

**SYLLABUS FOR SEMESTER I AND II POSTGRADUATE
PROGRAMME IN LIFE SCIENCES
(Academic Year 2026-27)**

Annexure A

COURSE STRUCTURE

Sem ester	Course Code	Course title (4 credits/course)	Nomenclature	Total Credits (80 credits)
I	PGMP-LS-C-1	Cell and Molecular Biology	DSC	16 credits (4 DSC's) + 4 credits (1 DSE) = 20 credits
	PGMP-LS-C-2	Advanced and Applied Microbiology		
	PGMP-LS-C-3	Biochemistry		
	PGMP-LS-C-4	Developmental Biology		
	PGMP-LS-E-1	Instrumentation and Techniques	DSE	
	PGMP-LS-E-2	Toxicology		
	PGMP-LS-E-3	Fermentation technology		
	PGMP-LS-E-4	Animal Behaviour		
II	PGMP-LS-C-5	Cell signalling and Regulation	DSC	16 credits (4 DSC's) + 4 credits (1 DSE) = 20 credits
	PGMP-LS-C-6	Immunology		
	PGMP-LS-C-7	Plant and Animal Physiology		
	PGMP-LS-C-8	Cytogenetics		
	PGMP-LS-E-5	Bioinformatics and Bioethics	DSE	
	PGMP-LS-E-6	Marine Biology		
	PGMP-LS-E-7	Pharmacology		
	PGMP-LS-E-8	Biostatistics		
III	PGMP-LS-E-9	Animal Biotechnology	DSE	8 credits (2 DSE's) + 4 credits (Generic elective) + 8 credits (Research specific electives) = 20 credits
	PGMP-LS-E-10	Plant tissue culture		
	PGMP-LS-E-11	Nanobiotechnology		
	PGMP-LS-E-12	Human Genetics		
	PGMP-LS-E-13	Industrial Biotechnology		
	PGMP-LS-E-14	Molecular biology and Genetic engineering		
	PGMP-LS-E-15	Genomics and Proteomics		
	PGMP-LS-E-16	Economic Botany and Zoology		
IV	-	Research specific elective	RSE	4 credits (RSE) + 16 credits (DSD/I) = 20 credits
	-	Discipline specific Dissertation/ Internship	DSD/I	

Legend- DSC: Discipline Specific Core; DSE: Discipline Specific Elective

DISCIPLINE SPECIFIC CORE COURSES FOR SEMESTER I

COURSE TITLE	: CELL AND MOLECULAR BIOLOGY (CORE 1 -THEORY)
COURSE CODE	: PGMP-LS-C-1
SEMESTER	I
CREDITS	03
MARKS	75
TOTAL HOURS	45

Course Objectives:

The course will provide a comprehensive overview on the cell organization, structural components, cell-cell communication, and delineation of the molecular basis of cell cycle and death. It will help elucidate the basic molecular processes of the central dogma of biology, various mutations and their repair mechanisms, regulation of gene expression and mechanism of gene transfer for cloning applications.

Course Learning Outcomes

On the successful completion of the course, students will be able to:

- CLO1 Understand the cellular structural components, its functions and molecular facets of the cellular life cycle.
- CLO2 Appreciate the molecular processes of central dogma of life and epigenetic interaction.
- CLO3 Comprehend regulation of gene expression in prokaryotes and eukaryotes, gene transfer and application in gene cloning
- CLO4 Gain experimental knowledge of techniques in cell, molecular biology and regulation of gene expression.

Module 1: Structural components of cell, cell cycle and death 15 hours

Cellular organelles and their functions (nucleus, Golgi complex, endoplasmic reticulum, mitochondria, chloroplast, lysosomes, peroxisomes and vacuoles); plasma membrane models and their functions; cytoskeleton and its architecture.

Molecular events in cell cycle stages – G₀, G₁, S, G₂ and M, activation of the cyclin-CDK complexes (G₁, S and G₂ cyclins-CDKs): its inhibitors, M phase cyclin in various mitotic phases, condensins, securin, separase and end of mitosis.

Apoptosis and necrosis, role in development and maintenance.

Module 2: Central dogma of molecular biology and epigenetics**15 hours**

Structure of Gene: Prokaryotic and eukaryotic gene, Split Gene, Pseudogenes.

Eukaryotic Genome: Satellite DNA, Tandem repeat array, Transposons: LINE and SINE.

DNA replication: enzymes, replication fork, fidelity, extrachromosomal replicons (plasmid).

Recombination: Homologous and Non-Homologous.

Types of genomic Mutations & DNA repair mechanisms.

Transcription in eukaryotes: transcription factors; TATA binding proteins (TBP), TBP associated factors (TAF); zinc finger motifs, Mechanism of transcription; silencing and activation mechanism, insulators, enhancers, hypersensitive sites, transcriptional activators and repressors; post-transcriptional modifications, spliceosomes, alternative splicing systems; genome editing-CRISPR-Cas9

Translation: Codon-Anticodon interaction; Translation mechanism in prokaryotes and eukaryotes, mechanisms to combat premature translation termination, suppressor tRNAs, inhibitors and its applications.

Epigenetics: Imprinting, Methylation and Acetylation mechanism

Module 3: Regulation of gene expression and gene cloning**15 hours**

Prokaryotic gene regulation, Master switches, Feedback Inhibition.

Eukaryotic gene regulation: chromatin remodeling in regulation of gene expression.

Post- translational modification, regulation through RNA interference, translational control, defects in regulation associated diseases- Brief overview of cancer genetics.

Gene cloning: DNA Cloning- Cell-based and cell independent cloning, Vectors: Plasmid vectors, Cosmids, Phagemids, lambda Bacteriophage vector, expression vectors, BACs and YACs, Gene transfer in eukaryotic and prokaryotic cells- transfection, liposomes, adenovirus, biolistics, microinjection, transduction, transformation, plant viruses as episomal expression vectors, Production of transgenic plants and animals (mice model); Gene libraries.

COURSE TITLE : CELL AND MOLECULAR BIOLOGY (CORE 1-PRACTICAL)
COURSE CODE : PGMP-LS-C-1
SEMESTER I
CREDITS 01
MARKS 25
TOTAL HOURS : 30 (15 SESSIONS)

Sr.No	Title of experiment	Practical session
1.	Chromosome preparation and study of anomalies from larval <i>Drosophila</i> or temperature sensitive mutants of yeast under various stress conditions	02
2.	Lac operon induction and assessment of enzyme activity using <i>E.coli</i>	01
3.	Transformation of <i>E.coli</i> with standard cloned plasmids & calculation of efficiency	01
4.	Isolation and estimation of DNA, RNA from prokaryotes and eukaryotes along with their electrophoretic separation.	02
5.	Technique for visualization of DNA and RNA by Southern and Northern blotting respectively.	02
6.	PCR amplification of 16s rRNA and visualization in agarose gel.	01
7.	Estimation of cell-cycle stages using PI/FITC staining by flow-cytometry.	01
8.	Histochemical/Immunochemistry localization of cytoskeleton elements by immunofluorescence staining	01
9.	Demonstration of cell organelles using confocal microscopy/SEM	01
10.	Practical assessments	03
Total sessions		15

REFERENCES

1. Cell and Molecular Biology – Concepts and Experiments (2018), by Karp, G. & Harris, D. John Wiley & Sons Inc, New York.
2. Lewin's GENES XII (2017) by Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick Jones and Bartlett Publishers
3. Molecular Biology of the Gene (2017) by James D. Watson Pearson Publisher

4. Molecular Cell Biology (2016) by Arnold Berk , Chris A. Kaiser , Harvey Lodish, Angelika Amon WH Freeman; 8 edition
5. iGenetics: A Molecular Approach (2016) by 3Rd Edn Peter J Russell, Pearson Education

WEB REFERENCES

1. <https://www.ncbi.nlm.nih.gov/books/NBK9851/> (Cell - Cell Interaction)
2. <https://www.khanacademy.org/test-prep/mcat/cells/eukaryotic-cells/a/organelles-article> (Cell Organelles and Structures)
3. <https://www.ncbi.nlm.nih.gov/books/NBK9876/> (Phases of the cell cycle)
4. <https://www.ncbi.nlm.nih.gov/books/NBK10019/> (Meiosis)
5. <https://open.umn.edu> › opentextbooks › textbooks › cell-and-molecular-biology
6. <https://molbiomadeeasy.files.wordpress.com> › 2013/09 › fundamental_molecular biology
7. <https://www.academia.edu> (Cell_and_Molecular_Biology_Concepts)

COURSE TITLE	: ADVANCED AND APPLIED MICROBIOLOGY (CORE 2-THEORY)
COURSE CODE	: PGMP-LS-C-2
SEMESTER	I
CREDITS	03
MARKS	75
TOTAL HOURS	45

Course Objective:

The course aims at familiarizing students with the applicative concepts of the microbial world.

Course Learning Outcomes:

Upon successful completion of the course, students will be able:

- CLO1 To enrich understanding about microbial world and their adaptations to environmental extremities and their applications
- CLO2 To create awareness of antibiotic resistance and their molecular mechanisms.
- CLO3 To understand the industrial applications of microorganisms.
- CLO4 To evaluate the practical aspects of microbiology.

Module 1: Microbial Diversity**15 hours**

Microbial diversity, Culture methods: Culture-dependent and independent techniques. Bioprospecting for active agents. Extremophiles: Physiology, Biochemistry and Applications of – Thermophiles, Psychrophiles, Piezophiles, Radiation resistant organisms.

