (genotyping of SNPs and microsatellite markers), expression and proteome analysis (microarray, 2-D analysis, pull down assays)

Unit VI: Population Genetics **(3 Lectures)**

Genotypic and allelic frequencies, linkage disequilibrium, haplotype construction (two loci using SNPs and/or microsatellites)

Unit VII: Mapping strategies **(3 Lectures)**

Physical maps (different types- restriction, cytogenetic maps, use of FISH in physical mapping, radiation hybrids and clone libraries in STS mapping) and genetic maps

Unit VIII: Identification of Genetic Basis of Disease (3 Lectures)

Principles and strategies, positional and candidate gene approaches, positional- cloning approach (examples- HD, CFTR), concept of twin and adoption studies

Unit IX: Prenatal Diagnosis (2 Lectures)

Brief introduction, methods of prenatal diagnosis

Unit X: Clinical Genetics: (4 Lectures)

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

Unit XI: Implications of Genome Research: (4 Lectures)

Diagnosis and screening of genetic disorders**,** prenatal genotyping for mutations in β- globin gene and sickle cell anemia**,** DNA profiling: establishing identity and relationships**,** applications in personalized medicine (genetic polymorphism in drug metabolism genes e.g. cytP450 and GST and their effect on drug metabolism and drug response)**,** genetic counseling

Unit XII: Guided short project (10 Lectures)

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

PRACTICALS

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

1. PTC testing to prove monogenic inheritance.
2. Demonstration of DNA fingerprinting.
3. Polymorphism analysis using PCR.
4. Mapping of clones/STS on plasmids or BACs.
5. Video based demonstration of tools for prenatal diagnosis.
6. Haplotype construction.
7. Web based analysis: retrieval of a desired human sequence from NCBI database and sequence alignment using BLAST.

SUGGESTED READINGS

1. Strachan and Read. Human Molecular Genetics.4th Edition. Garland Science, 2010. ISBN: 978-0815341499.
2. Cantor and Smith. Genomics, 2002, John Wiley and Sons, Inc. ISBN: 9780471599081.
3. J.N. Pasternak. An introduction to Human Molecular Genetics, 2nd Edition, Wiley-Liss, 2005. ISBN: 978-0-471-47426-5.
4. G.N. Wilson. Clinical Genetics: A short Course. Wiley-Liss, 2000. ISBN: 978-0471298069.
5. Vogel and Motulsky, Human Genetics: Problems and Approaches, 3rd Edition, Springer Verlag, 1997. ISBN: 978-3-540-37653-8.
6. T.A. Brown. Genomes, 2nd edition, Oxford: Wiley-Liss; 2002. ISBN-10: 0-471-25046-5.

BMS D: Medical Biochemistry

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 I: Basic Concepts and Scope **(02 Lectures)**

Unit II: Enzymes: Distribution and diagnostic significance **(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 III: Hormones **(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 **(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: Types of Lipoproteins (chylomicrons, 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)**

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)**

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 role of leptin, ghrelin and other hormones in regulation of body mass.

PRACTICALS

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

1. Preparation of 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 estimations performed.

SUGGESTED READINGS

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
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, 7thedition (2007), Chatterjea&Shinde, Jaypee Publications, ISBN: 81-8448-134-9.
5. Biochemistry, J. M. Berg, J. L. Tymoczko and L. Stryer, 6th edition (2006), W. H. Freeman and Co. ISBN-13: 978-0716787242
6. Fundamentals of Biochemistry: Life at the Molecular Level, 4th edition (2012), Donald Voet, Judith G. Voet, Charlotte W. Pratt; Wiley, ISBN-13: 978-0470547847

BMS E: Medical Biotechnology

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 Lectures: 48**

Unit I: **Introduction to Biotechnology** **(1 Lecture)**

Brief history and Importance

Unit II: **Basic techniques** **(4 Lectures)**

Agarose gel electrophoresis, Southern and Western blotting and hybridization, use of enzymatic and chemiluminiscent methods for detection of proteins, preparation of labeled probes.

