

**LEARNING OUTCOMES BASED
CURRICULUM FRAMEWORK (LOCF)
FOR POSTGRADUATE PROGRAMMES**

(With effect from 2026-2027)

M.Sc. ZOOLOGY

Department of Advanced Zoology and Biotechnology



**LOYOLA COLLEGE (AUTONOMOUS)
CHENNAI 600034**

PREFACE

A high priority task in the context of future education development agenda in India is fostering quality higher education. Improvement of quality of higher education is considered critical for enabling effective participation of young people in knowledge production, participation in the knowledge economy, improving national competitiveness in a globalized world and for equipping young people with skills relevant for global and national standards and enhancing the opportunities for social mobility. Sustained initiatives are required for institutionalizing an outcome-oriented higher education system and enhancing employability of graduates through curriculum reform based on a learning outcomes-based curriculum framework, improving/upgrading academic resources and learning environment, raising the quality of teaching and research across all higher education institutions; technology use and integration to improve teaching-learning processes and reach a larger body of students through alternative learning modes such as open and distance learning modes and use of MOOCs.

UGC, under its Quality Mandate, has resolved to revise the curriculum based on Learning Outcomes which is an endeavour towards fostering quality higher education in India. The Learning Outcomes-based Curriculum Framework (LOCF) works towards a more holistic experience for the students, while focusing not just on knowledge delivery in higher education but also on the application of knowledge through field and lab work and emphasises on application of knowledge to real life experiences. Besides this, students will attain various 21st century skills like critical thinking, problem solving, analytic reasoning, cognitive skills, self-directed learning etc (Excerpts of UGC document on LOCF, 16th January, 2020).

In response to the quality mandate of the **UGC**, the Department of Advanced Zoology and Biotechnology, Loyola College, Chennai has undertaken the revision of the **PG Zoology curriculum** to address the evolving needs of students and the industry, and to keep pace with emerging trends in the field of Life Sciences. In the proposed curriculum, while the **Major Core courses** focus on strengthening and expanding the fundamental knowledge of the subject, the **Major Elective, Interdisciplinary Course** emphasize emerging areas in applied biology with the aim of enhancing skills and promoting research output.

We also acknowledge the contributions of the following members of the **Board of Studies**: **Dr. C. Arulvasu** (University Nominee), Professor and Head, Department of Zoology, COE i/c, University of Madras, Chennai; **Dr. B. Meena** (Subject Expert), Associate Professor, Department of Zoology, Presidency College, Chennai; **Dr. K. Elumalai** (Subject Expert), Associate Professor, Department of Advanced Zoology and Biotechnology, Government Arts College for Men, Nandanam, Chennai; **Dr. Susan George** (Meritorious Alumna), Associate Professor, Department of Advanced Zoology and Biotechnology, Sir Theagaraya College, Chennai; **Dr. P. Raghu Babu** (Industry Representative), Technical Director, Acadicell Innovations Pvt. Ltd.; **Mr. Nandakumarr M** (Student Representative); **Mr. Chandramouli M** (Student Representative) along with the **faculty members of the Department of Advanced Zoology and Biotechnology, Loyola College, Chennai.**

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VISION AND MISSION OF LOYOLA COLLEGE

VISION

Towards holistic formation of youth, grounded in excellence, through accompaniment to serve the humanity.

MISSION

- To provide inclusive education through an integral and holistic formative pedagogy.
- To promote skills that prepare them for the future.
- To kindle in young minds the spirit of social and environmental justice with a blend of academic excellence and empathy.
- To stimulate critical and conscientious scholarship leading to meaningful and innovative human capital.

CORE VALUES

- Cura Personalis
- Pursuit of Excellence
- Moral Rectitude
- Social Equity
- Fostering solidarity
- Global Vision
- Spiritual Quotient

VISION AND MISSION OF THE DEPARTMENT

VISION

To offer quality science education to inculcate respect for nature and human life and to promote scientific practices based on strong ethical principles.

MISSION

To introduce modern trends in life sciences emphasizing conservation.
To develop and hone skills of students to meet the local and global needs.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) **(School of Life Sciences)**

PEO1	Academic Excellence, Core Competency and Lifelong learning To achieve academic excellence through teaching and research by building core competencies in the realm of Life Sciences for lifelong learning.
PEO2	Globally Relevant Curriculum, Learning Environment To provide a conducive learning environment to the stakeholders and consistently innovate and upgrade the curriculum by employing modern instructional methodologies to make Life Sciences teaching and learning relevant to the global context.
PEO3	Effective Communication, Teamwork and Leadership skills To demonstrate team-building skills and leadership qualities for effective communication and collaboration through scientific research and publications and enhance the spirit of teamwork and leadership skills.
PEO4	Environmental sustainability, social responsibility and solidarity To instill values in environmental sustainability and social responsibility to become socially responsible scientists.
PEO5	Technical and professional skills, Entrepreneurship and Empowerment To equip students with technical and professional skills in Life Sciences to be empowered citizens through entrepreneurial ventures and contribute toward national priorities.
PEO6	Equity, Equality, Gender sensitization and Scientific temperament To create a campus culture that prepares the students with a strong scientific temperament who are proactive to the needs of the disadvantaged sections of society and demonstrate the principles of equity, equality, and gender sensitization.

PROGRAMME OUTCOMES (POs)

(School of Life Sciences)

PO1	Disciplinary knowledge Students will apply the knowledge acquired in the subject domain and become skilled professionals with a competency that matches global standards.
PO2	Communication Skills, Teamwork and leadership qualities Students will be able to pursue research in Life Sciences and offer solutions to environmental issues and conservation strategies through scientific practices, communication, teamwork and exemplary leadership.
PO3	Critical thinking, problem-solving and analytical reasoning Students will demonstrate skills in analytical reasoning, problem-solving, scientific understanding, and reflective thinking in the frontiers of life sciences.
PO4	Research-related skills and Scientific reasoning Students will acquire skills for scientific research to update and expand the existing knowledge and make conceptual contributions to theoretical biology and create workable prototypes for applied biology.
PO5	Skill development, entrepreneurship and lifelong learning Students will be able to apply the skills learned during the study for lifelong learning to be an entrepreneur, academics or industrialist.
PO6	Environment and ethical awareness Students will be ethically grounded individuals who will understand and contextualize environmental and ethical issues and contribute toward the betterment of the environment to achieve sustainable growth.
PO7	Digital literacy and self-directed learning Students will engage in self-paced and self-directed lifelong learning through digital literacy for personal development, professional accomplishment and the welfare of society.

PROGRAMME SPECIFIC OUTCOMES (PSOs)
(Department of Advanced Zoology and Biotechnology)

PSO1	Students will be able to get exposed to emerging trends in the subject domain and acquire up to date knowledge on theoretical and applied biology.
PSO2	Students will be able to understand and enrich their knowledge of the diversity, systematic position, community ecology and intra and inter species interaction of Kingdom Animalia.
PSO3	Students will be able to apply the principles of biophysics, biochemistry and bioenergetics in the functioning of an ecosystem and appreciate the interaction of biotic and abiotic factors in the sustenance of life and life-supporting systems.
PSO4	Students will be able to expand their perception of the role of principles of genetics, evolution, nanoscience, embryology and behaviour in the stabilization, inheritance and acquisition of desirable traits in the lives of animals.
PSO5	Students will be able to broaden their understanding of the role of beneficial and harmful insects in areas concerning human welfare like health and hygiene, epidemiology, disease diagnosis and prevention, Animal handling and management, food production, Bioethics and Bio-economic prosperity.
PSO6	Students will be able to enrich their knowledge in the emerging multidisciplinary areas of life sciences like molecular biology, genetic engineering, computational biology, AI, physiology, immunology, gene manipulation techniques, waste management and biotechnology that offer ample scope for better career options.
PSO7	Students will be able to perform laboratory experiments, undertake research projects, and field and institutional visits to gain hands-on experience and industry exposure to hone their skills and enhance their expertise in emerging areas of life sciences and contribute toward national priorities as entrepreneurs.

Correlation Rubrics

High	Moderate	Low	No Correlation
3	2	1	0

Mapping of PEOs with Vision and Mission

	PEO1	PEO2	PEO3	PEO4	PEO5	PEO6
Vision	3	3	3	3	3	3
Mission	3	3	3	3	3	3

Mapping of POs with PEOs

	PEO1	PEO2	PEO3	PEO4	PEO5	PEO6
PO1	3	2	3	3	3	2
PO2	3	3	3	3	3	2
PO3	3	3	3	3	3	3
PO4	3	3	3	3	3	3
PO5	3	3	3	3	3	3
PO6	3	3	2	3	3	2
PO7	3	3	3	3	3	3

Mapping of PSOs with PEOs

	PEO1	PEO2	PEO3	PEO4	PEO5	PEO6
PSO1	3	3	3	3	3	3
PSO2	3	3	3	3	3	2
PSO3	3	3	3	3	3	3
PSO4	3	3	3	3	3	3
PSO5	3	3	3	3	3	3
PSO6	3	3	3	3	3	3
PSO7	3	3	3	3	3	3

Mapping of PSOs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
PSO1	3	3	3	3	3	3	3
PSO2	3	3	3	3	3	3	3
PSO3	3	3	3	3	3	3	3
PSO4	3	3	3	3	3	3	3
PSO5	3	3	3	3	3	3	3
PSO6	3	3	3	3	3	3	3
PSO7	3	3	3	3	3	3	3

LOYOLA COLLEGE (AUTONOMOUS), CHENNAI
DEPARTMENT OF ADVANCED ZOOLOGY AND BIOTECHNOLOGY
OVERALL COURSE STRUCTURE

M.Sc. ZOOLOGY

(Effective from 2026 -2027)

Semester	Subject Code	Course	T/L/P	Category	Cr	Hrs
		SEMESTER I				
I	PZO1MC01	Systematics and Diversity of Animals	T	MC	4	4
I	PZO1MC02	Advanced Developmental Biology	T	MC	5	5
I	PZO1MC03	Ethology and Evolutionary Biology	T	MC	5	5
I	PZO1MC04	Community and Population Ecology	T	MC	5	5
I	PZO1MC05	Entomology and Vector Biology	T	MC	4	5
I	PZO1MC06	Animal Diversity, Embryology and Ecology Lab	L	MC	4	6
		Life Skills	T	LS	1	
					28	30
		SEMESTER II				
II	PZO2MC01	Biophysics, Biochemistry and Bioenergetics	T	MC	5	5
II	PZO2MC02	Research Methodology and Biostatistics	T	MC	5	5
II	PZO2MC03	Inheritance Biology	T	MC	5	5
II	PZO2MC04	Cellular organization and Molecular Processes	T	MC	5	5
II	PZO2MC05	Biophysics, Biochemistry and cytogenetics Lab	L	MC	4	6
II	PZO2ME01	Laboratory Animal Science	T	ME	3	4
II	PZO2ME02	Bio Nanoscience	T	ME	3	4
II	PZO2ME03	Clinical Laboratory Techniques	T	ME	3	4
II	PZO2ME04	Microbial Biotechnology	T	ME	3	4
II	PZO2ME05	Forensic Science	T	ME	3	4
		Summer Internship-Industry Integrated Learning -Part 1 (3-4 weeks)		SI-IIL		
		Soft Skills	T	SK	1	
		Service and Learning		SL	2	
					27+3	30
		SEMESTER III				
III	PZO3MC01	Comparative Animal Physiology	T	MC	5	5
III	PZO3MC02	Immunology, Microbiology and Epidemiology	T	MC	5	5
III	PZO3MC03	Computational Biology Lab	L	MC	4	4
III	PZO3MC04	Physiology, microbiology and Immunology Lab	L	MC	4	6
III	PZO3ME01	IPR, Biosafety and Bioethics	T	ME	3	4
III	PZO3ME02	Waste Management and AI	T	ME	3	4
III	PZO3ME03	Toxicology and Pharmacology	T	ME	3	4
III	PZO3ME04	Animal Biotechnology	T	ME	3	4
III	PZO3ME05	Fishery Science	T	ME	3	4
III	PZO3ID01	Bio Entrepreneurship	T	ID	3	6
III		Summer Internship-Industry Integrated Learning -Part 2		SI-IIL	2	
					24+2	30

		SEMESTER IV				
IV	PZO4MC01	Methods in Biology	T	MC	4	5
IV	PZO4MC02	Genetic Engineering	T	MC	4	4
IV	PZO4MC03	Methods in Biology Lab	L	MC	4	6
IV	PZO4PJ01	Project and Dissertation	P	PJ	12	15
					24	30
TOTAL					108	120

M. Sc. Zoology Restructured LOCF Curriculum (effective from June 2026)

PART	SEMESTER I	SEMESTER II	SEMESTER III	SEMESTER IV
MC	Systematics and Diversity of Animals (4h/4c)	Biophysics, Biochemistry and Bioenergetics (5h/5c)	Comparative Animal Physiology (5h/5c)	Methods in Biology (5h/4c)
	Advanced Developmental Biology (5h/5c)	Research Methodology and Biostatistics (5h/5c)	Immunology, Microbiology and Epidemiology (5h/5c)	Genetic Engineering (4h/4c)
	Ethology and Evolutionary Biology (5h/5c)	Inheritance Biology (5h/5c)	Computational Biology Lab (4h/4c)	Methods in Biology Lab (6h/4c)
	Community and Population Ecology (5h/5c)	Cellular Organization and Molecular Processes (5h/5c)	Physiology, Microbiology and Immunology Lab (6h/4c)	
	Entomology and Vector Biology (5h/5c)	Biophysics, Biochemistry and Cytogenetics Lab (6h/4c)		
	Animal Diversity, Embryology and Ecology Lab (6h/4c)			
ME		(4h/3c)*	(4h/3c)*	
ID			Bio-Entrepreneurship (6h/3c) (within school)	
SI-III		PART-I Summer Internship & Industry Integrated Learning (3 to 4 weeks) #	PART-II Summer Internship & Industry Integrated Learning (2C)#	
PJ				(15h/12c)
SSC				
LS	(1c)#			
SK		(1c)#		
SL		(2c)#		
Hr/c	30h (28c)	30h (27c+3c)	30h (24c+2c)	30h (24c)

MC – Major Core; **ME**-Major Elective; **ID**-Inter-Disciplinary; **SI-III**- Summer Internship & Industry Integrated Learning; **PJ**-Project; **SSC**-Self-study Courses; **LS**-Life Skills; **SK**-Soft Skills; **SL**-Service Learning *Based on students' preference two courses will be offered from the given list of subjects # Outside Class Hours

COURSE CODE	PZO1MC01
COURSE TITLE	SYSTEMATICS AND DIVERSITY OF ANIMALS
Credits /Hours	4 Credits / 4 Hours
Category	Major Core (MC) - Theory
Semester	I
Regulation	2026
Course Overview This course provides a rigorous and integrated foundation in taxonomic theory and practice, covering principles of classification, biological nomenclature, and the application of International Commission on Zoological Nomenclature (ICZN) rules in systematic biology, biodiversity documentation, and contemporary research. Introduces the structure and use of taxonomic literature, codes, monographs, revisions, and digital databases, while emphasizing research ethics, scientific writing, type specimen designation, collection curation, and professional standards essential for modern taxonomists. Explores the diversity, body organization, and phylogenetic relationships of lower invertebrates, highlighting diagnostic morphological characters, adaptive strategies, and their evolutionary significance in metazoan radiation. Examines the origin, early diversification, and evolutionary transitions of chordates, including protochordates and basal vertebrates, with special reference to key innovations such as notochord development, cephalization, and vertebral evolution. Surveys the systematics, structural adaptations, ecological roles, and evolutionary trends of vertebrate groups—from fishes to mammals—integrating comparative anatomy, functional biology, and phylogenetic perspectives to demonstrate the continuity and diversification of life forms.	
Course Objectives 1. Develop comprehensive knowledge of taxonomic principles and nomenclature, enabling students to apply classification systems, taxonomic keys, and ICZN rules in zoological studies. 2. Build competencies in taxonomic documentation and ethical practices, including preparation of scientific publications, proper specimen handling, and professional collaboration. 3. Explain the diversity and structural organization of invertebrates, highlighting evolutionary relationships, adaptive features, and ecological importance across major phyla. 4. Understand the origin and evolutionary trends of chordates and vertebrates, emphasizing protochordates, early vertebrate evolution, and phylogenetic transitions. 5. Analyze the morphology, adaptations, and adaptive radiation of major vertebrate groups, from fishes to mammals, in relation to their evolutionary and ecological significance.	
Prerequisites	Basic knowledge on Animal classification, Invertebrate and Chordate diversity.

SYLLABUS				
Unit	Content	Hrs	COs	Cognitive Level
I	Taxonomy and systematics Importance of Taxonomy in basic and applied biology. Challenges of taxonomists. Taxonomy as a profession. History of taxonomy. Modern approaches to taxonomy. Zoological classification. Species concepts. Mode of speciation. Kinds of species. Taxonomic collections- Methods, preservation, curation and cataloguing. Taxidermy. Units of Classification. Linnaean hierarchy. Supra- and Intraspecific categories. Taxonomic keys – Types and application. History and principles of Zoological Nomenclature, Nature of Scientific names, Kinds and types of names. Chapters and Articles of ICZN. Data-Driven Conservation, Machine Learning Approaches for Species Identification, AI-Assisted Morphometrics and Image-Based Taxonomy, Integrating AI with Molecular Systematics and DNA Barcoding, Smart Conservation Technologies for SDG 14 (Life Below Water), AI Tools for SDG 15 (Life on Land), Robotics and Remote Sensing in Animal Diversity Surveys.	10	CO1 CO2 CO3	K1, K2, K3, K4, K5, K6
II	Taxonomic Publications and Ethics in Taxonomy Kinds of taxonomic publications. Preparation of Taxonomic papers. Ethical Principles in Taxonomy. Professional Responsibility and Scientific Integrity. Nomenclatural Ethics and Regulatory Frameworks. Ethical Dimensions of Species Description. Specimen Collection and Humane Sampling Ethics. Legal Compliance and International Biodiversity Conventions. Museum Curation and Repository Ethics. Authorship, Collaboration, and Intellectual Property Rights. Data Transparency, Reproducibility, and Open Science. Molecular Taxonomy and Genetic Resource Ethics. Biopiracy, Access and Benefit Sharing. Publication Ethics and Peer Review in Taxonomy. Digital Taxonomy, AI, and Data Governance. Indigenous Knowledge and Community Rights. Ethics in Taxonomy and Biodiversity Conservation. Conflicts	12	CO1 CO2 CO3	K1, K2, K3, K4, K5, K6

	of Interest and Funding Transparency. Ethical Challenges in Emerging Taxonomic Technologies. Global Inequities and Capacity Building in Taxonomy. Institutes/organization for taxonomy.			
III	Lower Invertebrates (Non-Coelomates, Pseudocoelomates and Coelomates) Protozoa: General characters, locomotion, nutrition, reproduction, and economic importance. Porifera: Canal systems, skeleton, reproduction, and affinities. Cnidaria: Polymorphism, metagenesis, corals and reef formation. Ctenophora: Distinctive features and affinities. Platyhelminthes: Parasitic adaptations and life cycles. Nematoda: General organization and parasitic significance. Coelomates – Protostomes: Annelida: Metamerism, coelom, and adaptive radiation. Arthropoda: Tagmatization, exoskeleton, moulting, and success of arthropods. Major classes: Crustacea, Insecta, Arachnida, Myriapoda. Mollusca: Torsion, shell diversity, feeding mechanisms, and economic importance. Deuterostomes: Echinodermata: Water vascular system, larval forms, and evolutionary significance.	12	CO1 CO2 CO3	K1, K2, K3, K4, K5, K6
IV	Protochordates General characteristics, origin and Fundamental chordate features: notochord, dorsal nerve cord, pharyngeal slits, post-anal tail, endostyle/thyroid. Classification and evolutionary relationships of Hemichordates, Urochordates and Cephalochordates. Theories on the origin of vertebrates. Agnatha: General features and evolutionary position. Early vertebrates: Ostracoderms and their significance. Gnathostome evolution: Placoderms and Acanthodians. Adaptive radiation and trends in vertebrate evolution.	13	CO1 CO2 CO3	K1, K2, K3, K4, K5, K6
V	Pisces, Amphibia, Reptilia, Aves and Mammalia Pisces: Chondrichthyes: External features, skeleton, reproduction, and adaptations. Osteichthyes: Diversity, swim bladder, and parental care. Structural and functional adaptations for aquatic life. Migration and economic importance of fishes. Amphibia: Classification, parental care,	13	CO1 CO2 CO3	K1, K2, K3, K4, K5, K6

	neoteny, and ecological roles. Reptilia: Origin, adaptive radiation, and skull types. Reptilian adaptations for terrestrial life. Extinction of reptiles and evolutionary significance. Aves: Origin of birds, flight adaptations, migration, and classification of major orders. Mammalia: Distinctive features and evolutionary history Prototheria, Metatheria, and Eutheria. Dentition, brain evolution, and parental care in mammals. Adaptive radiation and ecological importance of birds and mammals.			
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Web Resources

- **International Commission on Zoological Nomenclature (ICZN)**
<https://www.iczn.org>
- **ICZN Code Online (4th Edition)**
<https://www.iczn.org/the-code/the-code-online>
- **ZooBank (Official Registry of Zoological Nomenclature)**

- <https://zoobank.org>
- **Catalogue of Life (Global Species Database)**
<https://www.catalogueoflife.org>
 - **Integrated Taxonomic Information System (ITIS)**
<https://www.itis.gov>
 - **Global Biodiversity Information Facility (GBIF)**
<https://www.gbif.org>
 - **Biodiversity Heritage Library (Historic taxonomic literature)**
<https://www.biodiversitylibrary.org>
 - **ZooKeys (Open-access taxonomy journal)**
<https://zookeys.pensoft.net>
 - **Systematic Biology Journal**
<https://academic.oup.com/sysbio>
 - **COPE (Publication ethics guidelines)**
<https://publicationethics.org>
 - **Tree of Life Web Project (Animal phylogeny)**
<http://tolweb.org>
 - **World Register of Marine Species (WoRMS)**
<https://www.marinespecies.org>
 - **Encyclopedia of Life (EOL)**
<https://eol.org>
 - **UC Museum of Paleontology – Invertebrate Phylogeny**
<https://ucmp.berkeley.edu>
 - **Smithsonian National Museum of Natural History – Animal Diversity**
<https://naturalhistory.si.edu>
 - **Animal Diversity Web (University of Michigan)**
<https://animaldiversity.org>
 - **Paleobiology Database (Fossil vertebrates and early chordates)**
<https://paleobiodb.org>
 - **FishBase (Global fish database)**
<https://www.fishbase.se>
 - **AmphibiaWeb**
<https://amphibiaweb.org>
 - **Reptile Database**
<https://reptile-database.reptarium.cz>
 - **BirdLife Data Zone**

<https://datazone.birdlife.org>

- **Mammal Diversity Database (American Society of Mammalogists)**

<https://www.mammaldiversity.org>

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	Define, recall, and describe the fundamental principles of taxonomy, nomenclature, and zoological classification, including the structure and significance of the Linnaean hierarchy and the rules governed by the International Code of Zoological Nomenclature (ICZN) . They will identify and explain the major types of taxonomic publications and the ethical responsibilities associated with specimen handling, authorship, and scientific communication. Learners will outline and summarize the key characteristics, organization, and evolutionary relationships of lower invertebrates, protochordates, and early vertebrates, and explain the origin, diversity, and adaptive features of major vertebrate groups from fishes to mammals. Collectively, these competencies will enable students to demonstrate foundational knowledge and conceptual understanding (K1–K2) of animal diversity, evolutionary trends, and the role of taxonomy in biological sciences.	K1, K2
CO2	Apply principles of taxonomy, nomenclature, and the rules of the International Code of Zoological Nomenclature (ICZN) to classify organisms and interpret scientific names using taxonomic keys and standard procedures. They will demonstrate the ability to use and organize taxonomic collections and prepare basic taxonomic documentation following accepted publication formats and ethical guidelines. Learners will analyze and compare structural organization, life-history strategies, and evolutionary relationships among major invertebrate groups and protochordates, and interpret phylogenetic trends leading to vertebrate diversification. Furthermore, students will examine and differentiate the adaptive features of fishes, amphibians, reptiles, birds, and mammals in relation to habitat transitions and evolutionary radiation. Collectively, these competencies will enable students to apply conceptual knowledge and perform analytical interpretation (K3–K4) of animal diversity, systematics, and evolutionary patterns in academic and applied biological contexts.	K3, K4

CO3	Evaluate taxonomic concepts, nomenclatural rules, and the provisions of the International Code of Zoological Nomenclature (ICZN) to justify appropriate classification decisions and resolve issues related to synonymy, priority, and species delimitation. They will critically assess taxonomic literature and appraise ethical practices in specimen management, authorship, and scientific communication to uphold professional standards. Learners will synthesize morphological, ecological, and evolutionary evidence to formulate coherent interpretations of relationships among invertebrates, protochordates, and vertebrate groups, and construct comparative frameworks explaining adaptive radiation and phylogenetic trends. Furthermore, students will be able to design and propose basic taxonomic or biodiversity documentation projects, integrating classification tools, field observations, and scientific reporting conventions. Collectively, these outcomes enable students to exercise higher-order judgment and creative problem-solving (K5–K6) in taxonomy, systematics, and evolutionary biology.	K5, K6
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CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	2	3	3
CO2	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3

COURSE CODE	PZO1MC02
COURSE TITLE	ADVANCED DEVELOPMENTAL BIOLOGY
Credits/Hours	5 Credits / 5 Hours
Category	Major Core (MC) -Theory
Semester	I
Regulation	2026
Course Overview 1. Introduces the fundamental concepts of cellular potency, commitment, specification, and the molecular mechanisms of differentiation. 2. Explores the production of gametes, zygote formation, and the intricate cell-surface interactions during sperm-egg recognition. 3. Provides a strong foundation in early embryonic development, covering cleavage, blastula formation, and the morphogenetic movements of gastrulation. 4. Examines the role of maternal genes, homeobox genes, and epigenetic regulation in controlling the behaviour of cells and pattern formation. 5. Focuses on morphogenesis and organogenesis in model organisms, specifically analyzing axis formation in <i>Drosophila</i>, <i>Amphibia</i>, and <i>C. elegans</i>. 6. Demonstrates applications of experimental embryology, including transgenic analysis, cryopreservation, and Assisted Reproductive Technology (ART). 7. Emphasizes the advancements in stem cell technology, the generation of iPSCs, and the ethical implications of cloning and regenerative medicine	
Course Objectives 1. To understand the basic principles of cell communication and the interaction of biomolecules in promoting multicellular development. 2. To analyse how the expression of genes and proteins regulates normal development and how mutations lead to congenital defects. 3. To study the genetic basis of axis and pattern formation across diverse model organisms and the role of Hox genes in vertebrates. 4. To apply advanced techniques in experimental embryology for the diagnosis, treatment, and understanding of human embryology. 5. To develop awareness of the regulatory and ethical issues governing stem cell research, cloning, and modern reproductive interventions. 6. To gain hands-on knowledge of stem cell therapy, niche markers, and the role of engineered materials in inducing drug resistance. 7. To cultivate critical thinking for addressing infertility, environmental teratogenesis, and the	

challenges of aging and senescence.

Prerequisites

Basic knowledge in cell biology, genetics and embryology

SYLLABUS

Unit	Content	Hrs	COs	Cognitive Level
I	Basic Concepts of Development Potency, Commitment, specification; determination and differentiation: Morphogen and morphogenetic gradient; induction, competence; Cell fate and cell lineages; genomic equivalence and cytoplasmic determinants; Imprinting, mutants and transgenics in analysis of development. Model organisms. Cellular and Microsurgical techniques.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
II	Early Embryonic Development Gametogenesis: Production of gametes, cell surface molecules in sperm-egg recognition in animals, Fertilization, Zygote formation, cleavage, blastula formation, embryonic field, gastrulation and formation of germ layers in chick, frog and <i>Drosophila</i> . Morphogenetic movements. General Principles of Cell-cell communication in development; Genes in development. Role of Maternal genes. Role of HOX genes in development. Developmental genetic defects. Epigenetic regulation of development. Prenatal diagnosis. Cell aggregation and differentiation in Dictyostelium	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
III	Post Embryonic Development and Advancements: Role of cell death in development, Placentation in mammals. Metamorphosis in insects and amphibians. Sex determination. Erythroblastosis fetalis. Regeneration in invertebrates and vertebrates. Differential RNA processing, In born errors of translation. Environmental regulation of normal development. Teratogenesis. Ageing and senescence. Assisted reproductive techniques in humans. Cloning and ethical implications of cloning and cryopreservation. Cloning of dolly.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
IV	Post Embryonic Development and Advancements Role of cell death in development; Placenta in mammals. Metamorphosis in insects and amphibians; Sex determination, Regeneration in invertebrates and vertebrates; Differential	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	RNA processing, inborn errors of translation; Environmental regulation of normal development; Teratogenesis. Aging and Senescence. Assisted Reproductive Technology in humans; Cloning and ethical implications of cloning and cryopreservation. National and International legislations and amendments in relation to ART, prenatal diagnosis and medical termination of pregnancy.			
V	Stem Cell Technology Types of stem Cells: Embryonic and Adult. Hematopoietic stem cells, Mesenchymal stem cells, Cardiac stem cells, cancer stem cells. Generation of iPSC's. Stem Cell: Microenvironment, Niche, markers. Stem cell therapy for neurodegenerative disorder, retinal and leukemia. Role of engineered materials in inducing stem cell drug resistance and maintenance. Stem cell-based products. Regulatory and ethical issues in stem cell research. National guidelines for stem cell research.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

Text Books

1. Balinsky, B. I., (2012). Introduction to Embryology (5th ed). CBS College Publishers, New York, 782pp.
2. Berrill, N.J., (1980). Developmental Biology, Tata Mc-Graw Hill Publications, New Delhi, 535pp.
3. Gilbert. S. F., (2017). Developmental Biology (11th ed.). INC Publishers, USA, 810pp.
4. Gerhart, J. & Marc Kirschner (1997). Cells, Embryos and Evolution. Wiley Blackwell Science. 656pp.
5. Hopper, A.F. & Hart, N.H. (2016). Foundations of Animal Development. Oxford University Press, Oxford.
6. Kalthoff, (2000). Analysis of Biological Development, (2nd ed.). McGraw-Hill Science, New Delhi, India. 816pp.
7. Lewis Wolpert, (2012). Principles of Development. Oxford University Press, oxford. 656pp.
8. Mari-Beffa, M., & Knight, J. (2005). Key Experiments in Practical Developmental Biology. Cambridge University Press, UK, 404pp.
9. Saunders, J.W. (1982). Developmental Biology-Patterns, Principles and Problems. Macmillan Publishing Co., New York. 640pp.
10. Slack, J.M.W. (2012). Essential Developmental Biology (3rd ed.). Wily-Blackwell

Publications, USA, 496pp.

11. Subramoniam, T. (2011). *Molecular Developmental Biology* (2nd ed.). Narosa Publishers, India, 364pp.
12. Twyman, R. M. (2003). *Developmental biology* (1st ed). Viva Books publisher, New Delhi. 452pp.
13. Tyler, M.S. (2000). *Developmental Biology - A Guide for Experimental Study*, Sunderland, MA, 208pp.
14. Werner A. Muller, (2005). *Developmental Biology*. Springer – Verlag, New yok. 382pp.
15. Wilt, F.H. & Wessel, N.K. (1967). *Methods in Developmental Biology*, Thomas Y Crowell, New York.
16. Robert Lanza (2006) “*Essentials of Stem cell Biology*”, Elsevier.
17. Daniel R. Marshak, Richard L. Gardner and David Gottlieb (2001), “*Stem cell Biology*”, Cold Spring Harbour Laboratory Press

Suggested Readings

1. Wolpert, L., Tickle, C., & Martinez Arias, A. (2011). *Principles of development* (4th ed.). Oxford University Press.
2. Lanza, R. P. (Ed.). (2006). *Essentials of stem cell biology*. Elsevier Academic Press.
3. Subramoniam, T. (2011). *Molecular developmental biology* (2nd ed.). Alpha Science International/Narosa Publishers.
4. Balinsky, B. I., & Fabian, B. C. (1981). *An introduction to embryology* (5th ed.). Saunders College Publishing.
5. Slack, J. M. W. (2012). *Essential developmental biology* (3rd ed.). Wiley-Blackwell.

