Appendix-53
Resolution No. 14-1 (14-1-6)

INDEX
BIOMEDICAL SCIENCE
Faculty of Science

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

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

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

Learning objectives

The students will learn

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

Learning outcomes

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

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

SYLLABUS OF BIOMED-DSC-10:

Unit I: Overview of Immune System (05 hrs)

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

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

Unit II: Innate Immune response (10 hrs)

Physical and Chemical barriers.

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

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

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

Concept of inflammation.

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

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

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

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

Unit IV: Adaptive Immune Response (10 hrs)

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

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

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

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

Concept of hypersensitivity.

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

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

Unit VI: Vaccines (05 hrs)

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

Practical (30 hrs)

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

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

Essential readings:

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

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

Suggestive readings:

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

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

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

Learning objectives

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

Learning outcomes

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

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

SYLLABUS OF BIOMED-DSC-11

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

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

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

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

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

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

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

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

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

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

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

Practical (30 hrs)

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

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

Essential readings:

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

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

Suggestive Readings

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

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

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

Learning objective

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

Learning outcomes

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

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

SYLLABUS OF BIOMED-DSC-12

Unit-I: Introduction to pharmacology (07 hrs)

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

Unit-II: Pharmacokinetics and pharmacodynamics (09 hrs)

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

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

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

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

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

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

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

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

Practical **(30 hrs)**

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

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

Essential reading

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

Suggestive readings

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

Pool of DSEs

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

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

Learning objectives

The Learning objectives of this course are as follows:

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

Learning outcomes

The Learning outcomes of this course are as follows:

- Having successfully completed this course, students shall be able to learn and appreciate:
- To integrate the biochemical pathways of different biomolecules; the point of divergence and convergence and will have a comprehensive overview of the metabolic and hormonal regulation of pathways and cycles.
- Students will understand how disruptions in intermediary metabolism can lead to manifestations of diseases. Additionally, hormonal actions in maintaining body mass shall be understood and factors leading to disorders such as obesity and diabetes will also be learnt.

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

SYLLABUS OF BIOMED-DSE-04

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

Basic Concepts and Scope of Medical Biochemistry.

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

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

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

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

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

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

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

Unit IV: Vitamins (7 hrs)

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

Practical (30 Hrs)

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

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

Essential Reading:

- Nelson, D.L. and Cox, M.M. (2021). *Lehninger: Principles of Biochemistry* (8th ed.). Macmillan. ISBN: 9781319322328

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

Suggestive reading

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

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

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

Learning objectives

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

Learning outcomes

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

- Students would be given a glimpse of extraction of fermentation products and maintenance of sterility in fermenters. Different types of nutritive products/beverages such as beers, wines, spirits, bread, single cell proteins can be obtained using fermenters.
- At the end of syllabus students would learn the process of waste water treatment by municipal corporations.

SYLLABUS OF BIOMED-DSE-05

Unit I: Scope of Industrial Microbiology (6 hrs)

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

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

Unit II: Industrial Microorganisms (8 hrs)

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

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

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

Basic Nutrient Requirements of Industrial Media; Criteria for the Choice of Raw Materials Used in Industrial Media; Raw Materials Used in Compounding Industrial Media; Potential Sources of Components of Industrial

Media; Use of Plant Waste Materials in Industrial Microbiology: Saccharification of Polysaccharides, Standard microbes used in Industry, like useful *E.coli* and *Pichia.*

Unit IV: Fermenters and its Operation (7 hrs)

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

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

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

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

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

Practical (30 hrs)

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

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

Essential Readings

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

Suggestive Readings

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

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			

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

Learning objectives

The Learning objectives of this course are as follows:

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

Learning outcomes

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

- Surroundings and environment, renewable/non-renewable natural resources and their exploitation. Sensitizing about environmental crisis can promote them to for search alternatives to reduce our dependence of non-renewable natural resources and their usage.
- Studies on pollution and deforestation will help them to understand their impact on environment and human health. Conservation of forests and recycling policies will promote social awareness about sustainable development.
- Learning about various methods of sustainable development is an important for skill development in students so that they can design better strategies to protect our environment.
- Generation of biomedical waste is alarmingly increasing but the awareness of appropriate waste disposal methods is completely lacking. Development of new methods for waste management and strategies in this area will help them to reduce and segregate waste at point source.
- At the end of this course, students will be able to understand the severity of the problem and influence of biohazards on human health

SYLLABUS OF BIOMED-DSE-06

Unit I: Environment and Environmental Crisis (08 hrs)