Module 2: Medical Microbiology**15 hours**

Mechanisms of Virulence Regulation: Types of Regulation, Bacterial communication and virulence: Quorum Sensing signaling molecules, Mechanisms of quorum sensing in Gram Negative and Gram-positive bacteria. Antibiotic Resistance, Genetic Basis of antimicrobial resistance; Mechanistic basis of antimicrobial resistance, its modification, changes in target sites, Resistance due to global cell adaptation. Epidemiology: Tuberculosis, Botulism, Zika virus /SARS. Quality Control and diagnostics in Medical Microbiology.

Module 3: Industrial Microbiology**15 hours**

Fermentation: Media formulations, raw materials, Modes, Equipments and Instruments, The development of inocula for industrial fermentations, Development of inocula for unicellular bacterial process, Development of inocula for mycelial process. Improvement and Preservation of industrially important strains of organisms. Applications in: Bioremediation, Bioprospecting, Waste Management, Food Processing, enzyme production, Bioplastics and Agriculture.

COURSE TITLE : ADVANCED AND APPLIED MICROBIOLOGY (CORE 2 - PRACTICAL)
COURSE CODE : PGMP-LS-C-2
SEMESTER I
CREDITS 01
MARKS 25
TOTAL HOURS : 30 (15 SESSIONS)

Sr. No.	Practical Title	Practical sessions
1.	Isolation of lignocellulosic degrading bacteria and its morphological and biochemical characterization	02
2.	Determination of Milk quality by MBRT, Resazurin test.	01
3.	Screening of Halophilic bacteria from salt pans and identification of a promising isolate.	02
4.	Detection of specific types of Antibiotic Resistance using MRSA technique.	01
5.	Citric acid production/acetic acid by selected fungal /bacterial strains	02
6.	Preparation and standardization of yeast inoculums for alcohol fermentation	02
7	Estimation of Microplastic degradation	01
8.	Industry Visit	01
9	Practical Assessments	03
Total		15

REFERENCES:

1. Willey, J., Sherwood, L. and Woolverton, C. (2022). Prescott's Microbiology: 12th Edition. McGraw-Hill Higher Education
2. Microbial diversity and bioprospecting by Alan T Bull, 2020
3. Virulence Mechanisms of Bacterial Pathogens (2016). Indira Kudva, Nancy Cornick et al, Fifth ed, ASM Press, 2016
4. Introduction to Diagnostic Microbiology for the Laboratory Sciences, Maria Dannessa Delost, 2015, Jones and Bartlett Learning
5. Bacterial Pathogenesis- A Molecular Approach Brenda Wilson, Abigail Saylers et al, Third ed, ASM Press, 2011
6. Handbook of Microbiological Quality Control, Pharmaceutical and Medical Devices Rosamund M Baird. (CRC Press)

7. Microbial diversity – Exploration and Bioprospecting by S Ram Reddy, M A Singara Charya and Girisham , Scientific publishers (India)
8. Aneja, K.R. (2008). A Textbook of Basic and Applied Microbiology. New Age International (P) Limited.

WEB REFERENCES:

1. <https://biomed.brown.edu/Courses/BIO48/20.SpeciesConcepts.HTML>
2. https://www.researchgate.net/publication/264238213_Bioprospecting

COURSE TITLE	: BIOCHEMISTRY (CORE 3 - THEORY)
COURSE CODE	: PGMP-LS-C-3
SEMESTER	I
CREDITS	03
MARKS	75
TOTAL HOURS	45

Course Objective:

This course aims at providing an overview of biochemistry and it also includes an in-depth understanding of how various biochemical pathways are linked to each other to coordinate metabolism

Course Learning Outcomes

On the successful completion of the course, students will be able to:

- CLO1 Appreciate the foundations of biochemistry and how the structure of various biomolecules are critical for their respective functions.
- CLO2 Comprehend the nuances in the various biochemical pathways and how these pathways are linked to each other.
- CLO3 Understand the principles that govern enzymology as well as mechanisms of various enzymes and biosignaling.
- CLO4 Gain experimental knowledge of techniques used in advanced biochemistry studies.

Module 1: Principles of Biochemistry**15 hours**

Foundations of Biochemistry (Physical, Chemical, Cellular, Genetic, and Evolutionary); interactions in biological systems.

Overview of the molecules (structure & function) that constitute living organisms: Water, Carbohydrates, Proteins, Lipids, Nucleic acids, Vitamins

Basic biochemical principles and bioenergetics: Weak electrolytes and their biological significance in pH, pKa, titration curve of amino acids; Thermodynamics, ATP and other high energy compounds, redox reactions, standard redox potentials and Nernst equation

Module 2: Biochemistry of biomolecules/Intermediary metabolism**15 hours**

Metabolic pathways: Carbohydrate, amino acid, fatty acid, and nucleic acid metabolism; TCA cycle, Oxidative and photophosphorylation, Urea cycle, cholesterol and steroid metabolism, xenobiotic metabolism.

Intermediary metabolism: metabolite links between various pathways

Module 3: Enzymology**15 hours**

Enzymology: Nature of enzymes, structure and classification, enzyme kinetics (single substrate and bi-substrate reaction), problem-solving on enzyme kinetics, mechanism of chymotrypsin, lysozyme, hexokinase; enzyme regulation, allosteric, homotropic and heterotropic enzymes

Industrial enzymology (for the production of important enzymes).

COURSE TITLE : BIOCHEMISTRY (CORE 3 - PRACTICAL)

COURSE CODE : PGMP-LS-C-3

SEMESTER I

CREDITS 01

MARKS 25

TOTAL HOURS : 30 (15 SESSIONS)

Sr.No	Title of experiment	Practical session
1.	Isolation of glycogen (liver/muscle)	02
2.	Determination of total & reducing sugars in glycogen	02

3. Isolation of Cholesterol	01
4. Isolation & characterization of enzyme from a suitable source	03
5. Enzyme kinetics of isolated enzyme	02
6. Protein estimation using Bradford's method	02
7. Practical Assessments	03

Total sessions 15

REFERENCES

1. Stryer, L., Berg, J. M., Tymoczko, J. L. and Gatto, G. (2019) Biochemistry. 5th edition. W. H. Freeman and Co., New York, USA.
2. Murray, R. K., Granner, D. K., Mayes, P. A. and Rodwell, V. W. (2003). Harper's Illustrated Biochemistry. 26th edition. McGraw-Hill Companies.
3. Jain, J. L., Jain, S. and Jain, N. (2004). Fundamentals of Biochemistry. 7th edition. S. Chand and Company, Ltd., New Delhi.
4. Harvey, R.A. and Ferrier, D.R. (2013). Lippincott's Illustrated Reviews, Biochemistry. 6th edition. Lippincott Williams and Wilkins.
5. Voet, D. and Voet, J. G. (2010). Biochemistry. 4th edition. John Wiley & Sons, Inc, USA
6. Nelson, D. L. and Cox, M. M., (2008). Lehninger's Principles of Biochemistry. 5th edition. Worth Publishers, New York, USA.

WEB REFERENCES

1. <https://openstax.org/details/books/biology-2e> - free book resource
2. [3: Bioenergetics - Thermodynamics and Enzymes - Biology LibreTexts](#)
3. [8.6: The pH Concept - Chemistry LibreTexts](#)
4. [Definition of pH \(video\) | Khan Academy](#)
5. [5.3: Energy - Photophosphorylation - Biology LibreTexts](#)
6. [Lecture 5.5 Enzymology - Biology LibreTexts](#)
7. [Basics of enzyme kinetics graphs \(article\) | Khan Academy](#)
8. [Enzyme Kinetics - Structure - Function - Michaelis-Menten Kinetics](#)

COURSE TITLE	: DEVELOPMENTAL BIOLOGY (CORE 4 - THEORY)
COURSE CODE	: PGMP-LS-C-4
SEMESTER	I
CREDITS	03
MARKS	75
TOTAL HOURS	45

Course Objective

This course is intended to provide an understanding of the overall chronology in the vertebrate and invertebrate development and the role of various morphogens in specification and determination of various organs and body axis formation.

Course Learning Outcomes

On the successful completion of the course, students will be able to:

CLO1 Foster understanding of the basic mechanisms of growth and development in animals.

CLO2 Understand concepts of tissue differentiation, embryonic development and organogenesis in plants.

CLO3 Know the concepts associated with development and regeneration in model organisms.

CLO4 Gain experimental knowledge of developmental processes in plants and animals.

Module 1: Early embryonic developments in invertebrates and vertebrates 15 hours

Ultra structure of gametes; Recognition of sperm and egg during fertilization; Molecular events in fertilization (Prevention of Polyspermy, genetic fusion, Activation of egg metabolism);

Cleavage - Types and Regulation; Blastulation; Gastrulation; Early development of embryo;

Positional information (proximal – distal, anterior – posterior, dorso - ventral axis); fate maps.

Development of extra embryonic membranes.

Module 2: Plant developmental biology 15 hours

Permanent tissues of plants, shoot apical meristem (SAM), root apical meristem (RAM), vascular development, secondary growth.

Leaf development – leaf initiation and expansion, dorsoventral patterning, stomata density and distribution control.

Flower development – flowering genes, ABCDE model, homeotic genes, MADS box.

Development of reproductive organs – development of gametophyte and gametes (microsporogenesis and megasporogenesis), pollination and self-incompatibility, fertilization.

Embryogenesis – development of embryo, embryonic pattern formation and polarity development.