Unit III: **Manipulation of DNA** (**5 Lectures)**

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)**

Basic biology of plasmids, Plasmid vectors (pBR322 and pUC vectors, T-vectors) and phage vectors (Bacteriophage vectors- replacement and insertion vectors), cosmids, *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)**

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

Unit VI: **Polymerase chain reaction (PCR)** **(4 Lectures)**

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)**

Immunochemical methods of screening, nucleic 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)**

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)**

(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)**

PRACTICALS

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

1. To 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.

SUGGESTED READINGS

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.
3. 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.
4. DNA Replication, 2nd edition (1992), Arthur Kornberg; University Science Books, ISBN -13:978- 0716720034.
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), Three-volume set by Michael R. Green, Joseph Sambrook; Cold Spring Harbor Laboratory Press, ISBN-13: 978-1936113422.

Generic Elective (GE) Courses

B.Sc. (Hons) Course in Biomedical Science

GE: Generic Elective Courses

BMS-G1: Basics of Immunology

BMS-G2: Biological Chemistry

BMS-G3: Biosafety and Bioethics

BMS-G4: Biostatistics

BMS-G5: Bridging Information Technology and Biotechnology

BMS-G6: Concepts in Biotechnology

BMS-G7: Concepts in Medicinal Chemistry and Drug Development

BMS-G8: Intellectual Property Rights (IPR) for Biologists

BMS-G9: Pathological Basis of Diseases

BMS-G10: Pharmacology and Toxicology

BMS-G11: Tools and Model organisms in Biomedical Research

In alphabetical order

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

BMS G1: Basics of Immunology

Preamble: Immunology is the study that helps us to distinguish between self and non-self molecules and how our immune system mediates protection against attack by potentially infectious organisms. Malfunctioning of the immune system leads to a number of disorders and diseases. 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 elaborates the functional interrelationships of primary and secondary lymphoid organs and the residing cells, their function and regulation by the immune system.

THEORY **Total Lectures: 48**

Unit I: Overview **(02 Lectures)**

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

Unit II: Our immune system **(10 Lectures)**

(a) T and B lymphocyte, NK cells, monocytes and macrophages; neutrophils, eosinophils, basophils, mast cells and dendritic cells; thymus and bone marrow; lymph nodes, spleen.

(b) General overview of the Complement system: Components of the complement activation (classical pathway); biological consequence of complement activation.

Unit III: Immune response **(20 Lectures)**

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

Unit IV: Antigen-antibody interactions based immunological techniques (8 Lectures)

Concept of affinity and avidity, cross reactivity, precipitation, agglutination, immunodiffusion, ELISA.

Unit V: Vaccines (4 Lectures)

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

Unit VI: Dysfunctions of immune system (4 Lectures)

Types of hypersensitivity, overview of autoimmunity. Immunodeficiency disorders: Animal models of primary immunodeficiency (nude mouse and SCID mouse).

PRACTICALS

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

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

SUGGESTED READINGS

1. Immunology, 6th edition, (2006), J. Kuby et al, W.H. Freeman and Company, New York. ISBN-13: 978-1429202114.
2. Microbiology, 7th edition, (2008), Prescott, L., John Ii Harley, Donald A. Klein, McGraw Hill. ISBN-13: 978-0071102315.

BMS-G2: Biological Chemistry

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

Total Lectures: 48

Unit 1: Ionic Equilibria (10 Lectures)

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases(concept of pKa), pH scale and effect of pH on the structure of biomolecules. Common ion effect. Buffer solutions and its action, Henderson-Hasselbach equation, buffering zone, buffer index. Solubility and solubility product of sparingly soluble salts - applications of solubility product principle. Qualitative treatment of acid base titration curves (NaOH vs HCl, mono amino acid), isoelectric point, concept of pI and zwitter ion.

Unit 2: Application of Chemical Bonding and Molecular Structure in Biomolecules

(10 Lectures)

Ionic Bonding: General characteristics of ionic bonding. Lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Polarizing power and polarizability, Fajan's rules, ionic character in covalent compounds.

Covalent bonding: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements.

Coordinate bonding:

Quantum numbers, Shapes of s, p and d atomic orbitals. Rules for filling electrons in various orbitals, Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, anomalous electronic configurations.