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

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

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

Unit III: Measures for Sustainable development (09 hrs)

Phytoremediation of chemopollutants, bioconversion of industrial wastes into value-added polyhydroxyalkanoate (eg sugar and oils), Role of fungal and bacterial resources in heavy metal/radioactive waste material contaminated soil remediation and ecological restoration, xenobiotics bioremediation using fungi, Impact of pesticides usage in agricultural practices on microbial communities and soil bioprocesses: a biochemical, physiological, and molecular perception; Possibilities of biofuel production from microalgae as renewable energy source for environmental sustainability, integrated algal industrial waste treatment and bioenergy generation

Unit IV: Biomedical waste management (07 hrs)

Definition and classification of biomedical waste, Infectious, non-infectious and chemical waste;

Waste management: designation of waste, segregation, packaging and transportation.
Treatment: steam sterilization, chemical disinfection, incineration, emerging treatment technologies, treated waste disposal, regulatory and advisory considerations, Training of supportive staff

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

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

Practical (30 hrs)

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

1. Document the Biological Wealth (flora and fauna) of your campus.
2. Calculate the water footprint of your organization.
3. Examine the current status of organization for waste management. Develop guidelines to reduce waste by improved methods of handling and disposing of wastes.
4. Plan guidelines for the safety of workers working at hazardous waste sites.
5. A case study on "Make sustainability more than just the right thing to Do"
6. A case study on handling and disposal of wastes.
7. Develop green design of organization to maintain and enrich the biological wealth.
8. Understandings of energy missions and follow up for classroom energy audit.
9. Prepare a questionnaire to asses knowledge, attitude and practices among students about Sustainable Development
10. Prepare a poster on Bio-augmentation and Bio-stimulation**.**
11. Make a poster on success stories of environment polices and movements that have reduced pollution or reversed diminishing populations of unique species.
12. Determine your carbon foot printing.

Essential readings

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

Suggestive readings:

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

SEMESTER-V
BIOMEDICAL SCIENCE

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

	Credits	Credit distribution of the course			

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

Learning objectives

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

Learning outcomes

- Students will acquire basic concepts of genome, its organization and maintenance, packaging of DNA into chromosome structure, changes in histone and chromosome remodeling proteins.
- Students will learn the concept of regulatory mechanisms governing over-expression and under-expression of genes. They will understand transcriptional and translational control in prokaryotes and in eukaryotes.
- Students will also learn about post-translational control-mRNA decay and Proteolysis. Students will understand regulatory RNA in prokaryotes and in eukaryotes (sRNA, riboswitches, CRISPER- Cas system, RNA interference, miRNA and siRNA, Piwi interacting RNA) and Regulatory RNA in X-inactivation.

SYLLABUS OF BIOMED-DSC- 13

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

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

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

Prokaryotic gene regulation- Histone like proteins, overlapping genes.

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

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

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

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

Difference between gene regulation in Prokaryotes and Eukaryotes. Cis-acting regulatory sequences- Promoters, Enhancers, Insulators, Boundary elements. Regulatory proteins-Activators, Repressors and Co-activators, their structure and mechanism of working, Structural difference among the different DNA binding domains, Regulation of LCR, Signal integration and Combinatorial control, Signal transduction pathways- MAP kinase and STAT pathways. Techniques for studying DNA-Protein interaction: EMSA, DNA foot printing, ChIP assay.

Unit-V: Regulatory RNAs (6 hrs)

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

RNA- structure, origin and working. Regulatory RNA and X-inactivation: long non-coding RNA. Mechanism of X-inactivation.

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

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

Practical (30 hrs)

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

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

Essential Readings

- Klug, W. S. Cummings, M. R. Spencer, C. A. and Palladino, M. A. Killian, D. (2019*).* 12th Edition*. Concepts of genetics.* San Francisco, USA: Benjamin Cummings Publishers. ISBN-13:978-0134604718

