ANNEXURE-4.01.01(22)
ITEM NO. – 4-1-1
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INDEX
B.SC (H) BIOMEDICAL SCIENCE
SEMESTER-VI

B.Sc (Hons.) Biomedical Science

Discipline Specific Core Course (BIOMED-DSCs)
SEMESTER- VI

DISCIPLINE SPECIFIC CORE COURSE -16 (BIOMED-DSC-16) BIOPHYSICS

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			
Biophysics **BIOMED-DSC-16**	4	3	-	1	**Class XII Passed**	**Basic knowledge of Bio-physical Techniques**	**Biomedical Science**

Learning objectives

The Learning objectives of this course are as follows:

- The course will demonstrate the role of fundamentals of chemistry and physics in understanding the biological processes including the methods to study the structure and functions of macro molecules and the chemical reactions occurring in living cells.
- The students will be able to learn theoretical basis of various analytical and biomedical techniques including various spectroscopic techniques, hydrodynamic methods, molecular biophysics.
- The students will be introduced to various physical principles responsible for maintaining the basic cellular function and integrity of biological membranes including transport across them.

Learning outcomes

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

- The interdisciplinary frontier of science in which the principles and techniques of physics are applied to understand biological problems at every level, from atoms and molecules to cells, organisms and environment and analyze the data generated through spectroscopic techniques such as UV-Visible, Infrared, Mass spectroscopy, NMR, etc.
- Understand the concepts of viscosity and sedimentation methods and their biological applications.

- Comprehend the thermodynamics of the structure of biomolecules and consequences of their structural instability and apply their biophysics knowledge to analyze the known experiments and to develop newer experimental methods for new biophysical applications.
- Understand the physical basis of transport across biological membranes. Additionally, they will be able to perform the experiments and demonstrate the interpretation of the data and further be able to deliver scientific conclusions. Further, they can apply their biophysics knowledge to analyze the known experiments and to develop newer experimental methods for new biophysical applications.

SYLLABUS OF BIOMED-DSC-16

Unit-I: Basic Spectroscopic Techniques (10 hrs)

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

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

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

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

Unit II: Advanced Biophysical Techniques (10 hrs)

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

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

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

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

Unit-III: Hydrodynamic Methods (10 hrs)

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

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

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

Unit-IV: Molecular Biophysics (7 hrs)

Basic thermodynamics: Concept of entropy, enthalpy, free energy change, heat capacity. Forces involved in biomolecular interactions with examples: Configuration versus conformation, Vander Waals interactions, Electrostatic interactions, Stacking interactions, Hydrogen bond and hydrophobic effect, Ramachandran plot.

Supercoiling of DNA: Linking number, twist and writhe.

Protein folding: Marginal stability of proteins, Thermodynamic and kinetic basis of protein folding.

Unit-V: Biological Membranes (8 hrs)

Biophysical basis of transport of solutes and ions, Fick's laws of diffusion, Transport equation, Membrane potential, an introduction to ionophores.

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

Essential readings

- Skoog D.A., Holler, F.J. and Crouch, S.R. (2017). 7thEdition. Principles of Instrumental Analysis. Boston, USA: Cengage Learning. ISBN-13:978-1305577213.
- Sheehan, D. (2009). 2nd Edition. Physical biochemistry: Principles and applications. Oxford, UK: JohnWiley.ISBN-13:978-0470856031.
- Freifelder, 1983). 2nd Edition. Physical biochemistry: Applications to biochemistry and molecular biology. NewYork, USA: W.H. Freeman and Company. ISBN-13:978-0716714446.