Module 3: Model systems of plants and animals

15 hours

Animal Model systems: Specification of body axes in sea urchin, nematode- *C.elegans*, *Drosophila*, *Xenopus*, Chick and Mouse embryo.

Plant Model System: *Arabidopsis*

Cellular communication: Paracrine factors and signal transduction cascade (Jak-Stat pathway, Notch pathway, Wnt signaling pathway, Smad pathway).

Regeneration ability of animals, Types of regenerations in animals (Hydra, Planaria, Star fish, Salamander).

COURSE TITLE : DEVELOPMENTAL BIOLOGY (CORE 4 - PRACTICAL)

COURSE CODE : PGMP-LS-C4

SEMESTER I

CREDITS 01

MARKS 25

TOTAL HOURS : 30 (15 SESSIONS)

Sr.no	Title of Experiment	Practical sessions
1	Observation of permanent slides of developmental stages in invertebrates: Cleavage, Morula, Blastula, Gastrula, Larval stages..	01
2	<i>In vitro</i> observation of different extra embryonic membranes in chick.	01
3.	Study of morphallactic regeneration in hydra	01
4.	Observation/Preparation of permanent slides of chick embryo: 24 hours till hatching	03
5	Study of cytohistological zonation in shoot apical meristem (SAM) in sectioned and double-stained permanent slides.	01

6.	Isolation of embryos from suitable plants to study stages of development.	02
7.	Examination of shoot apical meristem in monocots in T.S. and L.S. to show origin and arrangement of leaf primordia.	01
8.	Study of pollen types using acetolysed and non-acetolysed pollen.	02
9.	Practical Assessments	03

Total sessions 15

REFERENCES

1. Barresi, M., and Gilbert, S. (2023). *Developmental Biology*, 13th edition, Sinauer Associates Inc., Sunderland, USA.
2. Gilbert, SF. (2016). *Developmental Biology*, 11th edition, Sinauer Associates Inc., Sunderland, USA.
3. SA. (2014). *Principles of Developmental Genetics*, Academic Press. New York.
4. Jain, P.C. (2013). *Elements of developmental biology*, Vishal Publications, Jalandhar.
5. Slack, J.M.W. (2006). *Essential developmental biology*. Blackwell Publishing, U.K.
6. Beffa-Mari, M. and J.Knight. (2005). *Key experiments in practical developmental biology*. Cambridge University Press.
7. Raghavan, V. (2000). *Developmental Biology of Flowering Plants*. Springer New York.
8. Tyler, M.S. (2000). *Developmental biology: a guide for experimental study*. Sinauer Associates, Inc. Publishers, Sunderland, MA.

DISCIPLINE SPECIFIC ELECTIVE COURSES FOR SEMESTER I

COURSE TITLE	: INSTRUMENTATION AND TECHNIQUES (ELECTIVE 1 -THEORY)
COURSE CODE	: PGMP-LS-E-1
SEMESTER	I
CREDITS	03
MARKS	75
TOTAL HOURS	45

Course Objectives

This paper will provide students with an understanding of the principles of operation, processing, interpretation, application and limitations of various advanced instruments and equipment commonly utilized in life science research. In addition, it will guide students in designing experiments and foster critical thinking skills in selecting appropriate instrumentation and techniques, ensuring accuracy and precision to address specific research questions.

Course Learning Outcomes

On the successful completion of the course, students will be able to:

- CLO1 Proficiently explain the operation and application of microscopes, centrifuges, and spectrophotometer
- CLO2 Describe the different hyphenated techniques
- CLO3 Elucidate electrophoresis, concepts of radiobiology and molecular techniques
- CLO4 Operate instruments frequently used in life science research

Module 1: Microscopy, Centrifugation and Spectroscopic techniques 15 hours

Principle and working, applications of Fluorescence microscopy, Confocal, Phase contrast, Electron microscopy (SEM and TEM),

Principle of centrifugation, ultracentrifuge, gradient centrifugation, analytical, preparative, microcentrifuge

Principle, Instrumentation and applications of UV-VIS spectrophotometry; IR (infrared) spectrophotometry; Nuclear Magnetic Resonance spectroscopy (NMR), Mass spectrometry, MALDI-TOF, Spectrofluorometry, Atomic/flame spectrophotometry; Raman spectroscopy, X-ray spectroscopy.

Module 2 : Advanced spectrometry and electrophoretic techniques**15 hours**

LC-MS/MS, GC-MS/MS, HPTLC-MS,

General Principles, techniques and application of Native Polyacrylamide gel electrophoresis, SDS–PAGE (sodium dodecyl sulphate), 2D electrophoresis, Capillary electrophoresis, Pulse-Field gel electrophoresis, Electrophoretic mobility shift assay (EMSA).

Module 3: Tools in Radiobiology**15 hours**

Different types of ionizing radiation, Isotopes; Types of radioactive decay; Gieger Muller counters, Liquid scintillation counter, proportional counters, autoradiography, ionization chambers, solid state detectors, gamma spectroscopy, neutron detection, radiation dosimeters, applications of radioisotopes in biological sciences; Safety aspects of use of radioisotopes.

**COURSE TITLE : INSTRUMENTATION AND TECHNIQUES
(ELECTIVE 1 -PRACTICAL)****COURSE CODE : PGMP-LS-E-1****SEMESTER I****CREDITS 01****MARKS 25****TOTAL HOURS : 30 (15 SESSIONS)**

Sr.No	Title of experiment	Practical Session
1.	Verification of Beer's law using a spectrophotometer and understanding substance absorption by λ max values.	01
2.	Separation of RNA and DNA by electrophoresis technique.	02
3.	SDS-PAGE of membrane proteins.	02
4.	Structural analysis of plant lipids by FTIR	02
5.	Demonstration of Electrophoretic Mobility Shift Assay (EMSA)	01
6.	Demonstration of Fluorescence spectrophotometry.	01
7.	Demonstration of Atomic absorption spectrophotometry.	01

8.	Demonstration of Gas Chromatography technique.	01
9.	Visit to research institute	01
10.	Practical assessments	03

Total sessions 15

REFERENCES

1. Wilson, K., Hofmann, A., Walker, J. M., & Clokie, S. (Eds.). (2018). *Wilson and Walker's principles and techniques of biochemistry and molecular biology*. Cambridge university press.
2. Kemp, W. (2017). *Organic spectroscopy*. Bloomsbury Publishing
3. Bisen, P. S., & Sharma, A. (2012). *Introduction to instrumentation in life sciences*. Crc Press.
4. Goldys, E. M. (2009). *Fluorescence applications in biotechnology and life sciences*. John Wiley & Sons.
5. Siesler, H. W., Kawata, S., Heise, H. M., & Ozaki, Y. (Eds.). (2008). *Near-infrared spectroscopy: principles, instruments, applications*. John Wiley & Sons.
6. Petry, R., Schmitt, M., & Popp, J. (2003). Raman spectroscopy—a prospective tool in the life sciences. *chemphyschem*, 4(1), 14-30.

WEB REFERENCES

1. <https://www.thermofisher.com/in/en/home/electron-microscopy.html> (Electron Microscopy)
2. https://www.hitachi.com/rev/1999/revjun99/r3_101.pdf (LC/MS, HPLC, DNA sequencer)
3. <https://microbenotes.com/category/instrumentation/> (Chromatography and Centrifugation)
4. <https://www.britannica.com/technology/microscope/The-compound-microscope> (Compound microscope)
5. <https://www.iaszoology.com/instrumental-methods/> (ELISA, FISH, blotting techniques)
6. <https://pubmed.ncbi.nlm.nih.gov/27619256/> (Radiobiology)

COURSE TITLE : TOXICOLOGY (ELECTIVE 2 -THEORY)
COURSE CODE : PGMP-LS-E-2
SEMESTER I
CREDITS 03
MARKS 75
TOTAL HOURS 45

Course Objective:

On successful completion of the course, students will be able to identify, classify and characterize a variety of environmental toxins. Students would understand the biochemical and environmental impacts of toxicology.

Course Learning Outcomes:

Upon successful completion of the course, students will be able:

CLO1 Classify plant, animal and microbial toxins and understand their mechanism of action.

CLO2 To learn biochemical mechanisms involved in metabolism and detoxification.

CLO3 To understand the impact of toxicity on the environment.

CLO4 To evaluate the practical aspects of toxicology

Module 1:Toxin classification-plant, bacterial and animal 15 hours

Introduction to Toxicology and Toxicity. Toxicology: efficacy, effectiveness, potency, biological half-life. Classification of Toxicants and Toxins. Classification of toxins: natural toxins, animal toxins, plant toxins, bacterial toxins, food toxins, genetic poisons and chemical toxins; mode of action of toxicants.

Dose-effect and dose-response relationship - acute toxicity, chronic toxicity reversible and irreversible effects.

Module 2: Biochemical toxicology 15 hours

Mechanism of toxicity -Delivery, absorption, distribution and excretion of toxicants; reaction of toxicants with target molecules.

Cytochrome P450 enzyme system, metabolism; detoxification pathways and mechanisms, induction, Biotransformation Phase I, Biotransformation Phase II, bio-conjugating agents, drug-drug and drug-herb interactions, elimination pathways and bioaccumulation.

Module 3: Environmental Toxicology**15 hours**

Introduction, Ecotoxicology - examples of ecotoxicology, scientific approach to ecotoxicology; Entry, movement and fate of pollutants in ecosystems.

biochemical basis of toxicity: mechanism of toxicity and receptor mediated events. Factors influencing toxicity; Bioaccumulation and Bio-magnifications of toxic materials in food chain; Basic concepts of Environmental forensics; Concepts of Bioassay- types (physico-chemical and microbial), characteristics, importance and significance.