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

Suggestive Readings

- Karp, G. (2020). 9th Edition. *Cell and molecular biology: Concepts and experiments.* NewJersey, USA: Wiley Publishers, ISBN-13: 978-1119598244
- Cooper, G.M. and Hausman, R.E.(2013). 6th Edition. *The cell: A molecular approach.* Massachusetts, USA: Sinauer Associates. ISBN-13:978-1605351551.
- Green M.R. and Sambrook J. (2012). 4thEdition, (three-volume set). *Molecular cloning: A laboratory manual.* Cold Spring Harbor Laboratory Press. ISBN-13: 978-1936113422.
- Snustad, D. P. and Simmons, M. J. (2011). 6th Edition*. Principles of genetics.* New York, USA: John Wiley and Sons. ISBN-13: 978-0470903599.
- Hardin ,J. Bertoni, G. P. Kleinsmith, L.J. and Becker, W.M.(2008).7thEdition. *The world of the cell.* San Francisco, USA: Benjamin Cummings Publishers. ISBN-13:978-0805393934.
- Kornberg, A. (2005). 2nd Edition. *DNA replication.* California, USA: University Science Books. ISBN-13: 9781891389443.
- Cantor, C. R. and Smith, C. L. (1999). 1st Edition. *Genomics: The Science and technology behind the human genome project.* NewYork, USA: JohnWiley and Sons. ISBN-13:978-0471599081.

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

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

BIOMED-DSC-14							

Learning objectives

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

Learning outcomes

- Students will learn the contemporary techniques being applied in the field of medical biotechnology which include PCR, Gene Cloning, Gel electrophoresis etc.
- Students will gain a comprehensive understanding of DNA manipulation techniques and how to create recombinant DNA molecules by making a suitable choice of vectors and expression hosts.
- An in-depth understanding of gene cloning, expression in prokaryotic and eukaryotic systems and on the production of recombinant proteins shall prepare students to apply the gained knowledge on different organisms.
- Having grasped the fundamentals of recombinant DNA technology, its robust potential and the limitations & challenges, students shall discern the applications of biotechnology in human medicine. Their gained knowledge shall be imbued with a deeper understanding of the safety and limitations of molecular tools used in the diagnostics of infectious diseases, production of biopharmaceuticals and gene therapy.

SYLLABUS OF BIOMED-DSC-14

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

(13 hrs)

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

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

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

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

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

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

Unit IV: Applications of Medical Biotechnology (10hrs)

(a) Production of recombinant biopharmaceuticals: Insulin and Factor VIII.
(b) Gene Therapy: Strategies and limitations, Somatic and germline gene therapy, Vectors used in gene therapy (viral and non-viral) and their comparison.
(c) Polymerase chain reaction (PCR): Principle and applications. Importance of RT PCR in diagnosis of infectious diseases.
(d) Biosafety and ethical concerns in medical biotechnology.

Practical (30 hrs)

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

1. Plasmid DNA isolation
2. Designing of gene-specific primers

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

Essential Readings

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

Suggestive Readings

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

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

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

Learning objectives

The Learning objectives of this course are as follows:

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

Learning outcomes

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

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

SYLLABUS OF BIOMED-DSC-15

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

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

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

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

Unit-III: Hemodynamic Pathology (7 hrs)

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

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

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

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

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

Unit-VI: Pathophysiology of Diseases (8 hrs)

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

Practical (30 hrs)

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

1. Urine Analysis: Gross examination of urine for colour, odor etc. Abnormal constituents like protein, ketone bodies, glucose, blood, urea (any three)
2. Histopathology Tissue Processing, embedding, sectioning. Staining and preparation of permanent histological slides.
3. Study of four distinct stages of alcoholic liver disease through permanent slide.
4. Study of histological slides showing hypertrophy, hyperplasia, dysplasia, leukemia, cirrhosis
5. Hematological assessment: Study and analysis of a blood report: CBC, KFT, LFT, lipid profile, thyroid profile.
6. Measurement of Erythrocyte Sedimentation Rate.

7. To perform Platelet count and its pathological significance
8. To perform reticulocyte count its pathological significance
9. Study of fractures
10. Diagnostic tests: Detection of various Diseases – Montoux test, CRP, VDRL, RA, Pregnancy (any two)

Essential Readings

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

Suggestive Readings

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

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

Pool of DSEs

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course	Eligibility	Pre-requisite of	Department offering the course

		Lecture	Tutorial	Practical /Practice	criteria	the course	
Medical Lab Technology BIOMED-DSE-07	**4**	**3**	**-**	**1**	**XII Passed**	**Basic knowledge of biology**	**Biomedical Science**

Learning objective

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

Learning outcomes

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

- Develop specific laboratory skills, such as accurate pipetting, mixing, filtration, dispensing etc. using multi-step methods.
- Learn about ethics of working in biomedical labs and concerns about the medico legal aspects in Medical Laboratory Science.
- Comply with laboratory safety regulations and standards. Analyze and appreciate the quantum of biomedical waste that is generated and managed in various Labs.
- Exhibit skills essential to identify and determine blood group incompatibility. These skills would help them to analyze any mismatch during the blood transfusion reactions.