Suggestive readings

- Hofmann, A. and Clokie, S. (2018). 8th Edition. Wilson and Walker's principles and techniques of biochemistry and molecular biology. Cambridge, UK: Cambridge University Press. ISBN: 978-1108716987.
- Watson, J.D., Baker T.A., Bell, S.P., Gann, A., Levine, M., Losick, R.(2013).7th Edition. Molecular Biology of the Gene. New York, USA: Cold Spring Harbor Laboratory Press, ISBN-13:978-0321762436.
- Tinoco I., Sauer, K. Wang, J.C., Puglisi, J.D., Harbison, G. and Rovnyak, D. (2013). 5thEdition. Physical chemistry: Principles and applications in biological sciences Pearson, Prentice Hall. ISBN-13:978-0136056065.
- Kuriyan, J., Konforti, B. and Wemmer, D. (2012). 1st Edition. The molecules of life: Physical and chemical principles. New York, USA: Garland Science. ISBN-13: 978-0815341888.
- Frauen felder, H., Chan, S.S. and Chan, W.S. (2010). 1stEdition. The physics of proteins: An introduction to biological physics and molecular biophysics. NewYork, USA:Springer, ISBN-13: 978-1441910431.
- Rhodes, G. (2006). 3rd Edition. Crystallography made crystal clear: Guide for users of macro molecular models. Massachusetts, USA: Academic Press. ISBN-13:978-0125870733.
- Van Holde, K.E., Jhonson, W.C. and Shing Ho, P. (2005). 2nd Edition. Principles of physical biochemistry. NewJersey, USA: Prentice Hall Inc.ISBN-13:978-0130464279
- Branden, C. and Tooze, J. (1999). 2nd Edition. Introduction to protein structure. New York, USA: Garland Science, ISBN-13: 978-0815323051.
- Hoppe, W., Lohmann, W., Markl, H. and Ziegler, H.(1983). 1st Edition. Biophysics. Berlin, Germany: Springer-Verlag and Heidelberg GmbH & Co., ISBN-13:978-3540120834.
- Cantor, C.R. Schimmel, P.R. (1980). 1st Edition. Biophysical Chemistry. New York, USA: W.H. Freeman and Company. ISBN-13:9780716711889.

DISCIPLINE SPECIFIC CORE COURSE- 17 (BIOMED-DSC-17) HUMAN GENETICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Human Genetics **BIOMED-DSC-17**	**4**	**3**	**-**	**1**	**Class XII Passed**	**Basic Knowledge of Genetics**

Learning objectives

The Learning objectives of this course are as follows:

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

Learning outcomes

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

- Students will understand the patterns of inheritance of monogenic traits from pedigree data for both Mendelian and non-Mendelian traits.
- They will comprehend the techniques and advances in the analysis of DNA, identification of genes involved in diseases, and gene/sequence mapping strategies.
- Students will be able to describe objectives, tools, approaches and outcomes of the Human Genome Project (HGP). They will be aware of the ethical and societal issues raised by the new knowledge derived by using new technologies.
- Students will be able to apply principles of genetics at population level.
- They will understand the genetic basis of common diseases and methods of prenatal diagnosis.
- Students will be able to proficiently explore relevant literature, web sites and databases for research into human genetics.

SYLLABUS OF BIOMED-DSC-17:

Unit- I: Inheritance for Monogenic Traits (08 hrs)

History of Human Genetics: Early Greek concepts about inheritance, Cytogenetics history (the works of Winiwater, Painter and Tjio and Levan), Landmark achievements of Galton, Garrod etc. Patterns of Inheritance: Recapitulation of principles of human inheritance pattern through pedigree analysis: Autosomal inheritance- dominant, recessive, sex-linked inheritance, sex- limited and sex- influenced traits and mitochondrial inheritance. Deviations from the basic pedigree patterns- non-penetrance, variable expressivity, pleiotropy, late onset, anticipation, consanguinity and its effects, mosaicism and chimerism, genetic heterogeneity, uniparental disomy, and genomic imprinting.

Unit- II: Genetic and Physical Maps (06 hrs)

Genetic markers and their applications. Overview of genetic maps. Physical maps (different types- restriction, cytogenetic maps, use of FISH in physical mapping, radiation hybrids and clone libraries in STS mapping)

Unit- III: Identification of Human Disease Genes (08 hrs)

Principles and strategies, positional and candidate gene approaches, (examples- HD, CFTR), concept of twin and adoption studies.DNA sequencing (Principles of Maxam-Gilbert and Sanger Method, introduction to NGS with an example of illumina based sequencing), DNA fingerprinting, polymorphism screening (genotyping of SNPs and microsatellite markers)

Unit- IV: Human Genome Project (04 hrs)

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

Unit- V: Population Genetics (05 hrs)

Genotypic and allelic frequencies, Hardy-Weinberg Equilibrium, linkage disequilibrium, haplotype construction (two loci using SNPs and/or microsatellites).

