Draft Model Curriculum for 3yr./4yr. Degree Course with Apprenticeship Embedded Degree program

B.Sc. in Zoology with Double Major in Integrative Bio Sciences

Higher Education Department
Government of Odisha

Under National Education Policy 2020

Semester	Course (paper)	Course Name	Credit
Semester I	MJ -1.1	Cell Biology	4
	MJ -1.2	Microbiology & Microbial Technologies	4
	MJ -1.3	Zoological Museum Technologies	4
	MJ- 1.4	Entomology & Integrated Pest management	4
	MJ -2.1	Animal diversity	4
	AEC (Ability Enhancement Courses)	English: Business Communication	4
	VAC (Value Added Course)	Environmental Studies & Disaster Management	3
		TOTAL	**27**
Semester II	MJ 1.5	Fundamentals in Biochemistry	4
	MJ 1.6	Molecular Biology	4
	MJ 1.7	Principles of Genetics	4
	MJ- 1.8	Immunology	4
	MJ 2.2	Physiology: Life Sustaining Systems	4
	AEC (Ability Enhancement Courses)	English: Word and Presentation skill	4
	VAC (Value Added Course)	Good Citizenship / **or any other discipline**	3
		TOTAL	**27**
Semester III	MJ 1.9	Biochemistry of metabolic Processes	4
	MJ 1.10	Biostatistics & Bioinformatics	4
	MJ 1.11	Instrumentation & Techniques in Biology	4
	MJ- 1.12	Animal Biotechnology	4
	MJ 2.3	Physiology: Controlling & Coordinating Systems	4
	MJ -2.4	Developmental Biology	4
	MDC (Multidisciplinary Course)	Vector Borne Diseases & Epidemiology / **or any other discipline**	3
	SEC (Skill Enhancement Course)	Molecular Diagnostics **or/ any other discipline**	3
		TOTAL	**30**
Semester IV	MJ -1.13	Wildlife & Conservation Biology	4
	MJ- 1.14	Aquaculture and Sustainable Fish Farming	4
	MJ- 1.15	Environment Impact Assessment & Toxicology	4
	MJ -2.5	Taxonomy & Evolutionary Biology	4
	MJ -2.6	Comparative Anatomy of Vertebrates	4
	MDC (Multidisciplinary Course)	Bio-resource Technologies & Bio-products **/or any other discipline**	3
	SEC (Skill Enhancement Course)	Marine Biotechnology **/or any other discipline**	3
		TOTAL	**26**
Semester V	**Internship/Apprenticeship/Industry Training**		**20**
Semester VI	**Internship/Apprenticeship/Industry Training**		**20**

**** The 4yr. program of AEDP shall be as per 3 yr./4yr. UG Degree Program under NEP-2020***

Program Outcomes (POs)

PO1. Fundamental Biological Knowledge

Demonstrate comprehensive understanding of core concepts in integrative biosciences, zoology, microbiology, genetics, immunology, biotechnology, ecology, and animal sciences.

PO2. Laboratory and Technical Competency

Apply standard laboratory techniques, instrumentation, molecular tools, museum techniques, and biological analytical methods for scientific investigation and experimentation.

PO3. Computational and Quantitative Skills

Use biostatistics, bioinformatics, data analytics, and logical reasoning tools for interpretation of biological data and scientific problem-solving.

PO4. Research and Analytical Ability

Design, conduct, analyse, and interpret biological experiments using scientific methodologies, critical thinking, and evidence-based approaches.

PO5. Biodiversity, Conservation, and Environmental Awareness

Understand biodiversity conservation, wildlife management, environmental toxicology, ecosystem sustainability, and environmental impact assessment for ecological stewardship.

PO6. Health and Disease Understanding

Develop foundational understanding of epidemiology, vector-borne diseases, immunology, molecular diagnostics, and public health-related biological systems.

PO7. Industry and Employability Readiness

Acquire practical skills relevant to biotechnology industries, aquaculture, diagnostics, environmental consultancy, pest management, and applied biosciences through internships and apprenticeship training.

PO8. Entrepreneurship and Innovation

Demonstrate entrepreneurial aptitude in areas such as vermitechnology, aquaculture, integrated pest management, biological products, and startup-oriented bioscience applications.

PO9. Communication and Professional Ethics

Communicate scientific concepts effectively through technical writing, presentations, and interdisciplinary collaboration while adhering to ethical and biosafety principles.

PO10. Lifelong Learning and Multidisciplinary Integration

Adapt to emerging developments in biosciences, biotechnology, environmental sciences, and interdisciplinary research through continuous learning and professional development.

Program Specific Outcomes (PSOs)

PSO1: Develop practical expertise in molecular biology, microbiology, genetics, immunology, biotechnology, and animal sciences for higher studies and industrial applications.

PSO2: Apply biological instrumentation, museum technology, analytical techniques, and computational tools in research laboratories, healthcare, and industrial settings.

PSO3: Demonstrate competency in biodiversity assessment, wildlife conservation, environmental monitoring, toxicological analysis, and ecological management.

PSO4: Acquire hands-on professional experience through internships/apprenticeships in biotechnology industries, aquaculture units, diagnostic laboratories, environmental agencies, and research organizations.

PSO5: Develop innovation and entrepreneurship capabilities in bioscience-based sectors including pest management, sustainable agriculture, aquaculture, waste management, and biological product development.

Industry Linkage Framework

1. **Objectives of Industry Linkage**

The Industry Linkage Framework aims to:

- bridge academia and industry,
- enhance employability and skill development,
- provide practical exposure,
- facilitate internships/apprenticeships,
- promote entrepreneurship,
- encourage collaborative research and innovation.

2. **Major Industry Sectors Linked to the Program**

Domain	**Relevant Industry Sector**
Biotechnology	Biotech companies, genomics labs
Diagnostics	Molecular diagnostic laboratories
Healthcare	Public health agencies, hospitals
Environmental Science	Environmental consultancies, pollution control
Agriculture	Pest management industries, agri-biotech
Wildlife & Conservation	Forest departments, NGOs
Aquaculture	Fisheries and aquaculture industries
Bioinformatics	Computational biology and data analytics
Museum Technology	Natural history museums and archives
Research & Innovation	Universities, CSIR/ICMR/DBT laboratories

3. **Potential Institutional and Industry Partners (India)**

Biotechnology and Molecular Biology

- Department of Biotechnology
- Biocon
- Serum Institute of India
- Bharat Biotech

Public Health and Diagnostics

- Indian Council of Medical Research
- National Centre for Disease Control
- Regional Medical Research Centre, Bhubaneswar

Environmental and Wildlife Sector

- Odisha State Pollution Control Board
- Zoological Survey of India
- Wildlife Institute of India

Aquaculture and Fisheries

- Central Institute of Freshwater Aquaculture
- ICAR-Central Institute of Brackishwater Aquaculture

4. **Internship and Apprenticeship Framework**

Semester V

Short-Term Industrial Internship (4–6 Weeks)

Students may be placed in:

- Biotechnology industries
- Diagnostic laboratories
- Environmental monitoring laboratories
- Aquaculture facilities
- Wildlife conservation agencies
- Pest management industries

Expected Outputs

- Internship report
- Skill logbook

- Industry mentor evaluation
- Presentation/viva

Semester VI

Advanced Apprenticeship/Research Project (8–12 Weeks)

Students may undertake:

- Industry-based project
- Field-based ecological survey
- Diagnostic laboratory training
- Bioinformatics mini-project
- Entrepreneurship incubation project

Deliverables

- Dissertation/project report
- Research poster/seminar
- Prototype/model/startup idea
- Employability assessment

5. **Skill Development and Certification Integration**

Proposed Add-On Certifications

Skill Area	**Certification**
Bioinformatics	Python/R for Biology
Diagnostics	Molecular Diagnostic Techniques
GIS & Ecology	GIS and Remote Sensing
Entrepreneurship	Startup and Innovation Management
Instrumentation	Laboratory Instrument Handling
Data Science	Biostatistics and Data Analytics

6. **Entrepreneurship and Startup Support**

Students may be encouraged to develop startups in:

- Vermicomposting
- Biofertilizers
- Aquaculture
- Pest management products
- Diagnostic kits
- Environmental monitoring services
- Biodiversity consultancy

Suggested Support Mechanisms

- Innovation clubs
- Incubation centres
- Industry mentoring
- Seed funding competitions
- DBT/Startup India/ National Skill Development Corporation (NSDC) linkage

7. **Research and Innovation Ecosystem**

Collaborative Activities

- Industry lectures

- Hands-on workshops
- Joint projects
- Field training camps
- Hackathons in biosciences
- Research internships

Student Research Areas

- Vector-borne diseases
- Toxicology
- Molecular diagnostics
- Wildlife conservation
- Microbial biotechnology
- Aquaculture innovation
- Animal behaviour studies

8**. Graduate Employability Pathways**

Graduates may pursue careers as:

- Research assistants
- Laboratory technicians
- Diagnostic technologists
- Wildlife and biodiversity analysts
- Environmental consultants
- Aquaculture professionals
- Pest management executives
- Bioinformatics trainees
- Public health field investigators
- Museum and biodiversity curators

9. **Higher Education Pathways**

Eligible for:

- M.Sc. Biosciences
- M.Sc. Zoology
- Biotechnology
- Microbiology
- Bioinformatics
- Wildlife Science
- Environmental Science
- Public Health
- Molecular Biology
- Integrated Ph.D. programs

10. **Distinctive Features of the Program**

- Strong interdisciplinary bioscience integration
- Industry-oriented curriculum
- Skill-intensive practical framework
- Dedicated internship semesters
- Emerging areas like bioinformatics and molecular diagnostics
- Employability-focused training
- Entrepreneurship orientation
- Conservation and sustainability emphasis
- NEP-aligned multidisciplinary design

Potential Institutional and Industry Partners (India)

Biotechnology and Molecular Biology

- Department of Biotechnology
- Biocon
- Serum Institute of India
- Bharat Biotech

Public Health and Diagnostics

- Indian Council of Medical Research
- National Centre for Disease Control
- Regional Medical Research Centre, Bhubaneswar

Environmental and Wildlife Sector

- Odisha State Pollution Control Board
- Zoological Survey of India
- Wildlife Institute of India

Aquaculture and Fisheries

- Central Institute of Freshwater Aquaculture
- ICAR-Central Institute of Brackishwater Aquaculture

Semester -I

Major 1.1 **Credit-04**

1.1 Cell Biology

Course Objectives

The course is designed to:

- Introduce students to the fundamental principles of cell biology and the organization of living systems.
- Develop understanding of prokaryotic and eukaryotic cell structure, membrane organization, and cellular transport mechanisms.
- Familiarize students with cytoskeletal systems and endomembrane organelles and their roles in cellular organization and metabolism.
- Explain the structure, function, and bioenergetics of mitochondria and related cellular organelles.
- Develop understanding of nuclear organization, chromatin packaging, cell cycle regulation, and cell division.
- Introduce basic mechanisms of cellular communication and signal transduction pathways.
- Provide hands-on laboratory skills in microscopy, cytological techniques, staining methods, and histochemical demonstrations relevant to modern biological sciences.

Course Outcomes (COs)

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

CO1: Explain the structural and functional organization of prokaryotic and eukaryotic cells and describe acellular entities including viruses, viroids, prions, and mycoplasma.

CO2: Interpret plasma membrane organization and evaluate mechanisms of membrane transport and cell–cell communication.

CO3: Describe the organization and functions of cytoskeletal components and endomembrane systems in maintaining cellular architecture and intracellular transport.

CO4: Explain mitochondrial structure and function, cellular bioenergetics, respiratory mechanisms, and organelle evolution.

CO5: Demonstrate understanding of nuclear organization, chromatin structure, nucleosome packaging, and regulation of cell division and cell cycle progression.

CO6: Interpret fundamental cell signalling pathways and their significance in cellular regulation and physiological responses.

CO7: Perform basic laboratory techniques including microscopy, staining, mitotic and meiotic preparations, histochemical reactions, and osmosis demonstrations.

Course Structure (4 Credits= 4 Hours per week)

UNIT I

Cell Organization and Plasma Membrane (10 Hours)

Overview of Cells: Cell theory and diversity of life, Prokaryotic and eukaryotic cells

Comparative organization and cellular complexity, **Acellular Biological Systems**: Viruses, Viroids, Mycoplasma, Prions, Biological significance and disease associations, **Plasma Membrane Organization:** Structure and composition of plasma membrane, Historical and modern membrane models, Fluid mosaic model and membrane dynamics, **Transport Across Membranes:** Passive transport, Active transport, Facilitated transport, Membrane permeability and transport proteins, **Cell Junctions:** Tight junctions, Desmosomes, Gap junctions, Functional significance in multicellular systems.

UNIT II

Cytoskeleton and Endomembrane System (10 Hours)

Cytoskeleton: Structure and Functions of Microtubules, Microfilaments and Intermediate filaments, Cytoskeletal organization and cellular motility

Endomembrane System: Structure and Functions of Endoplasmic reticulum, Golgi apparatus and Lysosomes

Intracellular Transport and Organelle Interactions: Vesicular transport, Protein sorting and trafficking, Cellular secretion pathways

UNIT III

Mitochondria, Peroxisomes and Cellular Bioenergetics (8 Hours)

Mitochondria: Ultrastructure and organization, Semi-autonomous nature, Mitochondrial genome and replication, Endosymbiotic hypothesis

Cellular Respiration and Bioenergetics: Mitochondrial respiratory chain, ATP synthesis, Chemiosmotic hypothesis, Bioenergetic significance

Peroxisomes: Structure and biogenesis, Functions in cellular metabolism, Detoxification and oxidative metabolism

UNIT IV

Nucleus, Cell Division and Cell Signalling (12 Hours)

Nuclear Organization: Structure of nucleus, Nuclear envelope, Nuclear pore complex, Nucleolus and nuclear functions

Chromatin Organization and Packaging: Euchromatin and heterochromatin, Chromatin organization, Nucleosome and DNA packaging

Cell Division and Cell Cycle: Mitosis, Meiosis, Cell cycle phases, Cell cycle regulation and checkpoints

Cell Signalling: Principles of cell signalling, G-protein coupled receptors (GPCR), Second messenger systems, Role of cyclic AMP (cAMP)

PRACTICAL

1. Understanding and operation of simple and compound microscopes
2. Study of different cell types: Buccal epithelial cells, Striated muscle cells (using suitable stains/virtual slides/prepared slides)
3. Preparation of temporary squash of onion root tip for mitosis
4. Study of meiotic stages in grasshopper testis/prepared slides/virtual material
5. Preparation of permanent slide showing Barr body in human female cheek/blood cells
6. Demonstration of: DNA by Feulgen reaction, DNA and RNA by Methyl Green–Pyronin (MGP), Mucopolysaccharides by PAS reaction, Proteins by Mercuric Bromophenol Blue/Fast Green
7. Demonstration of osmosis using RBC/egg/other suitable models

Suggested Teaching–Learning Methods

- ✓ *Interactive lectures*
- ✓ *Demonstration-based laboratory classes*
- ✓ *Microscopy and slide-based learning*
- ✓ *Virtual microscopy and digital histology resources*
- ✓ *Group discussion and problem-solving exercises*
- ✓ *Animation-assisted learning for cellular processes*
- ✓ *Case-based learning and mini-project assignments*

Suggested Field / Industrial Exposure

Students may undergo exposure visits/training at:

- ✓ *University central instrumentation facilities*
- ✓ *Indian Council of Medical Research laboratories*
- ✓ *Department of Biotechnology supported centres*
- ✓ *Council of Scientific and Industrial Research laboratories*
- ✓ *Regional biomedical and life science research institutes*
- ✓ *Diagnostic laboratories (Government/Corporate)*

Suggested Readings

- ✓ *Alberts, B. et al. (2008). Molecular Biology of the Cell, V Edition, Garland Publishing.*
- ✓ *Becker, W.M. et al. (2009). The World of the Cell, VII Edition, Pearson Benjamin Cummings.*
- ✓ *Suvarna, S., Layton, C. and Bancroft, J.D. (2013). Theory and Practice of Histological Techniques, Churchill Livingstone, Elsevier.*
- ✓ *Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach, V Edition, ASM Press and Sinauer Associates.*
- ✓ *Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments, VI Edition, John Wiley & Sons.*
- ✓ *De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology, VIII Edition, Lippincott Williams & Wilkins.*

Major 1.2 **Credit-04**

1.2 Microbiology & Microbial Technologies

Course Objectives

The course is designed to:

- Introduce students to the historical development, scope, and significance of microbiology in modern biological sciences.
- Develop understanding microbial diversity, classification systems, and evolutionary relationships among microorganisms.
- Familiarize students with the structure, physiology, growth, reproduction, and genetics of microorganisms.
- Provide knowledge of microbial culture techniques, isolation methods, sterilization procedures, and microbial quantification.
- Explain the role of microorganisms in agriculture, healthcare, biotechnology, and industrial applications.
- Introduce viruses, bacteriophages, microbial toxins, antibiotics, antivirals, and vaccines with relevance to human health and disease management.
- Develop practical laboratory competencies in microbiological techniques, staining procedures, microbial culture maintenance, and growth analysis.