COURSE TITLE : TOXICOLOGY (ELECTIVE 2 - PRACTICAL)
COURSE CODE : PGMP-LS-E-2
SEMESTER I
CREDIT 01
MARKS 25
TOTAL HOURS : 30 (15 sessions)

Sr. No.	Practical Title	Practical sessions
1.	Effect of toxicity in water on microorganisms	02
2.	Determination of the histo-toxicity/ histopathology of a given sample.	02
3.	Histological processing of tissues/organs for toxicological tests	02
4.	Determination of toxic chemicals in different water and soil samples	02
5.	To evaluate qualitatively the presence of pesticide residues in vegetable samples	02
6.	Visit to Waste Management Unit / polluted water bodies	02
7.	Practical assessment	03
	Total	15

REFERENCES

1. Butler JC, (2022) Principle of Toxicology, John Wiley & Sons, NY.

2. Gupta P.K.(2010) Modern Toxicology, Pharma Med Press, Hyderabad.
3. Ernst Hodgson(2004) A Text Book of Modern Toxicology ,A John Wiley and sons Inc,Publication.
4. Sood, A., Sarup and Sons,1999. Toxicology, New Delhi.
5. Asthana, M. and Asthana, D.K. 1990. Environmental pollution and Toxicology, Alka Printers.
6. Sharma, P.D. 1994. Environmental biology and Toxicology, Rastogi andLamporary.
7. Casnrell & Doul's Toxicology- The basic science of poisons by Curtis Klalsen, McGraw Hill

WEB REFERENCES:

1. Indian Institute of Toxicology Research, Government of India (iitrindia.org)
2. <https://moef.gov.in>

COURSE TITLE	: FERMENTATION TECHNOLOGY (ELECTIVE 3 - THEORY)
COURSE CODE	: PGMP-LS-E-3
SEMESTER	I
CREDITS	03
MARKS	75
TOTAL HOURS	45

Course Objectives

This course will provide a detailed understanding of how various fermentation processes are designed and developed, along with an overview of the various aspects of fermentation.

Course Learning Outcomes

On the successful completion of the course, students will be able to:

- CLO1 Understand the importance of various structures seen in a fermenter and microbial growth kinetics
- CLO2 Summarize various aspects of the microorganisms and the sterilization methods that are used in the fermentation industry
- CLO3 Correlate the entire process of fermentation that includes inoculum preparation, recovery and purification of the final products

CLO4 Obtain first-hand knowledge of fermentation processes at the small scale and large scale.

Module 1: Fermenters: types and design

15 hours

Introduction to Fermentation Processes: significance of microbial enzymes, biomass, and metabolites; the basic process of fermentation

Fermenters: Design, types, and structures - basic construction, agitator, baffles, spargers, sterilization, various ports, valves & probes; the difference between microbial and animal cell culture fermenters

Microbial growth kinetics: Batch culture, fed-batch culture, continuous culture.

Module 2: Upstream processing

15 hours

Isolation, screening, preservation & storage of important cultures, and improvement of microorganisms for fermentation processes; quality control; isolation of microorganisms for primary and secondary metabolites, improvement of microbial strains.

Inoculum development using various prokaryotic and eukaryotic organisms

Media for industrial fermentations - carbon & nitrogen sources, minerals, growth factors, buffers, precursors, inhibitors, inducers, media optimization

Sterilization: Media, fermenter, feed, waste, and air sterilization

Module 3: Downstream processing

15 hours

Important fermentation products: Ethanol, Antibiotics, Insulin, Enzymes, Vitamins, Biopolymers

Recovery and purification of fermentation products: removal of cell biomass, filtration, centrifugation, cell disruption; solvent recovery; chromatographic techniques and membrane processes for purification; drying and crystallization

Effluent treatment before disposal of wastes: physical, chemical, biological treatments.

COURSE TITLE : FERMENTATION TECHNOLOGY (ELECTIVE 3 - PRACTICAL)
COURSE CODE : PGMP-LS-E-3
SEMESTER I
CREDITS 01
MARKS 25
TOTAL HOURS : 30 (15 SESSIONS)

Sr.No	Title of experiment	Practical session
1.	Study of a fermenter and its parts. (<i>preferably an on-site functional fermenter</i>)	01
2.	Preparation and sterilization of media	01
3.	Isolation and screening of a potential microorganism for fermentation	02
4.	Comparative study of Fed-batch and continuous cultures for the production of antibiotics/enzyme	02
5.	Demonstration of Continuous culture using a rotary fermenter	03
6.	Recovery and purification of the product produced by the isolated microorganism	02
7.	Field visit to a distillery & brewery/ pharmaceutical industry	01
8.	Practical assessments	03
Total sessions		15

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- Stanbury, P. F., Whitaker, A., & Hall, S. J. (2017). Principles of Fermentation Technology. 3rd edition. Butterworth Heinemann
- Crueger, W., Crueger, A., & Aneja, K. R. (2017). Biotechnology: a Textbook of Industrial Microbiology. 3rd edition. Sunderland, MA : Sinauer Associates ; Madison, WI : Science Tech.
- Wittmann C., & Liao J. C., (2016). Industrial Biotechnology: Products and Processes. 1st edition. Wiley & Sons Incorporated

WEB REFERENCES:

- Fermentation Technology: Meaning, Methodology, Types and Procedure
- Fermentation Technology in the Development of Functional Foods for Human Health: Where We Should Head - PMC
- Novel Candidate Microorganisms for Fermentation Technology: From Potential Benefits to Safety Issues - PMC
- Solid-state fermentation: a promising microbial technology for secondary metabolite production
- The Role of Yeasts in Fermentation Processes - PMC
- Fermented Foods: Definitions and Characteristics, Impact on the Gut Microbiota and Effects on Gastrointestinal Health and Disease

COURSE TITLE	: ANIMAL BEHAVIOUR (ELECTIVE 4- THEORY)
COURSE CODE	: PGMP-LS-E-4
SEMESTER	I
CREDITS	03
MARKS	75
TOTAL HOURS	45

Course Objective

This course is intended to develop an understanding of the concepts in animal behaviour. Students will gain an insight into the introduction and concepts of ethology, approaches to studying behaviour, patterns of behaviour and communication behaviour.

Course Learning Outcomes

On the successful completion of the course, students will be::

CLO1 Acquainted with the basics of animal behaviours.

CLO2 Gain insight on the different types of behaviour used for survival in the animal kingdom.

CLO3 Understand the mechanisms underlying behavior.

CLO4 Analyze various behavioral patterns in animals.

Module 1: Ethology and its aspects**15 hours**

Introduction, history and types of behavior, economic and social aspects.

Concepts on Animal behaviour- evolutionary approach, stimulus response concept, reflexes, innate releasing mechanisms, fixed action pattern, ethogram releaser, motivation or drive with respect to hunger and sexual behaviour; Learning and memory.

Ethologists and their work – Konrad Lorenz, Nikolaas Tinbergen and Karl Von Frisch; M.K. Chandrashekar; WO Wilson; Richard Dawkins; WD Hamilton.

Module 2: Types of animal behaviour**15 hours**

Learning and imprinting, habituation, conditioning, trial and error, neural mechanism of learning in animals.

Communication in animals- Auditory (echolocation, infra and ultra sounds); tactile; visual; role of pheromones in vertebrates and invertebrates; language of honey bees (round and waggle dance); Camouflage and mimicry.

Migration of animals- Introduction, types and causes of migration in fishes and birds, advantages of migration. Methods of studying migration and navigation.

Biological clocks- types and clock genes.

Module 3: Social and Reproductive behaviour**15 hours**

Hamilton's theory and Altruism, cooperation, reciprocation and Eusociality.

Territorial marking (types, advantages and disadvantages); Aggressive behaviour in animals, natural weapons;

Schooling in fishes, herding in mammals, group selection, kin selection, inclusive fitness; social organization in insects (termites, bees and wasps); Jane Goodall and Dian Fossey; Contributions to sociobiology, advantages of a social group, social organization in primates.

Reproductive behaviour- sexual strategies and rituals, mating types and courtship; Role of hormones and pheromones in sexual and maternal behaviour.

Parental care- types; parent offspring conflict; brood parasitism.

Human ethology- Introduction, concepts of sign stimulus and imprinting, human social system, human beings and territorial behavior, human aggressive behavior.

COURSE TITLE : ANIMAL BEHAVIOUR (ELECTIVE 4 - PRACTICAL)
COURSE CODE : PGMP-LS-E-4
SEMESTER I
CREDITS 01
MARKS 25
TOTAL HOURS: 30 (15 SESSIONS)

Sr.no	Title of Experiment	Practical sessions
1.	Study the habituation to tactile stimulus in crabs.	01
2.	Study of social behaviour in termites by observing a Termitarium.	01
3	Demonstrate phototactic and geotactic responses in earthworms.	01
4.	Questionnaire/case study to understand human behaviours (fear, social bonding, aggression)	02
5.	Documentation of territorial behavior in insects / birds.	02
6.	Observation of foraging and parental behavior in birds/mammals.	03
7.	Case studies on migration of X chromosomes	01
8.	Visit to a Wildlife sanctuary/Zoo/ Apiary.	01
9.	Practical Assessments	03

Total sessions 15

REFERENCES:

1. Shukla. J.P (2023). Fundamentals of Animal Behaviour. Atlantic.
2. Bonner, J. T. (2018). The Evolution of Culture in Animals. United States: Princeton University Press.
3. Manning, A and Dawkins, M.S. (2016). Introduction to Animal Behaviour 6th edition. Cambridge University Press India.
4. Mathur, R. (2014). Animal Behaviour. India: Rastogi publications.
5. Alcock, J. (2013). Animal Behavior: An Evolutionary Approach. United States Oxford University Press, Incorporated.
6. Ehrman, L., Parsons, P. A. (1976). The genetics of behavior. United States: Sinauer Associate

DISCIPLINE SPECIFIC CORE COURSES FOR SEMESTER II

COURSE TITLE	: CELL SIGNALING AND REGULATION (CORE 5 - THEORY)
COURSE CODE	: PGMP-LS-C-5
SEMESTER	II
CREDITS	03
MARKS	75
TOTAL HOURS	45

Course Objective

This course will assist students in comprehending the intricate network of numerous cell signaling systems in order to investigate their possible technological applications in a variety of disciplines.