Unit- VI: Clinical Genetics (08 hrs)

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

Prenatal Diagnosis: Brief introduction, methods of prenatal diagnosis (invasive and non-invasive such as Amniocentesis, Chorionic villus sampling, Ultrasonography, Fetoscopy, Maternal serum screening, Fetal cells in maternal blood) and its application with examples of Aneuploidy and Thalassemia.

Pharmacogenetics and Pharmacogenomics(genetic polymorphism in drug metabolism genes e.g. cytP450 and GST and their effect on drug metabolism and drug response), genetic counseling.

Unit- VII: Guided short project (06 hrs)

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

Practical (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. Pedigree construction of some common phenotypic characteristics of humans.
2. Pedigree analysis and risk assessment.
3. Restriction mapping/ STS mapping from the given data.
4. Demonstration of DNA fingerprinting.
5. Polymorphism analysis using PCR.
6. Analysis of the given DNA sequencing data based on Maxam-Gilbert and Sanger sequencing methods.
7. Study of Hardy-Weinberg equilibrium by PTC tasting and ABO blood grouping.
8. Video based demonstration of tools for prenatal diagnosis.
9. Exploring DNA, RNA, and Protein Sequence Databases for retrieval of a desired human sequence and sequence alignment using BLAST.
10. Preparation of human metaphase chromosomes and Giemsa staining.

Essential readings:

- Strachan, T. and Read, A. (2018). 5th Edition. *Human molecular genetics*. Florida, USA: CRC Press, Garland Science. ISBN: 978-0815345893.
- Pasternak, J.N. (2005). 2nd Edition. *An introduction to human molecular genetics*. New York, USA: Wiley-Liss. ISBN: 978-0-471-47426-5.

- Cantor, C.R. and Smith, C.L. (1999). 1st Edition. *Genomics: The science and technology behind the human genome project*. New York, USA: Wiley-Interscience. ISBN: 9780471599081.

Suggestive readings:

- Brown, T.A. (2023). 5th Edition. *Genomes 4*. New York, USA: Garland Science. ISBN-13: 978-0815345084.
- 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: 978-047129806.

DISCIPLINE SPECIFIC CORE COURSE- 18 (BIOMED-DSC-18) TOXICOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Toxicology **BIOMED-DSC-18**	**4**	**3**	**-**	**1**	**Class XII Passed**	**Basic Knowledge of Pharmacology**

Learning objective

- The present course content is designed to provide the basics of toxicology. The course would help to understand the influence of toxic substances on various body organs. It provides insight into measurement of toxicity, principles of exposure, molecular mechanism of toxicity and toxicants that harm our environment.
- Relevant importance has been given to those topics which can build a strong foundation in the subject, based on which, facts can be assimilated during subsequent higher studies.

Learning outcomes

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

- Basics methods and biological parameters used to measure toxicity of a chemical. General mechanisms whereby toxicants cause toxicity; interaction of toxicants with target bio-molecules in the body and resultant toxicity. Basics of safety evaluation of toxicants.
- Mechanisms/processes involved in absorption, transport, chemical modification and excretion of toxicants from the body.
- Through examples of few common classes of toxicants such as pesticides and metals, students are able to learn; how humans are exposed to them, their mechanism of action and symptoms of toxicity.
- The process by which certain anthropogenic chemicals cause harm to wildlife/ ecosystem.
- Basics of management, clinical evaluation of toxic patients, methods used to prevent further toxicity, and use of antidotes.

SYLLABUS OF BIOMED-DSC-18

Unit-I: Introduction (07hrs)

Brief history, Different areas of modern toxicology, Classification of toxic substances, various definitions of toxicological significance, characteristic and types of toxic responses and tolerance to toxicants.