Course Outcomes (COs)

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

CO1: Describe the historical milestones in microbiology and explain the contributions of pioneering microbiologists to the development of microbial sciences.
CO2: Classify microorganisms using modern taxonomic systems and explain the evolutionary significance of microbial diversity.
CO3: Demonstrate understanding of microbial structure, nutrition, growth, reproduction, and genetic recombination mechanisms.
CO4: Apply microbiological techniques for sterilization, isolation, culture, maintenance, staining, and quantification of microorganisms.
CO5: Explain the beneficial and pathogenic roles of microorganisms in agriculture, healthcare, environmental systems, and biotechnology.
CO6: Describe viral structure, replication, transmission, microbial toxins, and the principles of antibiotics, antivirals, and vaccine action.
CO7: Perform fundamental microbiological laboratory procedures following biosafety and aseptic practices relevant to research and industrial microbiology.

Course Structure

UNIT-I

History and development of microbiology: Biogenesis and abiogenesis, Contribution of Francesco Redi, Lazzaro Spallanzani, John Needham, Louis Pasteur, John Tyndall, Joseph Lister, Robert Koch (germ theory), Edward Jenner and Alexander Fleming`s experiments on discovery of Penicillin, Modern trends and future scope of Microbiology.

UNIT-II

Microbial systems of classification: General features of Bergey's manual for classification of microbes, Whittakar's five kingdom concept, Carl Woese's 3 domain classification, Lynn Margulis theory of endosymbiotic theory. General features of Archaea: Structure, Nutrition.and Reproduction. General features, pathogenicity of Mycoplasma, Rickettsia and Spirochaetes.

UNIT-III

Isolation, culture and maintenance of microorganisms: Microbial growth, continuous culture (chemostat), Factors influencing growth of microbes, Role of microbes in agriculture and healthcare industry. Reproduction of Eubacteria, Genetic recombination in bacteria (Transformation, Conjugation and Transduction).

UNIT-IV

Virion and viroids: General characteristics and classification of viruses, morphology, nature of viral transmission. Bacteriophage replication, Oncoviruses & HIV: structure, transmission, pathogenicity and replication. Microbial toxins: types, mode of actions and pathogenicity (Exo and Endo-toxin). Antibiotics and their mode of action, Anti-virals and vaccine.

PRACTICAL

1. Study on aseptic techniques in microbiology: various methods of sterilization process.
2. Preparation and formulation of microbial media and methods of inoculation.
3. Methods of isolation of bacteria: spread plate, streak plate, pour plate, serial dilution.
4. Sampling and quantification of microorganisms in air, water and soil.
5. Morphological identification of microorganisms from various habitats through simple staining, differential staining, acid fast staining, spore staining.
6. Methods of microscopic measurements, micrometer (ocular and stage), haemocytometer.
7. Preparation of bacterial growth curve.

Suggested Teaching–Learning Methods

- ✓ *Interactive lectures and demonstrations*
- ✓ *Laboratory-based experiential learning*
- ✓ *Problem-solving and case studies*
- ✓ *Virtual microbiology simulations*
- ✓ *ICT-enabled microbial identification tools*
- ✓ *Industry and laboratory exposure visits*
- ✓ *Student seminars and mini-projects*

Suggested Field / Industrial Exposure

Students may undergo training/exposure visits at:

- ✓ *Clinical and Diagnostic Laboratories*
- ✓ *Industrial and Applied Microbiology Facilities (Fermentation and food industries, pharmaceutical industries, Biotechnology companies, Water quality testing laboratories*
- ✓ *Research Institutions (Council of Scientific and Industrial Research institutes (IMMT), Department of Biotechnology supported centres (ILS), Regional Medical Research Centre, Bhubaneswar)*
- ✓ *Environmental and Agricultural Microbiology Unit**s** (CRRI, CIFA, OUAT)*

Suggested Reading

- ✓ Tortora GJ, Funke BR and Case CL(2008). Microbiology: An Introduction .9th edition. Pearson Education
- ✓ Madigan M T, Martinko J M, Dunlap P V and Clark D P. (2014). Brock Biology of Microorganisms. 14th edition. Pearson International Edition
- ✓ Cappucino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited
- ✓ Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott's Microbiology. 9th Edition. McGraw Hill International.
- ✓ Atlas RM. (1997). Principles of Microbiology. 2nd edition. WM. T. Brown Publishers.
- ✓ Pelczar MJ, Chan ECS and Krieg NR.(1993). Microbiology. 5th edition. McGraw Hill Book Company.
- ✓ Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5th edition. McMillan.

Major 1.3 **Credit-04**

1.3 Zoological Museum Technology

Course Objectives
The course is designed to provide practical and technical knowledge in zoological museum technology, including specimen collection, preservation, taxidermy, skeletal preparation, documentation, curation, and museum display management. The course aims to develop professional competencies required for natural history museums, biodiversity repositories, wildlife institutions, and academic collections.

Course Outcomes (COs)
Upon completion of the course, students will be able to:
CO1: Understand ethical and scientific methods of specimen collection and preservation.
CO2: Perform basic taxidermy and wet preservation techniques.
CO3: Prepare and mount skeletal specimens for museum display.
CO4: Maintain museum records and digital databases.
CO5: Design museum displays and dioramas.
CO6: Apply modern documentation and inventory management techniques including QR-code-based cataloging.

Course Structure

UNIT I
Specimen Collection, Preservation and Wet Specimen Techniques (10 Hours)
Specimen Collection and Ethical Practices: Principles and objectives of zoological museums, Ethical and legal considerations in specimen collection, Wildlife protection laws and permissions, Field collection methods for vertebrates and invertebrates, Safety precautions during specimen handling
Anesthetization and Fixation: Principles of anesthetization, Common anesthetic agents, Fixatives and fixation methods, Preparation and use of formalin solutions, Factors affecting fixation quality
Wet Specimen Preservation: Principles of wet preservation, Use of alcohol, formalin, and glycerin, Preservation techniques for: fishes, amphibians, reptiles, invertebrates, Jar preparation and sealing techniques, Prevention of fungal and bacterial contamination

UNIT II
Taxidermy and Mounting Techniques (10 Hours)
Principles of Taxidermy: History and importance of taxidermy, Tools and materials used in taxidermy, Skinning techniques
Tanning and Preservation: Preservation of skins, Tanning agents and procedures, Pest prevention and maintenance,
Mounting Techniques: Stuffing materials and armature preparation, Mounting of: birds, small mammals, reptiles, Posture and anatomical accuracy, Finishing and display preparation

UNIT III
Skeletal Preparation and Osteological Techniques (10 Hours)
Introduction to Osteology: Importance of skeletal collections, Types of skeletal preparations
Skeletal Preparation Methods: Cleaning techniques, Maceration methods, Dermestid beetle cleaning, Degreasing procedures, Whitening and bleaching methods
Skeletal Assembly and Mounting: Bone identification and arrangement, Wiring and mounting techniques, Preparation of articulated skeletons, Conservation and storage of skeletal materials

UNIT IV
Museum Documentation, Curation and Display Management (10 Hours)

Documentation and Cataloguing: Museum accession procedures, Catalog preparation and specimen numbering, Labeling standards and metadata recording, Digital database management
Modern Inventory Systems: QR code and barcode systems, Digitization of museum collections, Image archiving and cloud-based documentation
Museum Display and Archive Management: Principles of exhibition design, Diorama preparation, Habitat simulation: foliage, rocks, backgrounds, Lighting and environmental control, Museum storage and archive maintenance, Pest management in museums

PRACTICAL

- Preparation of formalin and alcohol solutions
- Fixation and preservation of fish and amphibian specimens
- Preparation of wet museum jars,
- Labeling and sealing of preserved specimens
- Safety handling of chemicals
- Skinning demonstration of small vertebrates
- Preparation of study skins
- Basic stuffing and mounting techniques
- Preparation of bird and small mammal models
- Cleaning and maintenance of mounted specimens
- Cleaning and degreasing bones
- Identification of skeletal elements
- Assembly of small vertebrate skeletons
- Preparation of articulated skeletal displays
- Labeling and storage of osteological specimens
- reparation of specimen catalog sheets
- Digital database entry
- QR code generation and tagging
- Diorama preparation using artificial habitat materials
- Designing a small museum display unit

Teaching/Learning Methods

- Lectures
- Demonstrations
- Hands-on practical training
- Museum visits
- Field exposure
- Digital documentation exercises

Suggested Field/Industrial Exposure
Students may visit:

- Natural history museums
- Zoological Survey collections
- Wildlife interpretation centers
- University museums

Possible institutions in Odisha include:

- Zoological Survey of India
- Regional Museum of Natural History
- Nandankanan Zoological Park

Suggested Readings

- ✓ *Hall, E.R. — Collecting and Preparing Study Specimens of Vertebrates*
- ✓ *Simmons, J.E. — Fluid Preservation: A Comprehensive Reference, Bloomsbury Academic, 2025*
- ✓ *Kiersten F. Latham and John E. Simmons - Foundations of Museum Studies: Evolving Systems of Knowledge*
- ✓ *W.J. Holland — Taxidermy and Zoological Collecting*
- ✓ *Knudsen — Museum Registration Methods*
- ✓ *Carter & Walker — Care and Conservation of Natural History Collections*

Major 1.4 **Credit 04**

1.4 Entomology & Integrated Pest Management

Course Objectives

The course is designed to:

- Introduce students to the diversity, biology, ecology, and economic importance of insects.
- Develop understanding of major agricultural, medical, veterinary, and forensic insect groups.
- Provide theoretical and practical knowledge of Integrated Pest Management (IPM) approaches for sustainable pest control.
- Train students in pest surveillance, monitoring, identification, and eco-friendly management practices.
- Familiarize students with apiculture, bee management, pollination biology, and commercial bee products.
- Develop hands-on skills in field scouting, biological control methods, trap installation, pesticide safety, and insect preservation techniques.
- Enhance employability and entrepreneurship opportunities in agriculture, pest management industries, apiculture, public health, and environmental management sectors.

Course Outcomes (COs)

After completion of the course, students will be able to:

CO1: Explain the classification, biology, ecological significance, and economic importance of insects including beneficial and harmful species.

CO2: Identify major agricultural insect pests, recognize symptoms of infestation, and apply appropriate pest monitoring and surveillance techniques.

CO3: Demonstrate understanding of Integrated Pest Management principles and evaluate sustainable pest control strategies including biological, botanical, mechanical, and chemical methods.

CO4: Apply practical knowledge of apiculture including hive management, honey extraction, bee health management, and value-added bee products.

CO5: Recognize insects of medical, veterinary, and forensic importance and explain their role in disease transmission and criminal investigations.

CO6: Perform basic entomological field and laboratory techniques such as insect collection, identification, preservation, trap installation, pesticide handling, and vector surveillance.

CO7: Develop technical and entrepreneurial skills relevant to agriculture, pest management services, beekeeping enterprises, public health programs, and environmental consultancy sectors.

Course Structure

UNIT I

Fundamentals of Entomology and Economic Insects (10 Hours)

Introduction to Entomology: Scope and importance of entomology, Insect diversity and classification, General morphology and distinguishing characteristics of insects. **Beneficial& Harmful insects**: pollinators, predators, parasitoids, silk and lac insects, Harmful insects and economic losses, **Major Agricultural Insect Pests:** Major pests of cereals, pulses, oilseeds, fibre crops, fruits and vegetables, Nature of damage and pest symptoms, Economic threshold level and crop loss assessment, **Pest Surveillance and Monitoring**: Principles of pest surveillance, Pest forecasting and monitoring, Introduction to integrated crop protection approaches

UNIT II

Integrated Pest Management (IPM) and Sustainable Pest Control (12 Hours)

Principles and Components of IPM: Concept, history and importance of IPM, Components and strategies of IPM, Sustainable agriculture and ecological pest management, **Insect Biology Relevant to Pest Management**: Reproductive systems and reproductive behaviour, Mating behaviour and insect communication, Life cycles and metamorphosis, **Pest Monitoring Techniques**: Field scouting and sampling methods, Pheromone traps, Light traps, Sticky traps and bait traps, **Sustainable Pest Management Approaches**, Chemical Control (Classification of insecticides, Mode of action, Safe handling, storage and pesticide regulations), Biological and Botanical Control (Biological control agents, Bio-pesticides and microbial pesticides, Botanical pesticides and plant-derived compounds), Mechanical and Cultural Control (Mechanical methods, Cultural practices for pest suppression).

UNIT III

Apiculture and Commercial Beekeeping (8 Hours)

Introduction to Apiculture: Importance of bees in ecosystems and agriculture, Bee species and races, Pollination biology and ecological significance, **Bee Colony Organization and Behaviour:** Social organization of bee colonies, Bee communication and behaviour, **Bee Management Practices:** Hive construction and maintenance, Seasonal management practices, Swarming and migration management, **Bee Products and Entrepreneurship:** Honey flow seasons, Honey extraction and processing, Storage, marketing and quality control, Value-added bee products (wax, propolis, royal jelly, bee pollen), **Bee Health Management:** Bee diseases and pathogens, Bee enemies and predators, Colony protection and management practices

UNIT IV

Medical, Veterinary and Forensic Entomology (10 Hours)

Medical and Veterinary Entomology: Insects of medical and veterinary importance, Mosquitoes, flies, lice, fleas and ticks, Vector-borne diseases and their epidemiology, Insect Vectors and Disease Transmission, Mechanical and biological transmission, Vector surveillance and control measures, Public Health importance of insect vectors, **Introduction to Forensic Entomology:** Scope and applications of forensic entomology, Insect succession on decomposing bodies, Role of insects in criminal investigations, Collection and preservation of forensic entomological evidence

PRACTICAL

1. Entomological Identification and Collection: Identification of major crop pests, Identification of beneficial insects, Identification of termites, borers and disease vectors, Observation of insect developmental stages, Collection and preservation techniques
2. Pest Surveillance and Management: Observation of pest symptoms, Field scouting and sampling techniques, Survey of agricultural and forest insect pests, Installation and demonstration of pheromone and light traps, Preparation of botanical pesticides, Biological control demonstrations, Sprayer calibration and safe pesticide handling
3. Apiculture Training: Identification of bee species, Hive inspection and colony management, Honey extraction and processing methods, Bee disease diagnosis and colony protection practices
4. Medical and Forensic Entomology: Mosquito larval survey, Vector surveillance techniques, Preservation of forensic specimens, Case study analysis in forensic entomology

Suggested Teaching-Learning Methods

- Interactive lectures
- Demonstration-based practical classes
- Field visits and exposure training
- Case studies and problem-solving exercises
- ICT-enabled learning and digital pest identification tools
- Industry interaction and expert lectures
- Suggested Field / Industrial Exposure

Suggested Field/Industrial Exposure

Students may undergo exposure visits/training at:

- State Department of Agriculture
- Integrated Pest Management Centres
- Krishi Vigyan Kendras (KVKs)
- Agrochemical and bio-pesticide industries
- Beekeeping farms and honey processing units
- Apiculture training centres
- Khadi and Village Industries Commission (KVIC) honey units
- Public health departments
- Indian Council for Medical Reseach (ICMR) Vector-borne disease control programs
- Municipal mosquito surveillance units
- Zoological Survey of India
- Indian Council of Agricultural Research (ICAR)
- National Centre for Integrated Pest Management
- Forest departments and biodiversity parks

Suggested Reading

- ✓ *An Outline of Entomology (P.J. Gullan & P.S. Cranston), 2014, 5th Edison, Willey Blackwell*
- ✓ *Borror and DeLong's Introduction to the Study of Insects (C.A. Triplehorn & N.F. Johnson), 2020, Brooks/Cole.*
- ✓ *Entomology and Pest Management (Larry P. Pedigo & Marlin Rice), 2021, Waveland Press.*
- ✓ *A Text of Entomology (N. Arumugam), 2025, Saras Publication, Nagercoil, Tamilnadu, India.*

Major 2.1 **Credit 04**

2.1 Animal diversity

Course Objectives

1. The course is designed to:
2. Introduce students to the diversity and classification of major invertebrate and vertebrate animal groups.
3. Develop understanding of evolutionary trends and phylogenetic relationships among animal phyla.
4. Explain structural, functional, ecological, and adaptive features of representative animal groups.
5. Familiarize students with parasitic adaptations, life cycles, and pathogenicity of medically important helminths.
6. Provide knowledge of biological phenomena such as locomotion, metamorphosis, parental care, migration, social organization, and osmoregulation.
7. Develop understanding of evolutionary transitions from lower invertebrates to higher vertebrates.
8. Enhance observational, analytical, taxonomic, and biodiversity-related competencies relevant to zoological sciences and conservation biology.