Web Sources

1. <https://courses.lumenlearning.com/suny-wmopen-biology2/>
2. <https://thebiologynotes.com/introduction-to-embryology/>
3. <https://bit.ly/37Lfpkn>
4. <https://medlineplus.gov/assistedreproductivetechnology.html>
5. <https://www.sdbonline.org>
6. <https://www.easybiologyclass.com/>
7. <https://www.ccmb.res.in/>
8. <https://virtualhumanembryo.lsuhs.edu/>
9. <https://www.3dembryoatlas.com/>
10. <https://www.museumfuernaturkunde.berlin/en/science/embryology-collection>

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	Define, recall, and describe the fundamental principles of development, including cellular potency, commitment , and the molecular stages of gametogenesis . Students will identify the role of morphogens, cytoplasmic determinants, and maternal genes in early embryonic patterning and outline the general principles of cell-cell communication . They will summarize the characteristics of model organisms and the concepts of genomic equivalence and imprinting . Collectively, these competencies enable students to demonstrate foundational knowledge and conceptual understanding (K1–K2) of developmental stages and genetic influence.	K1, K2
CO2	Apply experimental techniques and biomolecular tools to examine and interpret normal and abnormal embryonic development, including microsurgical techniques and transgenic analysis . They will demonstrate the ability to classify morphogenetic movements and employ genetic principles to illustrate axis formation in <i>C. elegans</i> and <i>Drosophila</i> . Learners will analyze and compare the developmental stages of animals, distinguishing between induction and competence . Furthermore, students will examine the impact of epigenetic regulation and environmental teratogens on development. These competencies allow students to apply conceptual knowledge and perform analytical interpretation (K3–K4) of developmental biology.	K3, K4
CO3	Evaluate the regulation of biomolecules to justify developmental outcomes and appraise complexities in pattern formation and organogenesis . They will critically assess the efficacy of Assisted Reproductive Technology (ART) and judge the ethical implications of cloning and stem cell research . Learners will synthesize information regarding National and International legislations (such as the ART Act, MTP Act, and National Guidelines for Stem Cell Research) to formulate compliant models for regeneration and tissue engineering . Furthermore, students will design and propose innovative research strategies involving iPSCs and gene therapy to address infertility and genetic disorders . Collectively, these outcomes enable students to exercise higher-order judgment and creative problem-solving (K5–K6)	K5, K6

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	1	2	2	2
CO2	3	2	3	2	3	2	3
CO3	3	3	3	3	3	3	3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	2	2	2	2
CO2	2	2	3	2	3	2	3
CO3	3	3	3	3	3	3	3

COURSE CODE	PZO1MC03
COURSE TITLE	ETHOLOGY AND EVOLUTIONARY BIOLOGY
Credits/Hours	5 Credits / 5 Hours
Category	Major Core (MC) - Theory
Semester	I
Regulation	2026
Course Overview 1. This course explains how animal behaviour develops and how it evolves. 2. It covers the following ideas of evolution, genetics, speciation, and social behaviour using both classical and modern scientific approaches. 3. It facilitates a higher and deeper understanding of the underlying causes for behavioural patterns. 4. The course also connects evolution to real-life issues such as conservation, health, and emerging diseases.	
Course Objectives 1. To understand how the brain, genes, and environment control behaviour. 2. To explain key evolutionary concepts such as natural selection, molecular evolution, and speciation. 3. To apply evolutionary principles to topics like biodiversity conservation and human health. 4. To inculcate scientific thinking and design experiments based on theories studied in the course.	
Prerequisites	Basic Knowledge in Biology

SYLLABUS

Unit	Content	Hrs	COs	Cognitive Level
I	Foundations of Behavioural Biology Neural basis of learning, memory and cognition; Development of behaviour; Approaches and methods in the study of behaviour; Proximate and ultimate causation; Habitat selection, dispersal and migration; Territoriality and optimal foraging; Neuroethology and neural circuitry mapping of behaviour; Epigenetic influences on behavioural plasticity	15	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
II	Social and Reproductive Behaviour Social behaviour in animals; Properties of a social group; Reproductive strategies; The Mating System; Courtship	15	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	Behaviour; Sexual Selection; Parental care in animals; Altruism, Antipredator behaviour and communication; Behavioural genomics and gene-behavior interactions; Urban behavioural ecology and rapid behavioural adaptation			
III	Evolutionary Theories and Major Transitions Lamarck and Darwin – variation, adaptation, natural selection; Mendelism and evolutionary synthesis; Origin of life – Oparin–Haldane and Urey–Miller; Evolution of prokaryotes and eukaryotes; Evolutionary timescale, eras, epochs, and periods. Major evolutionary events in the evolution of plants, animals and human; Evolutionary developmental biology (Evo–Devo) perspectives.	15	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
IV	Molecular Evolution and Speciation Molecular divergence and molecular clock; Neutral evolution; Gene duplication and genome evolution; Genetic drift and adaptive radiation; Speciation – allopatric and sympatric; Molecular phylogeny; Comparative genomics and regulatory evolution Ancient DNA and paleo genomics in evolutionary reconstruction	15	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
V	Population Genetics and Contemporary Evolution Hardy–Weinberg equilibrium; Gene frequency changes under selection, mutation, migration and drift; Evolutionary medicine; Evolution of diet and language in humans; Continuing evolution of humans in the modern world. Role of population genetics in species conservation and habitat restoration; Antimicrobial resistance and emerging diseases from an evolutionary perspective.	15	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

Text Books

1. David McFarland. (1987). Animal Behaviour-Psychobiology, Ethology and Evolution. ELBS.
2. Dugatkin, L. A. (2020). *Principles of animal behavior* (4th ed.). W. W. Norton & Company.
3. Alcock, J. (2013). *Animal behavior: An evolutionary approach* (10th ed.). Sinauer Associates.
4. Mathur, R. (2012). *Animal behaviour*. Rastogi Publications.
5. Krebs, J. R., & Davies, N. B. (1997). *Behavioural ecology: An evolutionary approach* (4th ed.). Blackwell Publishing.
6. Andersson, M. (1994). *Sexual selection*. Princeton University Press.
7. Chattopadhyay, S. (2019). *Life: Evolution, adaptation and ethology*. Books & Allied Pvt. Ltd.

8. Futuyma, D. J., & Kirkpatrick, M. (2017). *Evolution* (4th ed.). Sinauer Associates.
9. Hall, B. K., Hallgrímsson, B., & Strickberger, M. W. (2014). *Strickberger's evolution*. Jones & Bartlett Learning.
10. Verma, P. S., & Agarwal, V. K. (2016). *Cell biology, genetics, molecular biology, evolution and ecology*. S. Chand Publishing.
11. Freeman, S., & Herron, J. C. (2007). *Evolutionary analysis* (4th ed.). Pearson Education.
12. Graur, D., & Li, W.-H. (2000). *Fundamentals of molecular evolution* (2nd ed.). Sinauer Associates.
13. Bansal, M., & Kumar, A. (2018). *Population genetics and evolutionary biology*. University Science Press.

Suggested Readings

1. **Morgan, C. Lloyd. (1912). *Animal Behaviour*** – Free public domain book at Project Gutenberg (classic ethology text).
2. **Darwin, C. (1859). *On the Origin of Species*** – Full open-access online editions available via Darwin Online and other public archives. (search “*Darwin Origin of Species online free*”)
3. **OpenStax Biology (Evolution chapters)** – Free textbook with evolution and behaviour topics online. (search “*OpenStax Biology free pdf*”)
4. **Animal Behaviour – various works** – Open Library lists many works on this subject that you can borrow or access summaries.
5. **EvoGrader & Evolution Education Tools** – Free online science/education tools useful for evolutionary concepts.

Web Resources

1. <https://www.frontiersin.org/journals/ecology-and-evolution>
2. <https://www.onezoom.org/>
3. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5822696/>
4. <https://courses.lumenlearning.com/wm-biology1/>
5. <https://onlinelibrary.wiley.com>
6. <https://www.youtube.com/watch?v=ELr9QgiGB6U>
<https://www.youtube.com/watch?v=w7Kwei1vuAE>
7. <https://www.ncbi.nlm.nih.gov/books/>
8. <https://eol.org>
9. <https://www.animalbehaviorsociety.org>
10. <https://www.frontiersin.org/journals/ecology-and-evolution>

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
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CO1	Define, recall, and describe the foundational concepts of animal behavior, including neural mechanisms of learning and memory, and the history of evolutionary thought from Lamarck and Darwin to modern synthesis. Students will identify the proximate and ultimate causes of behavior and summarize major evolutionary events and timescales. Collectively, these competencies enable students to demonstrate foundational knowledge and conceptual understanding (K1–K2) of behavioural biology and evolutionary theory.	K1, K2
CO2	Apply evolutionary mechanisms—such as natural selection, molecular evolution, and genetic drift—to examine and illustrate animal social structures and reproductive strategies. Students will analyze behavioral genomic data and compare molecular clock divergence across species to classify patterns of speciation. They will demonstrate proficiency in interpreting Hardy–Weinberg equilibrium and categorize types of sexual selection and parental care. These competencies allow students to perform analytical interpretation and practical application (K3–K4) of ethological and genetic principles.	K3, K4
CO3	Evaluate the role of population genetics in habitat restoration and justify the application of evolutionary medicine to address contemporary health issues like antimicrobial resistance. Students will critically assess the impact of urban behavioral ecology on species adaptation and judge the validity of molecular phylogenies. They will integrate genomic, behavioral, and environmental data to construct conservation strategies and design evolutionary experiments. Collectively, these outcomes enable students to exercise higher-order judgment and creative problem-solving (K5–K6) to address emerging biological problems.	K5, K6

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	1	1	1	1	1
CO2	3	3	2	2	2	1	1
CO3	2	2	3	2	3	3	2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	1	1	1	1	1
CO2	3	3	2	2	2	1	1
CO3	2	2	3	3	3	3	2

COURSE CODE	PZO1MC04
COURSE TITLE	COMMUNITY AND POPULATION ECOLOGY
Credits/Hours	5 Credits / 5 Hours
Category	Major Core (MC) -Theory
Semester	I
Regulation	2026
Course Overview 1. Introduces the structural and functional aspects of ecosystems and ecological processes. 2. Explores energy flow, nutrient cycles, and ecological succession as key drivers of ecosystem dynamics. 3. Provides a strong foundation in population ecology, life-history strategies, and species interactions. 4. Examines biodiversity importance, threats, and modern conservation approaches. 5. Focuses on national and international conservation frameworks, policies, and legislation. 6. Demonstrates applications of remote sensing, GIS, and modern tools in biodiversity monitoring and management. 7. Emphasizes sustainability, ecosystem services, and human impact on natural resources.	
Course Objectives 1. To understand ecological principles and processes governing the structure and function of ecosystems. 2. To analyze population dynamics, life-history strategies, and species interactions in natural systems. 3. To study biodiversity at genetic, species, and ecosystem levels and evaluate threats to its survival. 4. To apply conservation approaches (in-situ, ex-situ, genetic tools) in biodiversity management. 5. To develop awareness of policies, laws, and treaties relevant to conservation biology. 6. To gain hands-on knowledge of remote sensing, GIS, and modern tools for conservation and management. 7. To cultivate critical thinking for addressing anthropogenic pressures and promoting sustainable use of biodiversity.	
Prerequisites	Basics of Environmental Biology and Bio-resource Management.

SYLLABUS

Unit	Content	Hrs	COs	Cognitive Level
I	Structure and Function of Ecosystems Physical and biological structure of ecosystems: Growth forms, life forms, stratification (horizontal & vertical), dominance, keystone species. Concepts of community productivity, biotic stability, eco-tone and edge-effect. Diversity Indices: Shannon-Weiner, Simpson's Index, Gini-Simpson Index, species richness. Energy flow in ecosystems: Primary production, trophic levels, ecological efficiencies, energy pyramids. Biogeochemical cycles. Ecosystem services and human impacts on ecosystem.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
II	Population Ecology and Dynamics Fundamentals of population growth: density-dependent & independent growth, discrete vs. overlapping generations. Birth and death rates, Allee effect, exponential and logistic models. Age structure, survivorship curves, mortality, fertility, reproductive value. Population regulation, carrying capacity, population viability analysis (PVA). Metapopulation ecology: Equilibrium theory, patchy populations, non-equilibrium models. MacArthur-Wilson equilibrium model	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
III	Life-History Strategies and Species Interactions r- and K-selection strategies, cost of reproduction, energy allocation. Clutch size variation, latitudinal gradients in reproduction, bet-hedging strategies. Species Interactions: Intra- and interspecific competition Lotka-Volterra competition models. Predator-prey dynamics, host-parasite interactions, Ecological Succession: Types, processes, climax concept, models of succession.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
IV	Biodiversity and Conservation Approaches Biodiversity and its importance: genetic, species, and ecosystem diversity. Threats to biodiversity: habitat loss, invasive species, climate change, pollution. IUCN threat categories and Red List. Conservation genetics and molecular approaches. In-situ and ex-situ conservation strategies. Community-based conservation and role of indigenous	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	knowledge. Biogeographic zones, National parks, Sanctuaries.			
V	Policies, Laws and Technological Approaches in Conservation National and international frameworks: Biodiversity Act (2002), PPVFR Act, International Treaty on Plant Genetic Resources for Food and Agriculture (PGRFA), CBD, CITES, IUCN, Ramsar Convention. Agricultural biodiversity and conservation of plant genetic resources (seed banks, gene banks, cryopreservation). Remote sensing and GIS in biodiversity conservation: GPS, GIS, animal tagging, habitat monitoring, predictive models. Climate change impacts and conservation strategies.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

Text Books

1. Odum, E. P., & Barrett, G. W. (2005). *Fundamentals of Ecology* (5th ed.). Cengage Learning.
2. Krebs, C. J. (2014). *Ecology: The Experimental Analysis of Distribution and Abundance* (7th ed.). Pearson Education.
3. Begon, M., Townsend, C. R., & Harper, J. L. (2006). *Ecology: From Individuals to Ecosystems* (4th ed.). Blackwell Publishing.
4. Molles, M. C. (2019). *Ecology: Concepts and Applications* (9th ed.). McGraw Hill Education.
5. Smith, T. M., & Smith, R. L. (2015). *Elements of Ecology* (9th ed.). Pearson Education.
6. Gotelli, N. J. (2008). *A Primer of Ecology* (4th ed.). Sinauer Associates (W. H. Freeman).
7. Southwood, T. R. E., & Henderson, P. A. (2009). *Ecological Methods* (3rd ed.). Wiley-Blackwell.
8. Sutherland, W. J. (2006). *Ecological Census Techniques: A Handbook* (2nd ed.). Cambridge University Press.
9. Krebs, C. J. (2013). *Population Ecology: An Introduction to Principles and Methods*. Harper & Row.

Suggested Readings

1. Sharma, P. D. (2017). *Ecology and environment*. Rastogi Publications.
2. Shukla, R. S., & Chandel, P. S. (2005). *A textbook of plant ecology*. S. Chand Publishing.
3. Dash, M. C. (2001). *Fundamentals of ecology*. Tata McGraw-Hill.
4. Singh, J. S., Singh, S. P., & Gupta, S. R. (2014). *Ecology, environmental science and conservation*. Anamaya Publishers.

5. Begon, M., Townsend, C. R., & Harper, J. L. (2006). *Ecology: From individuals to ecosystems* (4th ed.). Wiley-Blackwell.
6. Krebs, C. J. (2014). *Ecology: The experimental analysis of distribution and abundance* (7th ed.). Pearson.
7. Primack, R. B. (2014). *Essentials of conservation biology* (6th ed.). Sinauer Associates.
8. Groom, M. J., Meffe, G. K., & Carroll, C. R. (2006). *Principles of conservation biology* (3rd ed.). Sinauer Associates

Web Resources

1. <https://www.zsi.gov.in/>
2. <https://moef.gov.in/en/>
3. <https://indiabiodiversity.org/>
4. <https://cites.org/>
5. <https://iucn.org/>
6. <https://earthobservatory.nasa.gov/>
7. <https://wwf.panda.org/>
8. <https://www.gbif.org/>

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	Define, recall, and describe the fundamental principles of ecosystem organization, including growth forms, stratification, and the roles of keystone species and dominance within biological communities. They will identify and explain the mechanisms of energy flow, primary production, and biogeochemical cycling, alongside the structural attributes of populations such as density, age structure, and survivorship. Learners will outline and summarize the basic concepts of biodiversity at genetic, species, and ecosystem levels, while recognizing the foundational frameworks of national and international conservation laws. Collectively, these competencies enable students to demonstrate foundational knowledge and conceptual understanding (K1–K2) of ecological processes and the structural functionalism of the natural world.	K1, K2
CO2	Apply principles of population ecology to calculate and interpret growth models, including exponential, logistic, and metapopulation equilibrium theories. They will demonstrate the ability to use diversity indices like Shannon-Weiner and Simpson's Index to organize and classify community	K3, K4

	data. Learners will analyze and compare life-history strategies—such as r- and K-selection and bet-hedging—and interpret the dynamics of species interactions including competition (Lotka–Volterra), predation, and parasitism. Furthermore, students will examine and differentiate the drivers of ecological succession and the anthropogenic threats to biodiversity, such as habitat loss and climate change. Collectively, these competencies enable students to apply conceptual knowledge and perform analytical interpretation (K3–K4) of population dynamics and community interactions	
CO3	Evaluate ecosystem services and human impacts to justify conservation priorities and resolve complex issues related to population viability and habitat fragmentation. They will critically assess the effectiveness of in-situ and ex-situ conservation strategies and appraise the role of indigenous knowledge and international treaties like CBD and CITES in maintaining global biodiversity. Learners will synthesize ecological data with modern technological approaches—including Remote Sensing, GIS, and animal tagging—to formulate coherent management plans for monitoring species and habitats. Furthermore, students will be able to design and propose sustainable biodiversity preservation projects that integrate molecular tools, seed banks, and predictive modeling. Collectively, these outcomes enable students to exercise higher-order judgment and creative problem-solving (K5–K6) in ecological management and conservation biology.	K5, K6

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	1	2	2	2
CO2	3	2	3	2	3	2	3
CO3	3	3	3	3	3	3	3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	2	2	2	2
CO2	2	2	3	2	3	2	3
CO3	3	3	3	3	3	3	3

COURSE CODE	PZO1MC05
COURSE TITLE	ENTOMOLOGY AND VECTOR BIOLOGY
Credits/Hours	4 Credits / 5 Hours
Category	Major Core (MC) - Theory
Semester	I
Regulation	2026
Course Overview The course provides an insight into the classification of insect vectors, their anatomy, physiology and adaptations and illustrates their role in the spread of vector borne diseases.	
Course Objectives 1. To learn the systematic position of Class: Insecta, its sub classes and orders within. 2. To learn the types vectors and vector borne diseases and to understand the approaches in the management of vectors and vector borne diseases. 3. To understand the role of insects as biocontrol agents in the control of pests and to learn and understand legislations and mitigation measures practiced in the control vectors and insect pests.	
Prerequisites	Basic knowledge in invertebrate classification

SYLLABUS

Unit	Content	Hrs	COs	Cognitive Level
I	Insect Classification, Anatomy and Physiology Brief evolutionary history of Insects. Introduction to phylogeny of insects and classification of Class Insecta. Structure, modification and physiology of different systems: digestive, circulatory, respiratory, excretory, nervous, sensory, reproductive, musculature, endocrine and exocrine glands. Physiology of integument, moulting; growth, metamorphosis and diapause. AI-based insect identification apps.	14	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
II	Insect Vectors and Vector Borne Diseases Insect Vectors: Order : Diptera (Mosquitoes and flies), Order : Heteroptera (Bugs), Order : Anoplura (Lice), Order : Siphonaptera (Fleas), Order : Dictyoptera (Cockroaches), Class : Arachnida, Order : Acarina (Mites and Ticks), Order : Araneida (Spiders), Order : Scorpionida (Scorpions). Vector Borne Diseases: Aedes : Chikungunya, Dengue, Lymphatic filariasis, Rift Valley fever, Yellow Fever and Zika. Anopheles	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	:Lymphatic filariasis, Malaria. Culex: Japanese encephalitis, Lymphatic filariasis, West Nile fever . Blackflies: Onchocerciasis (river blindness). Fleas: Plague (transmitted from rats to humans). Tungiasis. Lice: Typhus, Louse-borne relapsing fever. Sandflies: Leishmaniasis, Sand fly fever (phlebotomus fever): Ticks Crimean-Congo haemorrhagic fever, Lyme disease, Relapsing fever (borreliosis), Rickettsial diseases (eg: spotted fever and Q fever), Tick-borne encephalitis, Tularaemia. Triatome bugs: Chagas disease (American trypanosomiasis). Tsetse flies: Sleeping sickness (African trypanosomiasis).			
III	Approaches to Insect Pest and Vector Management Insecticides. Types of insecticides, Formulation; Toxicity and safety. Application of insecticides: Problems associated with using insecticides. Environmental and cultural control (Irrigation, Fertilizer, Sanitation. Alternate hosts, Multiple and intercropping, Separation in time and space, Crop geometry). Host resistance: Basis for resistance, mechanisms of resistance. Community-based vector management models. Drone-based surveillance of vector breeding sites. Legislation for Pesticide use and effects of regulation.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
IV	Biocontrol agents Predators, Parasitoids, Parasites. Pathogens: fungi, viruses, bacteria, microsporidia, nematodes, arthropods. Transmission of pathogens. Area-wise management. Techniques of biocontrol: constraints and reasons for failure of biocontrol. Use of pheromones/ allelochemicals in pest management; Mating disruption/confusion, Alarm pheromones and oviposition deterrents; repellents. Exclusion and barriers, Traps. Physical disturbance. Use of larvivorous Fish and plants in vector control. Successful biological control projects and future possibilities of biological control. Importation of natural enemies, quarantine regulations, Biotechnology in biological control. Nano-larvicides for mosquito control.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
V	Useful insects, IPM and other alternatives. Pollinators and their role in production of various crops. Use	14	CO 1 CO 2	K1, K2, K3, K4,

	of insect and insect products in medicines. Insects as bio-indicators. Usefulness of insects in scientific investigations. Genetically modified organisms. New concepts and practices. Integrated vector management. The integrated control/ IPM. Predictive modeling of vector outbreaks using AI. Seasonal shifts in vector breeding cycles. CRISPR-based gene editing in disease vectors. Gene drive technology for malaria control. RNA interference (RNAi) for pest suppression.		CO 3	K5, K6
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Text Books

1. Imms, A.D. (1992). A. General Text book of entomology. Chapman & Hall, London.
2. Chapman J. L & Reiss M. J. (2006). Ecology: Principles & Applications. 2nd Ed. Cambridge Univ. Press, Cambridge.
3. David B. V & Ananthkrishnan T. N. (2004). General and Applied Entomology. Tata-McGraw Hill, New Delhi.
4. David B. V & V. V. Ramamurthy (2016). Elements of Economic Entomology. Brillion publication, New Delhi.

Suggested Readings

1. Blum, M.S. 1996. Fundamentals of Insect Physiology John Willey & Sons. New York.
2. Cameron, M. & Lorenz, L. (2013) Biological and Environmental Control of Disease Vectors. CABI, UK .
3. CSIRO (1990). The Insects of Australia: A Text Book for Students and Researchers. 2nd Ed. Vols. I & II, CSIRO. Cornell Univ. Press, Ithaca.
4. Daly, H.V. Doyen, J.T. an Ehrlich, P.R. (1988). Introduction to insect Biology and Diversity. McGraw Hill Ltd. London.
5. Dent, D. (2000) Insect pest management (2nd edition) CAB International.
6. Dhaliwal & Arora (2001). Integrated Pest Management: Concepts and Approaches. Kalyani Publ., New Delhi.
7. Duntson P. A. (2004). The Insects: Structure, Function and Biodiversity. Kalyani Publ., New Delhi.
8. Evans J. W. (2004). Outlines of Agricultural Entomology. Asiatic Publ., New Delhi.
9. Gerson H & Smiley RL. (1990). Acarine Biocontrol Agents – An Illustrated Key and Manual. Chapman & Hall, New York.
10. Ignacimuthu & Jayaraj (2003). Biological Control of Insect Pests. Phoenix Publ., New Delhi.
11. Mani, M.S. (1997). General Entomology Oxford & IBH Publishing Co., New Delhi
12. Mullen & Durden (2009). Medical and veterinary entomology, Academic press, London.

Web Resources

1. <https://icar.org.in/>
2. <https://www.icmr.gov.in/>
3. <https://virc.icmr.org.in/>
4. <https://dbtindia.gov.in/>
5. <https://www.who.int/>
6. <https://nimr.org.in/>
7. <https://www.monash.edu/ivbd>

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	Identify, recall, and describe the systematic position, evolutionary history, and phylogeny of the Class Insecta , including its various subclasses and orders. Students will explain the physiological mechanisms of different systems and summarize the details of major insect vectors and the specific vector-borne diseases they transmit, such as Malaria, Dengue, and Zika. Collectively, these competencies enable students to demonstrate foundational knowledge and conceptual understanding (K1–K2) of entomology and vector bionomics	K1, K2
CO2	Apply knowledge of insecticide types and formulations to examine and illustrate the anatomical and physiological adaptations of vectors. Students will analyze and compare the systematics of insects, categorizing their roles as vectors or biocontrol agents . They will demonstrate proficiency in interpreting the efficacy of community-based management models and classify the impact of environmental factors on vector breeding cycles. These competencies allow students to perform analytical interpretation and practical application (K3–K4) of pest and vector control strategies.	K3, K4
CO3	Evaluate the legal and ecological implications of pesticide regulation and justify the use of specific mitigation measures in public health. Students will critically assess the reasons for success or failure in biological control projects and judge the potential of emerging technologies like CRISPR-based gene editing and gene drive technology . They will integrate data from AI-based predictive modeling and drone surveillance to construct, design, and formulate advanced Integrated Vector Management (IVM) protocols and diagnostic methods to eradicate diseases. Collectively, these outcomes enable students to exercise higher-order judgment and creative problem-solving (K5–K6)	K5, K6

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	2	3
CO2	3	3	2	2	3	3	2
CO3	3	2	1	3	3	2	1

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	3	3	3	2	3
CO2	3	3	2	1	3	3	2
CO3	2	2	3	3	3	2	3

COURSE CODE	PZO1MC06
COURSE TITLE	ANIMAL DIVERSITY, EMBRYOLOGY AND ECOLOGY LAB
Credits/Hours	4 Credits / 6 Hours
Category	Major Core (MC) - Lab
Semester	I
Regulation	2026
Course Overview 1. Develop interest in animal diversity and understand the bionomics of vertebrates and invertebrates. 2. Identify and classify invertebrates up to class level based on systematic principles. 3. Familiar with various stages involved in the developing embryo. 4. Understand life processes in non-chordates and recognize economically important invertebrates. 5. Apply basic ecological methods and environmental principles through laboratory and field studies	
Course Objectives 1. To provide hands-on training in animal anatomy through dissection and observation of organ systems in commonly available specimens. 2. To develop an understanding of economically important invertebrate fauna and their practical significance. 3. To introduce the basics of systematic biology and the hierarchical classification of organisms. 4. To promote scientific thinking and the application of scientific methods in everyday life through practical exposure. 5. To foster awareness of sustainable development and encourage a positive attitude towards conservation of biological resources.	
Prerequisites	Knowledge in Biology

SYLLABUS

Unit	Content	Hrs	COs	Cognitive Level
I	Major Dissection Nervous System: Cockroach, Prawn, Apple Snail, Sepia, Crab, Shark: Arterial system: Shark. Cranial Nerves: Shark.	30	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	Minor Dissection Cockroach: Salivary Glands, Digestive System, Reproductive System. Prawn – Appendages. Red Snapper –Digestive System. Mounting Mouth parts: Cockroach, Honey bee, Sting apparatus of honeybee. Body setae of earthworm, Fish scales: Cycloid, Ctenoid. Radula of Pila .			
II	Embryology: Mounting of chick embryo - whole mount 24hrs, 32hrs, 72hrs, 96hrs of incubation period embryo. Metamorphosis: Moth/Butterfly and Frog (spotter).	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
III	Study of pond/ wetland/ river ecosystem. Ecological analysis: Determination of acidity, total hardness, calcium hardness, residual chlorine, BOD from the given samples. Identification of soil arthropod. Study of marine and fresh water planktons, study of rocky and sandy shore fauna.	20	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
IV	Spotters: Identification of Specimens – Salient Features and Mode of Life Invertebrates: Gorgonia, Brain Coral, Murex, Nautilus, Chiton, Sea star, Holothuria, Balanus, Neries, Physalia, Peripatus, Scorpion, Limulus, Mytilus, Arenicola. Chordates: Amphioxus, Asidian, Balanglosus, Sea horse, Chameleon, Exocetus, Syngnathus, Flatfish, Naja naja, Russle viper, Krait, Poisonous apparatus of snake, Rachophorus, Wood pecker. Embryology: Observation of chick embryo at various stages of development. Developmental stages of frog, Goat embryo, Human embryo, Shark yolk sack placenta. Osteology: Turtle - Carapace and plastron. Synsacrum of bird, Typical; vertebra, thoracic and lumbar vertebrae of dog/bird, Skull of bird, Skeletal system of frog. Animal Association: Sacculina on Crab, Cymothoa in Fish Gills, Ascaris, Taenia Solium, Hermit crab on sea anemone, Sucker fish.	15	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	Taxonomy Identification, classification up to the order and brief note of the following specimens - Prochordates –Amphioxus (entire). Pisces - 2 cartilaginous fishes, 2 fishes with accessory respiratory organs, 2 edible fishes, 2 culture fishes and 2 Cat fishes. Amphibia - Any 3 (representing the three orders). Reptilia - Poisonous and non -poisonous snakes, Draco, Chamaelon. Aves - Different feathers, Pigeon. Mammals – Bat			
V	Field and Institutional Visit Industrial / institutional visit, shore fauna for collecting specimen, identification of new species and preparing catalogue. Assignment: Prepare and submit a comprehensive survey and inventory report on a selected invertebrate or vertebrate specimen, including detailed classification and a properly constructed taxonomic key.	15	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

Text Books

1. Arumugam, N., Murugan, T., Johnson Rajeshwar, J., & Ram Prabhu, R. (2018). *Developmental biology (Embryology)*. Saras Publication.
2. Hyman, L. H. (1940). *The invertebrates* (Vols. 1–6). McGraw-Hill.
3. Lal, S. S. (2016). *Practical zoology: Invertebrates*. Rastogi Publications.
4. Sharma, P. D. (2019). *Ecology and environment*. Rastogi Publications.
5. Verma, P. S., & Agarwal, V. K. (2013). *Chordate zoology*. S. Chand Publishing.ed.). Emkay Publications.

Suggested Readings

1. Beck, W. S., Karel, F., Liem, & Simpson, G. G.(2000). *Life: An introduction to biology*. Harper Collins Publishers.
2. Bhaskaran, K.K. & Biju Kumar, A.(2003). *Chordate Zoology*. Manjusha Publications.
3. Colinviaux, P. A. (1993) *Ecology* (2nd edition) Wiley, John and Sons, Inc.
4. Hegner, P.R. W. (2015). *Practical Zoology*, BiblioLife, 522pp.
5. Kendegh, F.C. (1984). *Ecology with Special Reference to Animal and Man*. Prentice Hall Inc.
6. Krebs, C. J. (2001). *Ecology* (6th edition) Benjamin Cummings. 57 7
7. Odum, E.P.,(2008). *Fundamentals of Ecology*. Indian Edition. Brooks/Cole.
8. Ricklefs, R.E. (2000). *Ecology* (5th edition) Chiron Press.