Transition elements- General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, and ability to form complexes. Stability of various oxidation states IUPAC nomenclature of coordination compounds, Werner's theory, valence bond theory (inner and outer orbital complexes), back bonding. Crystal field theory , shape of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Structure of Biomolecules- Haemoglobin, Nucleotides, Ascorbic acid.

Unit 3: Fundamentals of Organic Chemistry (10 Lectures)

Concept of hybridization of carbon. Cleavage of a covalent bond: homolysis and heterolysis. Electronic effects and their applications (inductive, electromeric, hyperconjugation and resonance). Structure and stability of reactive intermediates (carbocations, carbanions and free radicals). Relative acid strength: carboxylic acids (aliphatic, aromatic and halo-substituted aliphatic), alcohols, phenols. Relative basic strength of amines (aliphatic and aromatic).

Intermolecular and intramolecular forces, Types of intermolecular forces and their characteristics-ion-dipole, dipole-dipole, dipole-induced dipole and dispersion forces. Intermolecular and intramolecular hydrogen bonding. Effect of intermolecular and intramolecular forces on properties such as solubility, vapour pressure, melting and boiling points of organic compounds and effect of inter/intra-molecular forces on structure of different biomolecules-peptides and nucleotides.

Unit 4: Stereochemistry (10 Lectures)

Conformations w.r.t. ethane, butane, angle strain, cyclohexane and substituted cyclohexane,. Interconversion of Wedge Formula, Newman, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms).

Configuration: Geometrical- *cis* - *trans* nomenclature; CIP Rules and E / Z Nomenclature (for upto two C=C systems), Threo and erythro,

Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds), R/ S (for upto 2 chiral carbon atoms).

D and L nomenclature, General Properties of Glucose and Fructose (open chain and cyclic structure- Haworth projection), configuration and absolute configuration of Glucose and Fructose , Mutarotation, epimers, anomers (Glycosidic linkage, reducing and non-reducing sugars).

Unit 5: Reaction Mechanism and name reactions (8 Lectures)

Addition Reactions: Hydrohalogenation (Markovnikov's and anti-Markovnikov's addition), addition in α-β unsaturated carbonyl compounds.

Nucleophilic substitution reactions: mechanism of SN_1 and SN_2 reactions, Walden inversion.

Electrophilic Substitution Reactions (aromatic compounds): General mechanism of electrophilic substitution reactions (nitration, halogenation, sulphonation, Friedel Crafts alkylation and acylation), directive influence of substituents.

Biologically significant name reactions: Aldol (Glucogenesis), retro-aldol (Glycocolysis), Benzoin condesation (umpolung-decarboxylation of pyruvate in the presence of TPP) Claisen condensation (Synthesis of fatty acids), Knoevenagel (Application in drug synthesis), Michael addition (Dehydrases), Cannizzaro and Cross Cannizzaro (Sugar metabolism), Bayer Villiger reaction (FAD dependent ketone synthesis), Pinacole-pinacolone rearrangement (1,2-carbon carbon shift), Hoffmann bromamide degradation (synthesis of amine from amide).

PRACTICALS

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

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

2. Preparation of buffers.

3. Estimation of Mohr's salt/ oxalic acid by titrating with $KMNO_4$.

4. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.

5. Qualitative tests for carbohydrates to identify the given unknown carbohydrate solution: Mohlisch, Barfoed, Fehling/ Tollen/ Benedict, Selvinoff, Osazone, Bial'stests.

6. To determine the optical rotation of a biomolecule.

7. To find pKa value of given acetic acid/ amino acid.

8. Absorption spectrum of DNA/ Protein

9. Estimation of (i) Mg2+ or (ii) Zn2+ by complexometric titration using EDTA

SUGGESTED READINGS

1. Concise Inorganic Chemistry, 5th edition (1999), J. D. Lee; Wiley-Blackwell, ISBN-13: 9780632052936.

2. Organic Chemistry, 6th edition (1996), I L Finar (volume I and II); ELBS, Longman Higher Education. ISBN-13: 978-0582305601.

3. Barrow, G. M. Physical Chemistry Tata McGraw-Hill (2007). ISBN 13, 9780074620311 .

4. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004). ISBN 978-81-85015-59-0.