Course Outcomes (COs)

CO1: Classify major animal groups from Protista to Mammalia based on distinguishing morphological and evolutionary characteristics.
CO2: Explain structural organization, life processes, adaptations, and ecological significance of representative invertebrate and vertebrate taxa.
CO3: Describe important biological phenomena including locomotion, canal systems, polymorphism, metamorphosis, social organization, osmoregulation, migration, and parental care.
CO4: Interpret evolutionary relationships and phylogenetic significance of major animal groups including protochordates, onychophorans, echinoderms, amphibians, reptiles, birds, and mammals.
CO5: Explain life cycles, pathogenicity, and parasitic adaptations of important helminth parasites affecting human and animal health.
CO6: Analyze adaptive and evolutionary transitions involved in the origin of tetrapods, birds, and mammals.
CO7: Develop skills in zoological identification, comparative analysis, specimen observation, and biodiversity documentation.

Course Structure

UNIT I

Protista to Pseudocoelomates (10 Hours)

Protista: General characteristics and classification up to classes, Locomotion in Protista
Reproduction in Protista, **Porifera:** General characteristics and classification up to classes
Canal system in sponges and its significance, **Cnidaria and Ctenophora:** General characteristics and classification up to classes, Polymorphism in Cnidaria, Corals and coral reefs, Evolutionary significance of Ctenophora, **Platyhelminthes and Nematoda:** General characteristics and classification up to classes, Parasitic adaptations in helminths and helminth parasites of man

UNIT II

Coelomates (10 Hours)

Annelida: General characteristics and classification up to classes, Evolution of coelom and metamerism, **Arthropoda:** General characteristics and classification up to classes, Vision in In insects, Metamorphosis in insects, Parasitic Arthropods, **Onychophora**: General characteristics and Evolutionary significance of Onychophora, Mollusca, **Mollusca:** General characteristics and classification up to classes, Torsion in gastropods, **Echinodermata:** General characteristics and classification up to classes, Water vascular system in echinoderms, Affinities of echinoderms with chordates

UNIT III

Protochordates to Amphibia (10 Hours)

Protochordates: General characteristics and classification up to classes, Phylogeny of protochordates, Retrogressive metamorphosis in urochordates, **Pisces:** General characteristics and classification up to classes, Osmoregulation in fishes, Parental care in fishes; **Amphibia:** General characteristics and classification up to classes, Parental care in amphibians, Origin of tetrapoda.

UNIT IV

Reptiles, Aves and Mammals (10 Hours)

Reptilia: General characteristics and classification up to classes, Poisonous and non-poisonous snakes, Biting mechanism in snakes, **Aves:** General characteristics and classification up to classes, Archaeopteryx as a connecting link, Migration in birds Flight adaptations in birds, **Mammalia:** General characteristics and classification up to classes Evolutionary origin of mammals, Adaptive radiation in mammals

PRACTICAL

1. Identification of representative invertebrate and vertebrate specimens
2. Preparation and use of taxonomic keys
3. Observation of museum specimens and preserved materials
4. Study of coral structures
5. Study of insect metamorphosis
6. Identification of poisonous and non-poisonous snakes
7. Observation of parasitic helminths and life cycle stages
8. Biodiversity documentation and faunal survey techniques
9. Scientific drawing and zoological record maintenance
10. Suggested Field / Industrial Exposure

Suggested Teaching–Learning Methods

- Interactive lectures with multimedia support
- Taxonomic key-based learning
- Museum specimen demonstrations
- Virtual zoology and digital biodiversity resources
- Comparative anatomy and morphology discussions
- Field-based biodiversity observation
- Group discussion and seminar presentations
- Problem-solving and evolutionary case studies
- ICT-enabled taxonomy learning tools
- Student assignments and mini projects

Students may undergo field visits/training at:

- Biodiversity and Wildlife Centers
- Zoological parks and biodiversity parks
- Wildlife sanctuaries and national parks
- Wetland and mangrove ecosystems
- Research and Conservation Institutions
- Zoological Survey of India
- Wildlife Institute of India
- Forest and wildlife departments
- Aquaculture and Fisheries Exposure
- Fisheries, farms and hatcheries
- Aquaculture research centers
- Museum and Taxonomy Exposure
- Natural History Museums
- University museum facilities
- Taxonomic collections and repositories
- Public Health and Parasitology Laboratories
- Vector-borne disease laboratories

AEC Paper I

English: Business Communication

Credits: 4

S. No	Modules	Outcomes
1.	**English Language and Communication: Introduction**	• Communication, its Importance and Factors • Types of Communication • Verbal and Non-verbal Communication • Styles of Communication
2	**English Language and Communication: Listening and Speaking**	• Types of Listening • Speaking to communicate effectively • Style of speaking in Various Situations • English Pronunciation
3	**English Language and Communication: Reading and Writing**	• Reading methods and techniques. • Reading texts to Understand meaning • Writing Process • Writing short and Long texts
4	**English Language and Communication: Grammar and Vocabulary**	• Grammar • Sentence structure • Functions of Language

Reference Book: A Course book for ENGLISH COMMUNICATION (Publisher: Orient BlackSwan)

VAC Paper I

Environmental Studies & Disaster Management

(Credit-3)

Unit 1: Multidisciplinary nature of environmental studies (8 Period)

Definition, scope and importance

Need for public awareness

Environmental Pollution

Definition

• Cause, effects and control measures of:-

a) Air pollution

b) Water pollution

c) Soil pollution

d) Marine pollution

e) Noise pollution

f) Radiation pollution

Unit 2: Natural Resources: (8 Period)

Renewable and non-renewable resources:

Natural resources and associated problems.

a) Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people.

b) Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.

c) Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies.

d) Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, waterlogging, salinity, case studies.

e) Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. Case studies.

Biodiversity:- Introduction-Definition; Biogeographically classification of India

India as a mega diversity nation. Hot sports of biodiversity, Threats to biodiversity. Endangered and endemic species of India. Conservation of biodiversity. In Situ and Ex-so conservation of biodiversity

Unit-3: Disaster Management (8 Period)

1. Disaster Management: Types of disasters (natural and Man-made) and their causes and effect)

2. Vulnerability Assessment and Risk analysis: Vulnerability to various disasters (Flood, Cyclone, Earthquake, Heat waves, Desertification and Lighting)

3. Institutional Framework: Institutional arrangements for disaster management (National Disaster Management Authority (NDMA), State Disaster Management Authority (SDMA), Disaster Management Act, 2005, District Disaster Management Authority (DDMA), National Disaster Response Force(NDRF) and Odisha Disaster Rapid Action Force(ODRAF)

4. Preparedness measures: Disaster Management cycle, Early Warning System, Pre Disaster and Post-Disaster Preparedness, strengthening of SDMA and DDMA, Community Preparedness for flood cyclone, heat waves, fire safety, lightening and snake biting. Stake holders participation, Corporate Social Responsibility (CSR)

5. Survival Skills: Survival skills adopted during and after disaster (Flood, Fire, Earthquake, Cyclone and Lightening), Disaster Management Act-2005, Compensation and Insurance

Unit 4: Social Issues and the Environment (6 Period)

A. a) Environmental Ethics: Issues and possible solutions.

b) Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case studies

c) Environment Protection Act

d) Air (Preservation Control of Pollution) Act

e) Water (Preservation Control of Pollution) Act

f) Wildlife Protection Act

g) Forest Conservation Act

h) Solid waste management Cause, effect and Control Measure of Urban and Industrial waste (Role of each individual in conservation of Natural resources and prevention of pollution)

B. Human Population and the Environment

Population Ecology: Individuals, species, population, community

Human population growth, population control method

Urbanisation and its effect on society

Unit 5: Field work (15 Periods of 30 hrs)

- Visit to an area to document environmental assets: river/forest/flora/fauna, etc.
- Visit to a local polluted site- Urban/Rural/Industrial/Agricultural
- Study of common plants, insects, birds and basic principles of identification.
- Study of simple ecosystems-pond, river, Delhi Ridge , etc.

Semester -II

Major 1.5 **Credit 04**

1.5 Fundamentals in Biochemistry

Course Objectives

The course is designed to:

- Introduce students to the structure, classification, properties, and biological significance of major biomolecules including carbohydrates, lipids, proteins, nucleic acids, and enzymes.
- Develop understanding of molecular organization and biochemical functions of cellular constituents.
- Explain the structural hierarchy and functional significance of proteins and immunoglobulins.
- Familiarize students with nucleic acid chemistry, DNA organization, denaturation-renaturation dynamics, and molecular complementarity.
- Provide knowledge of enzyme classification, kinetics, inhibition, regulation, and catalytic mechanisms.
- Develop analytical understanding of biochemical reactions and molecular interactions relevant to modern biosciences and biotechnology.
- Prepare students for advanced studies and applications in molecular biology, biotechnology, diagnostics, biomedical sciences, and pharmaceutical research.

Course Outcomes (COs)

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

CO1: Describe the structure, classification, properties, and biological importance of carbohydrates, lipids, proteins, nucleic acids, and enzymes.

CO2: Explain the molecular organization and physiological significance of amino acids, proteins, immunoglobulins, and lipid biomolecules.

CO3: Interpret structural and functional relationships in biomolecules including glycoconjugates, phospholipids, nucleic acids, and enzyme systems.

CO4: Analyze DNA structure, complementarity, denaturation-renaturation processes, and different forms of nucleic acids.

CO5: Explain enzyme classification, catalytic mechanisms, enzyme kinetics, inhibition, and regulation of enzyme activity.

CO6: Apply biochemical concepts to understand physiological functions, metabolic regulation, molecular diagnostics, and biomedical processes.

CO7: Develop problem-solving and analytical skills relevant to biochemical experimentation, molecular sciences, biotechnology, and healthcare applications.

Course structure

UNIT I

Carbohydrates & Lipids: Structure and Biological importance: Monosaccharides, Disaccharides, Polysaccharides and Glycoconjugates; Structure and Significance: Physiologically important saturated and unsaturated fatty acids, Tri-acylglycerols, Phospholipids, Glycolipids, Steroids.

UNIT II

Amino Acids & Proteins: Amino acids: Structure, Classification and General properties of α-amino acids; Physiological importance of essential and non-essential α-amino acids.

Proteins: Bonds stabilizing protein structure; Levels of organization in proteins; Renaturation, Denaturation; Introduction to simple and conjugate proteins

Immunoglobulins: Basic Structure, Classes and Function, Antigenic Determinants.

UNIT III

Nucleic Acids: Structure: Purines and pyrimidines, Nucleosides, Nucleotides, Nucleic acids. Cot Curves, Base pairing, Denaturation and Renaturation of DNA, Types of DNA and RNA, Complementarity of DNA, Hypo and Hyperchromaticity of DNA.

UNIT IV

Enzymes: Nomenclature and classification, Cofactors, Specificity of enzyme action, Isozymes, Mechanism of enzyme action, Enzyme kinetics, Factors affecting rate of enzyme-catalyzed reactions, Derivation of Michaelis-Menten equation, Concept of Km and Vmax, Lineweaver- Burk plot, Multi-substrate reactions, Enzyme inhibition, Allosteric enzymes and their kinetics, Regulation of enzyme action.

PRACTICAL

1. Qualitative tests of functional groups in carbohydrates, proteins and lipids.
2. Paper chromatography of amino acids.
3. Estimation of protein by Biuret/ Lowry et al method.
4. Effect of pH, temperature and inhibitors on the action of salivary amylase/Urease/acid oralkaline phosphatase
5. Demonstration of proteins separation by SDS-PAGE and determination of molecular weight of proteins (gel pictures may be used for plotting semi log graph)

Suggested Teaching–Learning Methods

- Interactive lectures with molecular illustrations
- Concept-based teaching using biochemical pathways
- Problem-solving sessions and numerical exercises
- ICT-enabled teaching using animations and molecular visualization tools
- Group discussion and peer learning
- Seminar presentations and case-based learning
- Laboratory and Practical ApproachesAssignment-based learning
- Mini-projects on biomolecules and enzymes
- Scientific literature-based discussions
- Flipped classroom activities
- Biochemical case study analysis

Suggested Field / Industrial Exposure

Students may undergo educational visits/training at:

Biotechnology and Biochemistry Industries

- Biotechnology companies
- Enzyme production industries
- Fermentation industries
- Nutraceutical and food processing industries

Healthcare and Diagnostic Laboratories

- Clinical biochemistry laboratories
- Molecular diagnostic centres
- Pathology and immunology laboratories

Pharmaceutical and Biomedical Industries

- Pharmaceutical manufacturing units
- Vaccine and therapeutic production centres
- Drug discovery and analytical laboratories

Research and Academic Institutions

- Indian Council of Medical Research laboratories
- Council of Scientific and Industrial Research institutes
- Department of Biotechnology supported research centres
- University central instrumentation facilities

Industrial Exposure Components

- Enzyme assay and quality control laboratories
- Protein purification facilities
- Molecular biology and genomics laboratories
- Biochemical instrumentation units

Suggested Readings:

- ✓ *Cox, M.M and Nelson, D.L. (2008). Lehninger's Principles of Biochemistry, VEdition, W.H. Freeman and Co., New York.*
- ✓ *Jeremy M. Berg, Lubert Stryer, John L. Tymoczko, Gregory J. Gatto, Biochemistry, 8th edition, 2015.*
- ✓ *Victor W., Rodwell, David A., Bender, Kathleen M., Botham, Peter J., Kennelly, P. Anthony, Harper's Illustrated Biochemistry, 31st edition.*
- ✓ *Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2008). Molecular Biology of the Gene, VI Edition, Cold Spring Harbor Lab. Press, Pearson Publication.*
- ✓ *Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd., U.K.*
- ✓ *Devasena T. (2010). Enzymology Oxford University Press; 1 edition*
- ✓ *Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry, VI Edition, W.H. Freeman and Co., New York.*

Major 1.6 **Credit 04**

1.6 Molecular Biology

Course Objectives

The course is designed to:

- Introduce students to the molecular organization and functional significance of nucleic acids.
- Develop understanding of DNA replication, repair mechanisms, transcription, translation, and post-transcriptional modifications in prokaryotic and eukaryotic systems.
- Explain the molecular basis of gene expression and regulation including operon systems and regulatory RNAs.
- Familiarize students with mechanisms of RNA processing, alternative splicing, and RNA editing.
- Provide knowledge of molecular control systems such as RNA interference, miRNA, siRNA, and transcriptional regulation.
- Develop laboratory skills in microbial culture techniques, nucleic acid estimation, growth kinetics analysis, and cytogenetic observations.
- Prepare students for advanced studies and applications in molecular genetics, biotechnology, genomics, diagnostics, and biomedical research.

Course Outcomes (COs)

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

CO1: Describe the structure and functional organization of DNA and RNA and explain nucleic acid properties including denaturation, renaturation, Cot curves, and C-value paradox.

CO2: Explain the molecular mechanisms of DNA replication and DNA repair in prokaryotic and eukaryotic organisms.

CO3: Interpret the processes of transcription and translation and compare gene expression mechanisms in prokaryotes and eukaryotes.

CO4: Describe post-transcriptional modifications including RNA splicing, RNA editing, and processing of mRNA, rRNA, and tRNA.

CO5: Explain mechanisms of gene regulation including operon models, enhancers, silencers, RNA interference, miRNA, and siRNA pathways.

CO6: Perform basic molecular biology laboratory techniques including microbial culturing, nucleic acid estimation, and growth kinetics analysis.

CO7: Develop analytical and problem-solving abilities related to molecular processes, gene regulation, and modern molecular biology applications.

Course Structure

UNIT I

Nucleic Acids, DNA Replication & Repair: Salient features of DNA: Watson and Crick model of DNA, DNA denaturation and renaturation kinetics, Cot curves, C-value paradox, Salient features of RNA

DNA Replication in prokaryotes and eukaryotes: Semi-conservative, bidirectional and semi-discontinuous replication, Replication of circular and linear ds-DNA and RNA priming, replication of telomeres.