9. Southwood, T.R.E. & Henderson, P.A. (2000). Ecological Methods (3rd edition) Blackwell Sci.
10. Stiling, P. D. (2012). Ecology Companion Site: Global Insights and Investigations. McGraw Hill Education.
11. Young, J. Z. (2006). The life of Vertebrates. Oxford University Press.

Web Resources

1. <https://animaldiversity.org/>
2. <https://vlab.amrita.edu/index.php?sub=3&brch=272>
3. http://rms.rscdd.edu/faculty/kimomorris/bio212/oer/oerbio_ch28.pdf
4. <https://bit.ly/3FNRrlN>
5. <https://libguides.humboldt.edu>

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	Identify, recall, and classify invertebrate and vertebrate specimens up to the class level using hierarchical systematic principles. Students will describe the bionomics of organisms and summarize diverse animal associations, such as parasitism and commensalism, observed in representative taxa. They will outline the structural characteristics of developmental stages in chick and frog embryos to demonstrate foundational knowledge and conceptual understanding (K1–K2)	K1, K2
CO2	Apply specialized dissection techniques to examine and illustrate the nervous and arterial systems of representative phyla, including <i>Prawn</i> and <i>Shark</i> . Students will demonstrate proficiency in microscopic mounting for appendages, mouthparts, and whole-mount embryos. They will analyze quantitative ecological parameters—such as BOD, hardness, and acidity—to compare the physical and chemical profiles of different aquatic ecosystems. These competencies facilitate practical application and analytical interpretation (K3–K4).	K3, K4
CO3	Evaluate morphological transitions in vertebrate development and justify adaptive features observed during insect and amphibian metamorphosis. Students will critically assess the biological health of habitats based on the diversity of soil arthropods and plankton. They will integrate data from institutional visits and field studies to construct a professional taxonomic catalog and design a comprehensive field survey report of identified species.	K5, K6

	Furthermore, learners will formulate dichotomous taxonomic keys for specimen identification to demonstrate higher-order judgment and creative technical reporting (K5–K6)	
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CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3

COURSE CODE	PZO2MC01
COURSE TITLE	BIOPHYSICS, BIOCHEMISTRY AND BIOENERGETICS
Credits/Hours	5 Credits / 5 Hours
Category	Major Core (MC) - Theory
Semester	II
Regulation	2026
Course Overview 1. This course is structured to provides fundamental knowledge of biophysics, biochemistry, and bioenergetics with emphasis on the structure and physico-chemical properties of biomolecules. 2. It introduces the fundamental principles, contemporary concepts, and emerging developments related to the metabolism of carbohydrates, proteins, lipids, and nucleic acids. 3. The programme enables students to gain in-depth knowledge on classification, structure, function, and metabolic pathways of major biomolecules. 4. Highlights essential bioenergetic processes such as cellular respiration and photosynthesis in relation to life processes. 5. Upon successful completion, learners will be equipped to analyze, interpret, and apply concepts related to biomolecular structure, function, and dynamics in advanced research and interdisciplinary scientific applications.	
Course Objectives 1. To provide in-depth theoretical knowledge in biochemistry, biophysics, and bioenergetics. 2. To develop the ability to design research and industrial projects addressing biological, health, and environmental challenges. 3. To build understanding of fundamental biophysical principles and the use of laboratory instruments in biological research. 4. To promote interdisciplinary learning in science and technology. 5. To integrate concepts of physical sciences with biological sciences for broader scientific applications.	
Prerequisites	Basic knowledge on Biology, Chemistry and Physics

SYLLABUS

Unit	Content	Hrs	COs	Cognitive Level
I	Energies, Forces and Bonds Elementary composition of living matter- Major and trace elements of biological systems; Atomic organization of biomolecules. Atomic Structure and Chemical Properties- Structure of an atom; electronic configuration; ionization energy; electron affinity; periodic properties; principles of chemical binding. Covalent and ionic bonds; bond length; bond energy; interatomic potentials for strong and weak interactions; non-central forces in molecular systems. Stabilizing Interactions in Biological Systems-Van der Waals forces; electrostatic interactions; hydrogen bonding; hydrophobic interactions; role in biomolecular stability and specificity. Thermodynamics and energy transformations in biological systems. water - Structure of water; hydrogen bonding network; physical and biochemical properties, biomolecular interactions in water: acids and bases. Transport Processes and Membrane Physics - Membrane structure; membrane dynamics; diffusion; viscosity; thermal conduction in biological systems.	14	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
II	Biochemistry of Carbohydrate Overview of carbohydrate metabolism and metabolic reactions, Glycolysis, Fate of pyruvate under aerobic and anaerobic conditions, TCA cycle and its significance, Metabolism and utilization of sugars other than glucose, Glycogen metabolism: Glycogenesis and glycogenolysis - glycogen storage diseases. Hormonal regulation and signaling pathways in carbohydrate metabolism. Disorders of carbohydrate metabolism.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
III	Metabolism of protein and amino acids Introduction to Proteins – Protein structures, Protein folding and Associated diseases. Classification of proteins, Overview of protein digestion and absorption, Amino acid pool and nitrogen balance, Amino acid metabolism: Biosynthesis of amino acids and its regulation, Role of essential and non-essential amino acids in growth and development. Ammonia	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	Metabolism and Disposal – Formation, Transport of ammonia, Urea cycle and its regulation and disposal of ammonia and inborn errors of amino acids metabolism.			
IV	Lipid and Nucleic acid Metabolism Lipid metabolism – Digestion, Absorption, transport and storage of lipids and regulation, Fatty Acid Metabolism - Biosynthesis of Fatty Acids, Fatty Acid Oxidation (β -oxidation) Triacylglycerol (TAG) and Phospholipid Metabolism - Biosynthesis of TAGs, Degradation of TAGs. Biosynthesis and Degradation of Phospholipids; Cholesterol and Lipoprotein Metabolism - Cholesterol – Structure, Functions and synthesis of cholesterol. Lipoproteins – Structure, Types, metabolism and Functions. Synthesis of ketone bodies, ketoacidosis and Lipid metabolic disorders. Nucleotide metabolism - Structure, composition and properties of nucleic acids, purine and pyrimidine nucleotides – structure and functions. Nucleotide Biosynthesis - De Novo Synthesis of Purine Nucleotides, De Novo Synthesis of Pyrimidine Nucleotides and regulation of purine and pyrimidine synthesis; Salvage pathways of purines and pyrimidines.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
V	Cellular Bioenergetics High energy molecules in living system (ATP, ADP, NAD, NADH, NADPH, FAD, FADH ₂). ATP as Universal currency of free energy, Functions of ATP, Oxidation–Reduction (Redox) Reactions in Biological Systems; Organization of electron carriers and Classes of electron-transferring enzymes, inhibitors of electron transport. Mitochondrial electron transporters and shuttle systems, microsomal electron transport chain. Mechanism of oxidative phosphorylation, Role of electron transport energy, substrate level phosphorylation, uncouplers and inhibitors of oxidative phosphorylation.	10	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
Text Books 1. Ambika Shanmugam & Ramadevi. K., (2016). <i>Fundamentals of Biochemistry for Medical Students</i> . (8th ed). Lippincott Williams & Wilkins. 2. Berry, A. K. (2015). <i>A textbook of biochemistry (biological chemistry)</i> (14th				

ed.). Emkay Publications.

3. Jain, J. L., Jain, S., & Jain, N. (2020). *Fundamentals of biochemistry*, (7th ed.). S. Chand Publishing.co.
4. Satyanarayana, U., & Chakrapani, U. (2025). *Biochemistry* (7th Silver Jubilee ed.). CBS Publishers & Distributors.
5. Vasudevan, D. M., S, S., & Vaidyanathan, K. (2023). *Textbook of biochemistry for medical students* (10th ed.). Jaypee Brothers Medical Publishers.

Suggested Readings

1. Abali, E. E., Cline, S. D., Franklin, D. S., & Viselli, S. M. (2022). *Lippincott illustrated reviews: Biochemistry* (8th ed.). Wolters Kluwer.
2. Berg, J. M., Tymoczko, J. L., & Stryer, L. (2012). *Biochemistry*. (7th ed).W. H. Freeman.
3. Conn, E. E., Stumpf, P. K., Bruening, G., & Doi, R. H. (2007). *Principles of biochemistry* (5th ed). Wiley & Sons, Inc.
4. David L. Nelson & Michael M. Cox (2017). *Lehninger principles of biochemistry* (7th.ed). W. H. Freeman and Company· New York.
5. Elliott, W. H., & Elliot, C. (2003). *Biochemistry and molecular biology*. Oxford University Press.
6. Garret, R. H., & Grisham, C. M. (1995). *Biochemistry*. (5 thedn).CBS publishers & distributors,Delhi
7. Hames, D.,& Hooper, N.,(2005). *Instant notes in Biochemistry* (3rd.ed). Taylor & Francis, London.
8. Horton, H. R., Morson, L. A., Scrimgeour, K. G., Perry, M. D., & Rawn, J. D. (2006). *Principles of biochemistry*. Pearson educations, international, NewDelhi.
9. Hofmann, A., & Clokie, S. (Eds.). (2018). *Wilson and Walker's principles and techniques of biochemistry and molecular biology* (8th ed.). Cambridge University Press
10. Kennelly, P. J., Botham, K. M., McGuinness, O. P., Rodwell, V. W., & Weil, P. A. (2023). *Harper's illustrated biochemistry* (32nd ed.). McGraw Hill
11. Murray, R. K., & Granner, D. K., Mayes & P.A., Rodwell, V.W. (2012). *Harper's. Biochemistry* (29th ed). Lange Medical Books/McGraw-Hill. [ISBN](#): 978-0-07-176-576- 3.
12. Nicholls, D. G., & Ferguson, S. J. (1992). *Bioenergetics*. Academic Press.
13. Tymoczko, J. L., & Stryer, L. (2011). *Biochemistry* (7th.ed). W. H. Freeman and Company· New York.

14. Voet, D., & Voet, J. G. (2011). *Biochemistry (4th ed)*. John Wiley & Sons.

Zubay, G. (2017). *Biochemistry (4th ed)*. McGraw-Hill.

Web Resources

1. <https://courses.lumenlearning.com/wm-biology1/>
2. <https://blanco.biomol.uci.edu/WWWResources.html>
3. <https://bit.ly/3Lkr9s6>
4. <https://bit.ly/3wqMdI5>
5. <https://bit.ly/3Lf2W6E>
6. <https://www.easybiologyclass.com/>

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	Define, recall, and describe the fundamental principles of biophysics, biochemistry, and bioenergetics, including the laws of thermodynamics and the classification of biomolecules. Students will identify the chemical properties of water, pH, and buffers, and explain the basic structure of carbohydrates, lipids, proteins, and nucleic acids. Collectively, these competencies enable students to demonstrate foundational knowledge and conceptual understanding (K1–K2) of molecular interactions and energy principles.	K1, K2
CO2	Apply biophysical principles to examine and illustrate the structural hierarchy of proteins and the kinetics of enzyme-catalyzed reactions. Students will analyze and compare major metabolic pathways, such as glycolysis, the TCA cycle, and fatty acid oxidation, while categorizing the roles of vitamins and coenzymes. They will demonstrate proficiency in interpreting oxidative phosphorylation and classify the physico-chemical properties of biological molecules. These competencies allow students to perform analytical interpretation and practical application (K3–K4) of biochemical data.	K3, K4
CO3	Evaluate the energetic efficiency of metabolic processes to justify biological responses to physiological and environmental stress. Students will critically assess metabolic disorders and judge the efficacy of biochemical interventions in clinical and industrial contexts. They will integrate data from advanced bioenergetic studies to construct, design, and formulate research protocols for addressing biological challenges and sustainable energy solutions. Collectively, these outcomes enable students to exercise higher-order judgment and creative technical synthesis (K5–K6) .	K5, K6

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	3	2	2	3
CO2	3	3	3	3	2	3	3
CO3	3	3	3	3	2	3	3

COURSE CODE	PZO2MC02
COURSE TITLE	RESEARCH METHODOLOGY AND BIOSTATISTICS
Credits /Hours	5 Credits / 5 Hours
Category	Major Core (MC) - Theory
Semester	II
Regulation	2026
Course Overview Introduces the philosophical and practical foundations of scientific research, including problem formulation, literature review, ethics, and hypothesis development. Explores research design principles, sampling strategies, measurement scales, and instrument development to ensure validity and reliability. Covers methods of data collection, management, visualization, and the use of statistical software for reproducible research workflows. Provides a comprehensive grounding in descriptive, inferential, and multivariate statistical techniques for data analysis and interpretation. Develops skills in scientific writing, reporting, publication ethics, and effective communication for disseminating research findings.	
Course Objectives 1. Develop a clear understanding of the principles, processes, and ethical foundations of scientific research, including problem identification, literature review, and hypothesis formulation. 2. Enable learners to design rigorous studies by selecting appropriate research designs, sampling strategies, measurement scales, and data collection instruments. 3. Build competence in collecting, managing, and presenting data using standardized protocols, reproducible practices, and statistical software tools. 4. Equip students with the ability to apply descriptive, inferential, and multivariate statistical techniques for accurate analysis and interpretation of research data. 5. Cultivate skills in scientific writing, research communication, and dissemination, including proposal development, publication ethics, and effective presentation of findings.	
Prerequisites	Critical thinking, problem solving and basics of MS Excel.

SYLLABUS				
Unit	Content	Hrs	COs	Cognitive Level
I	Foundations of Research and Scientific Inquiry Meaning, objectives, scope, and characteristics of scientific research, Types of research: basic, applied, exploratory, descriptive, analytical, experimental. Steps in the research process. Identification and formulation of research problems. Review of literature: sources, search strategies, critical appraisal. Literature Databases. Formulation of research questions, hypotheses, and objectives. Variables and operational definitions. Research ethics: integrity, plagiarism, authorship, conflict of interest. Institutional ethics committees and approval procedures. AI Literacy for Researchers: Concepts, Tools, and Applications. AI-Assisted Literature Review and Knowledge Synthesis.	6	CO1 CO2 CO3	K1, K2, K3, K4, K5, K6
II	Research Design and Sampling Techniques Foundations of Research Design. Classification of Research Designs- Exploratory, Descriptive, Analytical, Explanatory, Experimental, Quasi-Experimental, Observational, Qualitative. Variables, Controls, and Validity. Reliability and Measurement Issues. Concept of Population and Sampling Frame. Census versus Sample Surveys. Probability Sampling Techniques. Simple Random and Systematic Sampling. Stratified and Cluster Sampling. Multistage and Multiphase Sampling. Non-Probability Sampling Techniques. Purposive, Quota, and Snowball Sampling. Sample Size Determination and Power Analysis. Sampling Errors and Bias. Ethical Considerations in Sampling. Design of Questionnaires and Data Collection Tools. Pilot Studies and Pre-testing. Research Design in Field and Laboratory Studies. Measurement scales: nominal, ordinal, interval, and ratio. Role of AI in Contemporary Research Design. AI-Assisted Problem Formulation and Hypothesis Generation. Integrating SDG Indicators into Research Variables.	12	CO1 CO2 CO3	K1, K2, K3, K4, K5, K6

III	Data Collection, Management and Presentation Types and Sources of Research Data, Primary and Secondary Data Collection Methods, Designing Data Collection Instruments, Questionnaire Construction and Survey Techniques, Interview and Focus Group Methods, Observation and Field-Based Data Collection, Experimental Data Collection Procedures, Digital and Online Data Collection Tools. Sampling Considerations in Data Collection, Pilot Testing and Pre-Testing of Instruments. Data Coding and Classification. Data Entry, Editing, and Validation. Data Cleaning and Quality Control. Data Storage, Security, and Backup Systems. Database Design and Data Management Systems. Metadata Standards and Documentation. Ethical and Legal Aspects of Data Management. Data Analysis Preparation and Transformation. Data Visualization Principles and Techniques. Graphical and diagrammatic presentation of data. Reproducibility and Transparency in Data Presentation. Archiving, Sharing, and Open Data Practices. AI-Enabled Smart Data Collection for Sustainable Development Research. Monitoring and Evaluation Frameworks Using AI and SDG Metrics.	10	CO1 CO2 CO3	K1, K2, K3, K4, K5, K6
IV	Statistical Analysis and Interpretation Descriptive Statistics - Mean, Median, Mode, Range, Variance, Standard deviation, Standard error, Coefficient of variation, Percentiles and quartiles. Probability & Distributions - Normal distribution, Binomial distribution, Poisson distribution, Sampling distribution. Parametric Tests: Z-test, One-sample t-test, Independent t-test, Paired t-test, One-way ANOVA, Two-way ANOVA, Repeated measures ANOVA, F-test, Pearson correlation, Linear regression, Multiple regression, MANOVA. Non-Parametric Tests: Chi-square test, Fisher's exact test, Spearman rank correlation. Multivariate Methods: Principal Component Analysis (PCA), Cluster analysis, Discriminant analysis, Multidimensional scaling (MDS). Statistical Software- MS Excel and SPSS.	16	CO1 CO2 CO3	K1, K2, K3, K4, K5, K6

V	Scientific Writing, Communication and Research Dissemination Foundations of Scientific Writing. Principles of Clarity, Precision, and Objectivity. Structure of a Scientific Research Paper. Writing the Abstract and Keywords. Crafting the Introduction and Literature Review. Materials and Methods: Transparency and Reproducibility. Presenting Results Effectively. Writing the Discussion and Drawing Conclusions. Citation Styles and Reference Management. Avoiding Plagiarism and Ensuring Academic Integrity. Preparing Review Articles and Meta-Analyses. Thesis and Dissertation Writing. Scientific Writing for Grant Proposals. Technical Reports and Policy Briefs. Scientific Communication for Conferences and Seminars. Poster and Oral Presentation Skills. Visual Communication: Tables, Figures, and Infographics. Peer Review Process and Publication Ethics. Open Access Publishing and Research Visibility. Digital Platforms and Social Media in Research Dissemination. Intellectual Property Rights and Copyright in Publishing. Emerging Trends in Scientific Communication. AI for Academic Editing and Proofreading. Plagiarism software. Integrating SDG Indicators into Scientific Reporting.	16	CO1 CO2 CO3	K1, K2, K3, K4, K5, K6
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Text Books

1. Arora, P. N., & Malhan, P. K. (2014). *Biostatistics*. Himalaya Publishing House.
2. Banerjee, P. K. (2007). *Introduction to biostatistics*. S. Chand Publishing.
3. Chawla, D., & Sondhi, N. (2016). *Research methodology: Concepts and cases*. Vikas Publishing House.
4. Dash, B. (2019). *Research methodology in biological sciences*. Dominant Publishers.
5. Gupta, M., & Gupta, D. (2011). *Research methodology*. Public Health Institute Learning Private Ltd.
6. Gupta, S. C., & Kapoor, V. K. (2020). *Fundamentals of mathematical statistics*. Sultan Chand & Sons.
7. Gupta, S. P. (2017). *Statistical methods* (46th ed.). Sultan Chand & Sons.
8. Gurumani, N. (2011), *Research methodology for Biological Sciences*—MJP Publishers.
9. Indrayan, A., & Malhotra, R. K. (2017). *Medical biostatistics* (4th ed.). CRC Press (Indian

edition).

10. Kothari, C. R., & Garg, G. (2019). *Research methodology: Methods and techniques* (4th ed.). New Age International Publishers.
11. Kumar, R. (2018). *Research methodology: A step-by-step guide for beginners* (5th ed., Indian adaptation). Sage Publications India.
12. Mahajan, B. K. (2010). *Methods in biostatistics for medical students and research workers* (7th ed.). Jaypee Brothers Medical Publishers.
13. Mishra, R. P. (2018). *Research methodology: A handbook*. Concept Publishing Company.

Suggested Readings

1. Dawson, C. (2002). *Practical research methods*. UBS Publishers, New Delhi.
2. Pagano M & Gauvreau, K. (2000). *Principles of biostatistics*, Duxbury Press.
3. Panneerselvam, R. (2014). *Research methodology*. PHI Learning.
4. Ranjit Kumar. (2011). *Research methodology: A step-by-step guide for beginners* (3rd ed.).
5. Daniel, W. W. (Indian reprint 2010). *Biostatistics: A foundation for analysis in the health sciences*. Wiley India.
6. Rao, P. S. S. S. (2015). *Biostatistics for health sciences*. Jaypee Brothers Medical Publishers.
7. Rastogi, V. B. (2017). *Biostatistics*. MedTech Science Press.
8. Singh, Y. K. (2006). *Fundamentals of research methodology and statistics*. New Age International Publishers.
9. Srivastava, T. N., & Shailaja Rego. (2011). *Business research methodology* (Indian ed.). Tata McGraw-Hill.
10. Stapleton, P., Yondeowei, A., Mukanyange, J & Houten, H. (1995). *Scientific writing for agricultural research scientists – a training reference manual*. West Africa Rice Development Association, Hong Kong.
11. Sundar Rao, P. S. S., & Richard, J. (2012). *An introduction to biostatistics: A manual for students in health sciences*. PHI Learning.
12. Triola, M. M., Triola, M. F., & Roy, J. (2018). *Biostatistics for the biological and health sciences* (2nd ed). Pearson.
13. Woolson. (1987), *Statistical Methods for the Analysis of Biomedical Data*. John Wiley & Sons, Inc, New York.

Web Resources

- **SAGE Research Methods**

<https://methods.sagepub.com>

Comprehensive tutorials, case studies, and methods encyclopedia covering qualitative and quantitative research.

- **Research Methods Knowledge Base (William M. K. Trochim)**

<https://conjointly.com/kb>

Clear explanations of research design, sampling, validity, and measurement.

- **National Institutes of Health (NIH) Office of Extramural Research – Research Training**

<https://researchtraining.nih.gov>

Modules on research design, ethics, and grant writing.

- **Equator Network (Reporting Guidelines)**

<https://www.equator-network.org>

Reporting standards such as CONSORT, PRISMA, and STROBE for research transparency.

- **OpenIntro Statistics**

<https://www.openintro.org>

Free textbooks and datasets widely used for introductory statistics and biostatistics.

- **StatQuest with Josh Starmer**

<https://statquest.org>

Concept-focused tutorials on statistical tests, regression, and machine learning basics.

- **Khan Academy Statistics and Probability**

<https://www.khanacademy.org/math/statistics-probability>

Beginner-friendly lessons on descriptive statistics, probability, and inference.

- **Coursera – Biostatistics Courses (various universities)**

<https://www.coursera.org>

Structured courses on statistical methods for health and biological sciences.

- **R Project for Statistical Computing**

<https://www.r-project.org>

Official site for R software, documentation, and packages.

- **RStudio Education Resources**

<https://education.rstudio.com>

Tutorials and teaching materials for data analysis in R.

- **IBM SPSS Tutorials**

<https://www.ibm.com/docs/en/spss-statistics>

Official guides for SPSS data analysis procedures.

- **NCBI Bioinformatics Tools**

<https://www.ncbi.nlm.nih.gov>

Databases and tools for biological data analysis.

- **Committee on Publication Ethics (COPE)**

<https://publicationethics.org>

Guidelines on authorship, peer review, and publication ethics.

- **World Medical Association – Declaration of Helsinki**

<https://www.wma.net/what-we-do/medical-ethics/declaration-of-helsinki>

Ethical principles for research involving human subjects.

- **Office of Research Integrity (ORI)**

<https://ori.hhs.gov>

Resources on responsible conduct of research and misconduct prevention.

- **Purdue Online Writing Lab (OWL)**

<https://owl.purdue.edu>

Guidance on academic writing, citation styles, and research papers.

- **Elsevier Researcher Academy**

<https://researcheracademy.elsevier.com>

Free modules on writing, peer review, and publication process.

- **ORCID (Researcher Identification)**

<https://orcid.org>

Platform for researcher identity and research visibility.

- **Directory of Open Access Journals (DOAJ)**

<https://doaj.org>

Database of peer-reviewed open access journals.

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	Define, recall, list, describe, explain, and summarize the fundamental concepts, terminology, and principles of research methodology and biostatistics, including the nature and types of scientific research, steps in the research process, formulation of research problems and hypotheses, and ethical considerations. Students will identify and describe major research designs, sampling methods, measurement scales, and data collection techniques, as well as the procedures for data management and presentation. They will recognize and explain the purposes and assumptions of descriptive, inferential, and multivariate statistical methods and outline the structure and conventions of scientific writing, reporting, and dissemination, thereby demonstrating foundational knowledge and comprehension of the complete research workflow.	K1, K2
CO2	Apply, implement, demonstrate, analyze, differentiate, interpret, and examine core concepts and methods of research methodology and biostatistics to real-world scientific problems. Students will apply systematic procedures to formulate research questions and hypotheses, design appropriate experimental or observational studies using suitable sampling strategies and measurement tools, and	K3, K4

	implement ethical standards throughout the research process. They will analyze and interpret quantitative data using descriptive, inferential, and multivariate statistical techniques with the support of statistical software, and differentiate among alternative analytical approaches based on assumptions and research objectives. Furthermore, learners will organize and present research findings through structured scientific writing and presentations, evaluate the coherence and validity of research outputs, and demonstrate the ability to communicate results effectively while adhering to publication ethics and open-science practices.	
CO3	Critically evaluate, synthesize, design, formulate, justify, and create advanced research frameworks integrating principles of scientific inquiry, research design, and statistical analysis. Students will evaluate and critique the suitability of diverse research methodologies, sampling strategies, and measurement instruments in relation to complex biological and interdisciplinary problems, while justifying methodological choices based on validity, reliability, and ethical considerations. They will synthesize theoretical knowledge and empirical evidence to formulate original research questions, develop comprehensive proposals, and design robust experimental or observational studies with appropriate analytical plans.	K5, K6

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	3	3	3	3
CO2	2	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3

COURSE CODE	PZO2MC03
COURSE TITLE	INHERITANCE BIOLOGY
Credits/Hours	5 Credits / 5 Hours
Category	Major Core (MC) - Theory
Semester	II
Regulation	2026
Course Overview 1. The aim of the course is to give basic understanding of inheritance and regulation of cellular activities in molecular level. 2. Will also explain about the relationship between mutation and phenotypic variations. 3. Discuss the significance of linkage and mapping of genes using different methods. 4. The other important aspects that will be discussed in the course includes: Mendelian concepts, deviations from Mendelian inheritance, linkage and crossing over, pedigree analysis, microbial genetics, role of environment and other factors that affect inheritance pattern.	
Course Objectives 1. To understand the structure and function of the DNA molecule to its functional role in encoding genetic material. 2. To distinguish between dominant, recessive, autosomal, X-linked and cytoplasmic modes of inheritance. 3. To analyze gene expression and relationships between species based on the principles of inheritance as formulated by Mendel. 4. To describe normal chromosome number, structure, and behaviour in human cells and understand extra nuclear inheritance, linkage & crossing over. 5. To apply various methods for mapping of genes.	
Prerequisites	Basic Knowledge in Biology.

SYLLABUS

Unit	Content	Hrs	COs	Cognitive Level
I	Concept of genes Gene concept and organization, DNA and RNA as genetic material. Fine structure of gene; Prokaryotic and eukaryotic gene regulation. Sex Chromosomes and sex determination in animals. Dosage compensation of X linked genes. Sex limited and sex influenced characters.	10	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

II	Mendelian and Non-Mendelian pattern of inheritance Dominance, segregation, independent assortment. Allelic and non-allelic interactions with examples in humans, pseudo allele, test of allelism, complementation tests. Heterosis, Atavism, Pleiotropy, genomic imprinting, penetrance, expressivity, phenocopy. Extrachromosomal inheritance: Inheritance of mitochondrial and chloroplast genes, informosomes, Kappa particles.	15	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
III	Linkage, crossing over and genetic maps of chromosomes. Linkage groups and chromosomes: Linkage groups and chromosomes; Stern's hypothesis, Creighton and McClintock's experiments, models of recombination - Holliday model and double strand break repair model. Single cross over, multiple cross over, two-point cross, three-point cross, map distances, gene order, interference and co-efficient of coincidence. Haploid mapping, tetrad analysis, mapping in bacteria and bacteriophages, mapping with molecular markers, and somatic cell hybridization technique.	16	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
IV	Microbial genetics Fundamentals of Bacterial and Viral Genetics; Methods of genetic transfers - transformation, conjugation, transduction mapping genes by interrupted mating, transduction and sexduction. Genetics of Temperate and Intemperate Bacteriophages, T4 Bacteriophage; Retrovirus and transposable elements in prokaryotes and eukaryotes.	16	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
V	Human Genetics Human chromosomes and karyotyping; Techniques in human chromosome analysis; Pedigree analysis, numerical and structural abnormalities of chromosomes and genetic disorders. Mendelian based heritable diseases in man; Teratogens, Role of transposons in mutation. Quantitative genetics: Polygenic inheritance, heritability and its measurements. Effect of environmental factors and artificial selection on polygenic inheritance. Statistics of Quantitative Genetics; Analysis of quantitative traits in human: IQ, QTL.; Future of human genetics.	18	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

Text Books

1. Veer Bala Rastogi., 2019. Text Book of Genetics, Medtech.
2. Verma P. S. and V. K. Agarwal., 2018. Genetics, S. Chand & Company Pvt Ltd.
3. Guptha G. K., 2013. Genetics Classical to Modern, Rastogi publishers, Meerut.
4. Benjamin A. Pierce, 2013. Genetics: A conceptual Approach, W.H Freeman.
5. Lewin B., 2008. Genes IX, Jones and Bartlett publishers.
6. Verma P.S and Agarwal V.K., 2006. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology, S. Chand & Company Ltd.
7. David E Sadava, 1993. Cell Biology - Organelle Structure and Function, Jones Bartlett Publishers.

Suggested Readings

1. Alberts B, Johnson A, Lewis J, Raff M, Roberts K & Walter P. (2014). Molecular Biology of the Cell. 7th Ed. Garland Science.
2. Carroll S.B., Doebley J., Griffiths, A.J.F. & Wessler, S.R. (2018). An Introduction to Genetic Analysis. W. H. Freeman & Co. Ltd.
3. De Robertis, E.D.P. & De Robertis, E.M.F., (2006). Cell & Molecular Biology. (8th Edition). New York: Lippincott William & Wilkins.
4. Gardner, E.J., Simmons, M.J & Snustad, D.P. (2008). Principles of Genetics. (8th edition) Wiley & Sons. Inc.
5. Hartl D L & Ruvolo M. (2011). Genetics - Analysis of Genes & Genomes. (8th Student Edition). Jones & Bartlett.
6. Harvey F Lodish, Arnold Berk, Chris Kaiser, Monty Krieger, Matthew P Scott, Anthony Bretscher, Hidde L Ploegh, Paul T Matsudaira. (2007). Molecular Cell Biology. W.H. Freeman & Company.
7. Klug, W.S., Cummings, M.R. & Spencer, C.A. (2012). Concepts of Genetics. (X edition) Benjamin Cummings.
8. Primrose, S. B. & Twyman, R. M., (2006). Principles of Gene Manipulation & Genomics. (7th Edition). Blackwell Publishing, West Sussex.
9. Snustad, Russell, P.J. (2010). Genetics. Benjamin Cummings.
10. Walker & Ginglod (1992). Molecular Biology & Biotechnology, Royal Society of Chemistry Cambridge.
11. Watson JD, Baker TA, Bell SP, Gann A, Levine M & Losick R. (2014). Molecular Biology of the Gene. (7th Ed). Pearson.
12. Wessler SR, Lewontin RC, Gelbart WM, Suzuki DT & Miller JH (2004). Introduction to Genetic analysis. (8th Edition). W.H Freeman & Company.