5. T. W. Graham Solomons: Organic Chemistry, John Wiley and Sons. ISBN-13: 978-1-118-14790-0.

6. L. Eliel: Stereochemistry of Carbon Compounds, Tata McGraw Hill. ISBN 13 9780070992900.

7. Organic Chemistry, 6th edition (1992), R. T. Morrison and R. N. Boyd; Pearson Education. ISBN-13: 9780136436690.

8. Bioorganic Chemistry, 3rd edition (1999), Hermann Dugas; Springer Verlag. ISBN-13: 978-0387989105

9. Atkins, P.W. & Paula, J. Physical Chemistry, Oxford Press, 2006. ISBN**:** 0-7167-8759-8

10. Huheey, J.E. Inorganic Chemistry, Prentice Hall 1993. ISBN: 0-06-642995-X

11. Vogel's Quantitative Inorganic Analysis, A.I. Vogel, Prentice Hall, 6th Edition. ISBN13: 978-0582226289

12. Senior practical Physical Chemistry, B.D. Khosla, R. Chand & Co. ISBN-13: 9788180450792

13. An Introduction to Practical Biochemistry, 3rd edition (1987), Plummer, McGraw-Hill College; ISBN-13: 978-0070841659

BMS-G3: Biosafety and Bioethics

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 not only affect us but also the plants, microflora, animals and the entire environment and the way we practice agriculture, medicine and food processing. An increase in our ability to change life forms in recent years has given rise to the new science of bioethics. 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 **(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 **(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 **(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 **(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)**

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

Unit VI: Foundation of Bioethics **(02Lectures)**

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

Unit VII: Codes, Covenants, Declarations and Guidelines **(05 Lectures)**

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)**

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 **(03Lectures)**

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)**

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

Unit XI: Critical care ethics **(04 Lectures)**

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 **(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 **(01 Lecture)**

PRACTICALS

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

1. A case study based on genetic modified organism (Bt-Cotton).
2. A case study based on genetic modified organism (Bt-Brinjal).
3. A case study based on terminator seeds.
4. A case study based on 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.

SUGGESTED READINGS

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.
4. 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.
5. Principles of Biomedical Ethics, 6th edition (2011), Beauchamp Tl, Childress JF; Oxford University Press, 2001. ISBN-13: 978-0195143317.
6. A Companion to Bioethics, 2nd edition (2012), Helga Kuhse, Peter Singer; John Wiley and Sons, ISBN-13: 978-1444350845.
7. 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.
8. Genetically Modified Organisms and biosafety, 1st edition (2004), Tomme Young. ISBN-13: 978-2831707983.
9. Environmental Safety of Genetically Engineered Crops, 1st edition (2011), Rebecca Grumet, James F. Hancock, Karim M. Maredia, CholaniWeebadde, Michigan State University Press ISBN-13: 978-1611860085.
10. Biosafety and Bioethics, 1st edition (2006), Rajmohan Joshi; Isha Books ISBN-13: 978-8182053779.
11. Bioethics and biosafety in biotechnology, 1st edition (2007), V. Sreekrishna; New Age International (P) Ltd., ISBN-13: 978-8122420852.

BMS-G4: Biostatistics

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

THEORY **Total Lectures: 48**

Unit I: Descriptive Statistics (13 lectures)

a) Data in Biology: Development in biostatistics, samples and populations, techniques of sampling (random and stratified), sampling and non-sampling errors, variables in biology, accuracy, precision, univariate and bivariate frequency distributions and their graphical representations**.**
b) Measures of Central Tendency: Arithmetic, geometric and harmonic means, mode, median and partition values.
c) Measures of Dispersion: Range, standard deviation, coefficient of variance and covariance.
d) Moments: Raw and central moments and their relationships.
e) Measures of Skewness: Pearson's, Bowley's and Kelly's coefficients of skewness; coefficient of skewness using moments.
f) Measures of Kurtosis.

Unit II: Probability and Probability Distributions (15 lectures)

a) Probability: Basic concepts, addition and multiplication rules of probability, conditional probability, Bayes' theorem and its applications in biostatistics.
b) Random variables: discrete and continuous.
c) Mathematical Expectation and Variance: definition and properties.
d) Probability Distributions: Probability mass function, probability density function and distribution function. Binomial distribution, Poisson distribution, normal distribution and exponential distribution along with their properties and relationships.