DNA repair mechanism: Base and nucleotide excision repair in bacteria, Mismatch repair, SOS repair.

UNIT II

Transcription & Translation: Transcription: RNA polymerase and transcription Unit, mechanism of transcription in prokaryotes and eukaryotes, synthesis of rRNA and mRNA, transcription factors and regulation of transcription.

Translation: Genetic code, Degeneracy of the genetic code and Wobble Hypothesis, Process of protein synthesis in prokaryotes: Ribosome structure and assembly in prokaryotes, Fidelity of protein synthesis, Aminoacyl tRNA synthetase and charging of tRNA; Proteins involved in initiation, elongation and termination of polypeptide chain; Inhibitors of protein synthesis; Difference between prokaryotic and eukaryotic translation.

UNIT III

Post Transcriptional Modifications and Processing of Eukaryotic RNA : Structure of globin mRNA; Split genes: concept of introns and exons, splicing mechanism, alternative splicing, exon shuffling, and RNA editing, Processing of rRNA and tRNA.

UNIT IV

Gene Regulation &Regulatory RNAs: Transcription regulation in prokaryotes: Principles of transcriptional regulation with examples from Lac-operon and Trp-operon; Transcription regulation in eukaryotes: Activators, repressors, enhancers, silencer elements; Gene silencing, RNA interference, miRNA, si-RNA.

PRACTICAL

1. Study of Polytene chromosomes from Chironomous / Drosophila larvae.
2. Preparation of liquid culture medium (LB) and raise culture of E. coli.
3. Estimation of the growth kinetics of *E. coli* by turbidity method.
4. Preparation of solid culture medium (LB) and growth of *E. coli* by spreading and streaking.
5. Quantitative estimation of calf thymus DNA using colorimeter (Diphenylamine reagent) or spectrophotometer (A 260 nm measurement).
6. Quantitative estimation of RNA using Orcinol reaction.
7. Study and interpretation of electron micrographs/photograph showing (a) DNA replication, (b) Transcription and (c) Split genes.

Suggested Teaching–Learning Methods

- Interactive lectures with molecular illustrations and animations
- Concept-oriented teaching of central dogma and gene regulation
- Comparative analysis of prokaryotic and eukaryotic systems
- Problem-solving sessions and molecular case studies
- ICT-enabled teaching using digital molecular models
- Group discussions and student seminars

Suggested Field / Industrial Exposure

- Students may undergo educational visits/training at:
- Molecular Biology and Biotechnology Laboratories
- Biotechnology and Pharmaceutical Industries
- Biotechnology industries
- Vaccine production facilities
- Pharmaceutical research laboratories
- Fermentation and microbial biotechnology industries
- Clinical and Diagnostic Centres
- Clinical Microbiology Laboratories

Research and Academic Institutions

- Indian Council of Medical Research laboratories
- Council of Scientific and Industrial Research institutes
- Department of Biotechnology supported centres
- University central instrumentation facilities
- Industrial Exposure Components
- DNA/RNA extraction and quantification units
- Molecular imaging and sequencing facilities
- Bioprocessing and fermentation units
- Quality control and molecular testing laboratories

Suggested Readings

- ✓ Karp G, Iwasa J, Marshall W. Karp's Cell and Molecular Biology, 9th Edition. John Wiley and Sons. Inc. ISBN: 978-1-119-59816-9
- ✓ Krebs JE, Goldstein ES, Kilpatrick ST. (2018) Lewin's Gene XII, Jones and Bartlett Publishers, Inc. ISBN: 9781284104493.
- ✓ DeRobertis E. D. P. (2017) Cell and Molecular Biology 8th Edition. ISBN: 10-8184734506, 13-978-8184734508
- ✓ Lodish H, Berk A, Kaiser CA, Kreiger M, Bretscher A, Ploegh H, Amon A, Martin KC. (2016) Molecular Cell Biology.8th Edition. WH Freeman. ISBN: 10-1464183392, 13-978-1464183393
- ✓ *Becker W. M., Kleinsmith L.J., Hardin J, Bertoni G.P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.*
- ✓ *Alberts B, Johnson A, Lewis J, Raff M, Roberts K, Walter P (2002) Molecular Biology of the Cell, 4th Edition. ISBN: 10-0815332181, 13-978-0815332183*
- ✓ *Cooper G.M. and Robert E. Hausman R.E. The Cell: A Molecular Approach***,** *V Edition, ASM Press and Sinauer Associates.*
- ✓ *McLennan A., Bates A., Turner, P. and White M. (2015). Molecular Biology IV Edition. GS, Taylor and Francis Group, New York and London.*
- ✓ *Lewin's Genes XII- by Jocelyn E. Krebs , Elliott S. Goldstein , Stephen T. Kilpatrick*

Major 1.7 **Credit 04**

1.7 Principles of Genetics

Course Objectives

The course is designed to:

1. Introduce students to classical and modern principles of genetics and patterns of inheritance.
2. Develop understanding of Mendelian genetics, linkage, crossing over, chromosomal mapping, and polygenic inheritance.
3. Explain mechanisms of mutation, chromosomal aberrations, and mutagenesis.
4. Familiarize students with sex determination systems and extra-chromosomal inheritance mechanisms.
5. Provide knowledge of recombination in bacteria and viruses and the biological significance of transposable genetic elements.
6. Develop analytical and problem-solving skills in genetic interpretation and chromosomal analysis.
7. Prepare students for advanced studies and applications in molecular genetics, genomics, biotechnology, agriculture, medicine, and biomedical research.

Course Outcomes (COs)

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

CO1: Explain principles of Mendelian and non-Mendelian inheritance including dominance relationships, epistasis, pleiotropy, and polygenic inheritance.

CO2: Analyze linkage, crossing over, recombination frequency, and chromosomal mapping using genetic crosses and numerical approaches.

CO3: Describe different types of gene mutations and chromosomal aberrations and explain their molecular basis and biological consequences.

CO4: Interpret mechanisms of sex determination and extra-chromosomal inheritance in various organisms.

CO5: Explain genetic recombination mechanisms in bacteria and bacteriophages including conjugation, transformation, transduction, and complementation tests.

CO6: Describe the structure, function, and significance of transposable genetic elements in prokaryotes and eukaryotes.

CO7: Develop analytical, quantitative, and critical thinking skills related to genetic problem-solving, hereditary patterns, and mutation analysis.

Course Structure

UNIT I

Mendelian Genetics, Linkage, Crossing Over and Chromosomal Mapping: Principles of inheritance, Incomplete dominance and co-dominance, Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Sex-linked, sex-influenced and sex-limited charactersinheritance. Polygenic inheritance with suitable examples; simple numerical based on it.

Linkage and crossing over, Cytological basis of crossing over, Molecular mechanisms of crossing over including models of recombination, Recombination frequency as a measure of linkage intensity, Two factor and three factor crosses, Interference and coincidence, Somatic cell hybridization.

UNIT II

Mutations: Types of gene mutations (Classification), Types of chromosomal aberrations (Classification, figures and with one suitable example of each), Molecular basis of mutations in

relation to UV light and chemical mutagens; Detection of mutations: CLB and sex- linked visible attached X method.

UNIT III

Sex Determination & Extra-chromosomal Inheritance

Chromosomal mechanisms of sex determination in Drosophila and Man; Criteria for extra-chromosomal inheritance, Antibiotic resistance in Chlamydomonas, Mitochondrial mutations in Saccharomyces, Cytoplasmic inheritance in Paramecium.

UNIT IV

Recombination in Bacteria and Viruses & Transposable Genetic Elements: Conjugation, Transformation, Transduction, Complementation test in Bacteriophage. Transposons in bacteria, Ac-Ds elements in maize and P elements in Drosophila,Transposons in human.

PRACTICAL

1. Study of Mendelian laws and gene interactions.
2. Linkage maps based on data from conjugation, transformation and transduction.
3. Linkage maps based on data from Drosophila crosses.
4. Study of human karyotype (normal and abnormal).
5. Pedigree analysis of some human inherited traits.
6. Experiments on epistatic interactions including test cross and back cross.
7. Experiments on probability and Chi-square test.
8. Study on sex linked inheritance in Drosophila.

Suggested Teaching–Learning Methods

Classroom Teaching Methods

- Interactive lectures using genetic diagrams and inheritance models
- Problem-solving sessions involving genetic crosses and pedigree analysis
- Concept-based teaching of chromosomal behavior and recombination
- ICT-enabled teaching using animations and genomic visualization tools
- Comparative discussion of classical and molecular genetics
- Student seminars and group discussions
- Assignment-based learning
- Case studies on genetic disorders and mutations
- Mini-projects on inheritance patterns and transposable elements
- Flipped classroom and peer-learning activities
- Scientific literature-based discussions
- Bioinformatics and genome database demonstrations
- Simulation of genetic crosses and recombination mapping
- Molecular visualization of chromosomal rearrangements
- Online tools for pedigree and linkage analysis
- Computational interpretation of genetic data

Suggested Field / Industrial Exposure

Students may undergo educational visits/training at:

Genetics and Molecular Biology Laboratories

Biotechnology and Biomedical Industries

Agricultural and Plant Breeding Institutes

Research and Academic Institutions

- Indian Council of Medical Research laboratories
- Council of Scientific and Industrial Research institutes
- Department of Biotechnology supported centres
- National Institute of Biomedical Genomics

Industrial Exposure Components

- Molecular diagnostics and genetic testing laboratories (e.g., InDNA)
- Cytogenetics and karyotyping units (e.g. Needan, GENEX, Lal's Patholab etc)
- Microbial genetics and recombinant DNA facilities (Heredity Life Science)
- Bioinformatics and genomics analysis units (ILS)

Suggested Readings:

- ✓ *Benjamin Cummings. Russell, P. J. (2009). Genetics- A Molecular Approach.IIIEdition.*
- ✓ *Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wileyand Sons Inc.*
- ✓ *Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. Introduction to Genetic Analysis. IX Edition. W. H. Freeman and Co.*
- ✓ *Fletcher H. and Hickey I. (2015). Genetics. IV Edition. GS, Taylor and FrancisGroup, New York and London.*
- ✓ *Benjamin Pierce, (2015) Genetics- A Conceptual Approach, 5th edition, WH Freeman publication*
- ✓ *Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics. XEdition.*

Major 1.8 **Credit 04**

1.8 Immunology

Course Objectives

The course is designed to:

1. Introduce students to the fundamental principles and components of the immune system.
2. Develop understanding of innate and adaptive immune mechanisms and their roles in host defense.
3. Explain antigenicity, immunogenicity, immunoglobulin structure, and antigen-antibody interactions.
4. Familiarize students with immunological techniques including ELISA and radioimmunoassay.
5. Provide knowledge of major histocompatibility complex (MHC), antigen processing, cytokines, and complement pathways.
6. Explain mechanisms of hypersensitivity reactions and advances in vaccine development.
7. Prepare students for advanced studies and applications in immunology, diagnostics, biotechnology, vaccine science, and biomedical research.

Course Outcomes (COs)

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

CO1: Describe the structure, organization, and functions of cells and organs involved in the immune system.

CO2: Differentiate innate and adaptive immunity and explain mechanisms of humoral and cell-mediated immune responses.

CO3: Explain antigenicity, immunogenicity, epitopes, immunoglobulin classes, and antigen-antibody interactions.

CO4: Interpret principles and applications of immunological techniques including ELISA and radioimmunoassay.

CO5: Describe the structure and functions of MHC molecules, cytokines, and complement pathways in immune regulation.

CO6: Explain mechanisms of hypersensitivity reactions and evaluate different types of vaccines and recent advances in vaccine technology.

CO7: Develop analytical and applied understanding of immunological concepts relevant to diagnostics, therapeutics, public health, and biomedical sciences.

Course Structure

UNIT I

Innate and Adaptive Immunity: Cells and organs of the Immune system. Anatomical barriers, Inflammation, Cell and molecules involved in innate immunity, Adaptive immunity (Cell mediated and humoral), passive: Artificial and natural Immunity, Active: Artificial and natural Immunity.

UNIT II

Antigens and Immunoglobulins: Antigenicity and immunogenicity, Immunogens, Adjuvants and haptens, Factors influencing immunogenicity, B and T-Cell epitopes, Immunoglobulins: Structure and functions of different classes of immunoglobulins, Antigen antibody interactions, Immunoassays (ELISA- Direct, Indirect, Competitive, Sandwich and RIA).

UNIT III

Major Histocompatibility Complex, Cytokines and Complement system: Structure and functions of MHC molecules. Endogenous and exogenous pathways of antigenprocessing and presentation; Cytokines – Types, properties and functions, Complement System -Components and pathways of complement activation.

UNIT IV

Hypersensitivity and Vaccines: Gell and Coombs' causes of hypersensitive reactions, classification and brief description of various types of hypersensitivities.
Vaccines -**v**arious types of vaccines, Advances in vaccine production.

PRACTICAL

1. Study of lymphoid organs.
2. Histological study of spleen, thymus, skin and lymph nodes through slides/ photographs
3. Preparation of stained blood film to study various types of White blood cells.
4. ABO blood group determination.
5. Total WBC counting.
6. Differential count.
7. WIDAL Test.
8. Demonstration of ELISA.
9. Demonstration of Bone marrow smears to study Immune cells.
10. ICT Tests

Suggested Teaching–Learning Methods

Classroom Teaching Methods

- Interactive lectures using immunological diagrams and flowcharts
- Concept-based teaching of immune mechanisms and pathways
- ICT-enabled teaching using animations and immunology simulations
- Comparative discussions on innate and adaptive immunity
- Case-based learning on immunological disorders and vaccines
- Student seminars and group discussions
- Assignment-based learning
- Mini-projects on vaccines and immunological disorders
- Scientific literature discussions
- Peer teaching and flipped classroom activities
- Clinical and epidemiological case analysis

Digital and Computational Learning

- Molecular visualization of antibodies and MHC molecules
- Online immunology databases and vaccine resources
- Simulation of immune pathways and complement activation
- Bioinformatics tools for immunological analysis
- Data interpretation of immunological assays

Suggested Field / Industrial Exposure

Students may undergo educational visits/training at:

- Immunology and Diagnostic Laboratories
- Clinical immunology laboratories
- Molecular diagnostic centres

- Serology and pathology laboratories
- Vaccine testing and quality control laboratories
- Biotechnology and Pharmaceutical Industries
- Vaccine production industries
- Biotechnology companies
- Immunodiagnostic manufacturing units
- Pharmaceutical and biomedical industries
- Healthcare and Public Health Institutions
- Hospitals and healthcare diagnostic facilities
- Epidemiology and public health laboratories
- Blood banks and transfusion centres

Research and Academic Institutions

- Indian Council of Medical Research laboratories
- Department of Biotechnology supported centres
- Council of Scientific and Industrial Research institutes
- National Institute of Immunology
- Industrial Exposure Components
- Immunodiagnostic kit production units
- Vaccine manufacturing and formulation facilities
- ELISA and molecular testing laboratories
- Biomedical instrumentation and quality assurance units

Suggested Readings:

- ✓ *Abbas K. Abul and Lechtman H. Andrew (2017). Cellular and Molecular Immunology. V Edition. Saunders Publication.*
- ✓ *Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J (2017). Immunology, VIEdition. W.H. Freeman and Company.*
- ✓ *Fahim Halim Khan (2009). The Elements of Immunology. Pearson Education.*
- ✓ *Peter J. Delves and Seamus J. Martin (2017) Roitt's Essential Immunology, Wiley-Blackwell; 13th edition.*
- ✓ *Immunology- Weir*
- ✓ *Lab manual in Biochemistry, Immunology and Biotechnology- Arti Nigam and Archana Ayyagari (McGraw-Hill Education (India).*

Major 2.2 **Credit 04**

2.2 Physiology: Life Sustaining Systems

Course Objectives

The course is designed to:

1. Introduce students to the physiological organization and functioning of major life-sustaining systems in animals and humans.
2. Develop understanding of digestive, respiratory, renal, circulatory, and cardiovascular physiology.
3. Explain the mechanisms underlying nutrient digestion, absorption, gas exchange, excretion, and maintenance of homeostasis.
4. Familiarize students with physiological regulation of blood composition, cardiac activity, respiration, and fluid-electrolyte balance.
5. Provide knowledge of blood physiology, haemopoiesis, blood groups, haemoglobin function, and clotting mechanisms.
6. Explain the physiological basis of health, disease, and adaptation in relation to life-supporting systems.
7. Prepare students for advanced studies and careers in physiology, biomedical sciences, healthcare, biotechnology, and clinical research.