Course Learning Outcomes

On Successful completion of the course the student will be able to:

CLO1 Explain the methods of cell signaling and associated pathways

CLO2 Understand the various interactions pertaining to the aspects of cell signaling.

CLO3 Apply their knowledge of cellular communication mechanism in order to diagnose specific genetic disorders and diseases

CLO4 To be able to comprehend the flow cytometry technique and perform as well as analyse its results in the best way possible to broaden understanding of cellular signaling aspects.

Module 1: Cell signaling mechanisms

15 hours

Introduction to cell signaling mechanisms and developmental processes in several model species; Cell signaling pathways- evolutionary commonalities. Cytoplasmic and nuclear receptors, orphan receptors, transcription factors, G protein-coupled receptor (GPCR) signaling, protein kinases and phosphatases, and second messengers as examples of intracellular signaling pathways.

Module 2: Interaction for Cell Signaling

15 hours

Recognition and adherence of cells; Interactions between receptors and ligands, receptor-to-signaling machinery coupling, regulation of receptor function, cell changes, and cell adaptation; calcium homeostasis, cellular roles of calcium, and techniques for monitoring intracellular quantities of second messenger calcium ions,

Module 3: Cell signaling and control**15 hours**

Signaling and development: cell signaling regulation, two-component systems, homeotic genes, epigenetics, the origin of innovation, diseases induced by signaling system defects; cell signaling and developmental biology in disease modeling, medication screening, and product creation.

COURSE TITLE : CELL SIGNALING AND REGULATION (CORE 5 - PRACTICAL)
COURSE CODE : PGMP-LS-C-5
SEMESTER II
CREDITS 01
MARKS 25
TOTAL HOURS 30

Sr. No.	Title of Experiment	Practical sessions
1	Understanding the activity of the JNK signaling pathway in cultured cells	02
2	Understanding the activity of the Nrf2 antioxidant pathway in cultured cells	02
3	Understanding activity of the PI3K/AKT signaling pathway and the transcriptional activity of FOXO proteins in cultured cells	02
4	Understanding the activity of the NF- κ B signaling pathway in the cultured cells	02
5	Understanding the activity of the Notch signaling pathway in cultured cells	02
6	Understanding the activity of TGF β /SMAD signaling pathway in the cultured cells	02
7	Practical Assessment	03
Total Sessions		15

REFERENCES

1. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts and P. Walter, Molecular biology of the cell. Garland Science; 7th Edition, 2022.

2. Eduardo D. P. De Robertis, E. M. F. De Robertis, Cell and molecular biology by Robertis, 2020
3. F. Marks, U. Klingmuller and K. Müller-Decker, Cellular signal processing: an introduction to molecular mechanisms of signal transduction, Garland Science; 1st Edition, 2008
4. R. K. Ockner, Integration of metabolism, energetics, and signal transduction, Springer; 4th Edition, 2007.
5. G. Krauss, Biochemistry of signal transduction and regulation, Wiley-VCH; 3rd Edition, 2003.

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1. <https://www.ncbi.nlm.nih.gov/books/NBK9851/> (Cell - Cell Interaction)
2. <https://www.khanacademy.org/test-prep/mcat/cells/eukaryotic-cells/a/organelles-article> (Cell Organelles and Structures)
3. <https://www.ncbi.nlm.nih.gov/books/NBK9876/> (Phases of the cell cycle)
4. <https://www.ncbi.nlm.nih.gov/books/NBK10019/> (Meiosis)
5. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC158550/> (Effect of temperature on Membrane Fluidity)

COURSE TITLE : IMMUNOLOGY (CORE 6 - THEORY)
COURSE CODE : PGMP-LS-C-6
SEMESTER II
CREDITS 03
MARKS 75
TOTAL HOURS 45

Course Objective:

The course will provide an in-depth understanding of the various facets of the immune system along with the knowledge of diseases of the system.

Course Learning Outcomes:

On the successful completion of the course, students will be able to:

CLO1 Outline the various types of immunities as well as the cells and organs of the immune system

CLO2 Correlate the function of antigens and antibodies and highlight the significance of this to the specificity of the immune system

CLO3 Comprehend MHC, hypersensitivity, autoimmunity and the relationship between cancer and the immune system

CLO4 Gain extensive training in various experiments that are governed by immunological reactions.

Module 1: Immunological principles

15 hours

Historical perspective, an overview of the immune system: Innate and adaptive immunity, humoral and cell-mediated immunity, immune dysfunction.

Cells and organs of the immune system; B cell and T cell maturation, activation, and differentiation, development of the immune system.

Antigen: nature, dosage & administration, adjuvants, B & T cell epitopes, haptens.

Antibody: Structure, affinity, avidity, bonus effect, classes, functions, biological activities, monoclonal and polyclonal antibodies

Antigen-Antibody interactions: precipitation reactions, immunodiffusion, immunoelectrophoresis, agglutination, RIA, ELISA, Western blotting, immunofluorescence.

Module 2: Immune cell receptors, complement system & MHC

15 hours

Gene rearrangement for variations in B- cell & T- cell receptors

The complement system: functions, complement components, classical pathway, alternative pathway, lectin pathway

MHC: General organization & inheritance, products of MHC genes: structure and function, Class I, II & III MHC molecules, regulation of MHC gene expression; relationship of MHC to immune responsiveness & disease susceptibility

Module 3: Hypersensitivity, Autoimmunity and Cancer

15 hours

Hypersensitive reactions: Classification, types I-IV,

Autoimmunity: Organ-specific diseases (Hashimoto's, thyroiditis, anemias, Goodpasture's syndrome, type I diabetes, Grave's disease, Myasthenia gravis); systemic diseases (Lupus, MS, Rheumatoid arthritis; treatment of autoimmune diseases

Cancer and the immune system: Tumor antigens, cancer immunotherapy

COURSE TITLE : IMMUNOLOGY (CORE 6 - PRACTICAL)
COURSE CODE : PGMP-LS-C-6
SEMESTER II
CREDITS 01
MARKS 25
TOTAL HOURS : 30 (15 SESSIONS)

Sr.No	Title of experiment	Practical session
1.	Study of permanent slides of sections of organs and cells of the immune system	01
2.	Total and differential WBC count	01
3.	Isolation of serum and plasma	01
4.	Radial immunodiffusion	02
5.	Double immunodiffusion	02
6.	Immuno-electrophoresis	02
7.	ELISA - Sandwich and Competitive	02
8.	Precipitation reactions (Widal)	01
9.	Practical Assessments	03
Total sessions		15

REFERENCES

1. Abbas A., Lichtman A., & Pillai S. (2021). Cellular and Molecular Immunology (10th Edition). Elsevier.
2. Richard, A. G., Thomas, J. K. & Barbara A. O., (2018). Kuby Immunology, (6th Edition). W. H. Freeman & Company, New York.
3. Punt J., Stranford S., Jones P, Owen, J. A. (2018). Kuby Immunology, (8th Edition). W. H. Freeman & Company, New York.
4. Roitt, I., Brostoff, J. & Male, D.K. (2012). Immunology, (8th Edition). Elsevier Health, UK
5. Rao, C. V. (2011). Immunology (5th Edition), Narosa Publishing House Pvt. Ltd.
6. Arora, M.P. (2006). Cell Biology, Immunology and Environmental Biology, Himalaya Publishing House.

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- [Major Histocompatibility Complex \(MHC Class I and II\)](#)
- [Major Histocompatibility Complex \(MHC\) Class I and MHC Class II Proteins: Conformational Plasticity in Antigen Presentation](#)
- [Introduction to T and B lymphocytes - Autoimmunity - NCBI Bookshelf](#)
- [Autoimmunity: Introduction | British Society for Immunology](#)
- [Immunology - Innate Immunity \(Complement System Overview\)](#)
- [Immediate Hypersensitivity Reactions - StatPearls - NCBI Bookshelf](#)
- [Biochemistry, Autoimmunity - StatPearls - NCBI Bookshelf](#)

COURSE TITLE	: PLANT AND ANIMAL PHYSIOLOGY (CORE 7 - THEORY)
COURSE CODE	: PGMP-LS-C-7
SEMESTER	II
CREDITS	03
MARKS	75
TOTAL HOURS	45

Course Objective:

The objective of this course is to provide students with a comprehensive understanding of fundamental principles governing physiological processes in plants and animals. In addition, they will learn mechanisms involved in growth, development, and response to environmental stimuli. Students will gain an insight into how organisms evolved their functional characteristics and how they stay alive in the face of constantly changing internal and external environments.