Unit III: Correlation and Linear Regression (05 lectures)

a) Correlation Analysis: Scatter diagrams, Pearson's and Spearman's coefficients of correlation, coefficient of determination, standard and probable errors.
b) Regression Analysis: Method of least squares, equations of lines of regression and their applications in biostatistics.

Unit IV: Hypothesis Testing: (15 lectures)

a) 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.
b) Large sample tests for single mean and difference of means, single proportion and difference of proportions.

c) Student's t-distribution: test for single mean, difference of means and paired t- test, chi-square distribution: tests for goodness of fit, independence of attributes and homogeneity, F-distribution, one-way and two-way analysis of variance (ANOVA).
d) Non-parametric analysis: Sign and run tests.

PRACTICALS

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

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

SUGGESTED READINGS

1. Primer of Biostatistics, 7th edition (2011), Stanton Glantz, McGraw-Hill Medical. ISBN-13: 978-0071781503.
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 KimberleeGauvrean, Thompson learning. ISBN-13: 978-0534229023.
4. Biostatistical Analysis, 5th edition (2009), Jerrold H. Zar, Pearson. ISBN-13: 978-0131008465.

BMS-G5: Bridging Information Technology and Biotechnology

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.

THEORY **Total Lectures: 48**

Unit I: Convergence of biotechnology and information technology (02 Lectures)
Introduction to bioinformatics and its applications, Internet and bioinformatics.

Unit II: Databases and genome browsers (08 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 (08 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.

Unit IV: Theory behind BLAST (04 Lectures)
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 (05 Lectures)
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 (03 Lectures)
The Ontologies: cellular component, biological process and molecular function.

Unit VII: Genome analysis (05 Lectures)
Features of DNA sequence analysis, gene prediction methods, SNP analysis (dbSNP), sequence assembly and genome annotation.

Unit VIII: Restriction site mapping and primer design (06 Lectures)
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 (04 Lectures)

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 (03 Lectures)

PCR diagnostic design, design strategy for over-expression of a therapeutic protein using specific examples to illustrate the strategy.

PRACTICALS

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

1. Retrieval of information from 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.

SUGGESTED READINGS

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.

BMS-G6: Concepts in Biotechnology

Preamble: The unique preposition of this paper is that the students learn the basic techniques and methods used in biotechnology. This paper aims to train students to understand how biological systems are applied in the advancement of biotechnology.

THEORY **Total Lectures: 48**

Unit I: **Introduction** **(1 Lecture)**

Brief history and importance

Unit II: **Basic techniques** **(6 Lectures)**

Isolation and purification of genomic and plasmid DNA, Agarose and polyacrylamide gel electrophoresis, blotting and hybridization of nucleic acids and protein (probes and detection methods- radioactive, fluorescent, enzymatic and chemiluminiscent).

Unit III: **DNA modification** (**5 Lectures)**

Restriction endonucleases: Restriction and modification systems, naming of restriction enzymes, isoshizomers etc, type I-IV, nomenclature and sequence recognition, restriction mapping.
Joining of DNA molecules: sticky end and blunt end ligations, role of DNA ligase, reaction mechanism of ligation in viruses and bacteria, adaptors, linkers, homopolymer tailing.

Unit IV: **Cloning** **(10 Lectures)**

Vectors: Plasmids (pBR322 and pUC vectors, T-vectors), Bacteriophage (replacement and insertion vectors), cosmids, phasmids;*in vitro* packaging; expression vectors (example of prokaryotic and eukaryotic expression vectors);shuttle vectors.

Challenges in expression of foreign proteins in heterologous host, factors affecting the expression, expression in eukaryotic cells (yeast and mammalian expression system, Baculovirus system), Bacterial transformation and selection and screening of transformants (blue/white and antibiotic selection methods).

Unit V: **Amplification and Sequencing of DNA** **(10 Lectures)**

Polymerase Chain Reaction (PCR): Principle, types of DNA polymerases, primer designing, hot start and its importance in PCR, types of PCR (,nested, multiplex, inverse and touchdown) and their applications.