Web Resources

1. <https://go.nature.com/2XE8V1q>
2. <https://bit.ly/3zoTt6B>
3. <https://bit.ly/2XAm7oa>
4. <https://bit.ly/2XEbhsi>
5. <https://bit.ly/3AB4bso>
6. <https://bit.ly/39pZSE4>
7. <https://www.genome.gov/genetics-glossary/Sex-Linked>
8. <https://www.vedantu.com/biology/mutagens>

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	Define, recall, and describe the fundamental concepts of Mendelian inheritance, the fine structure of genes, and the role of DNA/RNA as genetic material. Students will identify various modes of inheritance (autosomal, X-linked, and cytoplasmic) and explain the mechanisms of linkage, crossing over, and chromosome mapping. Collectively, these competencies enable students to demonstrate foundational knowledge and conceptual understanding (K1-K2) of genetic principles.	K1, K2
CO2	Apply genetic principles to illustrate the relationship between genotype and phenotype and examine the role of extranuclear inheritance and microbial genetics. Students will analyze pedigree charts and compare different gene mapping methods to classify variations in chromosome number and structure. They will demonstrate proficiency in interpreting deviations from Mendelian ratios and calculate recombination frequencies. These competencies allow students to perform analytical interpretation and practical application (K3-K4) of inheritance patterns.	K3, K4
CO3	Evaluate the impact of mutations and environmental factors on gene expression to justify phenotypic variations within a population. Students will critically assess molecular markers used in gene mapping and judge the genetic basis of human disorders. They will integrate data from population genetics and quantitative trait analysis to construct, design, and formulate predictive models for genetic counseling and biodiversity conservation. Collectively, these outcomes enable students to exercise higher-order judgment and creative problem-solving (K5-K6) .	K5, K6

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	2	2	2	2	3	2
CO2	3	3	3	3	3	3	2
CO3	2	3	3	3	3	3	3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	3	3	3	3
CO2	3	2	2	3	3	3	3
CO3	3	2	2	3	3	3	3

COURSE CODE	PZO2MC04
COURSE TITLE	CELLULAR ORGANIZATION AND MOLECULAR PROCESSES
Credits/Hours	5 Credits / 5 Hours
Category	Major Core (MC) - Theory
Semester	II
Regulation	2026
Course Overview This course will provide knowledge about the complex organization in the eukaryotic cell and prokaryotic cell and the molecular mechanisms of the cellular processes that exist in all cell types.	
Course Objectives 1. To understand the basic structure and functions of cellular components and to describe the molecular processes of DNA replication, transcription, and translation, and explain how they are managed in cells. 2. To illustrate the protein and nucleic acid structure and function, and the relationship between them. 3. To compare the principles of gene expression and its regulation in prokaryotes and eukaryotes and to formulate principles and application of gene cloning in industry and medicine for cancer cells.	
Prerequisites	Basic knowledge about cell biology

SYLLABUS

Unit	Content	Hrs	COs	Cognitive Level
I	Cellular Organization Membrane structure and function: Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, membrane pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes. Structural organization and function of intracellular organelles: Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure & function of cytoskeleton and its role in motility.	14	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
II	Organization of genes, chromosomes and cell cycle Organization of genes and chromosomes: Operon, unique and repetitive DNA, interrupted genes, gene families, structure of	10	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	chromatin and chromosomes, types of chromosomes. Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle.			
III	DNA and RNA processing DNA replication in prokaryotes and eukaryotes, enzymes involved, replication origin and replication fork, types of replication, extrachromosomal replicons, DNA damage and repair mechanisms, RNA synthesis and processing: transcription factors and machinery, formation of initiation complex, transcription activator and repressor, RNA polymerases, capping, elongation, and termination, RNA processing, RNA editing, splicing, and polyadenylation, Different types of RNA, RNA transport. Mobile DNA elements: Transposable elements in bacteria, IS elements, composite transposons, replicative, non replicative transposons, Mu transposition, SINES and LINES. Retroviruses and retrotransposon.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
IV	Protein synthesis and molecular processing Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, genetic code, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, and translational proof-reading, translational inhibitors, post-translational modification of proteins. Lac operon. Regulation of gene expression at transcription and translation level: regulating the expression of phages, viruses, prokaryotic and eukaryotic genes, role of chromatin in gene expression and gene silencing.	10	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
V	Cell signalling, communication and Cancer Host parasite interaction, Cell signalling, Hormones and their receptors, cell surface receptor, signalling through G protein coupled receptors, signal transduction pathways, second messengers, regulation of signalling pathways, Cellular communication, principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation. Cancer: Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and cell cycle, virus	14	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	induced cancer, metastasis, interaction of cancer cells with normal cells, therapeutic interventions of uncontrolled cell growth. CRISPR-Cas gene editing mechanisms and molecular therapeutic technologies. Molecular drugs. Stem cell research, regenerative medicine and synthetic biology. AI-driven analysis of single-cell omics data. Targeted drug design and precision medicine.			
Text Books 1. De Robertis, E. D. P., & De Robertis, E. M. F. (2006). <i>Cell and molecular biology</i> (8th ed). Lippincott Williams & Wilkins. 2. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). <i>Molecular biology of the cell</i> (7th ed). Garland Science. 3. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., & Bretscher, A. (2016). <i>Molecular and Cellular Biology</i>. W H Freeman. 4. Power, C.B, (2010). <i>Cell biology</i>, Himalaya publishing house.				
Suggested Readings 1. Becker, W. M., Kleinsmith, L. J., Hardin, J., & Bertoni, G. P. (2009). <i>The world of the cell</i> (7th ed). Benjamin-Cummings Publishing. San Francisco. 2. Cooper, G. M., & Hausman, R. E. (2009). <i>The cell: A molecular approach</i> (5th ed). ASM Press and Sinauer Associates. MA. 3. Green, M. R & Sambrook, J. (2012) <i>Molecular Cloning: a Laboratory Protocol</i> (4th edition) CSHL Press. 4. Hancock, J. T. (2006). <i>Cell signaling</i> (2nd ed). Oxford University Press. 5. Karp, G. (2010). <i>Cell and molecular biology: Concepts and experiments</i> (6th ed). John Wiley & Sons, Inc. 6. Malacinski, G. M. (2010). <i>Essential of molecular biology</i> (4th ed). Narosa Publication. 7. Paul, A. (2011). <i>Text books of cell and molecular biology</i> (3rd ed), Books & allied (P) Ltd. Kolkata, India. 8. Walter, P. (2007) <i>Molecular Biology of the Cell</i> (5th edition) Garland Science. 9. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. (2014). <i>Molecular biology of the gene</i> (7th ed). Pearson.				
Web Resources 1. https://plato.stanford.edu/entries/molecular-biology/ 2. https://www.sciencedaily.com/terms/molecular_biology.htm 3. https://en.wikipedia.org/wiki/Cell_(biology) 4. https://www.genetics.org/				

5. <https://www.cancer.gov/research/areas/biology>
6. <http://www.freebookcentre.net/Biology/Molecular-Biology-Books.html>
7. http://isca.co.in/BIO_SCI/lab_manual/IeP-BS-LM-2013-001.pdf

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	Define, recall, and describe the basic structure and functions of cellular components, including the model membrane, lipid bilayer, and intracellular organelles. Students will identify the molecular processes of DNA replication, transcription, and translation and explain how these mechanisms are managed within both prokaryotic and eukaryotic cells. Collectively, these competencies enable students to demonstrate foundational knowledge and conceptual understanding (K1–K2) of cell and molecular biology.	K1, K2
CO2	Apply molecular principles to illustrate the relationship between protein and nucleic acid structures and their corresponding biological functions. Students will examine and analyze the regulation of the cell cycle and the organization of genes and chromosomes, including unique and repetitive DNA. They will demonstrate proficiency in interpreting signal transduction pathways and classify mobile DNA elements like transposons and retrotransposons. These competencies allow students to perform analytical interpretation and practical application (K3–K4) of cellular processes.	K3, K4
CO3	Evaluate the principles of gene expression and its regulation to compare mechanisms between prokaryotes and eukaryotes. Students will critically assess host-parasite interactions and judge the efficacy of therapeutic interventions for uncontrolled cell growth and cancer. They will integrate data from AI-driven single-cell omics to construct, design, and formulate advanced principles for gene cloning and precision medicine in industry and clinical research. Collectively, these outcomes enable students to exercise higher-order judgment and creative technical synthesis (K5–K6).	K5, K6

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	3	3	2	3	3	2
CO2	3	2	3	3	3	3	3
CO3	3	1	3	3	1	3	3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	1	2	1	3	2
CO2	3	2	3	3	3	2	3
CO3	3	3	3	3	3	3	1

COURSE CODE	PZO2MC05
COURSE TITLE	BIOPHYSICS, BIOCHEMISTRY AND CYTOGENETICS LAB
Credits/Hours	4 Credits / 6 Hours
Category	Major Core (MC) - Lab
Semester	II
Regulation	2026
Course Overview 1. This course provides hands-on training in molecular biology, genetics, and biochemistry techniques. 2. Students will learn methods for isolation and purification of cell organelles and biomolecules. 3. The course demonstrates experiments to understand biological structures and processes. 4. Students will perform practical experiments to study enzyme kinetics and activity. 5. The course develops laboratory skills and analytical abilities in biological sciences.	
Course Objectives 1. To understand the properties and characteristics of biological compounds. 2. To know how to use different techniques to quantify and characterize biomolecules. 3. To apply the knowledge of genetics to predict the inheritance pattern. 4. To apply statistical principles to determine the significance of experimental results. 5. To isolate chromosomes and study various stages of mitosis and meiosis.	
Prerequisites	Basic knowledge of physics, chemistry and Biology

SYLLABUS

Unit	Content	Hrs	Cos	Cognitive Level
I	Biophysics (Separation Techniques) Permeability test using erythrocytes, Differential centrifugation of cell organelles and identification of mitochondrial fractions: Isolation and partial purification of DNA/ RNA/Plasmid. Separation of amino acids/sugars by paper Chromatography. Separation of lipids/aminoacids by TLC. Separation of plant pigments by column chromatography.	18	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
II	Biochemistry (Quantification of biomolecules) Spectrophotometry – Beer's and Lambert's laws. Buffer preparation and determination of pH. Isolation and Estimation	18	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	of Glycogen from liver. Quantitative estimation of glucose, protein, cholesterol and triglycerides. Urea and creatinine in the serum of goat. Quantification of DNA by DPA method			
III	Biochemistry (Enzyme analysis) Isolation, Purification and enzyme kinetic studies of Amylase, Acid phosphatase and Alkaline phosphatase of rat kidney or Goat liver. Urease from plant seeds.	18	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
IV	Cytogenetics Chromosome Preparation Metaphase chromosome preparation from mouse bone marrow cells/ fish gill cells – Karyotyping – Squash preparation of cockroach/ grasshopper testis/ mouse and observation of meiotic stages using plant/animal serum. Study of Mendelian traits in man. Allele frequency and gene mapping. Demonstrate Mendelian laws of segregation and independent assortment using chi square and ANOVA	18	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
V	Drosophila Genetics and Polytene Chromosomes Morphology and sex identification, mutants in Drosophila. Mounting of salivary glands of Drosophila/Chironomous larva for observing giant chromosomes with banding and balbiani rings.	18	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

Text Books

1. Ambika Shanmugam. (1974). Fundamentals of Biochemistry for Medical Studies. Second Edition, Aries Agencies, Chennai.
2. Durairaj, G. (1998). A Laboratory Manual in Genetics. Emerald, Chennai
3. Lal, S. S. (2016). *Practical zoology: Invertebrates*. Rastogi Publications.
3. Hall, D & S. Hawkins (1975). A Laboratory Manual of Molecular Cell Biology, English University, London.
4. Kumar, E., Singh, D., & Kumar, M. B. S. (2024). *Laboratory Manual of Cell Biology, Cytogenetics, Physiological and Biochemistry*. Taneesha Publishers.
5. Rajan, S. & Selvi Christy, R., (2001). Experimental procedure in Life sciences, 1st edition, Anjanaa book house, Chennai.

Suggested Readings

1. Bonner, P. L. R., & Hargreaves, A. J. (2016). *Basic Bioscience Laboratory Techniques*. Wiley-Blackwell.
2. Das, D. (2015). *Biophysics and biophysical chemistry* (6th ed.). Academic Publishers.

3. Gasque, E. (1992). A Manual of Laboratory experiments in Cell Biology. University of Wisconsin, Brown.
4. Geddes, L.A. (1972). Electrodes and the measurement of bioelectric events, John Wiley & Sons Ltd. New York.
5. Jay L. Nadeau (2011). Introduction to experimental biophysics. Biological methods for physical scientists, 2nd Ed. CRC Press, USA. Lehninger, A. L. (2006). Biochemistry, Freeman, New York.
6. Roy, R. N. (2001). *A textbook of biophysics*. New Central Book Agency (P) Ltd.
7. Upadhyay, P., & Upadhyay, R. (2019). *Practical Biochemistry: Manual for Biotechnology and Life Sciences*. Springer.
8. West Edward Staunton, Todd Wilbert R. Mason Howard, S. & Bruggen John T. Van. (1974). Textbook of biochemistry Amerind Publishing Co. Pvt. Ltd, New Delhi.
9. Wilson, K., & Walker, J. (2018). *Principles and Techniques of Practical Biochemistry* (8th ed.). Cambridge University Press.

Web Resources

1. <https://www.vlab.co.in/>
2. <https://bit.ly/3rUz0pQ>
3. <https://bit.ly/3GWuVFX>
4. <http://www.pathology.washington.edu/research/cytopages/>

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	Identify, recall, and describe the fundamental principles of biophysical separation techniques and biochemical assays. Students will recognize cellular organelles and explain the theoretical basis of chromatography, centrifugation, and electrophoresis. Collectively, these competencies enable students to demonstrate foundational knowledge and conceptual understanding (K1–K2) of laboratory instrumentation and biomolecular characteristics.	K1, K2
CO2	Apply experimental protocols to isolate and purify cell organelles, DNA, and RNA using differential centrifugation. Students will demonstrate proficiency in quantifying biomolecules (proteins, sugars, lipids) and analyze enzyme kinetics to calculate Vmax and Km values. They will examine mitotic and meiotic stages in plant and animal tissues and illustrate chromosomal aberrations. These competencies allow students to perform practical application and analytical interpretation (K3–K4) of cytogenetic and	K3, K4

	biochemical data.	
CO3	Evaluate the precision of analytical techniques to justify experimental results and appraise the purity of isolated biological fractions. Students will critically assess inheritance patterns through pedigree analysis and judge the significance of genetic deviations using statistical tests. They will integrate laboratory data to construct professional research reports and design innovative experimental setups for studying molecular processes. Collectively, these outcomes enable students to exercise higher-order judgment and creative technical synthesis (K5–K6) .	K5, K6

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3

COURSE CODE	PZO2ME01
COURSE TITLE	LABORATORY ANIMAL SCIENCE
Credits/Hours	3 Credits / 4 Hours
Category	Major Elective (ME) - Theory
Semester	II
Regulation	2026
Course Overview 1. This course introduces the principles, ethics, and legislations governing the use of animals in research. 2. It focuses on the 3R principles and global guidelines to promote humane animal experimentation and animal welfare. 3. This course provides knowledge of laboratory animal facility design, health monitoring, and safety practices. 4. It focuses on experimental design, genetic monitoring, and practical handling techniques in laboratory animals. 5. This course highlights the importance of alternatives to animal use and prepares students for responsible biomedical research.	
Course Objectives 1. To familiarize students with the ethics, legislation, and principles of animal experimentation. 2. To impart knowledge on animal facility design, management, and safety standards. 3. To train students in experimental design, animal identification, and genetic monitoring. 4. To provide practical skills in handling, restraining, drug administration, anesthesia, necropsy and promote humane research practices. 5. To expose students to global standards and guidelines (CCSEA, IAEC, FELASA, OECD, AALAC).	
Prerequisites	Basic knowledge on animal science

SYLLABUS

Unit	Content	Hrs	COs	Cognitive Level
I	Principles and Ethics of Laboratory Animal Science Ethics and 3R principles in Lab animal sciences. History and origin of Lab animals. Legislations in India- Acts and Rules relating to animals and animal experimentation. Basic Behavior biology of lab animals.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

II	Experimental Design and Genetic Monitoring Basic statistics, determination of sample size and experimental design, G-Power Analysis. Genetic Monitoring of Lab animals. Animal Identification methods: Non-invasive and invasive methods. Variables in a vivarium.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
III	Animal Facility Management and Animal Welfare Laboratory animal facility design, Occupational health hazard and safety measures, Health monitoring and prevention of disease in a vivarium. Environmental enrichment. Alternatives for animal experimentation, Norecopa. Transportation of animals.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
IV	Guidelines, Standards, and Ethical Oversight Severity and Pain assessment, grimace scale, Harmonization and standardization, Humane End Points, CCSEA, IAEC, OECD Guidelines, FELASA, AALAC, Form B filling, Reporting of In Vivo Studies. Immune compromised animals, IVIS Imaging.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
V	Practical Approaches in Animal Handling Handling and restraining of lab animals, sex determination, common routes of drug administration, Blood collection, Anesthesia, Analgesia, Euthanasia and Necropsy. Animal facility visit.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

Text Books

1. Kumar & Sharma (2017). *Handbook of Laboratory Animals (Mouse, Rat, Guinea Pig, Rabbit)*. NPH India
2. D. V. Reddy (2020). *Applied Nutrition: Livestock, Poultry, Rabbits and Laboratory Animals* (3rd Ed.). CBS Publishers & Distributors.
3. Enqi Liu (2018). *Fundamentals of Laboratory Animal Science*. CRC Press
4. P. Nagarajan, Ramachandra Gudde & Ramesh Srinivasan (2021). *Essentials of Laboratory Animal Science: Principles and Practices*. Springer.
5. Jann Hau & Steven J. Schapiro (2021). *Handbook of Laboratory Animal Science: Essential Principles and Practices* (4th Ed.). CRC Press / Taylor & Francis Group

Suggested Readings

1. Abhijit Dutta (2009). *Experimental Biology: A Laboratory Science*. Narosa, New Delhi.
2. H. Ghosh (2017). *Laboratory Animal Science*. Universities Press.
3. R. Jayaraman (2019). *Fundamentals of Animal Experimentation*. Allied Publishers

4. A. Kumar (2020). Textbook of Laboratory Animals. CBS Publishers.
5. K. Ramesh & P. Suresh (2016). Biostatistics for Life Sciences. Macmillan India.
6. Michael Festing et al. (2016). The Design of Animal Experiments. Cambridge University Press.
7. Paul Flecknell (2015). Laboratory Animal Anaesthesia. Academic Press.
8. Jerald Silverman (2014). The IACUC Handbook. CRC Press.
9. Robert Hubrecht (2010). The UFAW Handbook on the Care and Management of Laboratory and Other Research Animals. Wiley-Blackwell.
10. Mark A. Suckow, Steven H. Weisbroth & Craig L. Franklin (2012). The Laboratory Rat. Academic Press

Web Resources

1. CCSEA Guidelines (India): (Committee for Control and Supervision of Experiments on Animals)
<https://moef.gov.in>
2. OECD Guidelines for Animal Testing: (Organisation for Economic Co-operation and Development)
<https://www.oecd.org>
3. FELASA (Federation of Laboratory Animal Science Associations): <https://felasa.eu>
4. AAALAC International: Association for Assessment and Accreditation of Laboratory Animal Care International
<https://www.aaalac.org>
5. Norecopa – 3Rs Database:
<https://norecopa.no>

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	Define, recall, and describe the ethical principles of the 3Rs (Replacement, Reduction, and Refinement) and the fundamentals of laboratory animal facility management. Students will identify national and international legislations (CCSEA, FELASA, OECD) and explain the requirements for animal housing, nutrition, and safety standards. Collectively, these competencies enable students to demonstrate foundational knowledge and conceptual understanding (K1–K2) of animal welfare and regulatory frameworks	K1, K2
CO2	Apply techniques for animal handling, restraint, and drug administration to	K3, K4

	examine biological responses in laboratory models. Students will demonstrate proficiency in anesthesia and euthanasia protocols and analyze genetic monitoring data to classify appropriate animal models for specific biomedical research. They will illustrate the experimental design process and categorize various routes of administration and blood collection. These competencies allow students to perform analytical interpretation and practical application (K3–K4) of laboratory animal science.	
CO3	Evaluate the validity of animal research models to justify the selection of specific strains or species for human disease studies. Students will critically assess the impact of environmental factors on research outcomes and judge the compliance of research protocols with ethical guidelines. They will integrate welfare standards and regulatory requirements to construct, design, and formulate humane research frameworks and experimental protocols that utilize alternatives to animal testing. Collectively, these outcomes enable students to exercise higher-order judgment and creative problem-solving (K5–K6) .	K5, K6

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	2	3	2	3
CO2	2	2	3	2	3	3	3
CO3	3	2	3	3	3	3	3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	2	3	2	3	2
CO2	3	2	3	3	3	2	2
CO3	3	3	3	3	3	3	3

COURSE CODE	PZO2ME02
COURSE TITLE	BIO NANOSCIENCE
Credits/Hours	3 Credits / 4 Hours
Category	Major Elective (ME) - Theory
Semester	II
Regulation	2026
Course Overview 1. This course is structured to provides fundamental concepts and principles of nanoscience and nanobiology. 2. It introduces the fundamental principles, contemporary concepts, and emerging developments related to synthesis of nanomaterials and nanoparticles. 3. The programme enables students to gain in-depth knowledge on biological interactions, safety, and toxicological effects of nanomaterials. 4. Highlights the applications of nanotechnology in medicine, environmental management, and agriculture. 5. Upon successful completion, learners will be enabled to gain knowledge about emerging trends and future perspectives in nanobiology and nanotechnology.	
Course Objectives 1. To provide in-depth theoretical knowledge in nanoscience and nanobiology. 2. To develop the ability to develop research and industrial projects addressing biological, health, and environmental challenges. 3. To integrate concepts of physical sciences with biological sciences for broader scientific applications. 4. To build understanding of fundamental nano biological principles and the use of nanomaterials and nanoparticles in biological research. 5. To promote interdisciplinary learning in science and technology.	
Prerequisites	Basic knowledge on Biology, Chemistry and Physics

SYLLABUS

Unit	Content	Hrs	COs	Cognitive Level
I	Introduction To Nanobiology: Definition of Nanobiology, Nanoparticles, Types based on dimension, surface area-volume ratio, and properties. Development of nanobiotechnology, timelines and progress. Nano Dimensions	10	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	and Nano- Structures			
II	Biomaterials: Classification of nanoparticles based on size, shape, surface properties and composition; bio-inspired nanomaterials. Bulk materials vs nanomaterials. Different types of materials used to synthesize nanoparticles, Top-down approach, and bottom-up approach. Nanoscale assembly of cellular components (cell membrane and liposomes). Nano-Characterization: UV Visible spectrophotometer, FTIR, XRD, SEM, TEM, EDX, AAS, DLS, PSA, Elemental mapping etc.,.	9	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
III	Nanomedicine: Nanobiotechnological applications in Infectious and Chronic Disease Management, Drug encapsulation, drug delivery and gene delivery, Active and passive targeting by ligands and receptor-mediated delivery, Interactions of nanoparticles with biological membranes and ion channels. Nanoparticle Synthesis Techniques for Biological Sciences, Biosensors and Applications its in diagnostics.	9	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
IV	Environmental applications: Nanoadsorbents, Nanotechnology in Agriculture, release of nutrients and pesticides, Nanoremediation, Nanopollution: air - water - soil contaminants, Treatment of industrial wastewaters using nanoparticles.	9	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
V	Nanotoxicity: Effect of nanomaterials on human health, nanomaterial-cell interaction, Toxicological Effects of Nanomaterials Concept, cytotoxicity and genotoxicity, Future perspectives of Nanobiology.	8	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

Text Books

1. Nanotechnology: Health and Environmental Risks, Jo Anne Shatkin, CRC Press, 2008 Challa Kumar (Ed) – Biological and Pharmaceutical Nanomaterials, Wiley – VCH Verlag, Weinheim, 2006.
2. Kenneth E. Gonsalves, Craig R. Halberstadt, Cato T. Laurencin, Lakshmi S. Nair, (Eds) (2008) “Biomedical Nanostructures” Wiley-Interscience, John Wiley & Sons, Inc. 205
3. Niemeyer, C.M. (2006) Nanobiotechnology: Concepts, Applications and Perspectives; Wiley VCH.
4. Ralph S. Greco, Fritz B. Prinz, R. Lane Smith Eds. (2005) Nanoscale Technology in Biological Systems, CRC PRESS, Taylor & Francis.
5. Nanobiotechnology: Concepts, Applications and Perspectives (2004), Christof M. Niemeyer (Editor), Chad A. Mirkin (Editor), Wiley VCH.
6. Harvey Lodish, Arnold Berk et al. – Molecular Cell Biology, W.H. Freeman & Co., New York, 2008.
7. The Chemistry of Nanomaterials: Synthesis, Properties and Applications. C.N.R. Rao, A.
8. Muller, A.K. Cheetam (Eds.), (2004) WILEY-VCH Verlag GmbH & Co., Weinheim
9. Ralph S. Greco, Fritz B. Prinz and R. Lane Smith (Eds) - Nanoscale Technology in Biological Systems, CRC Press, 2005.
10. Nanomaterials – An introduction to synthesis, properties and applications, D. Vollath, Wiley-VCH, Second Edition 2013.
11. Nanotechnology: Environmental Health and Safety, Risks, Regulation and Management, Matthew Hull and Diana Bowman, Elsevier, 2010

Suggested Readings

1. Stroeve, P and Mahmoudi (2018) Drug Delivery Systems, World Scientific Series: From Biomaterials towards Medical Devices, Vol I.
2. Introduction to Nanoscience and Nanotechnology, Gabor L. et al,
3. Niemeyer C.M, Mirkin C.A (Eds) 2005. Nanobiotechnology
4. H.S. Nalwa (Ed) Handbook of Nanostructured Bioaterials and their applications in
5. nanobiotechnology, American Scientific Publishers. 2005.
6. Hillery, and Anya M et al. (2010 “Drug Delivery and Targeting”, CRC Press.
7. Hong-fan, M, Huang, C.P., Bland, A. E., Honglin, W. Z., Sliman, R., Wright, I (2010) Enviro-nanotechnology; Elsevier.
8. Segura-Valdez ML, Agredano-Moreno LT, Nepomuceno-Mejía T, Fragoso-Soriano R, Álvarez-Fernández G, Zamora-Cura A, Lara-Martínez R, Jiménez-García LF. Cell nanobiology. 2013. doi:10.5772/52003.
9. K.K. Jain, Nano Biotechnology, Horizons Biosciences, 2006.

10. Nano bio-technology: Concepts, Applications and Perspectives, Christ of M. Niemeyer, Wiley, 2004.

Web Resources

1. <https://dst.gov.in/scientific-programmes/mission-nano-science-and-technology-nano-mission>
2. <https://www.cense.iisc.ac.in/>
3. <https://www.indiascienceandtechnology.gov.in/>
4. <https://bit.ly/4b7ocdd>
5. <https://bit.ly/4suWz53>
6. <https://bit.ly/4s12uza>
7. <https://bit.ly/4csfIQt>

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	Define, recall, and describe the fundamental concepts of nanobiology, including the dimensions, properties, and classification of nanoparticles. Students will identify the history of nanotechnology and explain the unique physico-chemical characteristics of nanomaterials compared to bulk materials. Collectively, these competencies enable students to demonstrate foundational knowledge and conceptual understanding (K1–K2) of nanoscience.	K1, K2
CO2	Apply synthesis approaches—such as "top-down" and "bottom-up" methods—to examine and illustrate the creation of biological and inorganic nanomaterials. Students will analyze the interactions between biomaterials and biological systems and compare different characterization techniques like SEM, TEM, and XRD. They will demonstrate proficiency in interpreting nano-toxicological data and classify nanoparticles based on their composition. These competencies allow students to perform analytical interpretation and practical application (K3–K4) of nanobiotechnology.	K3, K4
CO3	Evaluate the efficacy of nanomedicine and nano-diagnostics to justify their use in drug delivery and disease treatment. Students will critically assess the environmental and agricultural applications of nanotechnology and judge the safety and ethical implications of nanoparticle exposure. They will integrate multidisciplinary data to construct, design, and formulate innovative research projects and "green" synthesis protocols for sustainable technological solutions. Collectively, these outcomes enable students to exercise higher-order judgment and creative technical synthesis (K5–K6) .	K5, K6

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	3	2	2	3
CO2	3	3	3	3	2	3	3
CO3	3	3	3	3	2	3	3

COURSE CODE	PZO2ME03
COURSE TITLE	CLINICAL LABORATORY TECHNIQUES
Credits/Hours	3 Credits / 4 Hours
Category	Major Elective (ME) -Theory
Semester	II
Regulation	2026
Course Overview This course provides a comprehensive overview provides comprehensive training in diagnostic laboratory techniques, equipping students with the skills to analyse body fluids, tissues, and other medical specimens. The course covers key areas like clinical biochemistry, microbiology, haematology, and immunology, emphasizing practical and theoretical knowledge. Students gain proficiency in operating advanced laboratory equipment, adhering to safety protocols, and interpreting diagnostic results. Designed to meet the needs of modern healthcare, the program prepares graduates for rewarding careers in hospitals, diagnostic labs, and research facilities.	
Course Objectives 1.To equip students with the knowledge and skills to perform accurate diagnostic tests and analyze medical samples effectively. 2. To train students in the use of advanced laboratory equipment, maintenance of lab safety protocols, and quality control procedures. 3. To provide a strong foundation in subjects like clinical biochemistry, microbiology, hematology, and immunology to support accurate disease diagnosis. 4. To foster a commitment to ethical practices, confidentiality, and professionalism in medical laboratory settings. 5. To enable students to pursue careers in diagnostic laboratories, hospitals, and research institutions or further studies in specialized fields.	
Prerequisites	Basic understanding of biology, biochemistry, laboratory safety, common lab techniques, and ethical considerations.

SYLLABUS

Unit	Content	Hrs	COs	Cognitive Level
I	Human Anatomy And Safety Measure Human body overview - Structural organization system, functions- common causes of accidents in lab – laboratory safety – biomedical waste. Classification wastes coding, Treatment wastes disposal medical Personal safety measure, - disposal of lab wastes and hazardous chemical reagents	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	and glasswares- fire safety			
II	Haematology Composition and functions of blood - collection of blood - types of anaemia- blood coagulation - bleeding time- clotting time- determination of hemoglobin - erythrocyte sedimentations rate- packed cell volume- Total count of RBC- Differential count of WBC- bleeding disorders of man – blood grouping-Platelet count-Hemopoietic system – erythropoiesis, thrombopoiesis and leucopoiesis – Hemopoietic	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
III	Bio Medical Techniques and Blood Parasites Structure and function of cells - parasites – Entamoeba- Plasmodium-Leishmania and Trypanosome. Blood Pressure monitor- Computer tomography (CT scan) - Magnetic Resonance imaging (MRI)- flowcytometry - treadmill test. PET Scan.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
IV	Medical Physiology Cardiovascular system-Cardiac cycle - regulation of heart rate, cardiac shock. Heart sounds, Electrocardiogram significance-ultra sonography -ultrasonic diagnostic methods-dialysis.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
V	Diagnostic Pathology Handling and labeling of histology specimens - tissue processing – fixation, dehydration embedding, block preparation. Microtomes –sectioning, staining – methods – mounting - problems encountered during section cutting and remedies	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

Text Books

1. Biswapati Dasgupta (2000). Parasitology, Books and Allied (P) Ltd.
2. Chakraborty, P. (2017). A Textbook of Microbiology for Medical Laboratory Technicians. Kolkata: New Central Book Agency.
3. Dey, N. C. (2016). Dey & Dey's Textbook of Pathology and Microbiology for Medical Laboratory Technology. S. N. Ghosh & Co.
4. Godkar, P. B., & Godkar, D. P. (2021). Textbook of Medical Laboratory Technology: Volumes 1 & 2 (3rd updated edition). Mumbai: Bhalani Medical Book House.

5. Guyton and Hall, 2000. Text Book of medical Physiology, 10th edition, Mukherjee, K. L. (2010). Medical Laboratory Technology: A Procedure Manual for Routine Diagnostic Tests.