Course Outcomes (COs)

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

CO1: Describe the structural organization and physiological functions of the gastrointestinal tract and associated digestive glands.

CO2: Explain the mechanisms of digestion, absorption, and hormonal regulation of gastrointestinal functions.

CO3: Interpret respiratory processes including pulmonary ventilation, gaseous exchange, transport of respiratory gases, and regulation of respiration.

CO4: Explain renal physiology including urine formation, osmoregulation, acid-base balance, and homeostatic regulation of kidney functions.

CO5: Describe the composition and functions of blood, haemopoiesis, haemoglobin, blood coagulation mechanisms, and blood group systems.

CO6: Explain the structure and physiology of the heart, cardiac cycle, electrocardiography, blood pressure regulation, and cardiovascular homeostasis.

CO7: Analyze physiological data and relate organ system functions to maintenance of health, homeostasis, and disease conditions.

Course Structure

UNIT I

Physiology of Digestion

Structural organization and functions of gastrointestinal tract and associated glands; Mechanical and chemical digestion of food; Absorptions of carbohydrates, lipids, proteins, water, minerals and vitamins; Hormonal control of secretion of enzymes in Gastrointestinal tract.

UNIT II

Physiology of Respiration

Histology of trachea and lung; Mechanism of respiration, Pulmonary ventilation; Respiratory volumes and capacities; Transport of oxygen and carbon dioxide in blood; Respiratory pigments, Dissociation curves and the factors influencing it; Carbon monoxide poisoning; Control of respiration.

UNIT III

Renal Physiology

Structure of kidney and its functional unit, Mechanism of urine formation, Regulation of water balance, Regulation of acid-base balance, Homeostatic regulation of tubular reabsorption and secretion.

UNIT IV

Blood and Physiology of Heart

Haemopoiesis, Components of blood and their functions; Structure and functions of haemoglobin, Blood clotting system, Blood groups: Rh factor, ABO and MN.

Structure of mammalian heart, Coronary circulation, Origin and conduction of cardiac impulses Cardiac cycle; Cardiac output and its regulation, Frank-Starling Law of the heart, nervous and chemical regulation of heart rate. Electrocardiogram, Blood pressure.

PRACTICAL

1. Determination of Blood group and Rh factor
2. Enumeration of red blood cells and white blood cells using haemocytometer.
3. Preparation of blood smear for differential count.
4. Estimation of haemoglobin using Sahli's haemoglobinometer.
5. Preparation of haemin and haemochromogen crystals.
6. Recording of blood pressure using a sphygmomanometer.
7. Examination of sections of mammalian slides: oesophagus, stomach, duodenum, ileum,rectum liver, trachea, lung, kidney.

Suggested Teaching–Learning Methods

Classroom Teaching Methods

- Interactive lectures supported by physiological diagrams and flowcharts
- ICT-enabled teaching using animations and virtual physiology simulations
- Case-based learning on physiological disorders
- Concept mapping of organ systems and regulatory pathways
- Student seminars and group discussions
- Problem-solving exercises involving physiological data interpretation

Digital and Computational Learning

- Virtual physiology laboratory simulations
- ECG and spirometry software demonstrations
- Digital anatomy and physiology atlases
- Online physiological databases and educational platforms
- Computer-assisted analysis of physiological parameters

Suggested Field / Industrial Exposure

Students may undergo educational visits and training at:

Healthcare and Diagnostic Facilities

- Clinical diagnostic laboratories
- Hospital physiology departments
- Cardiology and pulmonary function laboratories
- Blood banks and transfusion centres

Biotechnology and Pharmaceutical Industries

- Biomedical device manufacturing units
- Pharmaceutical research and development laboratories
- Clinical trial and pharmacology centres
- Healthcare technology companies

Research and Academic Institutions

- Indian Council of Medical Research laboratories
- All India Institute of Medical Sciences
- Council of Scientific and Industrial Research institutes
- National Institute of Nutrition
- University physiology and biomedical science laboratories

Suggested Readings:

- ✓ *Guyton & Hall, (2016) Textbook of Medical Physiology. Elsevier, 12th edition.*
- ✓ *Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons.*
- ✓ *Marieb E.N. and Hoehn K.N. (2009) Human Physiology. Pearson EducationPublication , 9th edition*
- ✓ *Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functionalcorrelations. XII Edition. Lippincott W. & Wilkins.*
- ✓ *Vander A Sherman J. and Luciano D. (2014). Vander's Human Physiology: TheMechanism of Body Function. XIII Edition, McGraw Hills.*
- ✓ *Moyes C.D., Schulte PM (2016), Principles of physiology, 2nd edition, Pearsoneducation, 3rd.*
- ✓ *Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. W.B. Saunders Company.*

AEC Paper II

English: Word and Presentation skill

Credits: 4

S. No	Modules	Outcomes
1.	**Basic Communication**	● Explain: ○ Structures in present and present continuous tense ○ Structures in past & past continuous tense ○ Structure in present perfect & present perfect continuous tense ○ Structures in future tense ○ Modals: helping verbs ○ Prepositions ○ Idioms ● Practice speech on a given topic. ● Practice Extempore speech
2	**Communication**	● Describe communication. ● Describe the Process of communication. ● Discuss the Importance of communication ● Explain various Types of communication. ● Demonstrate Useful Phrases for Everyday Use ● Explain the technique of Asking Questions
3	**Hotel English**	● Describe the Essential qualities of a good speaker. ● Discuss Speech improvement- pronunciation. ● Explain the importance of Stress in speech. ● Describe Intonation and modulation. ● Describe Common phonetics- difficulties

VAC Paper I

Good Citizenship

Credits:3

Objectives/Learning Goals of the Course

- Development of good human being and a responsible citizen
- Developing a sense of right and wrong leading to ethically correct behavior.
- Inculcating a positive attitude and a healthy work culture.

Learning Objectives:

- Understanding Basic Values of Indian Constitution.
- Understand how to be a patriot.
- Develop professionalism and understand the ethics relating to various professions.

1. **Indian Constitution (1 Credit= 15 hours)**

   Salient Values of Preamble: Sovereign, Socialist, Secular, Democratic, Republic, Justice, Liberty, Equality and Fraternity

2. **Patriotism (1 Credit= 15 hours)**

   Patriotic Value and ingredients of nation building, Concept of Good Citizenship, Emotional connection with the country, Duties of citizens and Qualities of good citizens

3. **Work Ethics (1 Credit= 15 hours)**

   Punctuality, Cleanliness, Law abidingness, Rational Thinking and Scientific Temper

Semester -III

Major 1.9 **Credit 04**

1.9 Biochemistry of Metabolic Processes

Course Objectives

The course is designed to:

1. Introduce students to the fundamental concepts of intermediary metabolism and cellular bioenergetics.
2. Develop understanding of catabolic and anabolic pathways involved in carbohydrate, lipid, and protein metabolism.
3. Explain the biochemical mechanisms of ATP generation, oxidative phosphorylation, and mitochondrial electron transport systems.
4. Familiarize students with metabolic regulation, compartmentalization, reducing equivalents, and metabolic integration.
5. Provide knowledge of glycolysis, citric acid cycle, pentose phosphate pathway, gluconeogenesis, glycogen metabolism, fatty acid metabolism, ketogenesis, and amino acid catabolism.
6. Develop analytical understanding of metabolic disorders and biochemical regulation of cellular energy pathways.
7. Prepare students for advanced studies and applications in biochemistry, biotechnology, molecular medicine, nutrition, and biomedical research.

Course Outcomes (COs)

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

CO1: Explain the organization of metabolic pathways and distinguish between catabolic and anabolic processes in living systems.

CO2: Describe the biochemical pathways and regulatory mechanisms involved in carbohydrate metabolism including glycolysis, TCA cycle, gluconeogenesis, glycogenolysis, and glycogenesis.

CO3: Interpret lipid metabolic pathways including β-oxidation, omega oxidation, fatty acid biosynthesis, and ketogenesis.

CO4: Explain amino acid metabolism including transamination, deamination, urea cycle, and metabolic fate of glucogenic and ketogenic amino acids**.**

CO5: Describe mitochondrial electron transport systems, oxidative phosphorylation, redox reactions, and mechanisms of ATP generation.

CO6: Analyze metabolic regulation, energy transfer, enzyme-mediated reactions, and the effects of inhibitors and uncouplers on cellular respiration.

CO7: Develop analytical and problem-solving skills related to biochemical metabolism, energy homeostasis, and metabolic disorders

Course Structure

UNIT I

Overview of Metabolism: Catabolism vs Anabolism, Stages of catabolism, Compartmentalization of metabolic pathways, Shuttle systems and membrane transporters; ATP as "Energy Currency of cell"; coupled reactions; Use of reducing equivalents and cofactors; Intermediary metabolism and regulatory mechanisms.

UNIT II

Carbohydrate Metabolism: Sequence of reactions and regulation of glycolysis, Citric acid cycle, Pentose Phosphate Pathway, Gluconeogenesis, Glycogenolysis and Glycogenesis.

UNIT III

Lipid and protein Metabolism: B-oxidation and omega -oxidation of saturated fatty acids with even and odd number ofcarbon atoms; Biosynthesis of palmitic acid; Ketogenesis.

Catabolism of amino acids: Transamination, Deamination, Urea cycle; Fate of C-skeleton of Glucogenic and Ketogenic amino acids.

UNIT IV

Oxidative Phosphorylation: Redox systems; Review of mitochondrial respiratory chain, Inhibitors and un-couplers ofElectron Transport System.

PRACTICAL

1. Estimation of total protein in given solutions
2. Measurement of SGOT and SGPT activity.
3. Determination of GSH level in serum/tissue.
4. Measurement of GST activity.
5. To study the enzymatic activity of Trypsin/ Lipase.
6. To perform the Acid and Alkaline phosphatase assay from serum/ tissue.
7. Dry Lab (Virtual): To trace the labelled C atoms of Acetyl-CoA till they evolve as CO_2 in the TCA cycle.

Suggested Teaching–Learning Methods

- Interactive lectures with biochemical pathway illustrations
- Concept-based teaching using metabolic maps
- ICT-enabled teaching using animations and molecular visualizations
- Problem-solving sessions on metabolic regulation and energetics
- Group discussions and seminar presentations
- Case-based learning on metabolic disorders
- Assignment-based learning
- Mini-projects on metabolic disorders and energy metabolism
- Scientific literature discussions
- Peer teaching and flipped classroom activities
- Clinical and nutritional case studies

Suggested Field / Industrial Exposure

Students may undergo educational visits/training at:

Biochemistry and Biotechnology Laboratories

- Clinical biochemistry laboratories
- Molecular metabolism research laboratories
- Enzyme and fermentation industries

Healthcare and Diagnostic Centres

- Clinical diagnostic laboratories
- Metabolic disorder screening centres
- Nutritional biochemistry laboratories

Pharmaceutical and Biomedical Industries

- Pharmaceutical manufacturing units
- Drug metabolism and toxicology laboratories
- Nutraceutical and biomedical industries

Research and Academic Institutions

- Indian Council of Medical Research laboratories
- Council of Scientific and Industrial Research institutes
- Department of Biotechnology supported centres
- University central instrumentation facilities

Industrial Exposure Components

- Metabolic assay and quality control laboratories
- Enzyme production and industrial fermentation units
- Biomedical instrumentation facilities
- Molecular diagnostics and analytical laboratories

Suggested Readings:

- ✓ *Cox, M.M and Nelson, D.L. (2008). Lehninger Principles of Biochemistry, V Edition, W.H. Freeman and Co., New York.*
- ✓ *Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). Harper's Illustrated Biochemistry, XXVIII Edition, International Edition,The McGraw-Hill Companies Inc.*
- ✓ *Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007).Biochemistry, VI Edition, W.H. Freeman and Co., New York.*
- ✓ *Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd., U.K.*
- ✓ *Satyanarayan and Chakrapani, (2017) Biochemistry, Elsevier; Fifth edition.*

Major 1.10 **Credit 04**

1.10 Biostatistics & Bioinformatics

Course Objectives

The course is designed to:

- Introduce students to the principles and applications of biostatistics in biological sciences and research.
- Develop understanding of statistical methods including descriptive statistics, probability distributions, hypothesis testing, correlation, and regression analysis.
- Familiarize students with biological databases, sequence analysis, phylogenetics, and genome organization.
- Provide knowledge of computational tools used in bioinformatics, genomics, proteomics, and protein structure prediction.
- Develop analytical and quantitative skills for interpretation of biological and molecular datasets.
- Explain applications of bioinformatics and statistical analysis in modern biotechnology, healthcare, genomics, and drug discovery.
- Prepare students for advanced studies and careers in bioinformatics, computational biology, biotechnology, biomedical data science, and research analytics.

Course Outcomes (COs)

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

CO1: Explain principles of biostatistics including data collection, descriptive statistics, probability distributions, and inferential statistical methods.

CO2: Apply statistical tools such as t-test, chi-square test, ANOVA, correlation, and regression for analysis and interpretation of biological data.

CO3: Describe biological databases, sequence data formats, and methods for biological data storage, retrieval, and analysis.

CO4: Perform sequence alignment and interpret phylogenetic relationships using computational approaches and scoring matrices.

CO5: Explain genome organization, transcriptomics, proteomics, and comparative genomic features of model organisms.

CO6: Describe protein structural hierarchy, structure prediction methods, Ramachandran plots, and applications in rational drug design.

CO7: Develop computational, analytical, and problem-solving skills relevant to biostatistics, bioinformatics, genomics, and biomedical research.

Course Structure

UNIT I

Introduction: definition and scope of biostatistics. Concepts of population and methods of sampling. Simple random sampling, stratified sampling, systematic and clustered sampling. Types of biological data: Qualitative and quantitative, cross sectional and time series, discrete and continuous. Data Measurement scales: Nominal, ordinal, interval and ratio. Data presentation: Tabular and graphical. Histogram and Frequency distribution, cumulative frequency distributions and its graphical representation

UNIT II

Basic concept of measures of Central tendency and Dispersion. Mean, Median and Mode. Arithmetic, Geometric and Harmonic means. Measure of Range, Variance (sample and population), Quartile deviation, Mean deviation, Standard deviation and their relative measures.

UNIT III

Probability distributions: Normal (Dispersion percentage & Z-score) and bionomial distribution. Inferential statistics: Hypothesis testing (Null hypothesis), p-value, X^2 test, t-test (one sample t-test and paired sample t-test). Principal component analysis

UNIT IV

Introduction to bioinformatics and its web resources: NCBI, EMBL-EBI, ExPASy, etc. Biological data resources, access and management. Various genome across the tree of life and major sequencing projects. Data base to store and analyze DNA, RNA, protein sequences and 3-D structures (motifs and domians). Local and Global Sequence alignment programs. Genome and protein BLAST. Scoring matrices, E-value and Bit-score. OTUs and molecular phylogenetics.