RT-PCR (Reverse transcription PCR): Reverse transcriptase, cDNA and applications.

Sequencing: Chemical (Maxam Gilbert) and Enzymatic (Sanger's dideoxy) methods, automated DNA sequencing concept.

Unit VI: **DNA Profiling** **(4 Lectures)**

Restriction Fragment Length Polymorphism (RFLP), Asymmetric Fragment Length Polymorphism (AFLP), Short Tandem Repeats (STRs), Variable Number Tandem Repeats (VNTR), Single Nucleotide Polymorphisms (SNP) and their applications.

Unit VI: **Genomic and cDNA libraries** **(5 Lectures)**

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

Unit VII: Application of Biotechnology **(5 Lectures)**

Protein engineering concept and examples of Subtilisin, and alpha-Antitrypsin (AAT)

Production of recombinant biomolecules: Insulin, somatostatin, Factor VIII and interferons.

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 VIII: Biosafety and ethical issues **(2 Lectures)**

PRACTICALS

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

8. To prepare general media and reagents.
9. To perform genomic DNA isolation.
10. To perform plasmid DNA isolation.
11. To perform agarose gel electrophoresis.
12. To perform SDS PAGE.
13. To amplify DNA using PCR.
14. To perform restriction digestion of plasmid DNA.
15. To analyze DNA sequence from autoradiogram/ electropherogram.
16. To demonstrate DNA fingerprinting.

SUGGESTED READINGS

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

9. 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.
10. DNA Replication, 2nd edition (1992), Arthur Kornberg; University Science Books, ISBN -13:978- 0716720034.
11. Genomics: The Science and Technology behind the Human Genome Project, 1st edition (1999), Cantor and Smith; John Wiley and Sons, ISBN-13:978-0471599081.
12. 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.

BMS-G7: Concepts in Medicinal Chemistry and Drug Development

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 **(02 Lectures)**

Definition and scope of drug design.

Unit II: Drug target classification **(08 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 **(08 Lectures)**

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

Unit IV: Drug receptor interactions **(08 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 **(08 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 pharmainformatics **(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

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

1. Preparation of 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.

SUGGESTED READINGS

1. Introduction to Medicinal Chemistry, 4th edition (2009), Graham l. 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.

BMS-G8: Intellectual Property Rights for Biologists

Preamble: *Developments in the recent years has increased the knowledge acquisition process, which is considered to have commercial value as well. The knowledge pool so generated can be considered as intellectual property which has grown tremendously in academic community and society at large. The pace with which our modern science is progressing today, various new and useful inventions take place. Through this paper, students are made aware to understand the need for creation, protection, and commercialization of intellectual property in the area. Various forms of Intellectual Property Rights are also explained. Paper also deals with the entire process of patent filling, taking some case studies.*

THEORY **Total Lectures: 48**

1. **Introduction to IPR** **(02 lectures)**
   Importance of IPR, advantages of IP protection, relationship with trade, Product / design patent and Terminologies.

2. **Types of IPRs** **(08 lectures)**
   Copyrights, trademarks, Trade Secrets, Patents, and Geographical indicators, IC layout design, plant variety protection.
   - **Copyrights** - Nature of Copyright, Author & ownership of Copyright, Rights Conferred by Copyright, Assignment, Transmission, Licensing of Copyrights, Copyright Societies, Office, Board, Registration of Copyrights & Appeals, International Conventions, Copyright pertaining to Software/Internet, Database, Copyright Protection/Database Protection, IP issues in cyber space, Legal Position in USA/Indian Law/WIPO Copyright Treaty
   - **Trademarks**- Meaning of Trademarks, Different kinds of marks (brand names, logos, signatures, symbols), Use of a Mark, Registration of Trademarks-Procedure, Opposition to Registration-Procedure, What Marks are Registrable/Not Registrable, Concurrent Registration, Similarity of Marks, Assignment/Transmission/Licensing of Trademarks, Infringement of Trademarks, Passing off Action.
   - **Patents**-
     i. General Introduction: Definition, Product / **Process** /Design Patents Claims, Dates Associated with patent, Patent Life and Geographical Boundaries, Patent Infringement, Utilization of Intellectual Assets, Ownership of Patents.
     ii. Patent Search, Patent Databases & Library (USPTO, WIPO, EPO), Practical Search Training.
     iii. Patent Terminology: (Abstract, Summary, Background, Drawings, Description, Claims)

- **Geographical Indicators**- Nature of Geographical Indicators, Conditions & Procedure for Registration, Offences, Penalties.