SYLLABUS FOR BIOMED-DSE-07

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

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

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

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

Unit-III: Clinical Biochemistry (10 hrs)

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

Unit-IV: Clinical Hematology (8 hrs)

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

Unit-V: Body Fluid Examination (04 hrs)

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

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

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

Practical:

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

1. Preparation of reagents routinely used in Medical Laboratories.
2. Standardization of 1.0 ml of volumetric pipette.
3. Working of various instruments used in Medical laboratory: Water baths, Incubators & Hot Air Oven, Centrifuges, Balances, Autoclave, pH Meter, Vortex mixer and magnetic stirrer. Maintenance of working manuals provided with the Instruments, formulating SOPs and LOG Books for each of the Instruments.
4. Calibration and standardization of spectrophotometer and other Instruments.
5. Selection of a filter for determining the intensity of a coloured solution.
6. Determination of an unknown concentration of a coloured solution by photometric method.
7. Organize a poster making competition for standard biomedical waste disposal procedure.
8. Medico legal experts maybe invited to deliver lecture on specific topics and share their experiences.
9. Visit to hospital for demonstration of Biomedical Waste Management.
10. Visit to hospital for demonstration of advanced instrumentation and auto-analyzers.

Essential Reading:

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

Suggested Reading:

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

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the Course
		Lecture	Tutorial	Practical / Practice			
Intellectual Property	**4**	**3**	**-**	**1**	**XII Passed**	**Basic knowle**	**Biomedical Science**

Rights for Biologists **BIOMED-DSE-08**						**dge of biology**	

Learning objectives:

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

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

Learning outcomes:

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

- Knowledge of various forms of Intellectual Property Rights, including patents, copyrights, trademarks, and trade secrets, legal frameworks and regulations governing these rights.
- Understanding of Biological Innovations and how Intellectual Property Rights apply specifically to biological innovations, such as genetically modified organisms, biotechnological inventions, pharmaceuticals, and plant varieties.
- Importance of IPR in Biotechnology and Biomedical Research.innovation, safeguards investments, and promotes the commercialization of research outcomes.
- Understanding of IP Protection Strategies in the field of biology, drafting patent applications, conducting patent searches, and navigating the patent filing process, would learn alternative forms of protection such as copyrights and trademarks, applicable to biological inventions.
- Patents of Trade mark, copyright & Design: The students will understand the legal issues related to the trade marks, logo design and the works related to arts.

- Ethical and Legal Considerations: Students will develop an understanding of the ethical and legal implications associated with Intellectual Property Rights in biology and explore issues of patent infringement, licensing, technology transfer, and access to genetic resources.

SYLLABUS FOR BIOMED-DSE-08

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

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

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

Unit II: Patent Protection Procedure (10 hrs)

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

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

First Examination Report (FER) and Responding to FER and hearing notice. Exercises and Ecommerce. Interaction Between IP Law and Competition Law regulating anti-competitive conduct of companies. IP Rights in digital environment and open source & open Access, Plagiarism. Importance of IP policy for an organization

Unit IV: Geographical indications & Trademarks (08 hrs)

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

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

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

Practical **(30 hrs)**

1. Drafting of specifications, claims and Patent Filing:

a) Drafting a patent specification

b) Claims Drafting

c) Patent filing – examples (05)

d) Exercises (05)

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

Essential Reading

- Intellectual property: A power tool for Economic Growth: Kamal Idris, Published by World Intellectual Property Organization, 2003. ISBN: 9280511149, 9789280511147
- Intellectual property and Human Development : Current trends and future Scenarios: T. Wong and G. Dutfield, Publisher Cambridge University Press, 2010. ISBN-13 : 978-0521190930
- Intellectual Property laws, Publisher: Universal Law Pub Co. P. Ltd., Delhi, 2015. ISBN-13 : 978-9350355855
- Intellectual property Law in India, Third Edition. Tamali Sen Gupta, Dhruv Shekhar, Publisher: Kluwer Law International, 2022. ISBN-13 : 9789403548111
- IIMA Business and Intellectual Property: Protect Your Ideas: Anurag K. Agarwal, Random House Publishers India Pvt. Limited, 2016. ISBN-13, 978-8184001402
- Technology Licensing and Development Agreements By Cynthia Cannady, Oxford University Press, 2013. ISBN-13: 978-0195385137
- Deborah Bouchoux : The Law of Trademarks, Copyright, Patents and Design, 2012. ISBN-13 , 978-1111648572.