PRACTICAL

- Manual and spreadsheet/software tools for descriptive statistics (mean, median, mode, standard deviation, standard error of mean)
- Graphical presentation of Data
- Hypothesis testing: Students' t-Test (paired, unpaird), Chi-square test and ANOVA
- Introduction to different operating systems - UNIX, LINUX and Windows
- Introduction to bioinformatics databases (any three): NCBI/PDB/DDBJ, Uniprot, PDB
- Sequence retrieval using BLAST
- Sequence alignment & phylogenetic analysis using clustalW & phylip
- Picking out a given gene from genomes using Genscan or other softwares (promoter
- Region identification, repeat in genome, ORF prediction). Gene finding tools (Glimmer, GENSCAN), Primer designing, Genscan/Genetool
- Protein structure prediction: primary structure analysis, secondary structure prediction using psipred, homology modeling using Swissmodel. Molecular visualization using jmol, Protein structure model evaluation (PROCHECK)
- Prediction of different features of a functional gene

Suggested Teaching–Learning Methods

- Interactive lectures with statistical and computational demonstrations
- Problem-solving sessions and numerical exercises
- ICT-enabled teaching using bioinformatics software and databases
- Concept-based discussions on genomics and computational biology
- Student seminars and group presentations
- Case studies on biological data analysis and drug discovery
- Assignment-based learning
- Mini-projects on biological datasets and genome analysis
- Scientific literature discussions
- Flipped classroom and peer-learning activities
- Data interpretation and case-based exercises

Suggested Field / Industrial Exposure

Students may undergo educational visits/training at:
Bioinformatics and Computational Biology Centres

- Genomics and proteomics laboratories
- Computational biology research centres
- Biomedical data analytics laboratories

Biotechnology and Pharmaceutical Industries

- Drug discovery and molecular modelling industries
- Biotechnology companies
- Genomics and sequencing facilities
- Bioinformatics service industries

Research and Academic Institutions

- Indian Council of Medical Research laboratories
- Council of Scientific and Industrial Research institutes
- Department of Biotechnology supported centres
- National Institute of Biomedical Genomics

Industrial Exposure Components

- Biological database management systems
- Genomic sequencing and analysis facilities
- Protein modelling and computational drug design units
- Biostatistics and biomedical analytics laboratories

Suggested Reading

- ✓ *Chainy GBN, Mishra G., Mohanty P.K. Biostatistics-Theory and Applications. Kalyani Publishers (2019).*
- ✓ *W. Danial: Biostatistics: A foundation for Analysis in Health Sciences, John Wiley and Sons Inc; 2004.*
- ✓ *Banerjee P.K. Introduction to Biostatistics (A Textbook of Biometry), S Chand and Company Ltd., New Delhi. 2004.*
- ✓ *Saxena Sanjay (2003) A First Course in Computers, Vikas Publishing House*
- ✓ *Pradeep and Sinha Preeti (2007) Foundations of Computing, 4th ed., BPB Publications*
- ✓ *Lesk M.A. (2008) Introduction to Bioinformatics. Oxford Publication, 3rd International*
- ✓ *Student Edition*
- ✓ *Rastogi S.C., Mendiratta N. and Rastogi P. (2007) Bioinformatics: methods and applications, genomics, proteomics and drug discovery, 2nd ed. Prentice Hall India Publication*
- ✓ *Primrose and Twyman (2003) Principles of Genome Analysis & Genomics. Blackwell.*

Major 1.11 **Credit 04**

1.11 Instrumentation & Techniques in Biology

Course Objectives

The course is designed to:

- Introduce students to the principles, instrumentation, operation, and applications of major analytical and molecular biology techniques used in biological sciences.
- Develop understanding of microscopy, spectroscopy, electrochemical techniques, radioisotope methods, centrifugation, chromatography, electrophoresis, blotting techniques, and flow cytometry.
- Familiarize students with modern laboratory instrumentation used in biological research, diagnostics, biotechnology, and pharmaceutical industries.
- Provide knowledge of molecular separation, identification, quantification, and characterization techniques for proteins, nucleic acids, and cellular components.
- Develop analytical skills for interpretation of biological data generated from advanced instrumentation.
- Enhance practical competencies required for research laboratories, biotechnology industries, and diagnostic facilities.
- Prepare students for advanced studies and careers in biotechnology, molecular biology, biomedical sciences, diagnostics, pharmaceutical sciences, and research.

Course Outcomes (COs)

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

CO1: Explain the principles, instrumentation, operation, and applications of light, fluorescence, and electron microscopes used in biological sciences.

CO2: Describe the principles and applications of UV-Visible spectroscopy, electrochemical techniques, pH measurements, and radioisotope-based analytical methods.

CO3: Apply principles of centrifugation and chromatography for separation, purification, and analysis of biological molecules.

CO4: Explain the methodology and applications of protein and nucleic acid electrophoresis techniques used in research and diagnostics.

CO5: Describe the principles, instrumentation, and applications of Southern, Northern, and Western blotting techniques.

CO6: Interpret the basic principles and applications of flow cytometry in cellular and molecular analyses.

CO7: Develop technical and analytical skills for handling biological instrumentation, interpreting experimental data, and applying modern techniques in research, diagnostics, and industrial settings.

Course Structure

UNIT I

Microscopic: Instrumentation and operation of Principle of Light, Fluorescence and Electron Microscopes and their applications.

UV-Visible absorption Spectroscopy: Principle, instrumentation and application.

Principles of electrochemical techniques: Electrochemical cells and reactions, potentiometry and voltammetry, pH electrode.

Radioisotope techniques: Measurement of radioactivity in biological materials (carbon dating, Geiger-Muller counting and liquid scintillation counting).

UNIT II

Centrifugation techniques: Basic principles of sedimentation, Rotor types, Types of centrifugation. **Chromatographic techniques**: Principles of chromatography (Adsorption and Partition chromatography), Planar chromatography (Paper and Thin-layer chromatography), Column chromatography (Gas chromatography, Gel exclusion/permeation chromatography, Ion exchange chromatography, Affinity chromatography, HPLC).

UNIT III

Electrophoretic techniques: Principle and applications of electrophoresis of proteins (SDS-PAGE, native gels, gradient gels, isoelectric focusing gels and two dimensional gels) and Nucleic acids (Agarose gel electrophoresis).

UNIT IV

Blotting techniques: Principle, Instrumentation and applications (Southern, Northern and Western blotting). **Flow cytometry**: Basic principle, Instrumentation and application.

PRACTICAL

1. Calibration of pH meter using standards and determine the pH of water samples.
2. Isolation of genomic DNA from animal tissue/blood.
3. Quantification and purity check of isolated DNA.
4. Agarose gel electrophoresis of DNA.
5. SDS PAGE (Demonstration).
6. Isolation of Mitochondria.
7. Study of Microscopic methods.
8. Study of Microtomy and Histological techniques.
9. Blotting Techniques (Demonstration).

Suggested Teaching–Learning Methods

Classroom Teaching Methods

- Interactive lectures with instrument schematics and animations
- Concept-based teaching using analytical workflows
- ICT-enabled teaching using virtual laboratory platforms
- Demonstration videos of sophisticated instrumentation
- Case studies on biomedical and industrial applications
- Group discussions and student seminars
- Problem-based learning
- Instrumentation-focused assignments
- Mini-projects involving biological data acquisition and analysis
- Peer learning and collaborative laboratory exercises
- Literature review of emerging analytical technologies

Suggested Field / Industrial Exposure

- Students may undergo educational visits and training at:
- Central Instrumentation Facilities of Universities, Advanced Research Instrumentation Centres, Analytical Testing Facilities

- Biotechnology and Molecular Biology Laboratories such as Molecular diagnostics laboratories, Genomics and proteomics centres, Biotechnology research laboratories, Cell culture and molecular biology facilities
- Healthcare and Diagnostic Institutions
- Pharmaceutical and Industrial Laboratories
- Research Organizations; DBT, CSIR, ICAR, ICMR, NISER and IISERs instrumentation facilities.

Suggested Reading

- ✓ *Biochemistry Laboratory: Modern Theory and Techniques: United States Edition - Rodney Boyer.*
- ✓ *Principles and techniques of Biochemistry and Molecular biology- Wilson K and Walker J (Cambridge University press)*
- ✓ *An Introduction to practical Biochemistry- David T. Plummer (Tata McGraw Hill).*
- ✓ *Biochemistry Laboratory: Modern Theory and Techniques: United States Edition - Rodney Boyer.*
- ✓ *Principles and techniques of Biochemistry and Molecular biology- Wilson K and Walker J (Cambridge University press)*
- ✓ *An Introduction to practical Biochemistry- David T. Plummer (Tata McGraw Hill).*
- ✓ *Mark F. Vitha. 2018. Spectroscopy: Principles and Instrumentation. Wiley, ISBN: 978-1-11943660-7.*
- ✓ *Kay Ohlendieck and Stephen E. Harding. 2017. Centrifugation and ultracentrifugation. Basic principles of sedimentation.*
- ✓ *Baraem Ismail and Suzanne Nielsen. 2010. Basic Principles of Chromatography. Food Science Texts Series, DOI 10.1007/978-1-4419-1478-1-27.*
- ✓ *Biophysical Chemistry: Principles and techniques – Upadhyay A, Upadhyay K and Nath N (Himalaya Publishing House).*
- ✓ *A Textbook of Biophysics- R N Roy (NCBA, New Central Book Agency)*

Major 1.12 **Credit 04**

1.12 Animal Biotechnology

Course Objectives

The course is designed to:

1. Introduce students to the principles, scope, and applications of animal biotechnology.
2. Provide knowledge of recombinant DNA technology, cloning vectors, restriction enzymes, and gene cloning methodologies.
3. Familiarize students with molecular techniques including PCR, DNA sequencing, DNA fingerprinting, blotting methods, and DNA microarrays.
4. Explain the production and applications of transgenic and cloned animals in agriculture, medicine, and research.
5. Develop understanding of animal cell culture technologies and expression of recombinant genes.
6. Introduce molecular diagnostic approaches for inherited genetic disorders and recombinant therapeutics.
7. Prepare students for advanced studies and careers in biotechnology, molecular diagnostics, pharmaceutical biotechnology, genetic engineering, and biomedical research.

Course Outcomes (COs)

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

CO1: Explain the principles, scope, and applications of animal biotechnology and recombinant DNA technology.:

CO2: Describe the structure, characteristics, and applications of various cloning and expression vectors used in genetic engineering.

CO3: Apply knowledge of restriction enzymes, genomic and cDNA library construction, transformation techniques, and molecular cloning strategies.

CO4: Explain molecular techniques such as PCR, DNA sequencing, DNA fingerprinting, DNA microarrays, and blotting methods used in modern biotechnology.

CO5: Describe methods for producing cloned and transgenic animals and evaluate their applications in biomedical research and biopharmaceutical production.

CO6: Explain principles of animal cell culture, recombinant protein production, molecular diagnosis of genetic disorders, and gene therapy approaches.

CO7: Develop analytical, technical, and problem-solving skills relevant to biotechnology industries, molecular diagnostics, translational medicine, and biomedical research.

Course Structure

UNIT I

Introduction to Animal Biotechnology: Concept and scope of biotechnology, **Cloning vectors**: Plasmids, Cosmids, Phagemids, Lambda Bacteriophage, M13, BAC, YAC and Expression vectors (characteristics). **Restriction enzymes**: Nomenclature, detailed study of Type II restriction enzymes. **Library construction & Screening:** Construction of genomic and cDNA libraries and screening by colony and plaque hybridization.

UNIT II

Molecular Techniques: DNA Transformation techniques (Calcium chloride method and electroporation), Polymerase Chain Reaction, DNA sequencing (Sanger method), DNA Finger Printing and DNA microarray.

UNIT III

Genetically Modified Organisms: Production of cloned and transgenic animals: Nuclear Transplantation, Retroviral Method, DNA microinjection, Applications of transgenic animals: Production of pharmaceuticals, production of donor organs, knock-out animals.

UNIT IV

Animal Cell Culture Techniques and Applications: Animal cell culture, expressing cloned genes in mammalian cells, Molecular diagnosis of genetic diseases (Cystic fibrosis, Thalassemia, Haemophilia and Sickle cell anemia), Recombinant DNA in medicines: Recombinant insulin and human growth hormone, Gene therapy.

PRACTICAL

Animal Biotechnology

1. Genomic DNA isolation from E. coli / Animal tissue
2. Plasmid DNA isolation (pUC 18/19) from E. coli
3. Restriction digestion of plasmid DNA / Lambda Phage DNA
4. Construction of circular and linear restriction map from the data provided.
5. Calculation of transformation efficiency from the data provided.
6. To study following techniques and interpretation through photographs/simulation/wet lab
    a. Southern Blotting
    b. Northern Blotting
    c. Western Blotting
    d. DNA Sequencing (Sanger's Method)
    e. PCR
    f. DNA fingerprinting.

- Interactive lectures with biotechnology workflow illustrations
- ICT-enabled teaching using animations and molecular visualizations
- Case studies on recombinant therapeutics and transgenic animals
- Problem-based learning on genetic engineering applications
- Group discussions on bioethics, biosafety, and GMOs

Suggested Field / Industrial Exposure

Students may undergo educational visits and training at:

- Biotechnology Industries
- Molecular Diagnostic Laboratories
- Animal Biotechnology and Research Centres
- Pharmaceutical and Biomedical Industries
- Research Organizations

Suggested Readings:

- ✓ *T.A. Brown. (2016) Gene Cloning and DNA Analysis: An Introduction. Wiley-Blackwell. ISBN-10-9781119072560*
- ✓ *S.B. Primrose and R.M. Twyman (2006) Principles of Gene Manipulation and Genomics. 7th Edition. Wiley-Blackwell. ISBN: 978-1-405-13544-3*
- ✓ *Richard J. Reece (2003) Analysis of Genes and Genomes. 8th Edition. ISBN: 978-0-470-84380-2*
- ✓ Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M. (2009). An Introduction to Genetic Analysis. IX Edition. Freeman and Co., N.Y., USA.
- ✓ Watson, J.D., Myers, R.M., Caudy, A. and Witkowski, J.K. (2007). RecombinantDNA-Genes and Genomes- AShort Course. III Edition, Freeman and Co., N.Y., USA.
- ✓ *BD Singh, (2014) Biotechnology: Expanding Horizons, Kalyani Publishers*
- ✓ *U.Satyanarayana and U Chakrapani, (2014) Biotechnology, Books & Allied Ltd*

Major 2.3 **Credit 04**

2.3 Physiology: Controlling and Coordinating systems

Course Objectives

The course is designed to:

1. Introduce students to the structural organization and functions of animal tissues and tissue systems.
2. Develop understanding of muscle physiology, nervous system organization, and mechanisms of neural communication.
3. Explain the physiological basis of sensory perception including vision, hearing, taste, smell, and somatic sensations.
4. Familiarize students with mechanisms of neuronal signaling, synaptic transmission, and neuromuscular coordination.
5. Provide knowledge of homeostatic regulation and physiological adaptations to environmental challenges.
6. Explain osmoregulation, thermoregulation, and maintenance of internal physiological balance in animals.
7. Prepare students for advanced studies and careers in physiology, neuroscience, biomedical sciences, healthcare, and biological research.

Course Outcomes (COs)

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

CO1: Describe the structure, classification, location, and functions of epithelial, connective, muscular, and nervous tissues.

CO2; Explain bone and cartilage organization, ossification processes, bone growth, and bone remodeling mechanisms.

CO3: Interpret the ultrastructure of skeletal muscles and explain the molecular basis of muscle contraction.

CO4: Describe the organization and functions of the central, peripheral, and autonomic nervous systems, including neuronal communication and reflex mechanisms.

CO5: Explain the physiology of sensory systems involved in vision, hearing, balance, olfaction, gustation, and somatic sensations.

CO6: Analyze mechanisms of homeostasis, body fluid regulation, osmoregulation, and thermoregulation in different animal groups.

CO7: Apply physiological concepts to understand adaptive responses, neural coordination, environmental regulation, and maintenance of internal stability.

Course Structure

UNIT I

Tissues & Tissue system: Structure, location, classification and functions of epithelial tissue, connective tissue, muscular tissue and nervous tissue. Structure and types of bones and cartilages, Ossification, bone growth and resorption.

UNIT II

Muscle & Nervous System: Histology of different types of muscle; Ultra structure of skeletal muscle; Molecular and chemical basis of muscle contraction. Introduction to CNS, PNS and ANS. Structure of neuron, Types of neurons, Action potential and its propagation, Synapse and synaptic transmission, Neuromuscular junction; Reflex action.

UNIT III

Physiology of Special senses: Sensory Neurons-types; Physiology and pathway- hearing and balance, Olfaction, Gustation and Vision. Interoception – Nociceptors, Baroreceptors, Chemoreceptors, Thermoreceptors, Osmoreceptors, Cutaneous Receptors.

UNIT IV

Homeostasis: Homeostasis and body fluids, Sources of body water and loss, Control of homeostasis, Homeostatic imbalances. Osmoregulation in fish, thermoregulation in Poikilotherms, homeotherms and heterotherms.

PRACTICAL

1. Demonstration of the unconditioned reflex action (Deep tendon reflex such as kneejerk reflex).
2. Study of permanent slides- Squamous epithelium, Striated muscle fibres, nerve cells and others relevant to the theory.
3. Microtomy: Preparation of permanent slides.
4. Models of mammalian tissues (Any five) /photographs.
5. Effect of salt concentration on cells.