Unit-II: Toxic exposure, response, evaluation of toxicity and mechanism of toxicity (14hrs)

Effect of duration, frequency, route and site of exposure of xenobiotics on its toxicity, various types of dose response relationships, assumptions in deriving dose response, LD50, LC50, TD50, NOAEL, ADI, MOE and therapeutic index. Concept of ultimate toxicant, general mechanisms by which various toxicants cause toxicity (up to molecular and cellular level).

Unit-III: Fate of xenobiotics in human body (12 hrs)

Absorption, distribution, excretion and metabolism of xenobiotics (biotransformation, Phase-I reactions including oxidations, hydrolysis, reductions and phase II conjugation reactions). Toxic insult to liver, its susceptibility to toxicants with reference to any two hepatotoxicants.

Unit-IV: Toxic agents (06hrs)

Human exposure, mechanism of action and resultant toxicities of the following xenobiotics: Metals: lead, arsenic; Pesticides: organophosphates, bipyridyl compounds and anticoagulant pesticides.

Unit-V: Eco-toxicology (02hrs)

Brief introduction to avian and aquatic toxicology, movement and effect of toxic compounds in food chain (DDT, mercury), concept of bio-accumulation, bio-magnification.

Unit-VI: Clinical toxicology (04hrs)

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

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

Essential reading

- Klaassen, C.D and Watkins, J.B. (2021). 4th Edition. *Casarett and Doull's Essentials of Toxicology.* McGraw Hill, ISBN-13: .1260452297-978
- Klaassen, C.D. (2018). 9th Edition. *Casarett and Doull's Toxicology, The Basic Science of the Poisons.* McGraw Hill. ISBN-13: 978-1259863745.

Suggestive readings

- Stine, K.E. and Brown T.M (2015). 3rd Edition. *Principles of Toxicology.* Florida, USA: CRC Press. ISBN-13: 9781466503434.
- Timbrell. J. (2001). 3rd Edition. *Introduction to Toxicology.* CRC Press. ISBN-13: 978-0415247634.

Pool of DSEs

DISCIPLINE SPECIFIC ELECTIVE COURSE– 10 (BIOMED-DSE-10)
FUNDAMENTALS OF NEUROSCIENCE

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			
Fundamentals of Neuroscience BIOMED-DSE-10	4	3	-	1	Class XII Passed	Basic knowledge of Physiology, biochemistry and Cell biology	Biomedical Science

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide a comprehensive overview of the basic principles and concepts in neuroscience, including the structure and function of the nervous system, neural communication, and basic neuroanatomy.
- The paper aims to investigate the neural mechanisms underlying a particular phenomenon, such as perception, memory, learning, decision-making, or emotion.
- To prepare students to undertake further research in the area of neuroscience.

Learning outcomes

Having successfully completed this course, students shall be able:

- To understand the fundamental organization, function and development of the nervous system.
- To conceptualize and compare the role of different neurotransmitters.
- To understand the mechanisms of different disorders associated with the nervous system.
- To appreciate the principles and applications of different tools and techniques used in neuroscience.
- To proficiently explore relevant websites and databases related to latest initiatives in the field of neuroscience.

SYLLABUS OF BIOMED-DSE-10

Unit I: Introduction to Neuroscience (10hrs)

Brief overview of Neuroanatomy: Timeline of the nervous system development, Organization of Central Nervous System (CNS), Peripheral Nervous System (PNS), Autonomic Nervous System (ANS). Meninges and Cerebrospinal Fluid (CSF), Vascular Supply of the Brain: blood brain barrier and blood CSF barrier.

Unit II: Neurochemistry and Neurophysiology (10hrs)

Introduction to Neurochemistry, overview of synaptic transmission and cellular signaling. Neurotransmitters and their receptors: Acetylcholine, Glutamate, GABA, Dopamine, Serotonin and Epinephrine. Neuropeptides, Gut-Brain axis. Membrane potentials, Post synaptic potential and synaptic integration, Neuromuscular junctions.