Course Learning Outcomes

On the successful completion of the course, students will be able to:

CLO1 Understand the fundamental processes of growth and development in plants..

CLO2 Acquire knowledge in various physiological processes of plants and animals and their regulation to environmental conditions.

CLO3 Gain knowledge on various physiological processes in animals.

CLO4 Enable students to conduct physiological and biochemical assays.

Module 1: Plant physiological processes**15 hours**

Basic concepts in plant-water relations; Aquaporins; Absorption (passive and active); ascent of sap and radial movement of water; Nerst equation and Donnan equilibrium; Transpiration and stomatal regulation, water use efficiency;

Mineral Nutrition: Overview of essential mineral elements (macro and microelements), mechanisms and kinetics of nutrient uptake by plants, long distance transport in plants, Phloem translocation; source-sink relationship, physiological and molecular control of sink activity – partitioning efficiency and harvest index.

Nitrogen metabolism: Biological nitrogen fixation, nitrate, nitrogenase enzyme complex and ammonia assimilation;

Photosynthesis: photosynthetic apparatus; light absorption, emission; pigment systems; light-harvesting complex; photosystems; Z-schemes; photophosphorylation (cyclic and non-cyclic electron flow); concept of quantum yield, CO₂ fixation in C₃, C₄ and CAM plants and its significance; Photorespiration; Significance of photosynthesis in plant growth, development and bio productivity; Artificial photosynthesis; Photosynthesis under stress physiology, impact of climate change on plant productivity.

Plant secondary metabolites: classification, biosynthesis and defense mechanisms.

Module 2: Regulation in plant and animal systems**15 hours**

Hormonal concept of growth and differentiation, classification of plant and animal growth regulators; Homeostasis transport and signaling; feedback mechanisms.

Physiological roles of plant hormones - (Auxins, cytokininins, gibberellins, ethylene, ABA, Salicylic acid, Jasmonates, Polyamines, Brassinosteroids) and animal hormones (Adrenaline, Nor-adrenaline, Cortisol, thyroid hormones) their biosynthesis, mode of action, signal transduction; practical utility of plant hormones in agriculture and horticulture.

Stress physiology: Concept of stress and strain; stressors, interaction with environmental stressors (tolerance, resistance, acclimation, acclimatization); types of strain; morphological and cellular adaptations, stress tolerance mechanisms.

Photoreception, Thermo-reception; Chemoreception; reflexes; Pheromones and other similar chemicals as means of communication among the animals.

Muscle contraction in animals- Neuro-muscular Junction; Neurophysiology: neuron and glia; Neurotransmitters and their physiological functions.

Module 3: Animal physiological processes

15 hours

Tissue systems and their functions;

Nutrition (Feeding and digestion) in non-chordates and chordates. Metagenome of mammalian gut, concept of gut-brain axis, Movements of gastrointestinal tract.

Physiological difference between pulmonary and systemic circulation of higher vertebrates; Lung volumes and their physiological interpretations and changes in lung volumes during pregnancy; Ventilation perfusion physiology.

Circulatory systems: electric and mechanical properties of myogenic and neurogenic hearts, heartcycle including electrocardiogram, hemodynamics, cardiovascular response to extreme stress conditions.

General view of excretion and osmoregulation in non-chordates and chordates in freshwater, physiology of mammalian and non-mammalian kidneys.

Various types of reproductive modes in non-chordates and chordates.

COURSE TITLE : PLANT AND ANIMAL PHYSIOLOGY (CORE 7 - PRACTICAL)
COURSE CODE : PGMP-LS-C-7
SEMESTER II
CREDITS 01
MARKS 25
TOTAL HOURS : 30 (15 SESSIONS)

Sr. No.	Title of experiment	Practical session
1.	Separation of plant pigments by TLC/ Paper chromatography	01
2.	Isolation and estimation of thylakoid proteins by SDS-PAGE	02
3.	Estimation of proline and MDA content from stressed plants	02
4.	Estimation of Jasmonic acid content from plant tissue	01
5.	Study of human lung volumes and capacities during before and after exercise using respirometer and oscillometric technique	02

6.	Study of ECGs and their evaluation.	01
7.	Study of nitrogenous waste products of different animals (ammonia, urea, uric acid)	01
8.	Total count of RBC and WBC	02
9.	Practical assessment	03

Total sessions: 15

REFERENCES:

1. Salisbury, F. B. and Ross, C. W. (2023). *Plant Physiology*. (4th ed). Wadsworth Publishing Company, Beverly.
2. Hill, Wyse and Anderson (2020). *Animal physiology*. (4th ed.)
3. Guyton and Hall (2020). *Textbook of Medical Physiology*. (14th ed.)
4. Taiz, Lincoln and Zeiger, Eduardo. (2018). *Plant Physiology*. (5th ed). Sinauer Associates Inc. Publishers.
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- <https://www.onlinebiologynotes.com/photosynthesis-definition-photosynthetic-pigments-stage-of-light-and-dark-reaction/>
- <https://www.biologydiscussion.com/biomolecules/secondary-metabolites-biomolecules/secondary-metabolites-meaning-role-and-types-44935>

COURSE TITLE	: CYTOGENETICS (CORE 8 - THEORY)
COURSE CODE	: PGMP-LS-C-8
SEMESTER	II
CREDITS	03
MARKS	75
TOTAL HOURS	45

Course Objective:

This course is intended to provide a comprehensive understanding of concepts and principles of genetics. Students will be able to understand the structure of genes and chromosomes, inheritance patterns and genetic disorders. Additionally, this course aims to equip students with practical skills in cytogenetic techniques, fostering their ability to contribute to genetic research and breeding programs.

Course Learning Outcomes

Upon successful completion of the course, students will be able:

CLO1 Understand the principles of cytogenetics, including structure of genes and chromosomes.

CLO2 Interpret the significance of chromosomal variations in plant breeding and agriculture.

CLO3 Knowledge of the genetic basis of common types of hereditary diseases.

CLO4 Demonstrate practical skills in plant cytogenetic laboratory procedures and develop knowledge on modern methods for clinical genetic diagnosis.

Module 1: Principle of inheritance and Pedigree analysis

15 hours

Chromosomes – Macro-molecular organization, Primary and secondary constriction, Heterochromatin and Euchromatin and its significance; Ultra structure of chromosome.

Mendel's laws of inheritance; extensions of Mendelian principles – codominance, incomplete dominance; penetrance, expressivity; lethal and essential genes; Multiple alleles and isoalleles (*Zea mays*, *Drosophila*, *Nicotiana*); gene interactions (non-epistatic and epistatic).

Karyotype and ideogram, Types of karyotyping, Banding techniques.

Pedigree analysis- symbols used in pedigree studies, pedigree construction, pedigrees of sex-linked and autosomal (dominant and recessive), Mitochondrial, Incomplete dominance and penetrance; lod score analysis.

Module 2: Cytoplasmic inheritance and chromosomal aberrations**15 hours**

Cytoplasmic inheritance and maternal effect.

Numerical chromosomal aberrations- Euploidy-Monoploidy, Haploidy and polyploidy; Aneuploidy – Monosomies and Trisomies with suitable examples.

Structural chromosomal aberrations- Deletions, Duplications, Translocation and Inversions with suitable examples; Chromosomal abnormalities in spontaneous mutations.

Evolutionary significance of chromosomal aberrations

Meiotic behaviour of chromosome and nondisjunction; Crossing over and linkages; modifiers, suppressors and pleiotropic genes.

Epigenetics – histone code; base modification; paramutation in maize; Callipygh sheep; Epigenomics.

Module 3: Genetic disorders and Diagnosis**15 hours**

Genetic diseases and inheritance pattern – Autosomal dominant inheritance (Neurofibromatosis), Autosomal Recessive inheritance (Phenylketonuria), X-linked recessive (Duchenne muscular dystrophy), Y-linked (Holandric gene), Multifactorial (Diabetes), Mitochondrial disease (Leber's hereditary optic neuropathy).

Oncogenetics- properties of malignant cells, Types- proto-oncogenes, oncogenes, cellular oncogenes, Tumor suppressor genes.

Human genome project and its implications.

Prenatal Diagnosis- Amniocentesis, Chorionic Villus sampling, Ultrasonography and fetoscopy.

Gene therapy – Haemophilia, cord blood banking and stem cell therapy.

Genetic counseling; Eugenics – implications.

COURSE TITLE: CYTOGENETICS (CORE 8 - PRACTICAL)**COURSE CODE: PGMP-LS-C-8****SEMESTER: II****CREDITS: 01****MARKS: 25****TOTAL HOURS: 30 (15 SESSIONS)**

Sr. No.	Title of Experiment	Practical session
1.	Study of translocation heterozygote in <i>Rhoeo discolor</i> .	01

2. Observation of permanent slides of chromosomal aberrations	01
1. Study of mutagen on plants by scoring chromosomal aberrations.	02
4. Manual Karyotyping of human chromosome plates:	02
a) Normal Male and Female	
b) Turners syndrome	
5. Verification of Down syndrome and Klinefelter's syndrome through Dermatoglyphics	01
6. Construction of linkage map using available data.	01
7. Slide Agglutination Reaction (blood groups – ABO with Rh).	01
8. Exercises for Multiple alleles and Multiple genes.	01
9. Construction and analysis of pedigrees.	02
10. Practical assessment	03
Total sessions 15	

REFERENCES:

1. Pierce, B.A. (2020). Genetics: A Conceptual Approach. (7th edition). W. H. Freeman and Company.
2. Turnpenny P, Ellard S. (2020) Emery's Elements of Medical Genetics and Genomics (16th edition), Elsevier.
3. Strachan T, Read A. (2018) Human Molecular Genetics (5th edition), Garland Science.
2. Alberts B, Johnson A, Lewis J, Raff M, Roberts K, and Walter P. (2014) Molecular Biology of the Cell (6th edition). Taylor & Francis Group, New York, USA.
3. 6. Griffiths, A.J.F., Wesler, S.R., Carroll, S.B and Doebley, J. (2010). Introduction to Genetic Analysis. (10th ed). USA:W. H. Freeman and Co.
- 5 Kothari ML, Mehta LA and Roychoudhury SS. (2009) Essentials of Human Genetics, Oxford University Press, India.