3. Biotechnology and the expanding boundaries of IP protection (02 lectures)
Biotechnology and Life Science Industries, Commercial importance of biogenetic resources.

4. **Highlights of Indian patent Law** (as amended in 2005) **(04 lectures)**
Elements of patentability - Patentable subject matter, Utility, novelty and non-obviousness, Patentability of biotechnological inventions –, biochemical and software.

5. Worldwide patent protection (04 lectures)
Paris Convention, World Trade Organization, World Intellectual Property organization, TRIPS Agreement, PCT, UPOV convention, Convention on Biological Diversity, Biopiracy, Traditional knowledge and benefit sharing.

6. **Patents filing (05 lectures)**
Patent filing in India and abroad, Building patent databases and library generation, Preparation of patent documents, Process for examination of patents, Patent Evaluation and Economics of patenting.

7. Intellectual property exploitation and management, Licensing and Technology transfer. **(02 lectures)**

8. **Case studies (06 lectures)**
(a) Infringement cases; (b) Biopiracy cases *(Hoodia case, the Quinoa case, the Enola bean case, The neem patents);* (c) Traditional knowledge and IP system; (d) Patents as assets; (e) Trade secrets; (f) Drug pricing as a result of patent filing. (f) Patenting of genetically-engineered micro-organism (Diamond Vs Chakravarthy); (g) Recent cases related to the provisions of Section 3(d) of The Patents Act (Novartis vs Generic Manufacturers, Roche vs Cipla, Astra Zeneca Vs Natco Pharma).

9. **Forums, Processes and Initiatives (05 lectures)**
(a) International: Conference of the parties to the convention on Biological diversity. (b) INDIA: Biodiversity conservation, trade and development, India's bio-scientific and technological capacities, implementing TRIPS, Regulatory Framework in Biotech Industry and Pharma setup in India, Clinical trials.

10. **Key Business concerns in commercializing Intellectual Property Rights (10 lectures)**
Competition and Confidentiality issues, Antitrust Laws; Employee Confidentiality; Assignment of Intellectual Property Rights; Technology Transfer Agreements; Intellectual Property Issues in the Sale of Business.
Future Developments of Intellectual Property Rights–Indian Traditional Medicine & IP Protection, Folklore, Patenting of Life Forms, International-Traditional Medicines & Health Foods

SUGGESTED READINGS

1. Prabuddha Ganguli – Intellectual property rights : unleashing the knowledge economy, Tata McGraw Hill Publishing.
2. Wadhera, Intellectual property Rights.
3. Patent law / by P Narayanan (Highly Recommended)
4. Selected Reading from Landis
5. The Patents Act (1970), with latest Amendments.
6. Manual of patent practice and procedure: Indian patent office website.

BMS-G9: Pathological basis of diseases

Preamble: Claude Bernad once said "Effects vary with the conditions which bring them to pass, but laws do not vary. Physiology and pathology states are ruled by the same forces; they differ only because of the special conditions under which the vital laws manifest themselves". 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** **(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 **(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)** **(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) (**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) (6Lectures)**

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

Unit VI: Nutritional diseases **(5 Lectures)**

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

Unit VII: Cancer (**7 Lectures)**

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)**

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

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

1. Urine analysis for abnormal constituents: protein, fats and glucose
2. 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)

SUGGESTED READINGS

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 B0007CBHKI.
5. Medical Laboratory Technology Methods and Interpretations, 6th edition (2009), Ramnik. Sood; Jaypee Brothers Medical Publishers, ISBN-13: 978-8184484496.
6. Pathophysiology, 3rd edition (2012), Lee-Ellen C. Copstead-Kirkhorn and Publisher. Saunders. ISBN-13: 978-1455726509.