Suggested Reading

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

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

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

Learning objectives

The Learning Objectives of this course are as follows:

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

Learning outcomes

Having successfully completed this course, students shall be able:

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

SYLLABUS OF BIOMED -DSE- 9:

Unit I: Structure of Proteins (08 hrs)

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

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

Unit II: Proteins as Drug Targets (08 hrs)

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

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

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

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

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

Unit V: Introduction to Molecular Mechanics (08 hrs)

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

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

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

Practical **(30 hrs)**

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

Essential readings:

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

Suggested readings:

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

Pool of Generic Electives (Semester III Onwards)

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

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

Learning Objectives

The Learning Objectives of this course are as follows:

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

Learning outcomes

The Learning Outcomes of this course are as follows:

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

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

SYLLABUS OF BIOMED-GE-04

Unit I: Introduction to Pandemics: (07 Hrs)

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

Unit II: Infectious Disease: (05 Hrs)

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

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

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

Unit IV: Precautions and Prevention: (06 Hrs)

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

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

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

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

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

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

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

Practical component (30 Hrs)

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

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

Essential readings:

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

Suggestive readings:

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

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

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

Learning Objectives

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

Learning outcomes

Having successfully completed this course, students will understand:

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

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

SYLLABUS OF BIOMED-GE-05:

Unit I: Organization of human genome (09 Hrs)

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

Unit II: Structural chromosomal abnormalities (06 Hrs)

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

Unit III: Numerical Chromosomal abnormalities (06 Hrs)

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

Unit IV: Monogenic Disorders (12 Hrs)

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

Unit V: Other genetic disorders (07 Hrs)

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

Unit VI: Genetic counselling (05 Hours)

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

Practical component **(30 hrs)**

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

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

Essential readings:

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

Suggestive readings:

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

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

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

Learning Objectives

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

Learning outcomes

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

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

- The student will be able to learn the process of hypothesis formulation, and utilization of appropriate test of significance for biological data analysis.

SYLLABUS OF BIOMED-GE-06

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

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

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

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

Unit III: Descriptive Statistics (10 Hrs)

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

Unit IV: Probability (07 Hrs)

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

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

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

Unit V: Inferential Statistics (09 Hours)

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

Practical **(30 hrs)**

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

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

Essential readings:

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

Suggestive readings:

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

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

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

Learning Objectives

The Learning Objectives of this course are as follows:

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

Learning outcomes

The Learning Outcomes of this course are as follows:

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

- Physical foundation of life: Students would learn the concept of enthalpy, entropy and free energy in a living system and understand the importance of the energy currency and the significance of coupled biochemical reactions.
- Biochemical events in the origin of life: Students would learn the origin of life and the nature of transformative changes that occurred for life to evolve from the pre-biotic world to the modern times.

SYLLABUS OF BIOMED-GE-07

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

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

Unit II: Cellular foundations of life (06 Hrs)

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

Unit III: Molecular basis of life (12 Hrs)

Common functional groups and linkages in biomolecules.

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

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

Unit IV: Physical foundation of life (11 Hrs)

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

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

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

Practical components **(30 Hours)**

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

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

Essential readings

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

Suggestive readings

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

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

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

Learning Objectives

The Learning Objectives of this course are as follows:

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

Learning outcomes

The Learning Outcomes of this course are as follows:

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

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

SYLLABUS OF BIOMED-GE-08

Unit I: Introduction: (12 Hrs)

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

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

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

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

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

Unit IV: Degenerative Diseases: (07 Hrs)

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

Unit V: Deficiency Diseases: (05 Hrs)

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

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

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

Practical component (30 Hrs)

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

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

Essential readings:

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

Suggestive readings:

- Tille, P. (2013). 13th Edition. Bailey & Scott's diagnostic microbiology. Missouri, USA: Mosby Publishers. ISBN-13: 978-0323083300.
- Madigan, M.T., Martinko, J.M., Stahl, D.A. and Clark, D.P. (2010). 13th Edition. Brock biology of microorganisms. California, USA: Benjamin Cumming. ISBN-13: 978- 0321649638.