Suggested Teaching–Learning Methods

Classroom Teaching Methods

- Interactive lectures supported by histological and physiological diagrams
- ICT-enabled teaching using animations of nerve impulse transmission and muscle contraction
- Concept-based discussions on physiological coordination
- Comparative studies of regulatory mechanisms across animal groups
- Group discussions and student seminars
- Case studies on neurological and sensory disorders
- Flipped classroom discussions
- Problem-based learning using physiological case studies

Digital and Computational Learning

- Virtual histology and anatomy platforms
- Neurophysiology simulations
- Interactive sensory pathway models
- Digital atlases of tissues and organ systems
- Computer-assisted physiological data analysis
- Online neuroscience and physiology learning modules

Suggested Field / Industrial Exposure

Students may undergo educational visits and training at:

Biomedical and Healthcare Institutions

- Neurophysiology laboratories
- Clinical neurology departments
- Sensory diagnostic and rehabilitation centres
- Audiology and vision assessment laboratories

Research and Academic Institutions

- Physiology and neuroscience research laboratories
- Biomedical research centres
- Animal physiology laboratories
- Environmental physiology research facilities

Biotechnology and Biomedical Industries

- Biomedical instrumentation companies
- Neurodiagnostic equipment manufacturers
- Health monitoring technology industries
- Physiological assessment laboratories

Museums and Specialized Centres

- Zoological museums with comparative anatomy collections
- Human anatomy and physiology museums
- Natural history museums

Research Organizations

- Indian Council of Medical Research laboratories
- National Institute of Mental Health and Neurosciences
- Council of Scientific and Industrial Research institutes
- All India Institute of Medical Sciences
- University neuroscience and physiology research centres

Suggested Books:

- ✓ *Textbook of Medical Physiology, Guyton & Hall, Elsevier, 12th edition, 2016.*
- ✓ *Marieb EN and Hoehn K, Human Physiology, (2013), 9th edition, Pearson Education,USA.*
- ✓ *Endocrinology, Hadley ME and Levine JE (2009), Pearson Education India; 6 edition.*
- ✓ *Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functionalcorrelations. XII Edition., Lippincott W. & Wilkins*
- ✓ *Martini F H, Nath J L and Bartholomew E F (2015) Fundamentals of Anatomy and Physiology. Pearson Education Publication,*
- ✓ *Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XIEdition John Wiley & sons.*

Major 2.4 **Credit 04**

2.4 Developmental Biology

Course Objectives

The course is designed to:

1. Introduce students to the principles, concepts, and historical development of developmental biology.
2. Explain the cellular and molecular mechanisms governing gametogenesis, fertilization, embryogenesis, and organogenesis.
3. Develop understanding of early and late embryonic development in vertebrate model organisms.
4. Familiarize students with mechanisms of cell differentiation, embryonic induction, pattern formation, and developmental regulation.
5. Provide knowledge of post-embryonic developmental processes including metamorphosis, regeneration, and ageing.
6. Explain developmental abnormalities, teratogenic effects, stem cell biology, assisted reproductive technologies, and prenatal diagnostic methods.
7. Prepare students for advanced studies and careers in developmental biology, reproductive biology, regenerative medicine, biotechnology, and biomedical research.

Course Outcomes (COs)

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

CO1: Explain the fundamental concepts, historical developments, and molecular basis of developmental biology including cell differentiation and pattern formation.

CO2: Describe the processes of gametogenesis, fertilization, egg organization, and mechanisms preventing polyspermy.

CO3: Interpret cleavage patterns, blastulation, gastrulation, fate mapping, and embryonic induction during early embryonic development.

CO4: Explain the formation and developmental significance of germ layers, extra-embryonic membranes, implantation, and placentation.

CO5: Analyze post-embryonic developmental processes including metamorphosis, regeneration, and ageing in different animal groups.

CO6: Evaluate the impact of teratogenic agents and explain applications of stem cells, in vitro fertilization, and prenatal diagnostic technologies.

CO7: Develop analytical and experimental understanding of developmental processes relevant to reproductive health, regenerative medicine, developmental disorders, and biotechnology.

Course Structure

UNIT I

Introduction to Developmental Biology, Gametogenesis & Fertilization

Historical perspective and basic concepts: Phases of development, Cell-Cell interaction, Pattern formation, Differentiation and growth, Differential gene expression, Cytoplasmic determinants and asymmetric cell division. Gametogenesis, Spermatogenesis, Oogenesis; Types of eggs, Egg membranes; Fertilization (External and Internal): Changes in gametes, Blocks to polyspermy.

UNIT II

Early Embryonic Development: Cleavage: Planes and patterns of cleavage, Types of Blastula, Fate maps (including Techniques); Early development of frog and chick up to gastrulation; Embryonic inductionand organizers.

UNIT III

Late Embryonic Development: Fate of Germ Layers; Extra-embryonic membranes in birds; Implantation of embryo in humans, Placenta (Structure, types and functions of placenta).

UNIT IV

Post Embryonic Development & Interferences in Developmental Biology: Metamorphosis: Changes, hormonal regulations in amphibians and insects; Regeneration:Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with one example each); Ageing: Concepts and Theories. Teratogenesis: Teratogenic agents and their effects on embryonic development; In vitro fertilization, Stem cell (ESC), Amniocentesis.

PRACTICAL

1. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpole (external and internal gill stages).
2. Study of whole mounts of developmental stages of chick through permanent slides: Primitive streak (13 and 18 hours), 21, 24, 28, 33, 36, 48, 72, and 96 hours of incubation (Hamilton and Hamburger stages).
3. Study of the developmental stages and life cycle of Drosophila from stock culture.
4. Study of different sections of placenta (photomicropgraph/slides).
5. Project report on Drosophila culture/chick embryo development.
6. Study of developmental stages by raising chick embryo in the laboratory.
7. Estimation of calcium in egg shell.
8. Estimation of carbohydrates and proteins in egg.

Suggested Teaching–Learning Methods

Classroom Teaching Methods

- Interactive lectures supported by embryological diagrams and developmental models
- ICT-enabled teaching using developmental animations and time-lapse embryogenesis videos
- Concept-based discussions on developmental mechanisms and gene regulation
- Comparative developmental studies across animal groups
- Student seminars and scientific presentations
- Case-based learning on developmental disorders and reproductive technologies
- Demonstration of stem cell and assisted reproductive technology concepts through multimedia resources
- Digital and Computational Learning
- Virtual embryology laboratories
- Developmental biology simulation software
- 3D embryonic development models
- Stem cell and regenerative medicine educational platforms

Suggested Field / Industrial Exposure

- Students may undergo educational visits and training at:
- Reproductive and Fertility Centres
- Assisted reproductive technology (ART) clinics
- IVF laboratories
- Fertility and reproductive health centres
- Biomedical and Stem Cell Research Laboratories
- Stem cell research facilities
- Regenerative medicine laboratories
- Developmental genetics laboratories
- Healthcare and Diagnostic Centres
- Prenatal diagnostic laboratories
- Cytogenetic and molecular diagnostic centres
- Maternal and fetal medicine units
- Biotechnology and Pharmaceutical Industries
- Reproductive biotechnology companies
- Regenerative medicine industries
- Biomedical research and development facilities
- Research and Academic Institutions
- Indian Council of Medical Research laboratories
- National Institute for Research in Reproductive and Child Health
- Department of Biotechnology supported centres
- Centre for Cellular and Molecular Biology
- Institute for Stem Cell Science and Regenerative Medicine

Suggested Reading

- *Lewis Wolpert (2010). Principles of Development. II Edition, Oxford University Press.*
- *Gilbert, S. F. (2017). Developmental Biology, XI Edition, Sinauer Associates, Inc.,Publishers, Sunderland, Massachusetts, USA*
- *Carlson, R. F. Patten's Foundations of Embryology.*
- *Kalthoff (2008). Analysis of Biological Development, II Edition, McGraw-HillPublishers.*
- *Verma PS and Agrawal VK, Chordata Embryology (2010) (S Chand Publication).*

MDC-I **Credit 03**

Vector Borne Diseases & Epidemiology

Unit I: Insects, Concept of Vectors, Insects as Vectors

General Features of Insects, Morphological features, Head – Eyes, Types of antennae, Mouth parts with reference to feeding habits, Brief introduction of Carrier and Vectors (mechanical and biological vector), Reservoirs, Host-vector relationship, Vectorial capacity, Adaptations as vectors, Host Specificity, Classification of insects up to orders, detailed features of orders with insects as vectors – Diptera, Siphonaptera, Siphunculata, Hemiptera.

Unit II: Vectors and diseases

Important insect vectors – Mosquitoes, Sandfly, Houseflies; Study of mosquito-borne diseases – Malaria, Dengue, Chikungunya, Viral encephalitis, Filariasis; Control of mosquitoes, Study of sand fly-borne diseases – Visceral Leishmaniasis, Cutaneous Leishmaniasis, Phlebotomus fever; Control of Sandfly, Study of house fly as important mechanical vector, Myiasis, Control of house fly

Unit III: Epidemiology-an introduction

Definition, Objective and uses and core functions of epidemiology, Epidemiologic approach, Historical evolution of epidemiology, Concept of health and disease, Determinants of health and diseases, Difference between epidemiology and clinical/preventive medicine, Epidemiology as the cornerstone of public health/health - for example: contribution of Nurses' Health study, British Doctors' study and Framingham Heart Study to public health etc.

Unit IV: Disease types, mode of transmission and management

Difference between infectious and communicable diseases vs. non communicable diseases, Natural history of disease, Chain of infection, Mode and route of transmission of diseases, Meaning of outbreak or epidemic, endemic and pandemic, incubation period, latency period, clinical case, subclinical case, carrier, infectivity, pathogenicity and virulence, theories and principles of causation- epidemiological triad, web of causation, Bradford Hill criteria and Rothman's Causal pies, levels of prevention and modes of intervention.

Suggested Readings

- ✓ *Mathews, G. (2011). Integrated Vector Management: Controlling Vectors of Malaria and Other Insect Vector Borne Diseases. Wiley-Blackwell*
- ✓ *Chapman, R.F. (1998). The Insects: Structure and Function. IV Edition, Cambridge University Press, UK.*
- ✓ *Mike Service (2012) Medical Entomology for Students Cambridge University Press; 5th edition.*
- ✓ *Pedigo L.P. (2002). Entomology and Pest Management. Prentice Hall Publication*
- ✓ *Victor Schoenback and Wayne B.Rosamond (2000) Understanding the fundamentals of Epidemiology- An evolving text..*
- ✓ *Modern Epidemiology- Kenneth Rothman, Sebastien Haneuse , Timothy L. Lash , Tyler J. Vander Weele (2021).*

SEC-1 **Credit-03**

Molecular Diagnostics

Unit I

Introduction and history of disease diagnosis, mode and type of infectious disease, philosophy and ethics for clinical samples. Various methods of collection, storage and transport/shipping procedures for clinical samples. Diagnosis of infectious disease caused by bacteria, fungi, viruses, protozoa and Helminthes.

Unit II

Biochemical parameters for detection and quantification of clinical samples (i.e. urine, blood, feacal matters, tissue biopsy) for bacterial disease. Detection and quantification of sugars, albumin, urea, protein, globulin and vitamins. Disease identification, genetic test for disorders, population screening for genetic disorder. Treatment and management in genetic diseases.

Unit III

Culture independent analysis of bacteria, PCR based microbial typing, Molecular diagnosis of fungal pathogens. DNA finger printing, Southern blotting and electrophoresis analysis, RAPD and RFLP techniques, DNA sequencing (Sanger). Multiplex-PCR analysis.

Unit IV

Principle and diagnosis techniques of immunoassays: Radio immunoassay (RIA), Enzyme linked immunosorbent assay (ELISA), chemiluminescent immunoassay (CIA), fluorescent antibody test/ immunoassay (FIA). Principle and techniques of Immunohistochemistry. Application of Biosafety cabinets and containment for clinical specimens. Good laboratory practices in handing clinical samples.

Suggested Reading

- ✓ *Lela Buckingham and Maribeth Flaws. (2007) Molecular Diagnostics: Fundamentals, Methods and Clinical Applications, F.A. Davis Company.*
- ✓ *Nader Rifai, Andrea Rita Horvarth, Kaqrl T Wittwer, Tietz Textbook of Clinical Chemistry and Molecular Diagnostics, 6th Edition, 2017, Elsevier.*
- ✓ *David E. Bruns, Edward R. Ashwood, Carl A. Burtis, Fundamentals of Molecular Diagnostics, 1st Edition, Elsevier.*

Semester -IV

Major 1.13 **Credit 04**

1.13 Wildlife & Conservation Biology

Course Objectives

The course is designed to:

1. Introduce students to the principles, values, and significance of wildlife conservation and management.
2. Develop understanding of wildlife habitats, ecological requirements, and habitat assessment methodologies.
3. Familiarize students with wildlife conservation laws, biodiversity protection strategies, and national and international conservation frameworks.
4. Provide knowledge of habitat restoration, in-situ and ex-situ conservation, and wildlife management practices.
5. Develop skills in wildlife population estimation, monitoring techniques, bio-telemetry, and ecological data interpretation.
6. Introduce wildlife health management, disease surveillance, rehabilitation, and quarantine procedures.
7. Prepare students for careers in wildlife conservation, biodiversity management, ecological consultancy, forestry, protected area management, and environmental governance.

Course Outcomes (COs)

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

CO1: Explain the ecological, economic, cultural, and conservation values of wildlife and the importance of biodiversity conservation.

CO2: Assess wildlife habitats using physical, biological, and technological approaches including GIS and remote sensing tools.

CO3: Evaluate habitat management strategies for restoration, conservation, genetic diversity preservation, and sustainable wildlife management.

CO4: Interpret wildlife protection laws, conservation policies, wildlife trade regulations, and legal frameworks governing biodiversity conservation.

CO5: Apply wildlife population estimation techniques, census methods, bio-telemetry, and ecological monitoring tools for wildlife assessment.

CO6: Analyze wildlife health issues, disease management, rehabilitation protocols, and conservation challenges in protected areas.

CO7: Develop wildlife management and conservation plans for protected areas, ecotourism initiatives, and species recovery programmes using scientific and ethical approaches.

Course Structure

UNIT I: Introduction to Wildlife

Values of wild life: Positive and negative; Conservation ethics; Importance of conservation; Causes of depletion; World conservation strategies, Conservation and protection Laws, Wild animal of India and Odisha. Habitat analysis, Physical parameters: Topography, Geology, Soil and water; Biological Parameters: food, cover, forage, browse and cover estimation; Standard evaluation procedures: remote sensing and GIS.

UNIT II: Management of Habitats

Setting back succession; Grazing logging; Mechanical treatment; Advancing the succession process; Cover construction; Preservation of general genetic diversity; Restoration of degraded habitats, *In-situ* and *Ex-situ* conservation, Wild life Protection acts, Wildlife trade and its related laws.

UNIT III Population estimation

Attributes of population: Density, natality, mortality, sex ratio computation, Bayesian models in abundance estimation (Spatial and Non Spatial); Faecal analysis of ungulates and carnivores: Faecal samples, slide preparation, Hair identification, Census methods; Bio- telemetry; Care of injured and diseased animal; Quarantine; Common diseases of wild animals.

UNIT IV Management planning of wildlife in protected areas

Estimation of carrying capacity; Ecotourism/ wildlife tourism in forests; Concept of climax persistence; Ecology of perturbence, National parks & sanctuaries, Community reserve; Important features of protected areas in India; Tiger conservation: Tiger reserves in India; Management challenges in Tiger reserve.

PRACTICAL

1. Study of equipments used in sample collection (Compass, Binoculars, Spotting scope, Range Finders, Global Positioning System, Various types of Cameras and lenses).
2. Study of museum specimens/ pictures (relevant to Wild Life).
3. Preservation and curation of specimens (Submission of 2 specimens collected and preserved).
4. Determination of population density in a natural/ hypothetical community by quadrate method and calculation of Shannon-Weiner diversity index for the same community.
5. Identification and Demonstration of different field techniques of fauna (Odisha and India)
6. Familiarization and study of animal evidences in the field; Identification of animals through pug marks, hoof marks, scats, pellet groups, nest, antlers, animal sounds.
7. Trail / transect monitoring for abundance and diversity estimation of mammals and bird (direct and indirect evidences).
8. Submission of field study report (national park/ reserve forest/ sanctuary).
9. Visit to Forest/ Wildlife Sanctuary/ Biodiversity Park/ Zoological Park to study animals and prepare a short report.