Unit III: Brain and Behavior (06 hrs)

Neuroplasticity, learning and memory, cognition, sleep, circadian rhythm, Affective immunology: emotions and Immunity

Unit IV: Diseases of the nervous system (10hrs)

Overview of neuroinflammation, Neurochemical and molecular mechanisms of different neurological conditions: Autism, Attention Deficit Hyperactivity Disorder (ADHD), Epilepsy, Anxiety and depression, Alzheimer Disease, Parkinson Disease/ Schizophrenia, and Amyotrophic Lateral Sclerosis (ALS)

Unit V: Tools and Techniques in Neuroscience / Kaleidoscopic Dimensions of Neuroscience(09hrs)

Methods and tools to study brain and behavior: neuroimaging techniques (MRI, PET), electrophysiological studies (EEG). *In vitro* models of neurosciences including cell culture, tissue culture and animal models. Introduction to Neuroinformatics.

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. Gross examination of the brain and its different parts (human and animal) through videos.
2. Histology of different brain sections through permanent slides.
3. Microanatomy of neurons using virtual labs.
4. Electrophysiological studies using physiological data acquisition systems (teaching modules)

5. Exploration and extraction of information about the brain from NCBI, NIF, Allen Brain Atlas, the virtual brain, Human Connectome Project, etc.
6. Behavioral studies using virtual lab- Motor functions tests (Rotarod Test, Grip Strength Test), Cognitive Functions tests – Learning and memory related test (Water Maze, open field test, etc.)

Essential readings:

- Kandel, E. R., Koester, J. D., Mack, S.H., et al. (2021). 6th Edition. Principles of Neural Science. McGraw Hill, ISBN: 978-1259642234
- Sontheimer, H. (2021). 2nd Edition. Diseases of the Nervous System. Elsevier, ISBN: 978-0128212288
- Squire, L., Spitzer, N. C., Berg, D., et al. (2012). 4th Edition. Fundamental Neuroscience, Academic Press, ISBN: 978-0123858702
- Brady, S. T., Siegel, G. J., Albers, R. W., et al. (2011). 8th Edition. Basic Neurochemistry. Academic Press, ISBN: 0125468075
- Zigmond, M. J., Bloom, F. E., Roberts, J. L., et al. (2008). 3rd Edition. Fundamental Neuroscience. Academic Press, ISBN: 978-0123740199

Suggested readings:

- Sanes, D. H., Reh, T. A., Harris, W. A., et al. (2019). 4th Edition. Development of the Nervous system. Academic Press, ISBN: 978-0128039960
- Gilbert, S. F., & Barresi, M. J. F. (2016). 11th Edition. Developmental Biology. Sinauer Associates Inc, ISBN: 978-1605354705
- Hall, J.E. (2015). 13th Edition. Guyton and Hall textbook of Medical Physiology. Philadelphia, USA: W B Saunders and Company. ISBN-13: 978-1455770052
- Aminoff, M., Greenberg, D., Simon, R. P. (2015). 9th Edition. Clinical Neurology. McGraw Hill Education, ISBN: 978-0071841429

DISCIPLINE SPECIFIC ELECTIVE COURSE –11 (BIOMED-DSE-11) GREEN CHEMISTRY METHODS IN PHARMACEUTICAL AND INDUSTRIAL APPLICATIONS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical /Practice			
Green Chemistry Methods in Pharmaceutical and Industrial Applications **BIOMED-DSE-11**	**4**	**3**	**-**	**1**	**Class XII Passed**	**Basic knowledge of organic reactions**	**Biomedical Science**

Learning objectives

The objective of this course is to make students aware of

- The toxicity, hazard and risk of chemical substances as well as to be aware of the importance of green chemistry in today's world.
- To familiarize students with environment-friendly alternatives for the synthesis of various chemicals.
- ·Course will help to understand the usage of various green approaches in synthetic chemistry and their applications for sustainable development.