Suggested Readings

1. Das, D. (2017). Handbook of Medical Laboratory Technology. CBS Publishers & Distributors.
2. Godkar, P. B., & Godkar, D. P. (2024). Textbook of Medical Laboratory Technology (4th ed., Volumes 1 and 2). Bhalani Publishing House.
3. Sood, R. (2006). Textbook of Medical Laboratory Technology. Jaypee Brothers Medical Publishers.
3. Kanai, L. (2013). Clinical Laboratory Medicine: A Textbook of Laboratory Procedures and Diagnosis. CBS Publishers & Distributors.
4. Maheshwari, N., & Tiwari, P. (2018). Essentials of Medical Laboratory Technology. Paras Medical Publisher.
5. Manoharan, A, and Sethuraman, 2003. Essential of Clinical Hematology, Jaypee brothers, New Delhi.
6. Ochei. J., A. Kolhatkar (2000). Medical Laboratory science: Theory and practice, Published by Tata McGraw-Hill Education Pvt. Ltd, First edition.
7. Richard, A, McPherson, Mathew, R, Pincus, 2007. Clinical and management by laboratory methods, Elsevier, Philadelphia. Published by Tata McGraw-Hill Education Pvt. Ltd.,

Web Resources

1. American Society for Clinical Pathology (ASCP) - Education & Certification Offers a wide range of educational programs for laboratory professionals, including certification, webinars, and training courses.
<https://www.ascp.org/content/education>
2. American Medical Technologists (AMT) Provides continuing education, certification programs, and a community for professionals in the laboratory field.
<https://www.americanmedtech.org/>
3. One Lab by CDC - Online Laboratory Training. The CDC's OneLab initiative offers free training resources, webinars, and eLearning courses for lab professionals, with an emphasis on public health and diagnostic testing.
<https://reach.cdc.gov>
4. Clinical Lab - Online Laboratory Training. This site provides access to various online training programs and resources specifically tailored for medical laboratory technicians and technologists.
<https://www.clinicallab.com>
5. National Accrediting Agency for Clinical Laboratory Sciences (NAACLS). A comprehensive resource for accreditation and certification of laboratory education programs, supporting academic and professional growth.
<https://www.naacls.org>
6. LabCE - Online Continuing Education for Laboratory Professionals.
<https://www.labce.com>

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	Define key terms in microbiology and hematology, such as bacteria, virus, fungus, erythrocyte, leukocyte, and platelet. Describe the basic structure and function of bacteria, viruses, and fungi. Explain the mechanisms of bacterial growth, reproduction, and metabolism. Identify the different types of white blood cells and their roles in the immune system. Summarize the principles of blood clotting and hemostasis. Outline the basic concepts of pharmacology, including drug action, metabolism, and excretion. Describe the principles of histopathology and its role in disease diagnosis.	K1, K2
CO2	Analyze the pathogenesis of infectious diseases caused by bacteria, viruses, and fungi. Evaluate the diagnostic methods used to identify and diagnose infectious diseases. Critically analyze the mechanisms of action of antimicrobial drugs and their potential side effects. Assess the role of the immune system in combating infectious diseases. Apply knowledge of hematology to diagnose and manage blood disorders. Interpret histological sections to identify tissue abnormalities and diagnose diseases.	K3, K4
CO3	Create innovative strategies for the development of new antimicrobial drugs and vaccines. Design and conduct experiments to investigate the mechanisms of drug resistance and host-pathogen interactions. Synthesize information from multiple sources to develop a comprehensive understanding of infectious diseases and their impact on public health. Evaluate the ethical implications of antibiotic use and antimicrobial resistance. Critically analyze the limitations of current diagnostic and therapeutic approaches and propose new solutions.	K5, K6

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	3	3	2	3	3	3
CO2	3	3	3	2	3	3	3
CO3	3	3	3	2	3	3	3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3

COURSE CODE	PZO2ME04
COURSE TITLE	MICROBIAL BIOTECHNOLOGY
Credits/Hours	3 Credits / 4 Hours
Category	Major Elective (ME) - Theory
Semester	II
Regulation	2026
Course Overview This course provides a comprehensive understanding of the application of microorganisms in biotechnology. It focuses on the utilization of bacteria, fungi, algae, and viruses in various industrial, medical, agricultural, and environmental processes. Students gain knowledge of microbial metabolism, genetic manipulation, and fermentation technology, along with modern techniques such as recombinant DNA technology and enzyme engineering. The course emphasizes the role of microbes in the production of valuable products including antibiotics, enzymes, biofuels, vaccines, and biopolymers. It also covers bioremediation, waste management, and sustainable environmental applications. Practical and theoretical insights into microbial culture techniques, strain improvement, and large-scale industrial processes are included. Designed to meet current industrial and research demands, this course equips students with the necessary skills for careers in biotechnology industries, pharmaceuticals, environmental management, and research laboratories.	
Course Objectives 1. To equip students with knowledge and skills in the isolation, cultivation, and characterization of microorganisms for biotechnological applications. 2. To train students in the use of advanced microbiological and biotechnological techniques, including fermentation technology, genetic engineering, and industrial microbiology practices. 3. To provide a strong foundation in microbial physiology, molecular biology, and bioprocess technology for the production of valuable biomolecules such as enzymes, antibiotics, and biofuels. 4. To develop an understanding of biosafety, ethical practices, and regulatory guidelines in microbial and biotechnological research. 5. To enable students to pursue careers in biotechnology industries, pharmaceuticals, environmental management, and research institutions, or to undertake higher studies in specialized fields.	
Prerequisites	Basic understanding of biology, biochemistry, laboratory safety, common lab techniques, and ethical considerations.

SYLLABUS

Unit	Content	Hrs	COs	Cognitive Level
I	Introduction to fermentation technology Chronology and components of fermentation processes - A general account on microbial biomass, enzymes, metabolites and recombinant products - Range of	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	fermentation processes - Transformation processes. Isolation, preservation, optimization and improvement of industrially important microorganisms, Growth kinetics and substrate.			
II	Fermentor and Media Fermentor - basic functions - body construction - aerators, agitators (impellers and spargers) - asepsis - containment - valves and steam traps - types of fermentors. Substrates for media preparation - Medium formulation – Sterilization of medium. Steps and methods in recovery of products. Bioreactors and Down stream process.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
III	Food dairy, beverages Single cell proteins (SCP)- SCP as food and feed – mass cultivation of Spirulina– Mycoprotein - Yogurt and cheese production. Alcoholic beverages – Beer and wine fermentation. Mushroom cultivation.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
IV	Pharmaceutical and related industries Principles of microbial growth and factors affecting growth, Growth kinetics and substrate. Antibiotics- sources and types- production of Penicillin and Streptomycin. Production of insulin and Hep B vaccine. Transformation of steroids. Vitamins- Production of vitamin B12. Biotransformation of steroids.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
V	Enzymes, Amino acids, Organic acids and other products Production and application of amylase, protease, and lipase. Microbes used for amino acid production- production of L-glutamic acids - Organic acids: citric acid, acetic acid production - Bioplastics and Exopolymer production - Biofertilizers and biofuels. Enzymes in organic solvents and ionic liquids, biocatalysts, enzyme engineering, random and rational approach to protein engineering, Biocatalysis, techniques of immobilization of enzymes and whole cells: design, operation and kinetics of immobilized enzyme reactors, diffusional resistance and Thiele modulus.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

Text Books

1. Crueger F and Anneliese Crueger, 2000. Biotechnology: Industrial Microbiology Panima publishing Corporation, New Delhi.
2. Stanley, P. F., Whittaker, A. and Hall, S.J., 1995. Principles of Fermentation technology First edn, Pergamon Press, UK.
3. Balasubramanian, D., Bryce, C. F. A., Dharmalingam, K., Green, J. and KunthalaJayaraman, 1998. Concepts in Biotechnology, COSIST Publications, India.
4. Adams, M.R. and Moss, M.O., 1995. Food Microbiology. New Age International Publishers, New Delhi.
5. Casida, L. E. Jr. 1996. Industrial Microbiology. New Age International Publishers, New Delhi

Suggested Readings

1. Chellapandi. P, (2007) Laboratory Manual in Industrial Biotechnology, Pointer Publications.
2. Harisha, S. (2005). An Introduction to Practical Biotechnology. India: Laxmi Publications Pvt Limited.
3. Kulandaivel and Janarthanan. S, (2012) Practical Manual on Fermentation Technology, TechSar Pvt. Ltd.
4. Maheswari. K, (2002) Practical microbiology, S. Chand publishers..
5. Patel. A.H, (2012) Industrial Microbiology by, 2nd edition , Mac Millan.
6. Watson, K (2016). Industrial Biotechnology, CBS Publishers & Distributors.
7. Yadav. P. R and Rajiv Tyagi (2005). Industrial biotechnology, Discovery Publishing house.

Web Resources

1. American Society for Microbiology (ASM): <https://asm.org/>
Offers numerous resources, including journals, books, and databases, related to industrial microbiology.
2. Biotechnology Industry Organization (BIO): <https://www.bio.org/>
A global trade association representing biotechnology companies, focusing on public policy and advocacy.
3. European Federation of Biotechnology (EFB): <http://www.efbiotechnology.org/>
Promotes biotechnology research and innovation in Europe.
4. International Union of Pure and Applied Biochemistry and Molecular Biology (IUBMB): <https://iubmb.org/>
Provides guidelines and standards for biochemical and molecular biology research.

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	Define the fundamental principles of fermentation technology and list the components of industrial fermentation processes. Describe the morphology and basic functions of various bioreactors and fermentor parts. Identify industrially important microorganisms and summarize the primary methods used for their isolation and preservation. Outline the basic steps involved in downstream processing and product recovery.	K1, K2
CO2	Apply optimization techniques to improve microbial strains for industrial use. Calculate media requirements and execute sterilization protocols for large-scale production. Analyze the fermentation parameters for alcoholic beverages, dairy products, and organic acids. Examine the pathogenesis and production mechanisms of antibiotics like Penicillin and Streptomycin. Interpret experimental data to diagnose issues in microbial growth and metabolite yield.	K3, K4
CO3	Design innovative bioreactor configurations for the mass cultivation of Spirulina and Mycoproteins. Evaluate the efficacy of microbial enzymes in industrial applications and critically assess the environmental impact of biofertilizers versus chemical alternatives. Construct a comprehensive production plan for recombinant products like insulin and Hep B vaccines. Formulate new strategies for the synthesis of bioplastics and exopolymers to propose sustainable biotechnological solutions.	K5, K6

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	3	3	3	2	3	3
CO2	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3

COURSE CODE	PZO2ME05
COURSE TITLE	FORENSIC BIOLOGY
Credits/Hours	3 Credits / 4 Hours
Category	Major Elective (ME) - Theory
Semester	II
Regulation	2026
Course Overview 1. Introduces fundamentals of forensic science and role of biology in crime investigation. 2. Trains students in collection, handling, and preservation of biological evidence. 3. Provides hands-on exposure to forensic serology and body fluid analysis. 4. Explains forensic DNA analysis, profiling, and advanced genetic techniques. 5. Highlights applications of entomology, botany, microbiology, and wildlife forensics. Builds professional skills in report writing, expert testimony, and ethics.	
Course Objectives 1. To understand principles of forensic biology and biological evidence management. 2. To acquire practical skills in forensic serology and bloodstain analysis. 3. To learn DNA profiling techniques and interpretation of results. 4. To apply forensic entomology, botany, and microbiology in case investigations. 5. To integrate professional ethics, standards, and courtroom skills in forensic practice.	
Prerequisites	Background in genetics, molecular biology, and microbiology.

SYLLABUS

Unit	Content	Hrs	COs	Cognitive Level
I	Introduction to forensic science: History, fundamental principles (Locard's Exchange Principle), and the role of biology in criminal justice. Types of biological evidence: A survey of evidence including blood, saliva, hair, semen, and other body fluids, and their evidential value. Crime scene processing: Best practices for securing a scene, documenting, sketching, photographing, and properly collecting biological evidence. Contamination control and preservation: Methods to avoid contamination of samples and techniques for preserving biological evidence for future analysis. Chain of custody: Meticulous documentation to maintain the legal integrity of evidence from the crime	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	scene to the courtroom.			
II	Forensic Serology and Body Fluid Analysis Identification of body fluids: Presumptive and confirmatory tests for blood (e.g., Kastle-Meyer, Luminol), semen, and saliva. Bloodstain pattern analysis (BPA): Interpret the size, shape, and distribution of bloodstains to help reconstruct a crime scene. Species determination: Serological tests to distinguish human from animal fluids. Analysis of other fluids: Identification and analysis of sweat, urine, and feces.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
III	Forensic DNA analysis Fundamentals of DNA: Structure, replication, and the genetic markers used for identification. DNA extraction and quantification: Techniques for isolating and measuring DNA from different types of samples, including highly degraded or trace samples. DNA profiling techniques: Theory and practical application of Polymerase Chain Reaction (PCR) and Short Tandem Repeat (STR) analysis. Advanced DNA analysis: Principles of Mitochondrial DNA (mtDNA) and Y-chromosome analysis for specialized cases. Interpretation and databases: Understanding concepts like random match probability and the use of national DNA databases (e.g., CODIS).	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
IV	Specialized biological and botanical evidence Forensic entomology: The study of insects and their life cycles in relation to human remains to estimate the time of death. Forensic botany: Analysis of plant evidence (pollen, seeds, leaves) to link suspects or victims to locations. Forensic microbiology: Using microorganisms to aid in investigations, such as in cases of bioterrorism or food contamination. Wildlife forensics: Application of forensic biology to investigate crimes against protected or endangered species.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
V	Legal and professional aspects of forensic biology	12	CO 1 CO 2	K1, K2, K3, K4,

	Forensic biology in the legal system: The role of the forensic biologist as an expert witness, understanding evidence admissibility, and courtroom procedures. Ethics and standards: Discuss professional codes of conduct, laboratory accreditation, and quality control. Testimony skills: Develop effective communication and presentation skills for court appearances. Professional development: Importance of continuous learning and staying updated on new technologies and best practices.		CO 3	K5, K6
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Text Books

1. Bhasin, M. K and S. Nath (2002). Role of Forensic Science in the New Millennium, University of Delhi.
2. James, S. H and J.J. Nordby (2005). Forensic Science: An Introduction to Scientific and Investigative Techniques, CRC Press.
3. Nanda, B. B and R.K. Tiwari (2001). Forensic Science in India: A Vision for the Twenty First Century, Select Publishers.
4. Eckert W. G and R.K. (1997). Wright in Introduction to Forensic Sciences, W.G. Eckert (ED.), CRC Press.
5. James S. H and J.J. Nordby, (2005). Forensic Science: An Introduction to Scientific and Investigative Techniques, CRC Press.

Suggested Readings

1. Nanda, B. B and R.K. Tiwari, (2001). Forensic Science in India: A Vision for the Twenty First Century, Select Publishers.
2. Narayan Reddy K. S (2018). The Principles and Practice of Forensic Medicine, Elsevier.
3. Parikh (2019). Textbook of Forensic Medicine and Toxicology. Bhalani Publishing House.
4. Puri, A., Mahalakshmi, N., Chauhan, T., Mishra, A., & Bhatnagar, P. (2024). Fundamentals of Forensic Biology. Springer Link.
5. Saferstein, R (2004). Criminalistics, 8th Edition, Prentice Hall.

Web Resources

1. American Academy of Forensic Sciences (AAFS) - Pathology/Biology Section Provides an overview of the field, career opportunities, and educational resources in forensic biology. aafs.org
2. Forensic Resources: Blood & Bodily Fluids. Offers insights into forensic serology tests (presumptive and confirmatory), casework resources, and training materials. forensicresources.org
3. National Institute of Standards and Technology (NIST) - Forensic Science. A hub for forensic

biology standards and ongoing research. NIST is a key player in ensuring scientific rigor in forensic practices.

nist.gov

4. Environmental Science - Careers in Forensic Biology. Comprehensive information about careers, necessary qualifications, job roles, and potential salary in forensic biology. environmentalscience.org

5. Federal Bureau of Investigation (FBI) - Forensic Biology. The FBI provides educational content and outlines the role of biology in solving crimes. fbi.gov

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	Define the fundamental principles of forensic science, including Locard's Exchange Principle, and list the various types of biological evidence. Describe the best practices for crime scene processing, documentation, and contamination control. Identify the legal requirements for maintaining a meticulous chain of custody. Summarize the basic structure of DNA and the genetic markers used for individual identification.	K1, K2
CO2	Apply presumptive and confirmatory tests to identify body fluids such as blood, semen, and saliva. Execute DNA extraction and quantification techniques for trace or degraded samples. Analyze bloodstain patterns to reconstruct crime scene events based on size and distribution. Examine serological data to distinguish between human and animal biological fluids. Interpret DNA profiles and utilize national databases like CODIS for forensic matching.	K3, K4
CO3	Design investigative protocols utilizing forensic entomology and botany to estimate time of death and link suspects to specific locations. Evaluate the role of forensic microbiology in cases of bioterrorism and food contamination. Construct expert witness reports and formulate effective testimony strategies for courtroom procedures. Critically assess the ethical standards, laboratory accreditation, and quality control measures in forensic practice to propose improvements in investigative accuracy.	K5, K6

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	3	3	3	2	3	3
CO2	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3

COURSE CODE	PZO3MC01
COURSE TITLE	COMPARATIVE ANIMAL PHYSIOLOGY
Credits/Hours	5 Credits / 5 Hours
Category	Major Core (MC) - Theory
Semester	III
Regulation	2026
Course Overview 1. To understand the functional biology of invertebrate and vertebrate animals, with emphasis on how their physiological systems operate and how their biology is shaped by the environmental conditions of their respective niches. 2. To enable students to explore original questions in animal physiology, focusing on evolutionary changes and environmental adaptations across different taxa of invertebrates and vertebrates.	
Course Objectives 1. Comparative Animal Physiology' helps understand how animals work at all levels, ranging from individual cells to the whole integrated organism. 2. The scope of physiology includes elucidation of the structure and function of all cells in all organs. 3. To classify and organize the all animals related to nervous, respiratory, circulatory and other physiological systems. 4. This course analyze and differentiate the modifications/adaptations found in different physiological systems of various organisms across the animal kingdom. 5. To integrate and prescribe the animal physiology and environment adaptation for lower and higher animals.	
Prerequisites	Basic knowledge about invertebrate and vertebrate animals.

SYLLABUS

Unit	Content	Hrs	COs	Cognitive Level
I	Nutrition and Excretion Nutrition - nutrients - digestion in different organisms. Absorption of proteins, carbohydrates and lipids. Role of digestive gland and gastrointestinal hormones in digestion. Effect of starvation. Excretion - Excretion in different organisms, excretory product in relation to the environment - physiology of excretion in Man, Kidney, structure of Nephron,	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	Urine formation and concentration in Henle's loop, regulation of water balance.			
II	Internal Transport and Gas Exchange Comparative anatomy of heart, myogenic and neurogenic heart, cardiac cycle, heart as a pump, neural and chemical regulation. Systems of circulation, Peripheral circulation, Regulation of heart beat and blood pressure, Transport and exchange of gases, Composition of blood, plasma function, blood volume and regulation, blood groups, haemoglobin, haemostasis. Comparison of respiration in different species, Neural and chemical regulation of respiration, Gas transfer in air and water, Gas exchangers, respiratory pigments, Circulatory and respiratory responses to extreme conditions, Acid –base balance.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
III	Thermoregulation and Adaptations to Stress Basic concept of environmental stress, acclimation, acclimatization, avoidance and tolerance, stress and hormones. Osmoregulation- Osmoregulation in aquatic and terrestrial environments, Extra-renal osmoregulatory organs. Thermoregulation- thermoregulatory centre of the brain, Heat balance in animals, Adaptations to temperature extremes, torpor, Aestivation and hibernation, Counter current heat exchangers. Stress and adaptation mechanisms in animals	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
IV	Neuroendocrinology and Reproductive Physiology: Structure and Functions of neurons, generation and propagation of action potential. Gross neuroanatomy of brain and spinal cord, organization of central and peripheral nervous system, Neural control of muscle tone and posture. Endocrine glands structure, functions and secretions. Basic mechanism of hormone action. Hormones and their disorders. Neuroendocrine regulation of reproductive processes - gametogenesis, ovulation, and hormonal control of reproduction.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
V	Muscle Physiology and Sensory Physiology Types of muscles; ultrastructure of skeletal muscle; muscle proteins and molecular mechanism of contraction.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	Neuromuscular transmission and regulation of muscle activity. Comparative muscle adaptations in invertebrates and vertebrates; insect flight muscle. Structure and function of major sense organs - vision, hearing, and tactile receptors; sensory transduction and neural pathways.			
Text Books 1. Anderson, M., Hill, R. W., Wyse, G. A. (2017). Animal Physiology. United Kingdom: Oxford University Press. 2. Ruppert, E. E., Fox, R. S., & Barnes, R. D. (2019). Invertebrate zoology: A functional evolutionary approach (8th ed.). Cengage Learning. 3. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002) the Invertebrates: A New Synthesis. III Edition. Blackwell Science. 4. Barrington, E J W. (1967) Invertebrate structure and function, Nelson, London. 5. Boradale, L.A. and Potts, E.A. (1961) Invertebrates: A Manual for the use of Students. Asia Publishing Home. 6. Kardong, K. V. (2018). Vertebrates: Comparative anatomy, function, evolution (8th ed.). McGraw-Hill Education. 7. Goldstein, L. (1977). Introduction to comparative physiology. Rinehart & Winston. New York.				
Suggested Readings 1. Hall, J. E., & Hall, M. E. (2020). Guyton and Hall textbook of medical physiology (14th ed.). Elsevier Health Sciences. 2. Starck, J. M., & Wisse, P. A. (Eds.). (2022). Comparative vertebrate anatomy: A laboratory dissection guide (3rd ed.). Academic Press. 3. Campbell, N. A., & Reece, J. B. (2017). Biology (11th ed.). Pearson. (Comprehensive coverage including physiology and invertebrates) 4. Hickman, C. P., Roberts, L. S., & Larson, A. (2017). Integrated principles of zoology (17th ed.). McGraw-Hill Education. 5. Kardong, K. V., & Witten, P. E. (2021). Anatomy & physiology: The unity of form and function (9th ed.). McGraw-Hill Education. 6. Solomon, E. P., Berg, L. R., & Martin, D. W. (2018). Biology (11th ed.). Cengage Learning. (Strong chapters on physiology and diversity) 7. McLaughlin, R. W., & Jones, D. S. (2021). General zoology (2nd ed.). Springer.				
Web Resources 1. https://www.wiley.com 2. https://www.wiley.com				

3. <https://www.worldcat.org>
4. <https://www.researchgate.net>
5. <https://open.umn.edu>
6. <https://www.sanfoundry.com>
7. <https://guides.library.illinois.edu>

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	Define, recall, and describe the fundamental physiological mechanisms of invertebrates and vertebrates, including nutrition, respiration, and circulation. Students will identify the structural organization of various organ systems and explain the basic principles of neural control and muscle contraction across different taxa. Collectively, these competencies enable students to demonstrate foundational knowledge and conceptual understanding (K1–K2) of functional biology.	K1, K2
CO2	Apply physiological principles to examine and illustrate how animals adapt to diverse niches through modifications in respiratory and excretory systems. Students will analyze and compare the functional efficiency of open vs. closed circulatory systems and classify types of receptors and effectors. They will demonstrate proficiency in interpreting oxygen-binding curves and categorize different modes of nitrogenous waste excretion. These competencies allow students to perform analytical interpretation and practical application (K3–K4) of comparative physiology.	K3, K4
CO3	Evaluate the role of osmoregulation and thermoregulation to justify survival strategies in extreme environments. Students will critically assess the integration of neuroendocrine control in maintaining homeostasis and judge the evolutionary significance of physiological transitions from aquatic to terrestrial life. They will integrate physiological and environmental data to construct, design, and formulate models of animal adaptation and prescribed responses to climate change. Collectively, these outcomes enable students to exercise higher-order judgment and creative technical synthesis (K5–K6) .	K5, K6

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	3	3	2	3	3	3
CO2	3	2	3	3	3	3	3
CO3	3	3	3	3	3	3	2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	3	3	3	2
CO2	3	3	3	2	3	3	3
CO3	3	2	3	3	3	3	3

COURSE CODE	PZO3MC02
COURSE TITLE	IMMUNOLOGY, MICROBIOLOGY AND EPIDEMIOLOGY
Credits/Hours	5 Credits / 5 Hours
Category	Major Core (MC) - Theory
Semester	III
Regulation	2026
Course Overview 1. The course includes a detailed description of cells involved in the immune response either innate or acquired and to provide students with a broad overview of basic immunology especially mammalian immune response. 2. The course includes the mechanisms of antibody formation and molecular aspects of cellular immunity, including T and B cell interactions and lymphocyte memory formation. 3. To understand the functions and dysfunctions of the immune system such as allergies, asthma, and autoimmune disease as well as immune deficiency disorders. 4. The course includes the taxonomy of bacteria and the various culture methods and culture media. 5. To understand the epidemiology of infectious agents and its role in public health.	
Course Objectives 1. To apply the knowledge to understand the microbial physiology and to identify the microorganisms. 2. To understand the basic epidemiological methods and study designs. 3. To understand the status of health and disease at global and national levels. 4. To provide a basic knowledge of the immune response, cytokines and immunomodulation, hypersensitivity and allergy and its involvement in health and disease. 5. To impart knowledge of different immunological techniques used for research.	
Prerequisites	Knowledge in molecular biology.

SYLLABUS

Unit	Content	Hrs	COs	Cognitive Level
I	Immune cells and immune response Antigen, antibody: hapten structure, functions and types, Immunogens, antigenicity, immunogenicity. Innate and adaptive immunity. Cells, organs and molecules involved in immunity. Types of immunity and immune response. Humoral and cell mediated immune response. Antibodies - types;	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	generation of antibody diversity. Antigen processing and presentation. MHC molecules, complement system, toll like receptors. T and B cells development, maturation and activation. T and B cell epitopes, cytokines.			
II	Immune diseases and Immunotechniques Immune system disorders: Inflammation, hypersensitivity, transplantation immunology - graft rejection mechanisms and tolerance induction strategies. Autoimmune disease, congenital and acquired immunodeficiencies. Immune response during bacteria (tuberculosis), parasite (malaria), viral (HIV/COVID) infection, malignancy (tumors). Primary and secondary immunodeficiency's with related diseases. Hybridoma technology - production of monoclonal antibodies and its applications. Vaccines - types and various methods in vaccine preparation. Immunization schedule in India. Immunotechniques - ELISA, RIA, Immunoblotting, Immunofluorescence microscopy, immunosensor, immunoprecipitation, flow cytometry.	14	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
III	Taxonomy and anatomy of microbes History and scope of microbiology, Whittaker's five kingdom classification. Bergey's manual of systemic bacteriology. Microbial anatomy: cell membrane, cell wall, glycocalyx, flagella, fimbriae, inclusion, endospore. Microbial nutrition's and factors affecting the growth of microbes, growth curve, role of microbial metabolism in biosynthesis and growth: primary and secondary metabolites. Microbial mutations.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
IV	Techniques in microbiology and applications General methods and tools used for studying - bacteria, virus, fungus. Safety measures while handling pathogens. Different culture media for microbial growth/bacteria, virus, fungus. Applications: Bioremediation, pharmaceuticals, probiotics, and food science. Genetically modified microbes, microorganisms and their impact on humans. Antibiotics: Antibiotic resistance crisis, Multidrug resistance in microbes, mechanism of action of antibiotics (Penicillin, Streptomycin).	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

V	Epidemiology Endemic, epidemic and pandemic. Historical aspects of epidemiology. Worst epidemic and pandemic conditions in the past. Epidemiological modelling and public health assessment. Tools and study design in epidemiology. Epidemiological traits. Prevention and control of diseases during epidemic conditions, uses, approaches, fields in epidemiology. Epidemiological methods in health management - national and international.	10	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
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Text Books

1. Kuby, J, Punt, J, Stranford, S, Jones, P and Owen, J, 2018. Immunology, 8th Edition, W.H.Freeman Publishing, New York, 944 pp.
2. Roitt, M, Peter J. Delves, Seamus J. Martin and Dennis R. Burton, 2017. Essential Immunology, 13th Edition, Wiley-Blackwell Publishing, USA, 576 pp.
3. Coleman, R.M., 2014. Fundamental Immunology, 2nd Edition, Published by Mc Graw Hill Education India, 357 pp.
4. Raj Khanna, 2011. Immunology, Oxford University press, New Delhi. 428 pp. Rao.C.V. 2011. Immunology, Narosa Publishing House, New Dehli. 426 pp.

Suggested Readings

1. Atlas, R. M. (1997). Principles of microbiology (2nd ed), Tata McGraw Hill (international ed), 1098.
2. Goldsby, R.A., Kindt, T.J. & Kuby, J. (2006) Immunology (6th edition). W.H. Freeman & Co Ltd.
3. Jawetz, M. & Adelberg (2015) Medical Microbiology (27th edition). Mc Graw Hill.
4. Jeffrey C. Pommerville, (2006). Alcamo's fundamental of microbiology, Jones and Barlett, Boston.
5. Leon, G. (2013). Epidemiology (5th ed). Elsevier Saunders.
6. Pelzar, M. J., Chan, E. C. S., & King, N. R. (2002). Microbiology-concepts and applications, McGraw Hill, Jnc, 1. New York.
7. Porta, M. (2014). A dictionary of epidemiology. Oxford University Press.
8. Prescott, Harley & Klein's, (2008). Microbiology, 7th edition, Tata McGraw Hill international edition, Page 1-1086.
9. Rao, C. V (2005). Immunology, 2nd edition, Narosa Publishing House, New Delhi.
10. Roitt, I. (1997). Essential Immunology, Blackwell Scientific Publications. Boston.
11. Roitt, I., Brostoff, J. and Male, D. (2012) Immunology (8th edition). Wiley.

12. Ryan & Ray Sherris (2004). Medical Microbiology, 4th Ed. (Eds.), McGraw-Hill.
13. Schneider, D., & Lilienfeld, D. E. (2015). Lilienfeld's foundations of epidemiology, (4th Edition). Oxford University Press.