BMS-G10: Pharmacology and Toxicology

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)**

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)**

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

Unit III: Pharmacokinetics (**6 Lectures)**

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)**

Mechanism of drug action, receptors and receptors subtypes, Dose response relationship and combined effect of drugs. Concept of LD_{50}, LC_{50}, TD_{50} and therapeutic index.

Unit V: Introduction and classification of the drugs acting on:

a. Central and autonomic nervous system, neurotoxic agents. **(6 Lectures)**
b. Cardiovascular system and cardiotoxic agents. **(6 Lectures)**
c. Kidney and nephrotoxic agents. **(4 Lectures)**

Unit VI: Introduction and classification

a. Anti-inflammatory and analgesic drugs and their related toxicity. **(4 Lectures)**
b. Endocrine drugs **(2 Lectures)**
c. Antimicrobial chemotherapeutic drugs **(2 Lectures)**

PRACTICALS

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

1. Handling of laboratory animals and various routes of drug administration.
2. To study presence of paracetamol/aspirin in the given sample.
3. Separation of a mixture of benzoic acid, beta- napthol and napthelene by solvent extraction and identification of their functional groups.
4. Determination of Dissolved water (DO) using Winkler'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.

SUGGESTED READINGS

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, McGrawHill Medical. ISBN-13: 978-0071470513.
4. Introduction to Toxicology, 3rd edition (2001), John Timbrell, Taylor and Francis Publishers. ISBN-13: 978-0415247627.
5. Cassarett and Doull's "Essentials of Toxicology", 2nd edition (2010), Klaassen and Whatkins, McGraw Hill Publisher. ISBN-13: 978-0071622400.
6. Principles of Toxicology, 2nd edition (2006), Stine Karen and Thomas M Brown, CRC Press. ISBN-13: 978-0849328565.
7. Lu's basic toxicology: Fundamentals target organ and risk assessment, 5th edition (2009), Frank C Lu and Sam kacow, Informa Health care. ISBN: 9781420093117.

BMS-G11: Tools and Model Organisms in Biomedical Research

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

Unit II: Microscopy (3 Lectures)
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)
Chromatography: Principle and applications of affinity, gel filtration and ion exchange chromatography, HPLC
Centrifugation: Principle and different types of centrifugation- differential, density gradient and equilibrium.
Flow cytometry: Flurochromes, fluorescent probe and principle, application in biomedical science.

Unit IV: Molecular Biology Methods (8 Lectures)
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)
Monoclonal antibody generation, isolation of various immune cells and their functional assays, generation and applications of nude mice. ELISA - direct, indirect, competitive and sandwich ELISA, Co-immuno-precipitation for protein-protein interaction studies.

Unit VI: Introduction to model organisms **(2 Lectures)**

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

Unit VII: Different model organisms

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.

Daniorerio **(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

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

1. Isolation and spectroscopic quantification of genomic DNA from blood/tissue/ *E.coli*, determination of melting temperature of DNA.
2. Optimization of PCR conditions for temperature (gradient PCR) and Mg^{2+} concentration.
3. Restriction digestion of DNA for RFLP and DNA fingerprinting.
4. To perform Southern hybridization.
5. Protein purification by affinity/ion exchange/gel filtration chromatography.
6. To perform sandwich ELISA.
7. Preparation of culture media for *Drosophila* and study different stages of life cycle of *Drosophila.*
8. Study of life cycle of *Dictyostelium discoideum.*

SUGGESTED READINGS

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.
8. 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.
9. Concepts of Genetics, 10th edition, (2012). William S. Klug, Michael R. Cummings, Charlotte A. Spencer, Michael A. Palladino. ISBN-13: 978-0321724120.
10. Physical Biochemistry: Applications to Biochemistry and Molecular Biology, 2nd edition (1982), David Freifelder, W.H. Freeman and Company. ISBN-13: 978-0716714446.
11. Principles and Techniques of Biochemistry and Molecular Biology, 7th edition (2010), Wilson K and Walker J., Cambridge University Press, 2010. ISBN-13: 978-0521516358.
12. Emerging Model Organisms: A Laboratory Manual, Volume 2, Lab manual edition (2010), Cold Spring Harbor Laboratory Press, ISBN-13: 978-0879698652.