Learning outcomes

After studying this course students should be able to:

- Understand the twelve principles of green chemistry and gain an in-depth understanding of chemical toxicity, hazard, and associated risk.
- Learn to create non-toxic chemicals, products, and processes than current alternatives.
- Comprehend the importance of inherently safer design for accident prevention
- ·Understand the advantages of using catalysts and biocatalysts, use of renewable feedstocks and green solvents for environmental protection.
- Appreciate the role of green chemistry in innovatively solving environmental issues.
- Green chemistry is a mean to maximize revenues, productivity, and sustainability while producing zero waste. They are also motivated to practice green chemistry by success stories and real-life examples.

SYLLABUS OF BIOMED-DSE-11

Unit I: Introduction to Green Chemistry (10 hrs)

Importance of Green Chemistry: Green Chemistry in nature (for example nitrogen fixation, photosynthesis, glucogenesis/ glycolysis), Twelve principles of green Chemistry:Prevention of waste, Atom economy, Designing less hazardous chemical synthesis, Designing safer products, Safer solvents and auxiliaries, Design for energy efficiency, Renewable resources, Reduce derivative, Use of selective catalyst, Design for degradation, You cannot control what you cannot measure, Inherently safer chemistry for accident prevention, Important environmental laws, the Pollution Prevention Act of 1990, Limitations and Obstacles in the Pursuit of the Goals of Green Chemistry.

Unit II: Conventional Chemistry vs Green Chemistry (10 hrs)

General concept of mixing of orbitals (Hybridization), Role of various electronic effects in the modulation of reactions; Homolytic and Heterolytic cleavage. Substitution reactions (hydrolysis of alkyl halides and Hydrolysis of esters), Addition reactions (Hydrogenation of alkenes), Elimination reactions (Hoffman elimination, Decarboxylation), Rearrangement (Diels-Alder reactions), Cis-trans isomerisation of alkenes, Condensation reactions: Aldol (replacement of ethanol with solvent free reaction) and Benzoin (replacement of KCN, TPP, Thiamine HCl). Prevention of waste/by-product pollution, calculation of atom economy with reference to above reactions.

Unit III: Green Solvents (10 hrs)

- Conventional solvents (Ethanol, Acetone, chloroform, DCM) and Green Solvents (water/buffer, supercritical fluids, ethyl lactate, Ionic liquids). Buffers (Phosphate, Acetate) and buffer action (concept of pKa), Relative acids/basic strength of organic acids and bases (aliphatic and aromatic).
- Advantages of green solvents in chemical synthesis: Supercritical CO_2 in the separation of coffee from coffee beans and perfume industry, water as a green solvent in reactions (Benzoin condensation, Hofmann Elimination, methyl benzoate to benzoic acid and Decarboxylation reaction).
- Ionic liquids: physicochemical properties, Advantages and Disadvantages (purification of complex mixtures and cost), Reactions of Ionic liquids: Imidazolium based ionic liquid for the synthesis of antiviral drug trifluridine, hydrogenation of alkenes, Diels-Alder reaction with copper (II) bisoxazolium complex having imidazolium tag.

Unit IV: Various Approaches to Green reaction synthesis (10 hrs)

- Enzyme-based reactions: Biocatalyst (concept of stereoselectivity and stereospecificity, and turnover number), Biocatalyst mediated synthesis of Sitagliptin drug and ethanol; Nanocatalysis (oxazole synthesis using nanocatalyst). Photocatalysis: Visible light induced Reactions (syntheses of vitamin D3, cis-trans isomerization of alkenes, waste water treatment with TiO2).
- Microwave-assisted green approach: Principle, merits, demerits and effect of solvent; Microwave-assisted reactions: solvent-free synthesis of aspirin, Renewable starting materials: Synthesis and properties of 5-Aminolevulinic acid (DALA) from levulinic acid. Design of degradable reactions (pesticides), Inherently Safer design in chemical synthesis: Principle and Subdivision eg. Bhopal Gas Tragedy.