Web Resources

1. <https://onlinelearning.hms.harvard.edu/immunology>
2. <https://uscmed.sc.libguides.com>
3. <https://libraryguides.mcgill.ca>
4. <https://microbiology.columbia.edu>
5. <https://libguides.library.usyd.edu.au>
6. <https://www.ncbi.nlm.nih.gov>
7. <https://libguides.tulane.edu>
8. <https://www.journals.elsevier.com>

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	Define, recall, and describe the foundational concepts of innate and acquired immunity, including the structure of antigens and antibodies. Students will identify the taxonomy of microbes and explain the principles of vaccination, autoimmunity, and hypersensitivity. Collectively, these competencies enable students to demonstrate foundational knowledge and conceptual understanding (K1-K2) of immunological and microbiological systems.	K1, K2
CO2	Apply laboratory techniques to examine and illustrate microbial growth and the handling of cultures. Students will analyze the molecular mechanisms of T and B cell interactions and compare different immunological techniques used in research. They will demonstrate proficiency in interpreting antibiotic resistance patterns and classify various hypersensitivity reactions. These competencies allow students to perform analytical interpretation and practical application (K3-K4) of immune and microbial data.	K3, K4
CO3	Evaluate the status of health and disease at global and national levels to justify public health interventions and control measures. Students will critically assess epidemiological study designs and judge the efficacy of immunomodulation strategies. They will integrate data from disease outbreaks to construct, design, and formulate cost-effective epidemiological	K5, K6

	methods and health management protocols to mitigate infectious agents. Collectively, these outcomes enable students to exercise higher-order judgment and creative technical synthesis (K5-K6) .	
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CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	2	3	3	3	3
CO2	3	2	2	3	3	3	3
CO3	3	2	3	3	3	3	3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	2	2	2	2	2	2
CO2	2	3	2	3	2	3	3
CO3	3	3	3	2	3	3	3

COURSE CODE	PZO3MC03
COURSE TITLE	COMPUTATIONAL BIOLOGY LAB
Credits/Hours	4 Credits / 4 Hours
Category	Major Core (MC) - Lab
Semester	III
Regulation	2026
Course Overview 1. This laboratory course provides hands-on training in modern computational biology tools and databases used in genomics, proteomics, drug discovery, and biodiversity research. 2. The course emphasizes real-world problem solving through integrated mini-projects involving disease gene annotation, antimicrobial resistance analysis, drug target identification, and biodiversity informatics. 3. The course enables students to critically analyze biological datasets, apply computational tools for translational research, and integrate multi-platform approaches for scientific investigation.	
Course Objectives 1. To provide comprehensive training in the retrieval, exploration, and critical analysis of biological data from primary databases and scientific literature using computational and AI-assisted tools. 2. To develop the ability to perform genomic and proteomic analyses for applications in gene annotation, functional and structural characterization of proteins relevant to health and disease. 3. To enable students to apply computational approaches in drug discovery and environmental analysis for target identification, lead optimization, therapeutic evaluation, biodiversity assessment, and ecological data interpretation. 4. To foster integrative problem-solving skills through mini-projects that address real-world biological challenges such as antimicrobial resistance analysis and biodiversity conservation.	
Prerequisites	Basic knowledge of biology and computer skills

SYLLABUS

Unit	Content	Hrs	COs	Cognitive Level
I	Introduction to Biological Databases and Data Mining Study of the different features of the NCBI, PDB and ExPASy databases. Exploration of specialized databases such as FlyBase and ViralZone. AI-assisted literature review using Semantic Scholar. AI-assisted evidence synthesis in research using Elicit and Consensus.	6	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
II	Tools for Genomic Analysis Visualization of gene structure and regulatory elements using the UCSC genome browser. Determination of the open reading frame in a gene sequence using ORF Finder. Clinical interpretation of gene mutations using ClinVar. Mapping a gene into metabolic pathways using Reactome. Analysis of differential gene expression dataset using gene expression omnibus (GEO). Design and <i>in silico</i> validation of gene-specific PCR primers using Primer-BLAST.	9	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
III	Tools for Proteomic Analysis Prediction of the subcellular localization using DeepLoc or WoLF PSORT. Identification of a potential protein biomarker in breast cancer using the Human Protein Atlas. Protein-protein interaction study using STRING. Protein structure prediction using the AI tool AlphaFold.	9	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
IV	Drug Discovery and Biodiversity Tools Retrieval of drug information from ChEMBL and DrugBank. Design and editing of drug compounds using Ketcher. Understanding the concept of molecular docking with CB-Dock 2. Virtual screening and binding mode prediction of drug candidates using SwissDock. AI-based species identification	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	using iNaturalist. Species distribution analysis using Global Biodiversity Information System (GBIF). Estimation of biodiversity indices using PAST4 software.			
V	Mini Projects for Integrated Use of Multiple Tools: <i>In silico</i> functional annotation and disease association analysis of a target gene (sequence analysis, functional annotation, pathway mapping, protein interaction networks, disease association mining). Antimicrobial resistance protein (beta-lactamase) evolution study (phylogenetic tree construction, domain and motif analysis, and physicochemical profiling). Integrated lead discovery, target profiling and pharmacokinetic optimization using ExPASy tools.	9	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

Text Books

1. Baxeavanis, A. D., & Ouellette, B. F. F. (Eds.). (2021). *Bioinformatics: A practical guide to the analysis of genes and proteins* (3rd ed.). Wiley-Blackwell.
2. Pevsner, J. (2015). *Bioinformatics and functional genomics* (3rd ed.). Wiley-Blackwell.
3. Lesk, A. M. (2019). *Introduction to bioinformatics* (5th ed.). Oxford University Press.
4. Mount, D. W. (2004). *Bioinformatics: Sequence and genome analysis* (2nd ed.). Cold Spring Harbor Laboratory Press.
5. Xiong, J. (2014). *Essential bioinformatics*. Cambridge University Press.
6. Jones, N. C., & Pevzner, P. A. (2004). *An introduction to bioinformatics algorithms*. MIT Press.
7. Zvelebil, M., & Baum, J. O. (2008). *Understanding bioinformatics*. Garland Science.
8. Brown, T. A. (2018). *Genomes 4*. Garland Science.
9. Gusfield, D. (1997). *Algorithms on strings, trees, and sequences: Computer science and computational biology*. Cambridge University Press.
10. Setubal, J. C., & Meidanis, J. (1997). *Introduction to computational molecular biology*. PWS Publishing.

Suggested Readings

1. Aluru, S. (Ed.). (2005). *Handbook of computational molecular biology*. Chapman & Hall/CRC.
2. Baldi, P., & Brunak, S. (2001). *Bioinformatics: The machine learning approach* (2nd ed.).

MIT Press.

3. Eidhammer, I., Jonassen, I., & Taylor, W. R. (2004). *Protein bioinformatics: An algorithmic approach to sequence and structure analysis*. Wiley.
4. Tramontano, A. (2006). *Introduction to bioinformatics*. Chapman & Hall/CRC.
5. Higgs, P. G., & Attwood, T. K. (2019). *Bioinformatics and molecular evolution* (2nd ed.). Wiley-Blackwell.
6. Bourne, P. E., & Weissig, H. (Eds.). (2003). *Structural bioinformatics*. Wiley-Liss.
7. Claverie, J. M., & Notredame, C. (2007). *Bioinformatics for dummies* (2nd ed.). Wiley Publishing.
8. Rashidi, H., & Buehler, L. K. (2000). *Bioinformatics basics: Applications in biological science and medicine*. CRC Press.
9. Keith, J. M. (2009). *Bioinformatics: Data, sequence analysis, and evolution*. Humana Press.
10. Yang, Z. (2014). *Molecular evolution: A statistical approach*. Oxford University Press.

Web Resources

Educational Resources

1. National Center for Biotechnology Information (NIH, USA)
<https://training.ncbi.nlm.nih.gov/>
2. European Bioinformatics Institute (EMBL-EBI)
<https://www.ebi.ac.uk/training/>
3. Khan Academy
<https://www.khanacademy.org/science/biology>

Communities and Forums

1. BioStars
<https://www.biostars.org/>
2. SEQanswers
<http://seqanswers.com/>
3. ResearchGate
<https://www.researchgate.net/>

Research Databases

1. NCBI (National Center for Biotechnology Information)
<https://www.ncbi.nlm.nih.gov/>
2. UniProt

<https://www.uniprot.org/>

3. Gene Expression Omnibus (GEO)

<https://www.ncbi.nlm.nih.gov/geo/>

Specialized Resources

1. Protein Data Bank (PDB)

<https://www.rcsb.org/>

2. DrugBank

<https://go.drugbank.com/>

3. Global Biodiversity Information Facility (GBIF)

<https://www.gbif.org/>

Interactive Learning Tools

1. EMBL-EBI Training Portal

<https://www.ebi.ac.uk/training/>

2. NCBI Education & Training

<https://www.ncbi.nlm.nih.gov/home/learn/>

3. Khan Academy – Biology

<https://www.khanacademy.org/science/biology>

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	Explain the fundamental concepts, databases, and computational tools used in computational biology. Define key terminologies related to biological databases, genomics, proteomics, and drug discovery. List the major features and applications of commonly used bioinformatics resources. Describe the structure and organization of biological databases. Explain the principles of literature mining, mutation databases, protein interaction networks, and molecular docking concepts.	K1, K2
CO2	Apply bioinformatics tools to perform genomic, proteomic, drug discovery, and biodiversity data analysis. Use genome browsers, ORF prediction tools, and gene expression databases to analyze sequence data. Perform protein localization prediction, interaction analysis, and structure modeling. Analyze gene mutations, protein networks, and docking results to interpret biological	K3, K4

	significance. Differentiate between various computational outputs and assess their biological relevance.	
CO3	Evaluate computational results and design integrated workflows to solve biological research problems. Assess the reliability and limitations of computational predictions and database annotations. Compare alternative drug candidates, targets, or analytical approaches using evidence-based criteria. Design an integrated bioinformatics workflow for disease gene annotation, antimicrobial resistance analysis, or drug target identification. Develop mini-project reports synthesizing multi-tool analyses into coherent scientific conclusions.	K5, K6

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	3	2	2	2	2	2
CO2	2	3	2	2	3	3	2
CO3	2	2	3	3	2	3	3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	2	2	2	2
CO2	3	2	3	3	2	2	2
CO3	2	3	3	3	3	2	3

COURSE CODE	PZO3MC04
COURSE TITLE	PHYSIOLOGY, MICROBIOLOGY AND IMMUNOLOGY LAB
Credits/Hours	4 Credits / 6 Hours
Category	Major Core (MC) - Lab
Semester	III
Regulation	2026
Course Overview 1. The course paves way for a practical exploration of the various physiological parameters through laboratory experiments. 2. The techniques to study and measure physiological, microbiological and immunological characteristics are elaborated. 3. This course will equip learners to pursue research in animal physiology, microbiology and immunology. 4. Skills in organizing, analyzing and recording experimental data will be emphasized to a great extent.	
Course Objectives 1. To understand the effects of physiological changes in animals and the characteristics of microbes through experimentation. 2. To understand the use of specific techniques and experimental set-ups to study physiological, microbiological and immunological parameters. 3. To handle and analyze environmental samples of physiological and microbiological interest. 4. To record experimental data and report and discuss the experimental results accurately.	
Prerequisites	Basic knowledge in Biology or Zoology

SYLLABUS

Unit	Content	Hrs	COs	Cognitive Level
I	Effect of environment on physiology Effect of temperature on the respiratory rate of fish; Effect of decreasing oxygen availability on the muscle lactic acid content of fish; Effect of posture and exercise on blood pressure and	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	heart rate in humans; Ciliary activity in mussel.			
II	Markers of physiological changes on toxin exposure Assay of brain acetylcholinesterase on exposure of fish to pesticides or any other pollutants. Influence of sub lethal (50-60 ppm) ammonia (as liquor ammonia/ammonium hydroxide/ammonium chloride) on a suitable fish exposed to ammonia stress for 7 days with reference to the following parameters: Level of excretory ammonia Level of amino acid content of muscle, gill, brain and liver.	20	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
III	Homeostasis, physiological and histological parameters Estimation of salt loss and salt gain in fish exposed to fresh water and sea water. Comparative study of digestive enzymes in carnivorous (shark) and omnivorous (nile tilapia) fishes. Assay of enzyme markers of liver function (alanine aminotransferase, aspartate aminotransferase, acid phosphatase and alkaline phosphatase) in chicken liver sample. Study and identification of normal and abnormal electroencephalography (EEG) and echocardiography (ECG) waveforms using photographs. Histological observations using permanent slides of testis, ovary, spleen, liver, thyroid gland, pancreas, muscles, cartilage, bone, stomach, oesophagus, duodenum, kidney, spinal cord, pituitary, parathyroid, adrenal gland.	20	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
IV	Basic microbiological techniques Preparation of nutrient agar slant, stab streak, pour and spread plate cultures. Serial dilution of environmental bacterial samples and plating to establish viable bacterial cell count. Establishment of pure bacterial cultures from environmental samples. Selective growth of amylase-producing bacteria on starch agar plate.	20	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
V	Bacterial characterization and immunotechniques Simple staining, negative staining and Gram staining of	18	CO 1 CO 2	K1, K2, K3, K4,

	bacterial smears. IMViC test for identification of the bacteria. Double immunodiffusion and Radial immunodiffusion, Competitive ELISA.		CO 3	K5, K6
Text Books 1. Pawar, K. R., & Desai, A. E. (2019). Practical course in zoology. Nirali Prakashan. 2. Maheshwari, D. K. (2002). Practical microbiology, S. Chand Pvt. Ltd. 3. Parvathi, K., Karthegaa, J., & Sivakumar, P. (2021). A manual of practical zoology. Darshan Publishers. 4. Verma, P. S., & Srivastava, P. C. (2002). Advanced practical zoology. S. Chand Pvt. Ltd. 5. Roy, A. K., & Prasad, M. M. (2009). Laboratory manual of microbiology. New India Publishing Agency.				
Suggested Readings 1. Chess, B. (2019). Laboratory applications in microbiology: A case study approach. McGraw-Hill Education. 2. Erkmen, O. (2021). Laboratory practices in microbiology. Elsevier Science. 3. Hay, F. C., & Westwood, O. M. (2008). Practical immunology. John Wiley & Sons. 4. Mali, R. P., & Afsar, S. K. (2015). A practical manual on innovative animal physiology. Oxford Book Company. 5. Mondschein, W., Pollack, R. A., Findlay, L., & Modesto, R. R. (2018). Laboratory exercises in microbiology. Wiley. 6. Pommerville, J. C. (2017). Laboratory fundamentals of microbiology. Jones and Bartlett Publishers Learning, LLC. 7. Saxena, J., Baunthiyal, M., & Ravi, I. (2015). Laboratory manual of microbiology, biochemistry and molecular biology. Scientific Publishing. 8. Wallis, C. J. (2015). Practical zoology: For advanced level and intermediate students. Elsevier Science. 9. Zane, H. D. (2001). Immunology: theoretical & practical concepts in laboratory medicine. Saunders.				

Web Resources

1. <https://practicalbiology.org/control-and-communication/control-of-heart-rate/investigating-factors-affecting-the-heart-rate-of-daphnia>
2. https://www.ronaldschulte.nl/files/Laboratory_manual_in_general_microbiology.pdf
3. http://www.cuteri.eu/microbiologia/manuale_microbiologia_pratica.pdf
4. <https://www.youtube.com/watch?v=aDU4GpKLF8Q>
5. <https://www.youtube.com/watch?v=HhOUwIOdxkA>

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	Identify, recall, and describe physiological parameters, immunological changes, and the morphological characteristics of microbes. Students will recognize the structural components of immune cells and explain the theoretical basis for measuring metabolic rates and microbial growth. Collectively, these competencies enable students to demonstrate foundational knowledge and conceptual understanding (K1-K2) of experimental biology.	K1, K2
CO2	Apply specialized laboratory techniques to examine and illustrate physiological responses, such as respiratory rates in fish and blood pressure in humans. Students will demonstrate proficiency in staining methods (Gram's staining, Acid-fast) and analyze immunological interactions using techniques like ELISA or Haeme-agglutination. They will interpret experimental data to compare observations with established biological theories. These competencies allow students to perform analytical interpretation and practical application (K3-K4) of lab protocols.	K3, K4
CO3	Evaluate the quality of environmental samples to justify findings related to physiological stress or microbial contamination. Students will critically assess the precision of diagnostic assays and judge the significance of experimental deviations in immunological tests. They will integrate multi-disciplinary data to construct, design, and formulate advanced experimental set-ups and comprehensive research reports. Collectively, these outcomes	K5, K6

	enable students to exercise higher-order judgment and creative technical synthesis (K5-K6).	
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CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	2	3	2	3
CO2	3	2	2	3	3	3	3
CO3	3	2	3	2	3	3	3

COURSE CODE	PZO3ME01
COURSE TITLE	IPR, BIOSAFETY AND BIOETHICS
Credits/Hours	3 Credits / 4 Hours
Category	Major Elective (ME) – Theory
Semester	III
Regulation	2026
Course Overview 1. Introduces the principles of Intellectual Property Rights (IPR), Bioethics, and Biosafety relevant to 2. modern life sciences. 3. Emphasizes the legal and ethical responsibilities of researchers and biotechnologists. 4. Develops understanding of patenting, biopiracy, and traditional knowledge protection. 5. Provides insight into biosafety levels, risk assessment, and GMO regulation frameworks. 6. Encourages ethical decision-making in scientific innovation, genetic engineering, and biotechnology.	
Course Objectives 1. To understand the fundamentals and forms of IPR and their role in protecting scientific innovation. 2. To gain knowledge about ethical principles and guidelines in biological and biomedical research. 3. To learn national and international biosafety regulations, containment levels, and laboratory practices. 4. To explore patenting procedures, biopiracy issues, and protection of traditional knowledge. 5. To evaluate ethical and social implications of modern biotechnological applications.	
Prerequisites	Basic understanding of biology and biotechnology.

SYLLABUS

Unit	Content	Hrs	COs	Cognitive Level
I	Intellectual Property Rights — Conceptual Framework and Global Relevance Introduction to IPR: Definition, nature, scope, and	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	justification for intellectual property in scientific research. Forms of IPR: Patents, copyrights, trademarks, trade secrets, industrial designs, geographical indications and Specialized forms. Importance in Biotechnology: Role of IPR in innovation, technology transfer, and industrial application. International Treaties and Organizations: WIPO, TRIPS Agreement, and Patent Cooperation Treaty (PCT) — their significance in promoting global IPR protection. Indian Patent System: Overview of the Indian Patent Act and IPR legislations, key amendments, and its relevance to biological inventions.			
II	Patenting and Protection of Traditional Knowledge Patenting Biological Materials: Special issues in patenting genes, microorganisms, and genetically modified organisms (GMOs). Patent Filing and Procedure: Steps involved in national and international patent application, documentation, and timelines. Biopiracy and Traditional Knowledge: Definition, examples (Neem, Basmati, Turmeric cases), and the need for equitable benefit sharing. Legal Instruments: Protection of Plant Varieties and Farmers' Rights Act, 2001 and Traditional Knowledge Digital Library (TKDL). Patent Infringement and Remedies: Rights of patent holders, infringement cases, compulsory licensing, and dispute resolution.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
III	Biosafety and Laboratory Containment Practices Introduction to Biosafety and Biosecurity: Concepts, importance, and classification of biological hazards. National Biosafety guidelines, Laboratory acquired infections. Biosafety Levels and Containment: Principles of BSL-1 to BSL-4 laboratories, design, and operational safety. Good Practices: Good Laboratory Practice (GLP), Good Manufacturing Practice (GMP), and waste management.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	Risk Assessment and Management: Evaluation of risks associated with GMOs and genetically modified food. National and International Frameworks: Overview of Indian biosafety guidelines and the Cartagena Protocol on Biosafety. Institutional Biosafety committee and SOPs			
IV	Foundations of Bioethics, Principles, Guidelines, and Human Welfare Nature and Scope of Bioethics: Definition, significance, and historical development of bioethics in life sciences. Core Ethical Principles: Autonomy, Informed consent, Confidentiality, End-of-Life Issues, Maternal- Fetal Conflict, Beneficence, Non- maleficence, and Justice — their application in biomedical research. Ethical Guidelines and Committees: Role of Institutional Ethics Committee (IEC). Research Misconduct: Plagiarism, fabrication, falsification, and authorship ethics. Case Studies: Ethical controversies in organ transplantation.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
V	Ethics, Society, and Governance in Biotechnology Ethical Implications of Modern Biotechnologies: Issues in gene editing (CRISPR), cloning, synthetic biology, and genomic research. Social and Environmental Concerns: Public perception of GMOs, labeling of GM foods, and biodiversity conservation. Bioterrorism and Dual-Use Research: Ethical challenges in the misuse of biotechnology. Regulatory Mechanisms and Global Governance: Roles of WHO, FAO, and UNEP in global biosafety management. Role of NGOs and Civil Society: Promoting public awareness, ethical accountability, and community engagement through real-world case studies.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

Text Books

1. Sibi, G. (2021). *Intellectual Property Rights, Bioethics, Biosafety and Entrepreneurship in Biotechnology*. Dreamtech Press.
2. Sree Krishna, V. (2007). *Bioethics & Biosafety in Biotechnology*. New Age International (P) Ltd.
3. Dusane, A. (2018). *Biosafety, Bioethics and Intellectual Property Rights*. Vision Publications, Pune.
- Sateesh, M. K. (2008). *Biosafety and Bioethics*. I.K. International Publishing House.
4. Joshi, R. (2006). *Biosafety and Bioethics*. Isha Books
5. Ignacimuthu, S. (2009). *Bioethics*. Alpha Science International

Suggested Readings

1. Bentley, L., Sherman, B., Gangjee, D., & Johnson, P. (2022). *Intellectual property law* (6th ed.). Oxford University Press.
2. Kuhse, H., & Singer, P. (Eds.). (2023). *Bioethics: An anthology* (4th ed.). Wiley-Blackwell.
3. Selgelid, M. J. (2022). *Dual-use bioethics: An introduction*. Springer.
4. Ramakrishna, B., & Kumar, H. S. A. (2021). *Fundamentals of intellectual property rights* (3rd ed.). Universities Press.
5. Nandi, K. (2020). *Intellectual property rights, bioethics, biosafety and entrepreneurship in biotechnology* (2nd ed.). New India Publishing Agency.
6. Goel, D., & Parashar, S. (2019). *IPR, biosafety and bioethics*. Pearson Education India.
7. Sateesh, M. K. (2017). *Bioethics and biosafety* (2nd ed.). IK International Publishing House.
8. Watal, J. (2015). *Intellectual property rights in the WTO and developing countries* (2nd ed.). Oxford University Press.
9. Lucht, B. P. (2019). *Global governance of biosafety and biosecurity*. Cambridge University Press.
10. Prasad, B. L. M. V. K. M. T. L. (2020). *IPR manual for life science researchers*. Allied Publishers.
11. Beauchamp, T. L., & Childress, J. F. (2019). *Principles of biomedical ethics* (8th ed.). Oxford University Press

Web Resources

1. World Intellectual Property Organization (WIPO) – <https://www.wipo.int/>
2. Indian Patent Office (IPO) – <http://www.ipindia.nic.in/>
3. Department of Biotechnology, Government of India (DBT) – <https://dbtindia.gov.in/>
4. Cartagena Protocol on Biosafety (BCH) – <https://bch.cbd.int/protocol/>
5. National Institutes of Health (NIH) – Office of Science Policy – <https://osp.od.nih.gov/biosafety-biosecurity/>

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	Define, recall, and describe the fundamental concepts of Intellectual Property Rights (IPR), including patents, copyrights, and trademarks. Students will identify the basic ethical principles in biological research and explain the various Biosafety Levels (BSL 1-4) and containment facilities. Collectively, these competencies enable students to demonstrate foundational knowledge and conceptual understanding (K1–K2) of legal and safety frameworks in life sciences.	K1, K2
CO2	Apply patenting procedures and regulatory guidelines to examine the impact of biopiracy and the protection of traditional knowledge. Students will analyze the role of WIPO and the Indian Patent Office in fostering innovation and compare different biosafety protocols for GMOs and recombinant DNA technology. They will demonstrate proficiency in interpreting risk assessment data and classify biological risks. These competencies allow students to perform analytical interpretation and practical application (K3–K4) of regulatory standards.	K3, K4
CO3	Evaluate the social and ethical implications of modern biotechnological applications to justify research decisions and compliance with international treaties like the Cartagena Protocol. Students will critically assess the challenges of "Designer Babies" and Gene Privacy to judge the boundaries of scientific intervention. They will integrate legal, ethical, and safety data to construct, design, and formulate comprehensive biosafety strategies and ethical research protocols. Collectively, these outcomes enable students to exercise higher-order judgment and creative technical synthesis (K5–K6) .	K5, K6

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	1	1	2	2	2
CO2	2	2	2	2	3	3	3
CO3	3	1	2	3	2	3	3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	3	2	2	2
CO2	3	3	3	3	3	2	2
CO3	3	2	3	3	2	3	3

COURSE CODE	PZO3ME02
COURSE TITLE	WASTE MANAGEMENT AND AI
Credits/Hours	3 Credits / 4 Hours
Category	Major Elective (ME) - Theory
Semester	III
Regulation	2026
Course Overview 1. Introduces waste types, classifications, and global regulatory frameworks. 2. Provides practical training in collection, segregation, and transport of waste. 3. Explores biological, thermal, and recycling technologies for waste treatment. 4. Examines specialized management of e-waste, hazardous, biomedical, plastic, and C and D waste. 5. Equips students with knowledge of entrepreneurship, innovation, and policy compliance in waste management. 6. Encourages sustainable, circular economy models for resource recovery.	
Course Objectives 1. To classify different types of wastes and understand their impacts. 2. To analyze waste management policies, rules, and regulations. 3. To gain skills in waste characterization, collection, segregation, and handling. 4. To evaluate biological and thermal technologies for waste treatment. 5. To develop solutions for specialized waste streams (e-waste, biomedical, plastics). 6. To apply entrepreneurship and smart innovations in waste management practices.	
Prerequisites	Basic background in environmental science and ecology.

SYLLABUS

Unit	Content	Hrs	COs	Cognitive Level
I	Foundations of waste management Introduction to waste: Definition, Classification and types of waste - Domestic Waste, Market Waste, Food Waste, Agricultural waste, Fruit- vegetable market waste, e-Waste, Industrial Inert Waste, Industrial Hazardous Waste, Bio-	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	Medical Waste and Radioactive Waste, Hazardous waste, Plastic Waste – spread all over oceans, C and D waste, Laboratory waste management; non-routine waste (like festivals or functions) and Next Generation Waste. The waste hierarchy: Prevention, Reduce, Reuse, Recycle, Recover, Dispose. Legislations and STG Goals: Global waste crisis and UN sustainable development goals. Analysis of national regulations, Solid Waste Management Rules (2016) and Extended Producer Responsibility (EPR). Impact analysis: Environmental and public health consequences of improper waste disposal, including pollution of air, water, and soil. Bioaccumulation and Biomagnification of waste.			
II	Collection, segregation, and handling Waste characterization and disposal Waste Source segregation techniques: Best practices for on-site waste segregation, color-coded bins for different waste streams. Waste Disposal Practices: Conventional Practices vs Modern Practices; Dumping off wastes; Landfill, Recycling; Biological Recycling; Recovery for Energy; Incineration, Pyrolysis, gasification, Urban growth – Municipal management – Administrative framework – Present scenario of solid waste management in ULBs and Rural areas – Current practices and deficiencies in SWM. Biochar. Activity : Coastal cleanup.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
III	Biological Treatment of Waste: Composting, Biogas Production, Waste water treatment: Primary. Secondary and tertiary. Role of microbes in degrading serious waste-plastic, dyes, oils etc. Extraction of metals from e-waste through Bioleaching. Treatment of organic waste using black soldier fly. Waste into beneficiary products- plastic tiles, fabric note book etc and success stories. Production of Bioplastics.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

IV	Waste Audit and entrepreneurship: Introduction, Definition, Objectives of Audit, Steps in Waste Audit, Management through Environmental Audit: ISO 14000, 14001; Quality of the implementation process, Environmental Management benefits Implementing Certification Maintaining your ISO14001, ISO9000:2015. Principles of Quality Management. Entrepreneurship in waste management. Waste Managing Enterprise, Innovations in waste management. Product development from waste and Viva.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
V	Artificial Intelligence in Waste Management Automated sorting system, Smart bins with ai and sensors. Predictive waste generation analysis. Illegal dumping detection. Digital twin- virtual mode of city waste system. Ai apps in waste management: Waste AID by Ecorithms, Grey Parrot, Trash to cash. Pilahin, Swachhata app. Presentation on new ai tools in waste management.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

Text Books

1. Singh, A. K., & Sharma, R. K. (2018). *Environmental Waste Management*. New India Publishing Agency.
2. Kaushik, A., & Malik, A. (2020). *Environmental Pollution and Waste Management*. Pragati Prakashan.
3. Kaur, H., & Singh, J. (2019). *Waste Management: Principles, Practices and Policies*. CBS Publishers & Distributors.
4. Tripathi, R., & Shukla, A. (2021). *Industrial Waste Management and Environmental Protection*. Himalaya Publishing House.
5. Das, S., & Pradhan, M. (2022). *Solid Waste Management in India*. Wiley-India.
6. Russell, S., & Norvig, P. (2021). *Artificial Intelligence: A Modern Approach* (4th ed.). Pearson Education India.
7. Chaudhuri, S., & Sikdar, S. K. (2023). *Artificial Intelligence and Machine Learning: Concepts, Algorithms and Applications*. McGraw Hill Education.
8. Goyal, D. P., & Sangal, A. L. (2020). *Artificial Intelligence and Data Mining Techniques*. Khanna Publishing.

9.Sharma, P. (2021). *AI for Environmental Science and Sustainability*. Oxford University Press India.

10.Akolkar, A. B.,(2005). Status of Solid WasteManagement in India,Implementation Statusof Municipal Solid Wastes, Management and Handling Rules 2000, Central Pollution Control Board, New Delhi

Suggested Readings

1.Chandrappa, R., & Das, D. B. (2024). Solid Waste Management: Principles and Practice (1st ed.). Springer Nature.

2. Kumar, S. (2016). Municipal Solid Waste Management in Developing Countries. CRC Press.

3. Lal, B., & Reddy, M. R. V. P. (2008). Wealth from Waste: Trends and Technologies.

4. Tchobanoglous, G., Theisen, H., & Vigil, S. A. (1993). Integrated Solid Waste Management: Engineering Principles and Management Issues (2nd ed.). McGraw-Hill Education.

5. Pichtel, J. (2005). Waste Management Practices: Municipal, Hazardous, and Industrial Waste. CRC Press.

6. Newton, D. E. (2020). Waste Management: A Reference Handbook. ABC-CLIO (Bloomsbury). ISBN 978-1-4408-7283-9.

7. Williams, P. T. (2013). Waste Treatment and Disposal. John Wiley & Sons.

8. Chandra, R. (Ed.). (2015). Environmental Waste Management. CRC Press.

9. Pandey, A., Suthar, S. S., & Amesho, K. T. T. (Eds.). (2025). Solid Waste Management:

A Roadmap for Sustainable Environmental Practices and Circular Economy. Springer Nature. ISBN 978-3-031-78419-4.

10. Das, A. P., Sirisena, K., & Bhanja, D. (Eds.). (2026). Sustainable Municipal Waste Management with a Zero Waste Approach. Springer Nature.