DISCIPLINE SPECIFIC ELECTIVE COURSES FOR SEMESTER II

COURSE TITLE	: BIOINFORMATICS AND BIOETHICS (ELECTIVE 5 - THEORY)
COURSE CODE	: PGMP-LS-E-5
SEMESTER	II
CREDITS	03
MARKS	75
TOTAL HOURS	45

Course Objectives:

The course will provide a comprehensive overview on database generation and data mining. It will help the students understand genome and protein biology by generating alignments of gene and protein sequences. The students would appreciate the significance of IPR and ethics in biology.

Course Learning Outcomes

On the successful completion of the course, students will be able to:

CLO1 Appreciate the core concepts of bioinformatics and analyze biological sequences.

CLO2 Design biological experimental systems and analyse using bioinformatics tools.

CLO3 Understand the importance of Intellectual property rights and ethics in life sciences.

CLO4 Gain experimental knowledge on various bioinformatics tools for genome and proteome analysis

Module 1: Bioinformatics

15 hours

Introduction and History of Bioinformatics, Current status and application of different Omics; Operating systems, internet sources for Flat file & Bioinformatics.

Data Mining: Data types, Data mining and warehousing, Databases knowledge discovery

Biological databases: Primary DNA and Protein Databases, Secondary Composite Structure

Databases, Secondary Protein Databases, Metabolism Database (KEGG), Protein Databank (PDB).

Module 2: Alignment tools and phylogenetic analysis

15 hours

Multiple Sequence Alignment (MSA) tools: Concept and objective, Methods for MSA: Dynamic programming approach, Heuristic approach, and their amalgamations.

Pairwise Alignment tools: Concept and objective, BLOSUM Matrix, PAM Matrix, Global alignment, Local alignment, The Dot Plot, BLAST and FASTA. Statistics: E and P value.

Phylogenetic Analysis: Phylogenetic-trees, Tree-reconstruction terminology, types-rooted vs un-rooted trees, gene vs species trees and their properties; Molecular-Phylogenetics, Methods: Neighbor-Joining Method, UPGMA, Maximum Parsimony.

Module 3: IPR and Bioethics

15 hours

Types of Intellectual property rights (IPR) – Patents, Copyrights, Trademarks, and related rights; Traditional vs. Novelty; Importance of IPR in environmental sciences and biology; Case studies and agreements - Madrid agreement; WIPO treaties; Budapest treaty; Indian Patent Act (1970).

Patents: types of patent application and its economics–Conventional, Divisional, and Patent of addition, Concept of Prior Art; patenting precautions; patent databases, licensing, infringement.

Bioethics: Basic Approaches to Bioethics: regulatory and legal issues; Applications of Bioethics; commercialism in scientific research, Regulatory Concerns, ‘Bioethical Conflicts’ in Biotechnology- Intervention with Nature, Human Genetic Engineering, Genetically modified organisms (GMOs).

COURSE TITLE : BIOINFORMATICS AND BIOETHICS (ELECTIVE 5 - PRACTICAL)
COURSE CODE : PGMP-LS-E-5
SEMESTER II
CREDITS 01
MARKS 25
TOTAL HOURS : 30 (15 SESSIONS)

Sr.No	Title of experiment	Practical session
1.	Sequence analysis by BLAST- BLASTn, BLASTp, primerBLAST.	01
2.	Multiple sequence alignment and Phylogenetic tree analysis	02
3.	Secondary Structure Prediction using Interproscan	01
4.	Motif Finding- MEME and myhits	01
5.	Use of KEGG for metabolism database analysis	01
6.	Protein structural domain analysis by CATH and SCOP	02
7.	Tertiary Structure analysis using PDB,Rasmol	02

8. Homology Modeling using SWISS-MODEL	01
9. Good Laboratory practices (GLP's)	01
10. Practical assessments	03

Total sessions 15

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1. Plummer D.T. (2018). An Introduction to Practical Biochemistry, 3 rd Edition, Tata McGraw, New York.
2. Harisha, S. (2017). Fundamentals of Bioinformatics, I. K. International Publishing House, Mumbai.
3. Krishna V.S. (2017). Bioethics & Biosafety in Biotechnology, New Age Publishers, Bangalore.
4. Xiong, J. (2016). Essential Bioinformatics, Cambridge University Press.
5. Mount, D.W. (2014). Bioinformatics – sequence and Genome analysis, CBS Publishers.

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- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3217699/> (Introduction to IPR)
- http://www.fao.org/fileadmin/user_upload/gmfp/docs/Biosafety%20Brochure.pdf
(Biosafety of GMOs)
- <https://vlab.amrita.edu/?sub=3&brch=273&sim=1432&cnt=1> (Phylogenetic tree construction)
- <https://science.jrank.org/pages/5210/Phylogeny/> (Phylogeny and Cladistics)
- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1186895/> (X-ray crystallography and protein structure determination)

COURSE TITLE	: MARINE BIOLOGY (ELECTIVE 6 - THEORY)
COURSE CODE	: PGMP-LS-E-6
SEMESTER	II
CREDITS	03
MARKS	75
TOTAL HOURS	45

Course Objective:

This course is intended to develop an understanding of the marine environment, adaptations and interactions among the marine life forms. Students will gain an insight into the complex interactions and adaptations in marine organisms.

Course Learning Outcomes

Upon successful completion of the course, students will be able:

CLO1 Develop an in-depth knowledge of life histories of marine organisms

CLO2 Gain knowledge on mariculture and its implications

CLO3 Understand the diversity of marine organisms.

CLO4 Analyze the adaptations in marine organisms.

Module 1: Marine Ecology

15 hours

Marine environment – ecological factors- light, temperature, salinity, pressure.

Classification of marine environment – pelagic, planktonic, nektonic, and benthic adaptations (intertidal, interstitial, and deep-sea adaptations)

Coastal environments- coral reefs, estuaries, mangroves, kelp forests and hydrothermal vents.

Oceanographic studies in India.

Ocean as a habitat- marine food chain and food web, ecological pyramids, energy flow.

Concept of niche, succession and community wise adaptations- fouling and boring community.

Module 2: Mariculture

15 hours

Scientific basis and Techniques of Mariculture.

Seaweed cultivation, *Laminaria* technique. Food and food products from Seaweeds: *Porphyra* as food, *Spirulina* as human food: Nutritional aspects. Economic and environmental aspects.

Commercial production and application of algae: Hydrocolloids, Lipids and polyols, Hydrogen production by algae.

Economic uses of algae, algae in environmental management, and harmful effects of algae.

Module 3: Marine Zoology

15 hours

Marine invertebrates – Porifera, Cnidarians, coral reefs, polychaetes (general characters and examples).

Crustacea- general characters, appendages, larval forms, distribution with examples.

Mollusca-general characters (bivalves, gastropods, cephalopods).

Echinodermata- general characters, examples, and forms in each taxon.

Marine vertebrates- Pisces-Cartilaginous and bony: General characters, classification, and distribution.

Marine reptiles- adaptive radiation in sea snakes and turtles.

Marine birds – general characters, adaptations, and importance.

Marine mammals- general characteristics, classification, and evolution of cetaceans and sirenians.

Distribution, adaptations, and importance. Endangered marine mammals and conservation strategies.

Economic importance and application of marine organisms

COURSE TITLE : MARINE BIOLOGY (ELECTIVE 6 - PRACTICAL)

COURSE CODE : PGMP-LS-E-6

SEMESTER II

CREDITS 01

MARKS 25

TOTAL HOURS : 30 (15 SESSIONS)

Sr. No.	Practical Title	Practical sessions
1.	Identification of representatives from each phyla (specimens/permanent slides).	02
2.	Culturing of algae/BGA using BG11.	02
3.	Identification and Observation of any two seaweeds.	02

4.	Extraction of algal pigments and their separation by paper chromatography.	01
5.	Field collection and preservation (Herbaria and formalin method) of biological samples.	02
6.	Field studies of selected inter tidal and mangrove ecosystems.	01
7.	Visit to National Institute of Oceanography	02
8..	Practical assessments	03
Total sessions		15

REFERENCES:

1. John F. Morrissey and James L. Sumich. (2012). Introduction to the Biology of Marine Life. Jones and Bartlett Learning
2. Sharma O P. (2011). Textbook of Algae. Tata McGraw Hill.
3. Levinton, J.S. (2009). Marine Biology: Function, Biodiversity, Ecology. Third Edition. Oxford University Press, Oxford, UK:640pp.
4. Sambamurty A V S. (2005). A Textbook of Algae. I K International publishers Pvt Lt.
5. Jeffery S. Levinton (2000) Marine Ecology, Biodiversity and function. Oxford University Press.