Unit V: Pharmaceutical and Industrial Applications for revenue, productivity and sustainability (5 hrs)

Vitamin C used in cosmetics/neutraceuticals industry: Synthesis using enzymes, commercial production of drugs/pharmaceutical product: anti-depressant drug sertraline, Removal of Drug from Waste water: Levofloxacin, an anti-bacterial drug with ZnO nanoparticles, Enzymatic synthesis of Zero Trans-Fats and Oils,

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.) (Any seven)

1. Preparation and characterization of biodiesel from vegetable oil preferably waste cooking oil.
2. Benzoin condensation using thiamine hydrochloride as a catalyst instead of cyanide
3. Mechanochemical solvent-free synthesis of succinic anhydride/phthalic anhydride
4. Hydrolysis of esters/ esterification using green methods.
5. Solvent-free, microwave-assisted one-pot synthesis of phthalocyanine complex of copper (II).
6. Cross aldol condensation reaction using base catalyzed green method.
7. Microwave-assisted synthesis of drug/ drug intermediates (Knoevenagel reaction, Aspirin)
8. Photoreduction of benzophenone to benzopinacol in the presence of sunlight.
9. Acetylation of primary aromatic amine using the green method.
10. Synthesis of nanoparticles using green approach.

Essential Reading:

- Matlack, A.S., Andraos. J, (2022); Introduction to Green Chemistry, 3rd Edition, CRC press (ISBN: 978-1032199429).

- Sharma, R.K.; Bandichhor, R. (2018), Hazardous Reagent Substitution, Royal Society of Chemistry. (ISBN: 978-1-78262-050-1)
- Lancaster, M. (2016), Green Chemistry: An Introductory Text, 3rd Edition, RSC Publishing. (ISBN: 978-1-78262-294-9)
- Wei Zhang, Berkeley W. Cue Jr (2012) "Green Techniques for Organic Synthesis and Medicinal Chemistry" John Wiley & Sons, Ltd (ISBN:9780470711828)
- Sharma, R.K.; Sidhwani, I.T.; Chaudhari, M.K. (2012), Green Chemistry Experiments: A monograph**,** I.K.International Publishing House Pvt Ltd. (ISBN: 978-9381141557)
- Kirchhoff, M.; Ryan, M.A. (2002), Greener approaches to undergraduate chemistry experiment**.** American Chemical Society, Washington DC. (ISBN: 8412-3866-9)
- Anastas, P.T.; Warner, J.C. (2000), Green Chemistry: Theory and Practice, Oxford University Press. (ISBN: 9780-198506980).
- El-Maraghy, C. M., El-Borady, O. M., & El-Naem, O. A. (2020). Effective Removal of Levofloxacin from Pharmaceutical Wastewater Using Synthesized Zinc Oxid, Graphen Oxid Nanoparticles Compared with their Combination. *Scientific Reports*, *10*(1), Article 1. https://doi.org/10.1038/s41598-020-61742-4

Suggestive readings

- Batra. S.K; Gulati, S; Shukla, S, (2020); Practical Green Chemistry: Strategies, Tools & Experiments, Shri Kala Prakashan (ISBN: 978-9385329456)
- Sidhwani, Tucker I; Sharma, R.K, (2020); An Introductory Text on Green Chemistry: For Undergraduate Students, Wiley (ISBN: 978-8126554072)
- Benyus, J.M. (2002); Biomimicry:Innovations Inspired by nature, HarperCollins. (ISBN: 9780060533229)
- Garay,A. L; Pichon, A.; James,S.L. "Solvent-free synthesis of metal complexes" Chem Soc Rev, 2007, 36,846-855.
- James H. Clark, Duncan Macquarrie (2002); Handbook of Green Chemistry and Technology, Wiley (ISBN: 9780632057153)

DISCIPLINE SPECIFIC ELECTIVE -12 (BIOMED-DSE-12) RESEARCH METHODOLOGY

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			
Research Methodology **BIOMED-DSE-12**	**4**	**3**	**-**	**1**	**Class XII Passed**	**Basic knowledge of biology, mathematics and computers**	**Biomedical Science**

Learning objectives

The Learning objectives of this course are as follows:

- The syllabus aims to educate students on the fundamentals of research methodology and familiarize them with the different search engines used in literature surveys.
- It will guide them in identifying research problems and developing research strategies to address them.
- The course will cover different approaches used in research, along with ethical considerations related to clinical research.
- In addition, students will learn about scientific writing and presentation skills.