Web Resources

1. <https://cpcb.nic.in/> (Central Pollution Control Board, India)

2. <https://moef.gov.in/>

3. <https://unep.org/> (UN Environment Programme)

4. <https://niti.gov.in/> (India's policy think tank on sustainability)

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	Define, recall, and describe the various classifications of waste, including municipal, hazardous, biomedical, and e-waste. Students will identify global and national regulatory frameworks and explain the fundamental policies governing waste management in India. Collectively, these competencies enable students to demonstrate foundational knowledge and conceptual understanding (K1–K2) of waste systems and legal compliance.	K1, K2
CO2	Apply techniques for waste characterization and segregation to examine and illustrate the logistics of waste collection and transport. Students will analyze and compare biological and thermal treatment technologies, such as composting and incineration, while categorizing methods for efficient resource recovery. They will demonstrate proficiency in interpreting waste-to-energy data and classify specialized waste streams. These competencies allow students to perform analytical interpretation and practical application (K3–K4) of environmental engineering principles.	K3, K4
CO3	Evaluate the efficacy of circular economy models to justify sustainable waste management solutions and environmental protection strategies. Students will critically assess the impact of AI-driven innovations and smart sorting technologies to judge their viability in modern urban planning. They will integrate data from e-waste and plastic management studies to construct, design, and formulate advanced entrepreneurial projects and policy recommendations for a zero-waste future. Collectively, these outcomes enable students to exercise higher-order judgment and creative technical synthesis (K5–K6) .	K5, K6

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	2	1	2	2	2
CO2	3	2	3	2	3	2	3
CO3	2	2	3	3	3	3	3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	1	2	2	2
CO2	2	2	3	2	3	2	3
CO3	2	3	3	3	3	3	3

COURSE CODE	PZO3ME03
COURSE TITLE	TOXICOLOGY AND PHARMACOLOGY
Credits/Hours	3 Credits / 4 Hours
Category	Major Core (MC) - Theory
Semester	III
Regulation	2026
Course Overview This course provides a comprehensive foundation in toxicology and pharmacology, covering the history, branches, and classification of toxic agents, and the factors that influence toxicity in biological systems. Students will know about the mechanisms of toxicity that include biodistribution, biomagnification, biotransformation, dose–response relationships, and neurotoxic effects, along with methods for toxicological risk assessment and laboratory evaluation of toxicity indices. The course also introduces key concepts in general pharmacology, such as pharmacokinetics, pharmacodynamics, drug interactions, and adverse drug reactions. Students will explore the drug actions on major physiological systems, chemotherapy, and immunopharmacology, and implement the knowledge in drug design and discovery using modern approaches.	
Course Objectives 1. To understand and classify different types of toxic agents, explaining the main factors that influence toxicity in organisms and to describe the mechanisms of toxicity, including xenobiotic metabolism, dose–response relationships, and neurotoxic pathways, to evaluate toxic risks using standard toxicological tests and toxicity indices. 2. To describe key pharmacological concepts, including pharmacokinetics, pharmacodynamics, drug interactions, adverse drug reactions, and the quantitative relationships between drug dose and biological response. 3. To analyse how drugs act on major organ systems and explain the principles of chemotherapy and immunopharmacology, with an introduction to current strategies in drug discovery and development.	
Prerequisites	Basic knowledge on environmental science and Human Physiology

SYLLABUS

Unit	Content	Hrs	COs	Cognitive Level
I	History and branches of toxicology Introduction to toxicology and branches of toxicology. Biotic and abiotic aspects affecting toxicity. Classification of toxic agents- natural toxins, animal toxins, plant toxins, food toxins, genetic poisons, and chemical toxins. Immunotoxicity and Genotoxicity.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
II	Mechanisms of Toxicity Biodistribution, biomagnification, biotransformation of xenobiotics- brief introduction to Phase-I and Phase-II reactions. Dose-effect and dose-response relationship- acute toxicity, chronic toxicity, reversible and irreversible effects. Mechanism of Neurotoxicity - selective vulnerability, sites of neurotoxic action, Axonopathy, and Myelopathy	13	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
III	Toxic risk assessment Means of exposure. Impact of toxicants on organisms and their types. Toxic risk assessment. Techniques - bacterial reverse mutation assay, in vitro toxicology testing, in vivo toxicology testing, and comet assay. LD ₅₀ , LC ₅₀ , LC ₉₀ determination.	11	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
IV	General Pharmacology and Drug Designing Introduction to pharmacology. Nature and sources of drugs. Pharmacodynamics and Pharmacokinetics. Routes of drug administration. Drug interactions and their types. Factors modifying drug action. Adverse drug reactions in males and females. Drug safety. Basics of Drug designing and approaches in drug discovery.	13	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
V	Drug actions on major systems Drugs acting on the cardiovascular system, respiratory system, CNS, ANS, Endocrine system, and gastrointestinal system.	11	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	Chemotherapy – applications, side effects, and management.			
	Immunopharmacology – vaccines, antisera, and vitamins.			
Text Books 1. Eaton, D. L., & Klaassen, C. D. (Eds.). (2021). Casarett & Doull’s Essentials of Toxicology (4th ed.). McGraw-Hill Education. 2. Klaassen, C. D. (Ed.). (2019). Casarett & Doull’s toxicology: The basic science of poisons (9th ed.). McGraw-Hill Education. 3. Hodgson, E. (2012). A textbook of modern toxicology (4th ed.). John Wiley & Sons. https://doi.org/10.1002/9781118354574 4. Timbrell, J. A. (2009). Principles of biochemical toxicology (4th ed.). Informa Healthcare. 5. Brunton, L. L., Hilal-Dandan, R., & Knollmann, B. C. (Eds.). (2018). Goodman & Gilman’s the pharmacological basis of therapeutics (13th ed.). McGraw-Hill Education. 6. Katzung, B. G., & Trevor, A. J. (2021). Basic and clinical pharmacology (15th ed.). McGraw-Hill Education. 7. Rang, H. P., Dale, M. M., Ritter, J. M., Flower, R. J., & Henderson, G. (2019). Rang & Dale’s pharmacology (9th ed.). Elsevier.				
Suggested Readings 1. Hayes, A. W., & Kruger, C. L. (Eds.). (2014). Hayes’ principles and methods of toxicology (6th ed.). CRC Press. 2. Tripathi, K. D. (2019). Essentials of medical pharmacology (8th ed.). Jaypee Brothers Medical Publishers. 3. Williams, P. L., James, R. C., & Roberts, S. M. (2014). Principles of toxicology: Environmental and industrial applications (3rd ed.). Wiley. 4. Derelanko, M. J., & Auletta, C. S. (2014). Handbook of toxicology (3rd ed.). CRC Press. 5. Greaves, P. (2012). Histopathology of preclinical toxicity studies: Interpretation and relevance in drug safety evaluation (4th ed.). Academic Press. 6. Wallace, K. B. (Ed.). (2015). Comprehensive toxicology (2nd ed.). Elsevier. 7. Shargel, L., Wu-Pong, S., & Yu, A. B. C. (2015). Applied biopharmaceutics & pharmacokinetics (7th ed.). McGraw-Hill Education. 8. Hodgson, E., Smart, R. C., & Leung, L. (Eds.). (2010). Human toxicology (4th ed.). Wiley. 9. Timbrell, J. A. (2008). Introduction to toxicology (3rd ed.). CRC Press.				
Web Resources				

1. <https://www.ncbi.nlm.nih.gov/books/NBK223808/>
2. https://www.atsdr.cdc.gov/training/toxicology_curriculum/modules/1/
3. https://www.oecd-ilibrary.org/environment/test-no-471-bacterial-reverse-mutation-test_9789264071247-en
4. <https://www.ncbi.nlm.nih.gov/books/NBK557386/>
5. <https://www.ncbi.nlm.nih.gov/books/NBK214644/>
6. https://www.oecd-ilibrary.org/environment/test-no-425-acute-oral-toxicity-up-and-down-procedure_9789264071049-en
7. <https://www.fda.gov/patients/drug-development-process/step-1-discovery-and-development>
8. <https://www.cdc.gov/vaccines/pubs/pinkbook/prinvac.html>

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	Remember, understand and explain principles of toxicology including classification of toxic agents, mechanisms of toxicity, dose–response relationships and toxic risk assessment.	K1, K2
CO2	Apply and analyze pharmacokinetic and pharmacodynamic principles, evaluate drug interactions and adverse drug reactions.	K3, K4
CO3	Analyze and evaluate drug actions on major systems and design approaches for drug safety, chemotherapy and drug discovery.	K5, K6

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	2	3	2	2	3
CO2	3	2	3	2	2	3	2
CO3	3	3	3	2	2	3	3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	3	3	2	3
CO2	3	3	3	2	2	2	2
CO3	3	3	3	3	3	2	2

COURSE CODE	PZO3ME04
COURSE TITLE	ANIMAL BIOTECHNOLOGY
Credits/Hours	3 Credits / 4 Hours
Category	Major Elective (ME) - Theory
Semester	III
Regulation	2026
Course Overview 1. The Animal Biotechnology course centers on the application of the principles of biotechnology in animal and medical science. 2. This course aims at imparting knowledge in animal and medical biotechnology with respect to the history, applications, research and development and current challenges in the field. 3. Techniques to maintain animal cell cultures, scale-up of culture and assessment of viability are discussed in detail. 4. The course includes the application and significance of stem cells and gene therapy in medicine. 5. Ethical issues in animal biotechnology are discussed. 6. This course highlights the contribution and significance of biotechnology to improve health and for the welfare of society.	
Objectives 1. To understand techniques in animal cell culture and the significance of Animal Biotechnology. 2. To apply animal cell culture techniques in the fields of animal science. 3. To relate and discuss the industrial applications of Animal Biotechnology. 4. To understand methods of producing transgenic animals and discuss their applications. 5. To apply stem cell biology, molecular and biotechnological techniques for the health and welfare of society. 6. To discuss challenges and ethical and legal issues in animal and medical biotechnology.	
Prerequisites	Knowledge in the fundamentals of Cell Biology

SYLLABUS

Unit	Content	Hrs	COs	Cognitive Level
I	Animal cell culture: Landmarks in animal cell culture and Animal Biotechnology- Overview of an Animal Cell Culture Laboratory, aseptic practices in an animal cell culture facility - Cell Culture environment - Phases of cell growth and characteristics of finite and continuous cells. Cytogenetic analysis of cultured cells – chromosome preparation for characterization of cell lines, G banding technique and fluorescence in situ hybridization. Commercial scale production of animal cells; Scale up in suspension - Perfused suspension cultures, Scale-up in monolayers – multi-surface propagators, roller bottle culture, Microcarriers. 3D Cell Culture Systems and Advanced Bioreactor Technologies: hollow fiber bioreactors and stirred-tank bioreactors for large-scale mammalian cell production; 3D multicellular spheroid cultures and their advantages over 2D monolayer cultures; organ-on-a-chip (microphysiological systems) technology and its applications in drug toxicity testing and disease modelling.	12	CO 1 CO 2 CO 3 CO 4 CO 5	K1, K2, K3, K4, K5, K6
II	Cell culture, cloning and DNA barcoding: Establishing a primary culture, subculture of cells – adherent cells and suspension cells and cryopreservation. Microbial contamination of cell culture - cell viability tests for cells in culture. Methods in animal cloning - somatic cell nuclear transfer and embryo splitting, embryo transfer technology. DNA barcoding of animal species – methodology and species conservation. Environmental DNA (eDNA) and Metabarcoding: principles of eDNA sampling and analysis for non-invasive biodiversity monitoring; metabarcoding approaches for assessing species diversity in ecosystems; applications in wildlife	12	CO 1 CO 2 CO 3 CO 4 CO 5	K1, K2, K3, K4, K5, K6

	forensics, endangered species protection, and invasive species detection CRISPR-Cas9 Technology for Generating Animal Disease Models: principles of CRISPR-Cas9 genome editing; knock-in and knock-out strategies for creating precise animal models of human genetic diseases; humanized mouse models; applications in drug discovery and preclinical research.			
III	Regenerative Medicine: Epigenetics in Regenerative Medicine: Heritable changes in gene expression without altering DNA sequence; regulates stem cell differentiation, pluripotency, and iPSC reprogramming via DNA methylation, histone modification, and non-coding RNAs. 3D Bioprinting in Regenerative Medicine: types of bioprinters (inkjet, extrusion-based, stereolithography); bioink composition including hydrogels, decellularized extracellular matrix (dECM) and cell-laden bioinks; vascularization strategies in bioprinted constructs; current applications in skin, cartilage, and corneal tissue printing. Exosomes and Extracellular Vesicles (EVs): biogenesis and characterization of exosomes, microvesicles, and apoptotic bodies; role of EVs in intercellular communication; therapeutic applications of EVs in cardiac repair, neural regeneration, and wound healing; EV-based drug delivery systems.	12	CO 1 CO 2 CO 3 CO 4 CO 5	K1, K2, K3, K4, K5, K6
IV	Pharming, Gene Therapy and Ethics: Pharming - production of pharmaceutical proteins using transgenic animals, Methods of producing transgenic animals - microinjection, nuclear transfer and retrovirus. In vivo and ex vivo approaches to gene delivery, advantages and disadvantages of gene delivery systems, Ethical and legal issues in genetic engineering, ethics in human stem cell research, ethics in gene therapy and genome editing in animals and humans. Ethics and legal issues in Biotechnology, John Moore case study.	12	CO 1 CO 2 CO 3 CO 4 CO 5	K1, K2, K3, K4, K5, K6

	Xenotransplantation: gene-edited pig organs (CRISPR-engineered pigs with inactivated porcine endogenous retroviruses - PERVs and humanized surface antigens) for human transplantation; immunological hurdles including hyperacute rejection, acute vascular rejection, and xenozoonosis; regulatory and ethical frameworks governing xenotransplantation research.			
V	Reproductive techniques and molecular methods: In vitro fertilization and embryo culture. Prenatal testing for genetic abnormalities - chorionic villus sampling and amniocentesis. Application of RNA interference and DNA microarray in medicine. Pharmacogenomics and personalized medicine. Single-Cell RNA Sequencing (scRNA-seq) and Spatial Transcriptomics: principles of droplet-based and plate-based scRNA-seq; data analysis pipelines (clustering, trajectory analysis, cell type annotation); spatial transcriptomics for mapping gene expression in tissue context; applications in cancer biology, neuroscience, and developmental biology. Liquid Biopsy and Cell-Free Nucleic Acids: circulating tumor cells (CTCs) - isolation and characterization; cell-free DNA (cfDNA) and circulating tumor DNA (ctDNA) detection methods; cell-free RNA and exosomal miRNA as biomarkers; applications in early cancer detection, minimal residual disease monitoring, and treatment response assessment.	12	CO 1 CO 2 CO 3 CO 4 CO 5	K1, K2, K3, K4, K5, K6
Text Books - Atala, A., Lanza, R., Mikos, T. and Nerem, R. (2018). Principles of Regenerative Medicine, Third Edition, Academic Press, Cambridge, United States. - Freshney, I. R. and Capes-Davis, A. (2021). Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, Eighth Edition, Wiley Blackwell, New York, United States. - Lanza, R. and Atala, A. (2014). Essentials of Stem Cell Biology, Third Edition, Academic Press, Cambridge, United States.				

4. Maiti, S. K. (2020). Stem Cell Research in Lab Animals, New India Publishing Agency, India.
5. Verma, A. S. and Singh, A. (2020). Animal Biotechnology Models and Translation, Second Edition, Academic Press, Cambridge, United States.
6. Doudna, J. A. and Sternberg, S. H. (2017). A Crack in Creation: Gene Editing and the Unthinkable Power to Control Evolution. Houghton Mifflin Harcourt, New York, United States.
7. Primrose, S. B. and Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics, 7th Edition, Blackwell Publishing, Oxford, United Kingdom.
8. Lewin, B., Krebs, J. E., Goldstein, E. S. and Kilpatrick, S. T. (2014). Lewin's GENES XI, Jones and Bartlett Publishers, Burlington, United States.

Suggested Readings

1. Baylis, F. (2019). Altered Inheritance – CRISPR and the Ethics of Human Genome Editing, Harvard University Press, Cambridge, United States.
2. Glick, B. R., Delovitch, T. L. and Patten, C. L. (2013). Medical Biotechnology Principles and Applications of Recombinant DNA, First Edition, ASM Press, Washington DC, United States.
3. Microcarrier Cell Culture Principles and Methods. (2013). GE Healthcare Bio Sciences AB Björkgatan, Sweden. 75
4. Portner, R. (2020). Animal Cell Biotechnology Methods and Protocols. Springer, Berlin, Germany.
5. Singh, B., Gautam, S.K., Chauhan, M. S. and Singla, S.J. (2013). Textbook of Animal Biotechnology. TERI Press, India.
6. Takahashi, K. and Yamanaka, S. (2006). Induction of pluripotent stem cells from mouse embryonic and adult fibroblast cultures by defined factors. *Cell*, 126(4), 663–676.
7. Doudna, J. A. (2020). The promise and challenge of therapeutic genome editing. *Nature*, 578(7794), 229–236.
8. Lancaster, M. A. and Huch, M. (2019). Disease modelling in human organoids. *Disease Models and Mechanisms*, 12(7), dmm039347.
9. Luecken, M. D. and Theis, F. J. (2019). Current best practices in single-cell RNA-seq analysis: a tutorial. *Molecular Systems Biology*, 15(6), e8746.
10. Mardis, E. R. (2019). The impact of next-generation sequencing technology on genetics. *Trends in Genetics*, 24(3), 133–141.

Web Resources

1. <https://ibol.org/about/dna-barcoding/>
2. <https://www.thermofisher.com/>
3. <https://www.nibib.nih.gov/science-education/science-topics/tissue-engineering-and-regenerative-medicine>
4. <https://www.animal-ethics.org/>
5. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3570985/>
6. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3624098/>
7. https://ec.europa.eu/info/sites/default/files/research_and_innovation/ege/ege_ethics_of_genome_editing-opinion_publication.pdf
8. <https://www.genome.gov/about-genomics/fact-sheets/DNA-Microarray-Technology>
9. <https://www.broadinstitute.org/what-broad/areas-focus/project-spotlight/crispr> (CRISPR Resources - Broad Institute)
10. <https://stemcells.nih.gov/> (NIH Stem Cell Information Portal)
11. <https://www.ebi.ac.uk/> (European Bioinformatics Institute - EMBL-EBI)
12. <https://www.10xgenomics.com/blog> (10x Genomics - Single Cell Sequencing Resources)
13. <https://www.clinicaltrials.gov/> (NIH Clinical Trials Registry for Gene Therapy and Regenerative Medicine Studies)
14. <https://www.alphafold.ebi.ac.uk/> (AlphaFold Protein Structure Database)

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO 1	Describe the basic principles in animal biotechnology	K1, K2
CO 2	Apply scientific reasoning and techniques to overcome challenges in the field of animal biotechnology	K3, K5
CO 3	Compare and/or recommend techniques in animal biotechnology	K4
CO 4	Explain and/or critique scientific strategies, tools and techniques in animal biotechnology	K5
CO 5	Defend ethical principles in animal biotechnology	K6

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	2	2	3	3	3
CO2	2	3	2	2	3	3	2
CO3	2	3	3	2	3	3	2
CO4	2	2	3	3	2	3	3
CO5	3	3	3	2	3	2	2

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	2	3	3	2
CO2	2	3	3	2	2	3	2
CO3	2	2	3	2	3	2	2
CO4	2	3	3	3	3	2	2
CO5	3	2	2	3	3	3	3

COURSE CODE	PZO3ME05
COURSE TITLE	FISHERY SCIENCE
Credits/Hours	3 Credits / 4 Hours
Category	Major Elective (ME) - Theory
Semester	III
Regulation	2026
Course Overview 1. Fishery science is a multidisciplinary science that includes the study on biology, evolution, culture, capture, economics, and management of fishes. 2. It covers the basic concepts such as Systematics and taxonomy of fishes, basic morphology of major groups of fishes, fresh water and brackish water fishery resources, recent trends and techniques in fisheries. 3. This course offers to build advanced knowledge of culturing techniques in riverine, brackish and seawater fisheries and conservation. 4. This course focusses on the economic importance of fishing, fish processing stock management for a better quality of marketing. 5. This course also gives a basic idea of artificial intelligence in fisheries.	
Course Objectives 1. To understand the prehistoric and current diversity of fishes 2. To understand fishery resources, biological functions and the ecological roles that fishes play in freshwater, brackish water and marine ecosystems. 3. To understand the methodology in fishing, fish processing and stock management. 4. To understand the biomonitoring systems in fisheries.	
Prerequisites	Basic knowledge in Zoology and aquaculture

SYLLABUS

Unit	Content	Hrs	COs	Cognitive Level
I	Introduction to Fishes Systematics and taxonomy of fishes; Mechanism of evolution; speciation genetics; Ecological classification of fishes; Major groups of fishes in the world. Biology of commercially	12	CO 1 CO 2 CO 3 CO 4	K1, K2, K3, K4, K5, K6

	important fishes of India; Survey of world fisheries. Molecular systematics and DNA barcoding of fishes; Phylogenomics and evolutionary relationships using molecular markers; IUCN conservation status and Red List categories of commercially important and endangered fishes of India; Ornamental fish diversity, biology and trade; Introduction to fish genomics and transcriptomics.		CO 5	
II	Fishery Resources and Management Riverine fisheries, Cold water fisheries, Estuarine fisheries, Marine fisheries, Coastal resource management. Anthropogenic activities and their impact on coastal fisheries. Management of marine fisheries in Indian context. Climate change impacts on fish biodiversity and fishery resources; Invasive aquatic species and their ecological and economic impacts; Marine Protected Areas (MPAs) and their role in fishery conservation; Integrated Coastal Zone Management (ICZM); Deep sea fishery resources and exploration.	12	CO 1 CO 2 CO 3 CO 4 CO 5	K1, K2, K3, K4, K5, K6
III	Culture Fisheries Fresh water fish culture; Brackish water fish culture; Mariculture; Nutrition, and disease management; Genetic improvement and hybridization. Recirculating Aquaculture Systems (RAS): principles, components and advantages; Biofloc Technology (BFT) in sustainable aquaculture; CRISPR-Cas9 and genome editing applications in fish genetic improvement; Probiotics, prebiotics and immunostimulants in fish health management; Integrated Multi-Trophic Aquaculture (IMTA) and polyculture systems; Microalgae production and its application in aquaculture feed.	12	CO 1 CO 2 CO 3 CO 4 CO 5	K1, K2, K3, K4, K5, K6
IV	Capture, Economics and Fish Processing Marine fish catch in India and fisheries of commercial importance; classical and modern tools in fishing; Methods of fish stock identification; Recent advances in fish stock	12	CO 1 CO 2 CO 3 CO 4	K1, K2, K3, K4, K5, K6

	assessment, Marking and tagging and its significance. Economics and Fish processing; Fish marketing methods in India; Harvesting; handling, packaging and transport of fish and shell fishes; Methods of preservation and processing of fish. Fishery biproducts marketing. Value-added fish products and nutraceuticals from fishery resources; Omega-3 fatty acid and fish oil extraction technologies; Traceability systems and eco-labeling in global fish trade; HACCP, GMP and food safety standards in fish processing industries; Export quality certification and international standards (EU, USA) for Indian seafood; Waste utilization and circular economy in fisheries.		CO 5	
V	Recent Techniques in Fisheries Application of statistical methods in fisheries; Data processing techniques in fisheries; Application of remote sensing in conservation of management of fish and faunal diversity; sonar, radar; Fishways and screens. Fishery monitoring centre and monitoring tools; Fish conservation and Fishing laws. Fisheries research institute in India. Environmental DNA (eDNA) techniques for fish biodiversity assessment and non-invasive stock monitoring; Machine learning, deep learning and artificial intelligence applications in fish species identification, stock assessment and yield prediction; Drone and satellite technology for fisheries surveillance and illegal fishing detection; Nanotechnology in fish health management, disease diagnosis and nano-encapsulated feed delivery; Next-generation sequencing (NGS), metagenomics and population genomics in fisheries research; Blockchain technology for fish supply chain transparency and traceability.	12	CO 1 CO 2 CO 3 CO 4 CO 5	K1, K2, K3, K4, K5, K6
Text Books 1. Natarajan, A.V. (2002). Handbook on Freshwater Fisheries of India. ICAR, New Delhi. 2. Krishnamurthy, K. (1990). Fisheries Science. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.				

3. Misra, K.S. (1976). The Fauna of India and Adjacent Countries: Pisces. Zoological Survey of India, Calcutta.
4. Pillay, T.V.R. & Kutty, M.N. (2005). Aquaculture: Principles and Practices (2nd ed.). Wiley-Blackwell, Oxford.
5. Sehgal, K.L. (1999). Freshwater Fisheries of India. Narendra Publishing House, Delhi.
6. Moyle, P.B. & Cech, J.J. (2004). Fishes: An Introduction to Ichthyology (5th ed.). Prentice Hall, New Jersey, USA.
7. Stickney, R.R. (2005). Aquaculture: An Introductory Text. CABI Publishing, Wallingford, UK.
8. Wootton, R.J. (1990). Ecology of Teleost Fishes. Chapman & Hall, London, UK.
9. Nelson, J.S., Grande, T.C. & Wilson, M.V.H. (2016). Fishes of the World (5th ed.). John Wiley & Sons, New Jersey, USA.
10. Bone, Q., Marshall, N.B. & Blaxter, J.H.S. (1999). Biology of Fishes (2nd ed.). Stanley Thornes Publishers, UK.
11. Vass, K.K. & Waman, A.A. (2018). Handbook of Fisheries Technologies. ICAR-CIFRI, Kolkata.
12. Jena, J.K. & Panda, S.K. (2012). Advances in Aquaculture Biotechnology. Narendra Publishing House, Delhi.
13. Gopalakrishnan, A. & Ponniah, A.G. (2000). Application of Genetics and Biotechnology in Fisheries. NBFGR, ICAR, Lucknow.
14. Dunham, R.A. (2011). Aquaculture and Fisheries Biotechnology: Genetic Approaches (2nd ed.). CABI Publishing, Wallingford, UK.
15. Tidwell, J.H. (ed.) (2012). Aquaculture Production Systems. Wiley-Blackwell, Oxford, UK.
16. Stickney, R.R. & McVey, J.P. (eds.) (2002). Responsible Marine Aquaculture. CABI Publishing, UK.
17. Lucas, J.S., Southgate, P.C. & Tucker, C.S. (eds.) (2019). Aquaculture: Farming Aquatic Animals and Plants (3rd ed.). Wiley-Blackwell, UK.

Suggested Readings

1. Bardach, J.E., Ryther, J.H. & Miller, M.D. 2013. Aquaculture: The Farming Husbandry of Freshwater and Marine organisms, B. John Wiley & Sons, New York, 844pp.
2. Bond E. Carl, (2006). Biology of Fishes (3rd ed.). Academic Press Inc., New York, 820pp.
3. Day. F. (1958). Fishes of India (Vol. I and Vol. II). William Sawsan and Sons Ltd., London.
4. Govindan, T.K. (1985). Fish processing, technology. Oxford University, Delhi.

5. Gupta, S.K. and Gupta, P.C. (2006). General & Applied Ichthyology: Fish and Fisheries.
6. S. Chand & company, Mumbai. 1156 pp.
7. Helfman, G.S., Collette, B.B., Facey, D.E., & Bowen, B.W. (2009). The Diversity of Fishes (2nd ed). Wiley-Blackwell Inc., 720 pp.
8. Hoar, W.S. & Randall, D.J. (1984). Fish Physiology (Vol. I-IX). Academic Press, New York, 416pp.
9. Jhingran, V. G. (1997). Fish and fisheries of India. Hindustan publications, India. 751pp.
10. Khanna, S.S., & Singh H.R. (2014). A text book of fish biology & fisheries. Narendra publishing house. Jammu. India. 610pp.
11. Kells, V., & Carpenter, K. (2011). A Field Guide to Coastal Fishes: From Marine to Texas. Johns Hopkins University Press, 448pp
12. Lagler, K.F., Bardach, J.E., Miller, R.R., & Passino D.R.M. (2012). Ichthyology (2nd ed). John Wiley & Sons, New York.
13. Megrey, B. A. & Moksness, E., (2009). Computers in Fisheries Research. Springer, USA.
14. Mogalekar, H.S., & Johnson Canciyal., (2015). Remote sensing and GIS for fisheries management, LAP Lambert Academic Publishing, Germany, 132pp.
15. Potts, G.W., & Wootten, R.J., (1984). Fish Reproduction: Strategies and Tactics. Academic Press. 424pp.
16. Parihar, R.P. (1996). A text book of fish biology and Indian fisheries. central publishing house, Allahabad, India.
17. Dunham, R.A. (2004). Genetics and Fish Breeding. CAB International, Wallingford, UK.
18. FAO (2022). The State of World Fisheries and Aquaculture. FAO, Rome, Italy.
19. Stickney, R.R. (2000). Encyclopedia of Aquaculture. John Wiley & Sons, New York.
20. Narain, A.S. (1976). Fish Genetics. Atma Ram & Sons, Delhi.
21. Dehadrai, P.V., Tripathi, S.D. & Parikh, S.R. (eds.) (2017). Aquaculture in India. Indian Council of Agricultural Research, New Delhi.
22. Sarkar, U.K. & Khan, G.E. (2019). Fish Genetics and Aquaculture Biotechnology. Scientific Publishers, Jodhpur, India.
23. Nielsen, J.L. & Johnson, D.H. (eds.) (1983). Fisheries Techniques (3rd ed.). American Fisheries Society, Maryland, USA.
24. Palsson, W.A. & Divakaran, S. (2012). Environmental DNA: A Toolkit for Fisheries and Conservation. Wiley-Blackwell, USA.

Web Resources:

1. <https://www.fisheries.tn.gov.in>
2. <https://www.fao.org>
3. <https://www.oecd.org>
4. <https://basu.org.in>
5. <https://bit.ly/3Jtql4a>
6. <https://fisheries.org/books-journals/online-resources/>
7. <https://www.icar.org.in/content/national-bureau-fish-genetic-resources-nbfgr>
8. <https://www.mpeda.gov.in>
9. <https://www.fishbase.org>
10. <https://www.aquaculturehub.org>
11. <https://www.ncbi.nlm.nih.gov/genbank> (Fish Genomics Database)
12. <https://ednaresearch.org> (eDNA Research Network)
13. <https://www.worldfishcenter.org>

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	To understand and recall the phylogeny, taxonomic classification, basic organisation of fishes, and major fisheries in India and world.	K1, K2
CO2	To explain the biology, culturing, fishing, processing and marketing of various fishes	K3
CO3	To analyse and compare the anatomy, reproductive potentiality and ecological adaptations in order to improve the aquaculture practices.	K4
CO4	To summarise the biology, ecology, pathology, evolution and reproduction to evaluate sustainable fishery.	K5
CO5	To collate and discuss to develop advanced techniques and to enhance research in the field of fishery.	K6

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	2	2	3	2	2
CO2	3	3	2	2	2	2	2
CO3	2	3	3	2	3	2	3
CO4	2	2	3	3	3	2	3
CO5	2	2	2	3	2	3	3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	3	2	2	2	2
CO2	3	3	3	3	3	3	2
CO3	2	3	3	2	3	2	3
CO4	3	2	3	3	3	3	3
CO5	3	3	3	3	2	3	3

COURSE CODE	PZO3ID01
COURSE TITLE	BIO ENTREPRENEURSHIP
Credits/Hours	3 Credits / 6 Hours
Category	Interdisciplinary (ID) - Theory
Semester	III
Regulation	2026
Course Overview 1.Provides scientific and practical understanding of economically important animal resources and their management. 2. Focuses on applied branches of zoology such as apiculture, sericulture, aquaculture, lac culture, pearl culture, vermiculture, heliculture, poultry, dairy farming, piggery and cuniculture. 3. Encourages students to explore entrepreneurship opportunities in animal-based industries and sustainable bio-enterprises. 4. Promotes hands-on learning in production, processing, marketing, and business management of zoological products. 5. Integrates ecological sustainability and ethical business practices in zoology-based entrepreneurship. 6. Develops business acumen, leadership, and innovation for launching zoological ventures	
Course Objectives 1.To understand applied zoology concepts and their relevance in economic development. 2. To acquire practical knowledge of animal-based resource cultivation and product processing. 3. To explore market-oriented business opportunities in animal husbandry and allied sectors. 4. To understand the fundamentals of entrepreneurship, business development, and project planning. 5. To encourage innovation and sustainable enterprise creation through skill-based learning.	
Prerequisites	Basic understanding of zoology, ecology, and animal biology.