COURSE TITLE : PHARMACOLOGY (ELECTIVE 7 - THEORY)

COURSE CODE : PGMP-LS-E-7

SEMESTER II

CREDITS 03

MARKS 75

TOTAL HOURS 45

Course objectives

This course provides a comprehensive overview of the concepts that govern pharmacology, pharmacodynamics and pharmacokinetics associated with drug development.

Course Learning Outcomes

On the successful completion of the course, the students will be able to:

CLO1 Explain the principles that govern pharmacology, pharmacodynamics and pharmacokinetics

CLO2 Understand the principles that govern drug formulation, administration and drug development

CLO3 Infer mechanism of action of drugs based on pathophysiology of the disease

CLO4 Gain basic experimental knowledge of pharmacology

Module 1: Principles of Pharmacology

15 hours

Introduction to Pharmacology, historical perspective; terminologies; nature and sources of drugs, Pharmacopeia

Pharmacodynamics: drug targets, desired and undesired effects of drugs; membrane transport; absorption of drugs

Pharmacokinetics: - Biotransformation, Excretion, Drug action; Mechanism & release, Placebo effect, Receptors & Signal Transduction; Agonists, Antagonism; Slow processes, Non-receptor mechanism; constant Rate infusion; single bolus dose, repeated (multiple) dosing

Module 2: Drug formulation, administration and drug development

15 hours

Drug formulation and administration: Bioavailability, Bioequivalence; generic vs. proprietary prescribing; Prodrugs; routes of administration

Drug Development: Introduction to drug development, processes involved in drug development, Toxicity, Clinical trials

ADR, idio-synchratic reaction

Module 3: Types of drugs for various applications

15 hours

Mechanism of action of drugs for the Nervous and Musculoskeletal Systems diseases: Insomnia, Anxiety, and Depressive illnesses; Parkinson's, Alzheimer's, and Migraines. (Any three relevant drugs of the above can be explained)

Mechanism of action of Anesthetics & Muscle relaxants, Analgesics, Anti Inflammatory drugs (Any three relevant drugs of the above can be explained)

Mechanism of action of drugs for the Circulatory & Respiratory system: Antihypertensive drugs, drugs used in ischaemic heart disease, Anticoagulants & antiplatelet drugs, drugs for heart failure drugs used to treat asthma, bronchitis. (Any three relevant drugs of the above can be explained)

Mechanism of action of drugs for the Gastrointestinal: Drugs for peptic ulceration & Esophageal disorders Diarrhea, Irritable bowel syndrome, Liver diseases, Drugs that modify appetite (Any three relevant drugs of the above can be explained)

Mechanism of action of drugs of the reproductive system: Estrogens, progestins, fertility drugs, abortifacient.

Antimicrobial drugs: Antibacterial, Antiviral, Antifungal drugs.

COURSE TITLE : PHARMACOLOGY (ELECTIVE 7 - PRACTICAL)
COURSE CODE : PGMP-LS-E-7
SEMESTER II
CREDITS 01
MARKS 25
TOTAL HOURS : 30 (15 SESSIONS)

Sr.No	Title of experiment	Practical session
1.	MIC of a store-purchased antibiotic	02
2.	Study of the efficiency of any antibacterial drug against standard organisms using diffusion method	01
3.	Study of the efficiency of any antifungal drug against standard organisms using diffusion method	01
4.	Case studies on the shelf life of a drug	01
5.	Estimating the quantity of active ingredients in store-bought Vitamins/drug	02
6.	Sterility testing of IV fluids and other fluid based drugs	02
7.	Effect of drugs on cancer cell lines	02
8.	Visit to a pharmaceutical industry	01
9.	Practical assessments	03
Total sessions		15

REFERENCES:

1. Kumar U. (2021). Medical Pharmacology (7th Edition). CBS Publishers and Distributors Pvt. Ltd.
2. Tripathi K. D. (2019). Essentials of Medical Pharmacology (8th Edition). Jaypee Brothers Medical Publishers (P) Ltd., London.
3. Whalen K. (2019). Lippincott Illustrated Reviews: Pharmacology
4. Katzung B., (2017). Basic and Clinical Pharmacology (14th Edition). McGraw-Hill Education/Medical.
5. Whalen K., (2018). Lippincott Illustrated Reviews: Pharmacology (Sangeeta Sharma & Thirumurthy Velpandian edition). Wolters Kluwer India Pvt. Ltd.
6. Ritter J. M., Lewis L. D., Mant T. GK., and Ferro A., (2008). A Textbook of Clinical Pharmacology and Therapeutics (5th Edition). Hachette Livre, U.K.

WEB REFERENCES:

- Principles of Pharmacokinetics - Holland-Frei Cancer Medicine - NCBI Bookshelf
- Pharmacology - PHARMACODYNAMICS (MADE EASY)
- Pharmacodynamics - StatPearls - NCBI Bookshelf
- Pharmacology - PHARMACOKINETICS (MADE EASY)
- Female Reproductive System Drugs – Nursing Pharmacology

COURSE TITLE	: BIOSTATISTICS (ELECTIVE 8 - THEORY)
COURSE CODE	: PGMP-LS-E-8
SEMESTER	II
CREDITS	03
MARKS	75
TOTAL HOURS	45

Course Objectives:

The objective of this course is to equip students with essential statistical tools and techniques for analyzing biological data. The course will allow the students to understand the fundamental concepts of biological data collection, graphical representation, analyze and interpret the outputs using statistical tests and use its applications in academic research and industry.

Course Learning Outcomes

Upon successful completion of the course, students will be able:

CLO1 Apply statistical concepts to analyze biological data.

CLO2 Interpret and communicate statistical results effectively.

CLO3 Learn fundamental concepts of data estimation and hypothesis testing.

CLO4 Gain practical knowledge by problem solving using statistical approaches.

Module 1: Data representation and measures of central tendency

15 hours

Introduction, scope and application and uses of statistics.

Collection and representation of data (Diagrammatic, graphical, and tabular); frequency distributions.

Displaying data: Histograms, stem and leaf plots, box plots

Measures of central tendency: Arithmetic mean – simple, weighted, combined, and corrected mean, limitations; median – calculation for raw data, for grouped data, for continuous series, limitations;

Mode – computation of mode for individual series, by grouping method in a continuous frequency distribution, limitations; Relationship between mean, median and mode; mid-range, geometric mean, harmonic mean, partition value, quartiles, deciles, percentile.

Module 2: Dispersion, correlation and regression and Probability

15 hours

Measure of dispersion: variability, Range, mean deviation, coefficient of mean deviation, standard deviation (individual observations, grouped data, continuous series), standard error, variance, coefficient of variance, limitations.

Correlation and regression: for ungrouped data; scatter and dot diagram; Linear regression and Karl Pearson correlation coefficient and equation for lines of regression; non-linear relationship transformable to linear form ($Y=ab^x$, $Y=a^xb$).

Dispersion, skewness (definition, positive, negative, purpose, measure, relative measure) and kurtosis.

Probability: definition, axiomatic definition, axioms of probability; addition theorem, multiplicative rule; conditional probability and applications in biology; Bernoulli trials.

Random variable and its distribution; binomial probability distribution, examples and conditions, means and variance; Poisson probability distribution, examples and conditions, means and variance, continuous variable, normal distribution.

Module 3: Population statistics and hypothesis testing**15 hours**

Population statistics: Population parameters and sample statistics; sampling techniques (simple random, stratified random, systemic).

Basic concept of hypothesis testing, type-1 and type-2 errors; one-tailed and two-tailed level tests; power of testing, effect size (Cohen's D).

Testing of hypotheses: null and alternative; sampling theory, sampling and non-sampling error, estimation theory, confidence limits testing of hypothesis.

t-Test, paired t-test, z-test, F-test and Chi square test for goodness of fit; level of significance.

Analysis of variance (ANOVA) for one-way and two-way classified data, post-hoc tests.

Census and sampling techniques.

Non-parametric tests: distribution free methods, sign tests for method pairs, Willcoxon test for unpaired data, run test.

COURSE TITLE : BIostatistics (ELECTIVE 8 - PRACTICAL)

COURSE CODE : PGMP-LS-E-8

SEMESTER II

CREDITS 01

MARKS 25

TOTAL HOURS 30

Sr. No.	Title of experiment	Practical session
1	Excel spreadsheet and data analysis	01
2	Classification of Data, Simple and Complex Table, Frequency and Frequency distribution.	01
3	Data analysis for Mean, Mode, Median, standard deviation, standard error & Representation of data in various forms – Graphs (line, scatter, dot), Pie Charts using excel	02
4	Linear equation analysis (regression analysis)	02
5	Hypothesis testing (t-test, Chi square, F-test)	01
6	Problem solving for ANOVA	02

7	Post-hoc tests (Tukey's /Duncan's)	02
8	Application of other software tools (graphpad / systat) for statistical analysis.	01
9	Practical assessment	03

Total sessions: 15

REFERENCES

1. Rastogi, V. B. (2019). Fundamentals of Biostatistics. Ane Books Pvt. Ltd, New Delhi.
2. Arora, P. N. and Malhan, P. K. (2016). Biostatistics. (2nd ed). Himalaya Publishing House.
3. Katikeyan.S. Chaturvedi, R.M , Bhosale, R.M, (2016). Comprehensive textbook of biostatistics and research methodology(1st edn). Bhalani Publishing
4. Banerjee, P. K. (2011). Introduction to Biostatistics, A textbook of biometry. S. Chand & company Ltd. New Delhi.
5. Zar, J. H. (2009). Biostatistical Analysis. (4th ed). New Delhi: Prentice Hall.