- Tortora, G.J., Funke, B.R. and Case C.L. (2006). 9th Edition. Microbiology: An introduction. California, USA: Benjamin Cummings. ISBN-13: 978-0536292117.
- Bonita, Ruth, Beaglehole, Robert, Kjellström, Tord & World Health Organization. (2 (2006nd edition. *Basic Epidemiology*, World Health Organization, ISBN 978 92 4 154707 9.
- Pelczar, M.J (2001). 5th Edition. Microbiology. New York, USA: McGraw Hill International. ISBN-13: 9780074623206.

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

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

Learning Objectives

The Learning Objectives of this course are as follows:

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

Learning outcomes

The Learning Outcomes of this course are as follows:

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

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

SYLLABUS OF BIOMED-GE-09

Unit I: Hallmarks of Health (03 Hrs)

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

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

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

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

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

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

Unit IV: Innate Immune response (08 Hrs)

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

Unit V: Adaptive Immune Response (10 Hrs)

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

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

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

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

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

Unit VII: Vaccines and Immunotherapeutics (04 Hrs)

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

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

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

Practical component (30 Hours)

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

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

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

Essential readings:

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

Suggestive readings:

- Ananthanarayan R and Jayaram Paniker CK (Author), Reba Kanungo (Editor) (2020) Ananthanarayan and Paniker's Textbook of Microbiology, Eleventh Edition. Universities Press (India) Pvt. ISBN **9389211433**
- Practical Ayurveda: Find Out Who You Are and What You Need to Bring Balance to Your Life Paperback – 5 June 2018 by Sivananda Yoga Vedanta Centre. Publisher : DK; Illustrated edition (5 June 2018) : ISBN-10 : ISBN-13 ,1465468498 978-1465468499.
- Willey, J. Sherwood, L and Woolverton, C.J. (2016). 10th Edition. *Prescott's Microbiology*. New York, USA: McGraw-Hill Education. ISBN-13:978-1259281594.
- Satomi Oshima; Zhen-Bo Cao; Koichiro Oka (2015) 'Physical Activity, Exercise, Sedentary, Behavior and Health' Springer Tokyo Heidelberg New York Dordrecht London ISBN 978-4-431-55333-5 (eBook)
- Guglielmo M Trovato (2012) Behavior, nutrition and lifestyle in a comprehensive health and disease paradigm: skills and knowledge for a predictive, preventive and personalized medicine. Trovato EPMA Journal 2012, 3:8 (Review Article)
- Kindt T. J., Osborne B. A. , Goldsby R. A. (2007). 6th Edition *Kuby Immunology*. New York, USA: W.H. Freeman and Company. ISBN-13: 978-1429202114 ISBN-10: 1429202114.
- Hay, F.C. and Westwood, O.M.R. (2002). 4th Edition. *Practical Immunology*. New Jersey, USA: Blackwell Science. ISBN:9780865429611

- BYG-002 Yoga and Health, Block 4 Yogic Lifestyle, School of Health Science, Indira Gandhi National Open University (https://drive.google.com/file/d/10j00rWXLsCEV5cTbzK-hM43ezlNvn0hl/view)

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

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

Learning Objectives

The Learning Objectives of this course are as follows:

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

Learning outcomes

The Learning Outcomes of this course are as follows:

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

SYLLABUS OF BIOMED-GE-10:

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

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

Unit II: Nervous System (06 Hrs)

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

Unit III: Muscular and Skeletal System (04 Hrs)

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

Unit IV: Cardiovascular and Respiratory System (06 Hrs)

Functional Anatomy of heart, The Cardiac Cycle, Electrocardiogram.

Circulatory system: Blood vessels, hemodynamics and regulatory mechanisms.

Lymphatic circulation - hemodynamics and regulation, micro-circulation

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

Unit V: Endocrine System (06 Hrs)

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

Unit VI: Gastrointestinal system (06 Hrs)

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

Unit VII: Renal Physiology (06 Hrs)

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

Unit VII: Reproductive System (06 Hrs)

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

Practical component (30 Hrs)

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

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

Essential readings:

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

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

Suggestive readings:

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

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

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

Learning Objectives

The Learning Objectives of this course are as follows:

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

Learning outcomes

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

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

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

SYLLABUS OF BIOMED-GE- 11

Unit-I: Introduction of Drugs (06 Hrs)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Practical component (30 Hours)

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

1. To study different routes of administration of drugs.
2. To study the presence of acetaminophen in a given sample.
3. Quantitative estimation of acetaminophen in a given sample using spectrophotometer.
4. Extraction of caffeine from tea leaves.

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

Essential readings:

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

Suggestive readings:

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