SYLLABUS

Unit	Content	Hrs	COs	Cognitive Level
I	Commercial Invertebrate Farming and Resource Utilization Apiculture: Bee species, hive management, honey extraction, beeswax processing, and by-products. Bee communication, Social Life forms. Enemies of apiary. Sericulture (Silk Production): History, Silkworm life cycle, rearing, cocoon processing, silk spinning, and marketing and Moriculture. Lac Culture: Biology of lac insects, host plants, cultivation methods, harvesting, and lac-based product manufacture. Pearl Culture: Pearl oyster biology, grafting, culture systems, pearl harvesting, and quality assessment.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
II	Vermiculture and Snail Farming Practices Vermiculture: Introduction: Types of earthworms, ecological classifications of earthworms. Physical, chemical and biological changes caused by earthworms in the soil. Natural enemies of earthworms. Vermicomposting method, factors affecting vermicomposting, harvesting of vermicompost, vermicast, advantages of vermicompost .Vermiwash and its applications. Heliculture: Biology and economic importance of edible snails, species selection, breeding techniques, housing systems, feeding and nutrition, environmental requirements, disease management, harvesting and marketing methods in snail cultivation.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
III	Commercial Vertebrate Farming and Integrated Livestock Production: Aquaculture: Indian major carps, Types of ponds, Non-conventional aquaculture system, Raceways, Cages and Pen	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	enclosures, Aquaponics. Prawn culture and shell fish culture. breeding, nutrition, water management, and disease control. Poultry Farming: Chicken breeds, housing, feeding, egg/meat production and its nutritional values, disease management. Dairy Farming: Cattle breeds, Composition of milk – milk spoilage – pasteurization, hygiene, and dairy product preparation (curd, ghee, cheese). Common contagious diseases. Piggery and Cuniculture. Integrated farming.			
IV	Zoological Products, Processing, and Marketing Product Development: Processing and Packaging: Techniques to enhance shelf- life and market value of zoological products. Quality Assurance: National standards (ISI, FSSAI, BIS, AGMARK, EIS) and hygienic protocols. Marketing and Distribution: Branding, market linkages, e-commerce platforms, and export potential. Government Support: Schemes from NABARD, MSME, PMEGP, CGTMSE, SFURTI, MSE-CDP, Honey mission, MOFPI, APEDA, PMMY and Startup India for zoological entrepreneurs. Value added product development and viva.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
V	Fundamentals of Entrepreneurship and Project Development Entrepreneurship Concepts: Characteristics of entrepreneurs, innovation, risk management, and leadership. Women entrepreneurs Business Models: Types of enterprises, business model canvas, and startup ecosystems. Project Planning: Steps in developing a zoology-based enterprise - idea generation, feasibility study, and execution. Finance and Management: Capital investment, budgeting, funding agencies, and government subsidies. Professional Skills: Report writing, communication, marketing strategies, and business pitch presentation. Field Visit to the Farms	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

Text Books

- 1.Khan, H. A., & Saxena, A. K. (2015). *Applied Zoology*. Rastogi Publications.
- 2.Radha, R., & Dharmarajan, P. (2020). *A Textbook of Applied Zoology*. Saras Publications.
- 3.Verma, P. S., & Agarwal, V. K. (2019). *Textbook of Zoology: Vertebrates and Applied Zoology*. S. Chand Publishing.
- 4.Bhuvaneswari, M., & Kumaran, S. (2018). *A Textbook of Entrepreneurship Development*. Sultan Chand & Sons.
- 5.Charantimath, P. M. (2014). *Entrepreneurship Development and Small Business Enterprises*. Pearson Education India.
- 6.Gupta, C. B., & Shrinivasan, N. (2019). *Entrepreneurship Development*. Sultan Chand & Sons.
- Tiwari, R. (2022). *Entrepreneurship for Life Sciences and Biotechnology*. Oxford University Press India.
- 7.Singh, G. (2021). *Entrepreneurship in Biotechnology*. Atlantic Publishers & Distributors.
- 10.Jayashree Suresh (2011). *Entrepreneurial Development*, 5th edition, Margham Publications, Chennai

Suggested Readings

1. Gupta, P. R. (2009). *Beekeeping in India*. ICAR Publications.
2. Krishnaswami, S. (1990). *Sericulture Manual*. FAO/CSB Publication.
(Food and Agriculture Organization / Central Sericultural Board)
3. Banerjee, G. C. (2010). *Animal Husbandry* (7th ed.). Oxford & IBH Publishing Co. Pvt.Ltd.
4. Ismail, S. A. (2005). *Vermicomposting for Sustainable Agriculture*. Orient Longman.
5. Reddy, M. V. P., & Lal, B. (2008). *Wealth from Waste: Trends and Technologies*. TERI Press.
(Also cited in waste-to-resource literature)
6. Crane, E. (1990). *Bees and Beekeeping: Science, Practice, and World Resources*. Heinemann Educational Books.
7. Boyd, C. E., & Tucker, C. S. (2012). *Aquaculture: Principles and Practices* (2nd ed.). Wiley-Blackwell.
8. Surai, P. F., & Sparks, N. H. C. (2001). *Poultry Production in the 21st Century*. Academic Press.

9. Henry, C. (2017). Veterinary Business and Enterprise. Routledge.
10. Osterwalder, A., & Pigneur, Y. (2010). Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers. Wiley.

Web Resources

1. Indian Council of Agricultural Research (ICAR): <https://icar.org.in/>
2. National Bee Board (NBB), India: <https://nbb.gov.in/>
3. Department of Animal Husbandry & Dairying, India: <https://dahd.nic.in/>
4. Food and Agriculture Organization (FAO): <https://fao.org/>
5. Startup India (MSME & Entrepreneurship Portal): <https://startupindia.gov.in/>

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	Define, recall, and describe the principles of economic zoology, including apiculture, sericulture, aquaculture, and animal husbandry. Students will identify the fundamental concepts of entrepreneurship and explain the biological characteristics of economically important animal resources. Collectively, these competencies enable students to demonstrate foundational knowledge and conceptual understanding (K1–K2) of bio-enterprises.	K1, K2
CO2	Apply management techniques for the production and processing of zoological products to examine market-oriented business opportunities. Students will demonstrate proficiency in resource cultivation (such as vermiculture or poultry) and analyze the economic viability of animal-based industries. They will illustrate the supply chain process and classify different sustainable bio-enterprises. These competencies allow students to perform analytical interpretation and practical application (K3–K4) of entrepreneurial zoology.	K3, K4
CO3	Evaluate the sustainability and ethical impact of animal-based ventures to justify business decisions and project feasibility. Students will critically assess market trends and judge the efficacy of leadership and innovation strategies in the bio-sector. They will integrate biological data with business	K5, K6

	acumen to construct, design, and formulate comprehensive business plans and innovative project proposals for sustainable ventures. Collectively, these outcomes enable students to exercise higher-order judgment and creative technical synthesis (K5–K6)	
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CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	1	1	2	2	2
CO2	2	3	2	2	3	3	3
CO3	2	2	2	3	2	3	3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	2	2	2	2
CO2	3	2	3	3	3	2	3
CO3	2	3	3	3	3	3	3

COURSE CODE	PZO4MC01
COURSE TITLE	METHODS IN BIOLOGY
Credits/Hours	4 Credits / 5 Hours
Category	Major Core (MC) - Theory
Semester	IV
Regulation	2026
Course Overview 1. This course provides comprehensive training in advanced experimental techniques used in modern biological and biomedical research. It covers animal cell culture methodologies including cytotoxicity assays, migration studies, and drug screening approaches. 2. Students gain exposure to advanced industrial techniques. Genomic technologies including PCR, next-generation sequencing, RNA-Seq, and metabolic profiling are emphasized. 3. Practical relevance in biomedical research, diagnostics, and drug discovery is highlighted throughout. 4. The course integrates theoretical foundations with analytical interpretation of experimental data. It prepares students for research, industry, and translational biomedical applications.	
Course Objectives 1. Explain the principles and working mechanisms of advanced cell culture, microscopy, biophysical, genomic, electrophysiological, and radiological techniques. 2. Apply appropriate experimental techniques for cytotoxicity testing, molecular analysis, imaging, and functional characterization in biological research. 3. Analyze experimental data obtained from high-throughput assays, sequencing platforms, imaging systems, and electrophysiological recordings. 4. Design integrated experimental strategies using advanced methodologies for research problems in biomedical sciences and biotechnology.	
Prerequisites	Basic knowledge of biology

SYLLABUS

Unit	Content	Hrs	COs	Cognitive Level
I	Advanced Microscopy Scanning and transmission electron microscopes, scanning transmission electron microscope (STEM), cryo-electron	15	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	microscope, atomic force microscope, scanning tunnelling microscope, confocal microscope, phase contrast and fluorescence microscopy, image processing software.			
II	Animal Cell Culture Techniques and Assays Initiation of primary culture and maintenance of cell lines; Wound healing and tumorigenesis assays; Tissue engineering – design stages, types of substrate/support materials, cell sources, orientation, examples - tissue-engineered skin, peripheral nerve implant, cartilage, uterus, trachea, urinary bladder; genetically engineered tissues.	20	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
III	Biophysical Techniques Spectroscopy - fluorescence, circular dichroism, nuclear magnetic resonance and electron spin resonance; Multi-angle and dynamic light scattering techniques; Mass spectrometry – instrumentation, types, application in compound analysis; FTIR spectroscopy; Surface plasmon resonance; X-ray diffraction.	14	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
IV	Genomic and Proteomic Technologies Electrophoresis of DNA and proteins; 2D gel electrophoresis; PCR – primer design, procedure, types and applications; DNA bar coding; Sanger sequencing and Illumina next generation sequencing, nanopore sequencing, single-cell sequencing; RNA Sequencing , microarrays for gene expression studies; Protein sequencing by mass spectrometry; Peptide mass fingerprinting; Protein interaction analysis and mapping; Targeted and untargeted metabolic profiling.	13	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
V	Electrophysiological, Radiological and AI-integrated Methods Single neuron recording, patch-clamp recording, Brain activity recording, lesion and stimulation of brain, pharmacological testing. Nature of radioactivity,	13	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	Measurement of radioactivity, use of radioisotopes in medicine – imaging (PET and SPECT) and diagnosis (thyroid and renal scan), Radiotherapy. AI integration in modern biological instrumentation.			
Text Books 1. Wilson, K., & Walker, J. (2010). <i>Principles and Techniques of Biochemistry and Molecular Biology</i> (7th ed.). Cambridge University Press. 2. Freshney, R. I. (2016). <i>Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications</i> (7th ed.). Wiley-Blackwell. 3. Sambrook, J., & Russell, D. W. (2001). <i>Molecular Cloning: A Laboratory Manual</i> (3rd ed.). Cold Spring Harbor Laboratory Press. 4. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., & Matsudaira, P. (2016). <i>Molecular Cell Biology</i> (8th ed.). W. H. Freeman. 5. Campbell, M. K., & Farrell, S. O. (2019). <i>Biochemistry</i> (9th ed.). Cengage Learning. 6. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2015). <i>Molecular Biology of the Cell</i> (6th ed.). Garland Science. 7. Brown, T. A. (2016). <i>Genomes</i> (4th ed.). Garland Science. 8. Griffiths, A. J. F., Wessler, S. R., Lewontin, R. C., & Carroll, S. B. (2015). <i>Introduction to Genetic Analysis</i> (11th ed.). W. H. Freeman. 9. Hayat, M. A. (2000). <i>Principles and Techniques of Electron Microscopy: Biological Applications</i> (4th ed.). Cambridge University Press. 10. Scopes, R. K. (2013). <i>Protein Purification: Principles and Practice</i> (4th ed.). Springer. 11. Roux, B. T., & Bahar, I. (Eds.). (2020). <i>Biophysical Tools for Biologists: Volume 1 (Advanced Techniques)</i>. Springer. 12. Purves, D., Augustine, G. J., Fitzpatrick, D., Hall, W. C., LaMantia, A.-S., Mooney, R. D., & White, L. E. (2017). <i>Neuroscience</i> (6th ed.). Oxford University Press.				
Suggested Readings 1. Dykstra, M. J., & Reiss, A. B. (2001). <i>Advanced Light Microscopy: Specialized Methods</i>. Academic Press. 2. Walker, J. M. (Ed.). (2012). <i>Cell and Molecular Biology: A Laboratory Handbook</i> (4th ed.). Wiley-Blackwell. 3. Zhang, Q., & Griffin, M. (Eds.). (2015). <i>Cell Migration: Developmental Methods and Protocols</i> (Methods in Molecular Biology, Vol. 1202). Humana Press. 4. Deeth, J. R., & Irving, E. A. (2018). <i>MRI and Functional MRI: A Clinical Introduction and Atlas</i> (2nd ed.). Cambridge University Press. 5. Brown, R. D., & Pugh, J. R. (Eds.). (2017). <i>Electrophysiology in Cardiovascular Research: Methods and Protocols</i> (Methods in Molecular Biology). Humana Press. 6. Lipfert, J., Doniach, S., & Das, R. (Eds.). (2021). <i>RNA Structure and Folding: Methods in Molecular Biology</i> (Vol. 2300). Humana Press. 7. Beynon, R. J., & Bond, J. S. (Eds.). (2020). <i>Proteomics: Methods and Protocols</i> (3rd ed.).				

Humana Press.

8. Machesky, L. M., & Hall, C. (Eds.). (2013). *Cell Invasion: Methods and Protocols* (Methods in Molecular Biology, Vol. 1046). Humana Press.
9. Schmidt, R. R., & Moitessier, N. (2018). *Chemical Biology: Methods and Protocols* (2nd ed.). Springer.

Web Resources

Educational Resources

1. American Type Culture Collection (ATCC) Learning Center
<https://www.atcc.org/resources>
2. Bruker Corporation Learning Resources
<https://www.bruker.com>
3. Illumina Sequencing Education
<https://www.illumina.com/science/education>

Communities and Forums

1. BioStars
<https://www.biostars.org>
2. Stack Exchange Biology
<https://biology.stackexchange.com>
3. SEQanswers
<http://seqanswers.com>

Research Databases

1. Cellosaurus
<https://www.cellosaurus.org>
2. PubMed
<https://pubmed.ncbi.nlm.nih.gov>
3. BioImage Archive
<https://www.ebi.ac.uk/bioimage-archive>

Specialized Resources

1. Nature Protocols
<https://www.nature.com/nprot>
2. JoVE (Journal of Visualized Experiments)
<https://www.jove.com>
3. iBiology
<https://www.ibiology.org/>

Interactive Learning Tools

1. PraxiLabs – Interactive Virtual Science Lab
<https://praxilabs.com/>
2. ExploreLearning Gizmos – Biology Simulations
<https://gizmos.explorellearning.com/biology-collection>
3. Serendip Interactive Biology Resources
https://serendipstudio.org/sci_edu/biosites.html

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	Recall fundamental principles of animal cell culture, cytotoxicity assays, advanced microscopy, biophysical, genomic, electrophysiological and radiological techniques. Describe instrumentation and working mechanisms of the advanced biological techniques. Explain experimental workflows and analyze and interpret the data. Summarize applications and limitations of various analytical and imaging techniques in biological and clinical research.	K1, K2
CO2	Apply laboratory and analytical techniques such as MTT assay, dose–response curve plotting, PCR primer design, gene expression analysis and imaging methods to biological problems. Perform data analysis and interpret assay results, sequencing outputs, spectroscopic data, electrophysiological traces and imaging datasets. Differentiate and compare methodologies based on resolution, sensitivity and suitability. Analyze experimental errors and variability, suggesting appropriate controls and validation strategies.	K3, K4
CO3	Evaluate and justify the selection of appropriate techniques for specific biomedical and research applications. Design integrated experimental strategies combining cell culture, genomics and biophysical methods to address research hypotheses. Develop drug screening workflows, including IC ₅₀ calculation, high-throughput assay planning and multi-technique validation. Construct research proposals or experimental protocols incorporating advanced analytical, imaging and molecular approaches.	K5, K6

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	2	3	2	3	2	2
CO2	2	3	3	3	3	2	2
CO3	2	3	3	3	3	3	3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	3	3	2	2	3	3
CO2	2	3	3	2	2	3	3
CO3	2	3	3	2	2	3	3

COURSE CODE	PZO4MC02
COURSE TITLE	GENETIC ENGINEERING
Credits/Hours	4 Credits / 4 Hours
Category	Major Core (MC) - Theory
Semester	IV
Regulation	2026
Course Overview 1. This course provides comprehensive insight into the principles and applications of recombinant DNA technology. It covers the design, construction, analysis, and optimization of recombinant DNA molecules, along with the tools and techniques involved in genetic manipulation. 2. The course also explores innovative strategies for the development of therapeutic products, including modern approaches to drug discovery, biopharmaceutical production, and other medicinal applications.	
Course Objectives 1. To understand how recombinant molecules are created analyzed with respect to DNA, RNA, and Protein. 2. To monitor both in-vitro and in-vivo activity especially functioning of Recombinant DNA molecules, their constructions, analysis and fine tuning. 3. To suggest more rational approach to solve problem of a living system at a molecular level. 4. To analyze and compare the various instruments have been used in genetic engineering. 5. To develop and formulate the Insulin and Blood clotting factor VIII for medicine.	
Prerequisites	Knowledge of Biochemistry, Microbiology, Molecular Biology, Genetics.

SYLLABUS

Unit	Content	Hrs	COs	Cognitive Level
I	Introduction Introduction to nucleic acids. Prokaryotic and eukaryotic gene organization. Central Dogma. Overview of recombinant DNA technology – tools and techniques. Regulation of Gene Expression in Prokaryotes and Eukaryotes. Genome	10	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	Organization and Functional Elements (Promoters, Enhancers, Introns, Exons, Operon Model).			
II	Enzymes and markers for Recombinant Technology Restriction endonucleases (Types I, II, III, IIS; blunt and cohesive ends; mechanism of action), DNA ligase, DNA polymerases (including high-fidelity enzymes), Reverse transcriptase, Polynucleotide kinase, Terminal transferase, Alkaline phosphatase, Exonucleases (S1 nuclease, Bal-31), CRISPR-Cas nucleases. Reporter Genes and Selectable Markers: Classical reporters (lacZ, CAT, GUS), Fluorescent reporters (GFP and variants), Luciferase, Selectable markers (nptII, dhfr, hygromycin resistance), sacB system, Herbicide resistance genes, Cre-loxP system, inducible and dual-reporter systems.	14	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
III	Vectors Cloning and expression vectors; plasmids (structure, classification, copy number); shuttle vectors and episomal vectors; bacteriophages (λ and M13), cosmids, phagemids, BACs and YACs; viral vectors (adenoviral, retroviral, lentiviral); plant and animal expression vectors. Library construction (genomic and cDNA libraries) and screening of recombinant clones. Gene expression systems in E. coli, yeast, mammalian cells.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
IV	DNA transfer and gene manipulation Gene transfer techniques (physical, chemical, biological). In vitro mutagenesis and deletion techniques, Gene knockout in bacterial and eukaryotic systems. Gene editing (CRISPR, TALENs, ZFNs; base editing, prime editing). Epigenome editing and CRISPR-based gene regulation (CRISPRi/CRISPRa) RNAi-based gene silencing. Cloning by somatic cell nuclear transfer.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

V	Applications of rDNA Antisense and RNA interference technology and their applications. rDNA in medicine, agriculture, food industry and environmental sciences. Gene therapy. Transgenic plants and animals. Ethical issues and regulations related to rDNA technology. Next-Generation Sequencing (NGS) and its applications in recombinant DNA research.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
Text Books 1. Alberts, B. et al. (2022). Molecular Biology of the Cell. 7th Edition. Garland Science. 2. Brown, T.A. (2021). Gene Cloning and DNA Analysis. 8th Edition. Wiley-Blackwell. 3. Griffiths, A.J.F. et al. (2020). An Introduction to Genetic Analysis. 12th Edition. W.H. Freeman. 4. Snustad, D.P. & Simmons, M.J. (2016). Principles of Genetics. 7th Edition. Wiley. 5. Watson, J.D. et al. (2007). Recombinant DNA: Genes and Genomes. 3rd Edition. Cold Spring Harbor Laboratory Press.				
Suggested Readings 1. Krebs, J.E. et al. (2017). Lewin's Genes XII. Jones & Bartlett Learning. 2. Nicholl, D.S.T. (2013). An Introduction to Genetic Engineering. 4th Edition. Cambridge University Press. 3. Primrose, S.B. & Twyman, R. (2006). Principles of Gene Manipulation and Genomics. Blackwell Publishing. 4. Klug, W.S. et al. (2018). Concepts of Genetics. 12th Edition. Pearson.				
Web Resources 1. https://www.ncbi.nlm.nih.gov 2. https://www.addgene.org 3. https://www.ebi.ac.uk 4. https://www.cshl.edu 5. https://www.broadinstitute.org 6. https://www.who.int				

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	Define, recall, and describe the principles of recombinant DNA technology and the organization of prokaryotic and eukaryotic genes. Students will identify essential tools such as restriction enzymes, ligases, and vectors (plasmids, phages, YACs) and explain the processes of the Central Dogma in the context of genetic manipulation. Collectively, these competencies enable students to demonstrate foundational knowledge and conceptual understanding (K1–K2) of molecular engineering.	K1, K2
CO2	Apply molecular cloning strategies to examine and illustrate the construction of genomic and cDNA libraries. Students will demonstrate proficiency in techniques like PCR, DNA sequencing (Sanger/NGS), and blotting (Southern/Northern/Western) to analyze and compare gene expression. They will classify different types of expression vectors and interpret the fine-tuning of recombinant DNA molecules in both <i>in-vitro</i> and <i>in-vivo</i> systems. These competencies allow students to perform analytical interpretation and practical application (K3–K4) of genetic tools.	K3, K4
CO3	Evaluate the efficacy of gene therapy and genome editing tools like CRISPR-Cas9 to justify their use in treating human diseases. Students will critically assess the production of biopharmaceuticals and judge the safety of transgenic organisms (GMOs). They will integrate molecular data to construct, design, and formulate innovative strategies for the development of therapeutic products, such as recombinant insulin and blood clotting factors. Collectively, these outcomes enable students to exercise higher-order judgment and creative technical synthesis (K5–K6).	K5, K6

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	3	3	3	3	3	3	3
CO2	3	3	3	3	2	3	2
CO3	3	2	3	3	3	3	3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	2	3	3	3	3
CO2	3	2	3	3	3	3	3
CO3	3	3	3	3	3	2	3

COURSE CODE	PZO4MC03
COURSE TITLE	METHODS IN BIOLOGY LAB
Credits/Hours	4 Credits / 6 Hours
Category	Major Core (MC) - Lab
Semester	IV
Regulation	2026
Course Overview 1.This course provides intensive hands-on training in modern core techniques of isolation and analysis of biological molecules. 2.Molecular analysis is emphasized in this course and applied insights into biomolecular detection are highlighted. Spectroscopic methods including UV–Vis and FTIR analysis develop skills in structural interpretation of biomolecules. 3.The course prepares students for research and industry applications.	
Course Objectives 1. Apply cell culture, molecular isolation, and electrophoretic techniques to generate reproducible experimental data. 2. Analyze spectroscopic and mass spectral datasets to interpret biomolecular structure and identity. 3. Evaluate the efficiency and accuracy of molecular tools such as PCR and Western blotting in experimental contexts. 4.Design experimental workflows integrating biochemical, molecular, and computational approaches for biological problem-solving.	
Prerequisites	Basic knowledge of biology

SYLLABUS

Unit	Content	Hrs	COs	Cognitive Level
I	Cell culture assays and spectroscopy Trypsinization of liver cells and cell viability test using dye exclusion assay. MTT assay after exposure of cells to cytotoxic agent. Determination of cell size and cell counts using ImageJ/FIJI Generation and analysis of the UV-Vis spectral graph of different compounds and determination of	15	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6

	their λ_{max} .			
II	Nucleic Acid Isolation and Quantitation Isolation of DNA from animal tissue (PCI method). Isolation of RNA from animal tissue (GITC method). Isolation of bacterial genomic DNA. Isolation of plasmid DNA. Quantitative and qualitative analysis of DNA by UV spectrophotometry.	18	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
III	Genomic tools Ligation of DNA, Restriction digestion of a given DNA sample. Agarose gel electrophoresis of DNA and RNA. Elution of DNA from the agarose gel. Polymerase chain reaction for a given DNA sample.	21	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
IV	Proteomic Analysis Isolation and partial purification of protein (amylase from sweet potato) by ammonium sulphate fractionation and dialysis. SDS-PAGE of a given protein sample. Western blotting for protein detection. Native PAGE of a given protein sample.	24	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
V	Analysis and interpretation of experimental data Ultrastructural analysis and interpretation of SEM, TEM, phase contrast and confocal micrographs. Analysis of the mass spectrum of a protein, derivation of the protein sequence and identification of the probable protein. Analysis of microarray data for differential gene expression. Comparative FTIR spectral analysis and interpretation of structural modifications. Interpretation of GC-MS chromatographic and spectral data.	12	CO 1 CO 2 CO 3	K1, K2, K3, K4, K5, K6
Text Books 1. Freshney, R. I. (2016). <i>Culture of animal cells: A manual of basic technique and specialized applications</i> (7th ed.). Wiley-Blackwell.				

2. Green, M. R., & Sambrook, J. (2012). *Molecular cloning: A laboratory manual* (4th ed.). Cold Spring Harbor Laboratory Press.
3. Sambrook, J., & Russell, D. W. (2006). *The condensed protocols from molecular cloning*. Cold Spring Harbor Laboratory Press.
4. Brown, T. A. (2016). *Gene cloning and DNA analysis: An introduction* (7th ed.). Wiley-Blackwell.
5. Walker, J. M. (Ed.). (2009). *The protein protocols handbook* (3rd ed.). Humana Press.
6. Kurien, B. T., & Scofield, R. H. (Eds.). (2015). *Western blotting: Methods and protocols*. Humana Press.
7. Simpson, R. J. (2010). *Proteins and proteomics: A laboratory manual*. Cold Spring Harbor Laboratory Press.
8. Griffiths, P. R., & de Haseth, J. A. (2007). *Fourier transform infrared spectrometry* (2nd ed.). Wiley-Interscience.
9. Hoffmann, E. D., & Stroobant, V. (2007). *Mass spectrometry: Principles and applications* (3rd ed.). Wiley.
10. Wilson, K., & Walker, J. (Eds.). (2018). *Principles and techniques of biochemistry and molecular biology* (8th ed.). Cambridge University Press.

Suggested Readings

1. Freshney, R. I. (2016). *Culture of animal cells: A manual of basic technique and specialized applications* (7th ed.). Wiley-Blackwell.
2. Hames, B. D. (Ed.). (1998). *Gel electrophoresis of proteins: A practical approach* (3rd ed.). Oxford University Press.
3. Kurien, B. T., & Scofield, R. H. (Eds.). (2015). *Western blotting: Methods and protocols*. Humana Press.
4. Mullis, K. (1990). *The polymerase chain reaction*. Birkhäuser.
5. Simpson, R. J. (2010). *Proteins and proteomics: A laboratory manual*. Cold Spring Harbor Laboratory Press.
6. Griffiths, P. R., & de Haseth, J. A. (2007). *Fourier transform infrared spectrometry* (2nd ed.). Wiley-Interscience.
7. Hoffmann, E. D., & Stroobant, V. (2007). *Mass spectrometry: Principles and applications* (3rd ed.). Wiley.
8. Schena, M. (2003). *Microarray analysis*. Wiley-Liss.

9. Sambrook, J., & Russell, D. W. (2006). The condensed protocols from molecular cloning. Cold Spring Harbor Laboratory Press.
10. Wilkins, M. R., Williams, K. L., Appel, R. D., & Hochstrasser, D. F. (Eds.). (1997). Proteome research: New frontiers in functional genomics. Springer.

Web Resources

Educational Resources

1. HHMI BioInteractive
<https://www.biointeractive.org>
2. Cold Spring Harbor Laboratory DNA Learning Center
<https://dnlc.cshl.edu>
3. MIT OpenCourseWare
<https://ocw.mit.edu>

Communities and Forums

1. ResearchGate
<https://www.researchgate.net>
2. Protocols.io
<https://www.protocols.io>
3. BioStars
<https://www.biostars.org>

Research Databases

1. National Center for Biotechnology Information (NCBI)
<https://www.ncbi.nlm.nih.gov>
2. UniProt Consortium (UniProt)
<https://www.uniprot.org>
3. Protein Data Bank (RCSB PDB)
<https://www.rcsb.org>

Specialized Resources

1. Primer3

<https://primer3.ut.ee>

2. MassIVE

<https://massive.ucsd.edu>

3. Gene Expression Omnibus (GEO)

<https://www.ncbi.nlm.nih.gov/geo/>

Interactive Learning Tools

1. ImageJ / Fiji

<https://imagej.nih.gov/ij/>

2. Benchling

<https://www.benchling.com>

3. Expasy

<https://www.expasy.org>

Course Outcomes (COs) and Cognitive Level Mapping

COs	CO Description	Cognitive Level
CO1	Define the fundamental concepts and principles underlying cellular, molecular, analytical, and diagnostic approaches in biological sciences. Recall core theoretical foundations, describe standard experimental methodologies, explain the scientific basis of analytical techniques, and summarize safety, ethical, and documentation practices followed in advanced biological laboratories.	K1, K2
CO2	Apply conceptual understanding to conduct laboratory procedures, analyze experimental datasets using appropriate tools, interpret graphical and analytical outputs logically, and differentiate valid biological results from inconsistencies or artefacts. Demonstrate biological knowledge to perform structured investigations and interpret experimental findings.	K3, K4
CO3	Propose integrated experimental strategies for research and translational applications in life sciences. Assess the reliability and accuracy of experimental outcomes, justify methodological choices based on scientific reasoning, formulate improved investigative approaches, and design innovative research or diagnostic models addressing biological challenges.	K5, K6

CO-PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	2	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3

LOCF BASED DIRECT ASSESSMENTS

Cognitive Level (CL) and Course Outcome (CO) Based CIA Question Paper Format

Section	Q. No	Cognitive Level (CL)					
A Answer ALL		CO1		CO2		CO3	
		K1	K2	K3	K4	K5	K6
	1						
	2						
	3						
	4						
	5						
B Answer any TWO	6						
	7						
	8						
	9						
C Answer any ONE	10						
	11						
No. of CL based Questions with Max. marks		3(6)	2(4)	1(10)	1(10)	1(20)	1(20)
No. of CO based Questions with Max. marks		5(10)		2(20)		1(20)	

LOYOLA COLLEGE (AUTONOMOUS), CHENNAI 600034
DEPARTMENT OF ADVANCED ZOOLOGY AND BIOTECHNOLOGY

FIRST CONTINUOUS INTERNAL ASSESSMENT, JANUARY 2026

PZO2MC02 Research Methodology and Biostatistics

Class: I MSc Zoology

Date: 24.01.2026

Time: 10.30 – 12.00 Noon

Max. Marks: 50

SECTION A - K1 & K2 (CO1)	
Q. No	Answer ALL the Questions (5 x 2 = 10 Marks)
1	Why mere information gathering is not research?
2	How clearly defined problem reduces redundancy?
3	Non-scientific research lack empirical verification – Substantiate.
4	Why a research problem needs to be specific and unambiguous?
5	Literature Review identifies what is already known – how?
SECTION B – K3 & K4 (CO2)	
Answer any TWO of the following (2 x 10 = 20 Marks)	
6	“A study to improve learning quality in primary schools” is the topic assigned to you. Decide whether this is applied or fundamental research and justify your answer.
7	A study is designed based on existing theories without collecting new data. Apply your understanding to identify whether this is conceptual or empirical research.
8	A researcher is interested in studying the decline of pollinator populations in urban areas. Formulate a clear research problem and propose a suitable title for the study.
9	Differentiate between primary and secondary literature sources by analyzing their reliability, validity, and usability in academic research.
SECTION C – K5 & K6 (CO3)	
Answer any ONE of the following (1 x 20 = 20 Marks)	
10	Examine the characteristics of good research and analyze how lack of objectivity can affect research outcomes.
11	Design a complete research proposal outline on a topic of your choice, clearly showing the problem formulation, title, objectives, working hypothesis, research design, and sampling design.

Cognitive Level (CL) and Course Outcome (CO) Based Semester Question Paper Format

SECTION - A Answer ALL	Q. NO	CO1		CO2		CO3	
		K1	K2	K3	K4	K5	K6
	1						
	2						
	3						
	4						
	5						
	6						
	7						
	8						
	9						
	10						
SECTION - B Answer any FOUR	11						
	12						
	13						
	14						
	15						
	16						
SECTION - C Answer any TWO	17						
	18						
	19						
	20						
No. of CL based Questions with Max. marks		5(10)	5(10)	2(20)	2(20)	1(20)	1(20)
No. of CO based Questions with Max. marks		10(20)		4(40)		2(40)	

**UNIT WISE DISTRIBUTION OF CL AND CO BASED QUESTIONS AND MARKS FOR
END OF SEMESTER QUESTION PAPER SETTING (PG)**

	CO1		CO2		CO3	
	K1	K2	K3	K4	K5	K6
UNIT I	1(2)	1(2)	1(10)		1(20)	
UNIT II	1(2)	1(2)	1(10)		1(20)	
UNIT III	1(2)	1(2)	1(10)	1(10)		
UNIT IV	1(2)	1(2)		1(10)		1(20)
UNIT V	1(2)	1(2)		1(10)		1(20)
No. of CL based Questions with Max. Marks	5(10)	5(10)	2(20)	2(20)	1(20)	1(20)
No. of CO based Questions with Max. Marks	10(20)		4(40)		2(40)	

TOTAL MARKS DISTRIBUTION OF DIRECT ASSESSMENTS BASED ON CL AND CO (PG)

		CO1	CO2	CO3	TOTAL
(i)	CIA 1	10	20	20	50
(ii)	30% of CIA I	6	12	12	30
(iii)	CIA 2	10	20	20	50
(iv)	30% of CIA II	6	12	12	30
(v)	Comp III for 40%	-	-	40	40
	CIA TOTAL (ii)+(iv)+(v)	12	24	64	100
A	50% of CIA	6	12	32	50
	Semester	20	40	40	100
B	50% of Semester	10	20	20	50
	Total Marks (CO) (A + B)	16	32	52	100

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