Learning outcomes

Upon completion of this course, students will achieve the following learning outcomes:

- Develop the ability to identify a research problem, design and execute experiments, and analyze the resulting data.
- Comprehend and follow ethical guidelines for conducting research and accurately document research activities.
- Utilize various tools to write research papers and review articles effectively.
- Demonstrate effective presentation skills to communicate scientific work.

SYLLABUS OF BIOMED-DSE-12

Unit I: Introduction (6 hrs)

Basics of research methodology: Background of research area and generation of hypothesis, Types of Research: Experimental vs Theoretical; Descriptive vs Analytical; Fundamental vs Applied; Quantitative vs Qualitative.

Unit II: Literature Review (08 hrs)

Importance of literature review, common search engines such as NCBI, Google Scholar etc. used for literature surveys. Exploring various types of academic journals and publications fundamental to research: journals and e-books. Introduction to reference and citation management tools like Mendeley, Zotero and EndNote.

Unit III: Identifying a Research Problem and Designing of Experiment: (10 hrs)

Identification of a research problem (any one disease of national importance: tuberculosis/leprosy/diabetes/cardiovascular disease/neurodegenerative disorders), its national and international status. Experimental strategies: number and types of replicates and control, Statistical analysis of data using MS Excel/ R-Statistical tools.

Unit IV: Methods in Biomedical Research (08hrs)

Clinical Research and associated methodology, Epidemiology: Concepts and methods in the context of illustrative projects. Classical examples of epidemiological studies such as TB and leprosy, its challenges and limitations.

Unit V: Research Ethics and Intellectual Property (07hrs)

Understanding research ethics and its significance in scientific writing, Plagiarism, peer-review, conflict of interest, and research misconduct. Introduction to Intellectual Property Rights (IPR) such as Patent, Trademarks, Copyright, and Trade Secrets. Importance of IPR in research and innovation.

Unit VI: Research Presentation (06 hrs)

To write a research paper and review article. To prepare an oral and poster presentation of a research paper.Steps in writing a research grant proposal

Practical **(30 hrs)**

1. Literature survey on any one disease of national importance: tuberculosis/leprosy/diabetes/cardiovascular disease/neurodegenerative disorders
2. Creating bibliography in different formats using any available tools like Mendeley/ Zotero/ EndNote, etc.
3. Group exercise by students
    1. Writing a review article
    2. Writing a research report
    3. Powerpoint presentation
    4. Poster presentation

Essential Readings

- Walliman, N. (2017) Research Methods: The Basics, **(**2nd ed.), London; New York: Routledge; ISBN-10:1138693995
- Kumar, R. (2014) Research Methodology: A Step-by-Step Guide for Beginners (4th ed.), SAGE publisher; ISBN-10: 9789351501336
- The Craft of Research (Guides to writing, editing and publishing) (2008), Booth, W.C., Colomb, G.G., Williams, J.M., University of Chicago Press, 2008. (ISBN-13: 978-0226065663)

Suggestive Readings

- Research Methodology: A Step-by-Step Guide for Beginners (2010) 3rd ed., Kumar R., Pearson Education. (ISBN-13: 978-1849203012)
- Cresswell, J. (2009) Research Design: Qualitative and quantitative Approaches Thousand Oaks CA, (3rd ed.), Sage Publications
- Research in Education (2005) 10th ed., Best, J.W. and Kahn, J.V., Prentice Hall of India Pvt. Ltd. (ISBN-13: 978-0205458400)
- At the Bench: A Laboratory Navigator (2005) Barker, K., Cold Spring Harbor Laboratory Press (New York). ISBN: 978-087969708-2.
- Research Methodology - Methods and Techniques (2004) 2nd ed., Kothari C.R., New Age International Publishers. (ISBN-13 / EAN: 9788122415223)