Suggested Teaching–Learning Methods

Classroom Teaching Methods

- Interactive lectures with wildlife case studies
- ICT-enabled teaching using GIS maps, wildlife documentaries, and conservation databases
- Group discussions on conservation challenges and wildlife policies
- Problem-based learning using real conservation scenarios
- Student seminars and wildlife conservation debates
- Expert talks from forest officers and conservation practitioners
- Wildlife conservation projects
- Biodiversity documentation assignments
- Protected area management case studies
- Ecotourism planning exercises
- Community-based conservation awareness activities
- GIS and remote sensing software demonstrations
- Wildlife database exploration
- Population modelling exercises
- Camera trap image analysis
- Biodiversity informatics applications
- Wildlife conservation decision-support tools

Suggested Field / Industrial Exposure

Students should undergo extensive field exposure through visits to:

Protected Areas and Wildlife Habitats

- Similipal Tiger Reserve
- Bhitarkanika National Park
- Satkosia Tiger Reserve
- Chilika Wildlife Sanctuary
- National parks and wildlife sanctuaries across India

Wildlife and Conservation Organizations

- Wildlife Institute of India
- Zoological Survey of India
- Bombay Natural History Society
- World Wide Fund for Nature India

Government Agencies

- State Forest Departments
- Wildlife Divisions
- Biodiversity Boards
- Nandankan Zoological Park
- Eco-development Committees

Conservation and Ecotourism Projects

- Community conservation initiatives
- Habitat restoration projects
- Wildlife rescue and rehabilitation centres
- Ecotourism development programmes

Suggested Readings:

- ✓ *The diversity of life (The College Edition), E.O.Wilson. W.W. Northern & co.*
- ✓ *Gopal Rajesh (2011) Fundamentals of Wildlife Management, Natraj Publishers.*
- ✓ *Caughley G and Sinclair ARE. (1994). Wildlife Ecology and Management. Blackwell Science.*
- ✓ *Woodroffe R, Thirgood S and Rabinowitz A (2005) People and Wildlife, Conflictor Co-existence? Cambridge University.*
- ✓ *Bookhout TA (1996). Research and Management Techniques for Wildlife and Habitats, 5th Edition. The Wildlife Society, Allen Press.*
- ✓ *Sutherland WJ (2000). The Conservation Handbook: Research, Management and Policy. Blackwell Sciences.*
- ✓ *Hunter ML, Gibbs JB and Sterling EJ (2008) Problem-Solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory. Blackwell Publishing.*

Major 1.14 **Credit 04**

1.14 Aquaculture and Sustainable Fish Farming

Course Objectives

- Introduce students to the fundamentals of aquaculture and fish farming.
- Develop knowledge on freshwater, brackish water, and integrated aquaculture systems.
- Provide practical skills in pond preparation, hatchery management, breeding and feeding
- Build entrepreneurial understanding in aquaculture-based enterprises.
- Promote sustainable and eco-friendly aquaculture practices.

Course Outcomes (CO)

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

- Understand the principles and scope of aquaculture
- Identify different aquaculture systems and cultivable species
- Apply pond management and water quality techniques
- Demonstrate fish breeding, feeding, and health management skills
- Develop small-scale aquaculture business and entrepreneurship ideas
- Understand sustainable and climate-resilient aquaculture practices
- Proficient in seed production and hatchery management

Course Structure

UNIT I

Introduction to Aquaculture: Definition, history, and scope of aquaculture, Types of aquaculture: Freshwater aquaculture, Brackish water aquaculture, Marine aquaculture, Extensive, semi-intensive, and intensive culture systems, Composite fish culture, Integrated fish farming, nets and gears used for fish catching, Net mending and making by hand and by machines.

UNIT II

Aquaculture Systems and breeding: Pond construction and design, Pond preparation methods, Cage culture and tank culture, Biofloc technology – basics and applications, RAS management. Natural and induced breeding, Hatchery management, Broodstock management, Nursery and rearing pond management.

UNIT III

Fish Nutrition and Feed Management: Types of fish feed, Natural and artificial feed, Feed formulation techniques, Feed ingredients and additives, Feed preparation and feed mill management, Extrusion feed preparation, Feed for different stages of fish, Feed Conversion Ratio (FCR), Storage and handling of feed, feeding management.

UNIT IV

Fish Health Management & sustainable aquaculture: Common fish diseases: Bacterial diseases, Viral diseases, Fungal diseases, Parasitic infections, Preventive healthcare measures, Safe use of chemicals and antibiotics.

Waste management in aquaculture, Ornamental fish culture, Fish processing and value addition.

PRACTICAL

1. Identification of cultivable fish species
2. Types of nets and gears used in fisheries
3. Pond soil and water analysis
4. Liming and fertilization calculations
5. Feed preparation and feeding methods
6. Preparation of aquaculture business model
7. Net mending and making by hand and by machines.
8. Biofloc and RAS in aquaculture
9. Field visit to hatchery/fish farm/feed mill and hands-on learning

Suggested Teaching–Learning Methods

- Lectures
- Demonstrations
- Laboratory practicals
- Field visits
- Skill-based training
- Hands-on-training on the following
    - Fish pond preparation
    - Hatchery operation
    - Biofloc and RAS management
    - Water quality monitoring
    - Feed formulation
    - Disease diagnosis
    - Farm economics
    - Fish marketing

Suggested Field Exposure

1. Government hatcheries (Krishi Vigyan Kendra, Govt. of Odisha)
2. Fisheries research institutes (ICAR-CIFA, Kausalyaganga, Bhubaneswar)
3. Private aquaculture farms (AVANTI, FALCON, HIMEDIA etc.
4. Fish feed industries (FALCON Feed, Godreg Feed, Avanti Feed, ABIS Feeds, TENSIFT Farmers fertilizer Pvt. Ltd. etc.)
5. Fish markets and processing units (FALCON, Hari Marine, Highland etc.)
6. Net and Gear making Industry: OPDC, GARWALE Industry etc.

Suggested Reading

- ✓ *Jhingran, V.G. (1985) Fish and Fisheries of India*
- ✓ *Rath, R.K. (2000) Freshwater Aquaculture*
- ✓ *Gupta, S.K and Gupta, P.C (2006) General and applied ichthyology (Fish and Fisheries)*
- ✓ *Ayyappan, S (2010) Handbook of Fisheries and Aquaculture*
- ✓ *Pillay, T.V.R (1993) Aquaculture Principles and Practices*
- ✓ *Srivastava, C.B.L (2006) A textbook of fishery science and Indian fisheries*
- ✓ *Paulraj, R (1997) Hand book on Aquafarming: Aquaculture Feed. Manual. MPEDA, Cochin.*
- ✓ *S.D. Gupta, P. Routray, D.K. Verma, B.C. Mohapatra, S.K. Sahoo, and N. Sarangi (2008). Textbook of breeding and hatchery management of carps*

Major 1.15 **Credit 04**

1.15 Environment Impact Assessment & Toxicology

Course Objectives

The course is designed to:

- Introduce students to the principles, objectives, scope, and methodologies of Environmental Impact Assessment (EIA).
- Develop understanding of environmental impact prediction, evaluation, and management for developmental projects.
- Familiarize students with environmental regulations, clearance procedures, Environmental Impact Statements, and international environmental agreements.
- Provide foundational knowledge of toxicology, toxicokinetics, dose-response relationships, and environmental contaminants.
- Explain mechanisms of toxicity, pollutant fate, bioaccumulation, biomagnification, and ecological risk assessment.
- Develop practical skills in environmental monitoring, toxicological evaluation, and environmental decision-making.
- Prepare students for careers in environmental management, consultancy, regulatory agencies, sustainability sectors, and ecological research.

Course Outcomes (COs)

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

CO1: Explain the concepts, objectives, significance, and methodologies of Environmental Impact Assessment in developmental planning.

CO2: Apply various EIA tools and techniques to identify, predict, evaluate, and communicate environmental impacts.

CO3: Assess environmental impacts on air, water, land, noise, biodiversity, and ecological systems using scientific approaches.

CO4: Interpret environmental clearance procedures, Environmental Impact Statements (EIS), regulatory frameworks, and environmental governance mechanisms.

CO5: Describe fundamental principles of toxicology, dose-response relationships, toxicity testing, and bioassay methodologies.

CO6: Analyze the environmental fate and toxic effects of pesticides, heavy metals, persistent organic pollutants, and other environmental contaminants.

CO7: Evaluate ecological and human health risks associated with environmental pollutants and propose appropriate mitigation and management strategies.

Course Structure

Unit I: Fundamentals of Environmental Impact Assessment (10 Hours)

Introduction to EIA: Objectives, concept and scope of Environmental Impact Assessment, Environmental Assessment Process and significance, Structure and components of EIA, Environmental attributes and indicators, Criteria for selection of EIA methodologies

Impact Assessment Process: Impact identification, Impact measurement, Impact interpretation, Impact evaluation, Impact communication

EIA Methodologies: Ad hoc methods, Checklist methods, Matrix methods, Network methods, Overlay methods

EIA Review Process: Baseline environmental conditions, Construction-stage impacts, Operational and post-project impacts, Environmental management and monitoring plans

Unit II: Environmental Impact Analysis and Regulatory Frameworks (10 Hours)
Environmental Impact Prediction and Assessment: Environmental impact analysis approaches, Comparative studies and modelling techniques, Prediction and assessment of environmental impacts
Assessment of Environmental Components: Air environment impact assessment, Water environment impact assessment, Noise environment impact assessment, Land environment impact assessment, Ecological impact assessment

Environmental Governance and Compliance: Environmental clearance procedures, Environmental Impact Statement (EIS), Public consultation and stakeholder participation, Projects requiring environmental clearance, Composition and role of Expert Appraisal Committees
Environmental Regulations and International Frameworks: Ecologically sensitive areas, National environmental regulations, International environmental agreements and conventions, Case studies of developmental projects

Unit III: Principles of Toxicology and Toxicity Assessment (10 Hours)
Introduction to Toxicology: Scope and significance of toxicology, Branches and sub-disciplines of toxicology, Environmental and ecological toxicology
Toxicity Testing and Evaluation: Dose-response relationships, Acute toxicity, Chronic toxicity, Sub-lethal toxicity, Determination of LD_{50} and LC_{50}
Bioassay Techniques: Principles of bioassays, Vertebrate bioassays, Invertebrate bioassays, Applications in environmental monitoring
Toxicokinetics: Absorption, Distribution, Metabolism (Biotransformation), Excretion, Factors influencing toxicity

Unit IV: Environmental Toxicants, Ecological Risk Assessment and Management (10 Hours)
Environmental Toxicants: Organochlorine insecticides (OCIs), Organophosphate insecticides (OPIs), Persistent Organic Pollutants (POPs)
Heavy Metal Toxicity: Arsenic, Lead and Mercury toxicity, Sources, environmental fate and biological effects
Ecological Consequences of Pollutants: Bioaccumulation, Biomagnification, Ecotoxicological impacts on food chains, Wildlife and ecosystem effects
Risk Assessment and Hazard Evaluation: Hazard identification, Toxicity assessment, Exposure assessment, Risk characterization, Environmental risk management and mitigation strategies.

PRACTICAL

1. Environmental sampling demonstrations
2. Water and soil quality assessment exercises
3. Toxicological data interpretation
4. Environmental monitoring techniques
5. Exposure and risk assessment exercises
6. Case study-based environmental audits
7. Environmental impact analysis projects
8. Group assignments on industrial pollution issues
9. Environmental policy review exercises
10. Literature surveys on emerging contaminants

11. Community-based environmental awareness activities
12. Digital and Computational Learning
13. GIS-based environmental mapping

Suggested Teaching–Learning Methods

- Interactive lectures supported by real-world environmental case studies
- Problem-based learning on environmental impact scenarios
- Group discussions on environmental regulations and sustainability
- ICT-enabled teaching using GIS maps, EIA reports, and environmental models
- Student seminars on pollution and toxicology issues
- Expert lectures from environmental professionals

Suggested Field / Industrial Exposure

Students may undergo educational visits and training at:

Environmental Regulatory Agencies

- Odisha State Pollution Control Board
- Central Pollution Control Board
- Environmental monitoring stations

Environmental Consultancy Firms

- EIA consultancy organizations
- Environmental auditing agencies
- Sustainability assessment companies

Industries and Infrastructure Projects

- Mining industries
- Thermal power plants
- Steel and metallurgical industries
- Waste treatment and recycling facilities
- Industrial effluent treatment plants

Conservation and Environmental Organizations

- Wildlife conservation centres
- Wetland management projects
- Biodiversity conservation programmes
- Environmental NGOs

Research Institutions

- National Environmental Engineering Research Institute
- Indian Institute of Toxicology Research
- Council of Scientific and Industrial Research laboratories
- Environmental research centres and universities

Suggested Reading

- ✓ *Anjaneyulu. Y and Manickam. V., Environmental Impact Assessment Methodologies, B.S. Publications, Hyderabad, 2007*
- ✓ *Barthwal, R. R., Environmental Impact Assessment, New Age International Publishers, 2002.*
- ✓ *Jain, R.K., Urban, L.V., Stracy, G.S., Environmental Impact Analysis, Van Nostrand Reinhold Co., New York, 1991.*
- ✓ *Rau, J.G. and Wooten, D.C., Environmental Impact Assessment, McGraw Hill Pub. Co., New York, 1996.*
- ✓ *Reference Books: 1. Environmental Impact Analysis Handbook – by Rau Whooten; McGraw Hill publications*
- ✓ *Environmental Impact Assessment – by Larry Canter; McGraw Hill publications*
- ✓ *Environmental Impact Analysis – A Decision Making Tool by R K Jain 4. Handbook of Environment Impact Assessment by Judith Petts; McGraw Hill publications*

- ✓ John H Duffs.; Howard G J Worth.; (Editors). (2015). “Fundamental Toxicology”. 2nd Edition Publisher: Royal Society of Chemistry; UK
- ✓ Environmental toxicology; John H. Duffs, 1980, Edward Arnold Publishers, New Delhi.
- ✓ Elements of toxicology; J. P Shukla and Pandey, Radha Publishers, New Delhi.

Major 2.5 **Credit 04**

2.5 Taxonomy & Evolutionary Biology

Course Objectives

The course is designed to:

- Introduce students to the principles, methods, and significance of taxonomy, systematics, and biological classification.
- Develop understanding of taxonomic procedures, nomenclature, biodiversity documentation, and modern taxonomic approaches.
- Explain the origin of life, major evolutionary theories, evidence supporting evolution, and extinction events.
- Familiarize students with population genetics and evolutionary mechanisms including natural selection, mutation, migration, and genetic drift.
- Develop understanding of speciation, adaptive radiation, phylogenetics, and macroevolutionary processes.
- Introduce students to the origin and evolution of humans using fossil and molecular evidence.
- Prepare students for careers in taxonomy, biodiversity conservation, evolutionary research, environmental management, museum sciences, and molecular systematics.

Course Outcomes (COs)

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

CO1: Explain the principles, procedures, and applications of taxonomy, systematics, and biological classification.

CO2: Apply taxonomic tools, nomenclatural rules, identification keys, and modern approaches such as DNA barcoding and molecular taxonomy for species identification.

CO3: Interpret major theories of evolution, origin of life hypotheses, fossil evidence, and extinction events that have shaped biodiversity.

CO4: Analyze evolutionary mechanisms including natural selection, mutation, migration, genetic drift, and population genetics using quantitative approaches.

CO5: Evaluate processes of speciation, adaptive radiation, and macroevolution responsible for biological diversity.

CO6: Construct and interpret phylogenetic relationships using morphological and molecular data.

CO7: Explain the evolutionary history of humans and critically assess evidence from paleontology, genetics, and molecular phylogenetics.

Course Structure

UNIT I: Concepts of Taxonomy

Importance & Applications of biosystematics; taxonomic characters, Hierarchy categories; biological classification; Taxonomic procedures: collections, preservation, curetting, identification, Keys; International Code of Zoological Nomenclature (ICZN): operative principles, important rules; Zoological nomenclature; Chemo and sero taxonomy, Cytotaxonomy, Numerical taxonomy, and DNA barcoding. Taxonomic publications: Kinds, Major features of manuscript for publication.

UNIT II: Theories, Evidences of Evolution and Extinction

Life's Beginnings: Chemogeny, RNA world, Biogeny, Evolution of eukaryotes. Historical review of evolutionary concept: Lamarckism, Darwinism, Neo-Darwinism. Evidences of Evolution: Fossil record (types of fossils, transitional forms, geological time scale, evolution of horse), Sources of

variations: Heritable variations and their role in evolution. Extinctions, Back ground and mass extinctions (causes and effects), detailed example of K-T extinction.

UNIT III: Process of Evolutionary changes

Population genetics: Hardy-Weinberg Law (statement and derivation of equation, application of law to human Population); Evolutionary forces upsetting H-W equilibrium; Natural selection (concept of fitness, selection coefficient, derivation of one unit of selection for a dominant allele, genetic load, mechanism of working, types of selection, density-dependent selection, heterozygous superiority, kin selection, adaptive resemblances, sexual selection). Genetic Drift (mechanism, founder's effect, bottleneck phenomenon); Role of Migration and Mutation in changing allele frequencies.

UNIT IV: Products of evolution, Species concept, Origin and Evolution of man

Micro evolutionary changes (inter-population variations, clines, races, Species concept, Isolating mechanisms, modes of speciation-allopatric, sympatric, Parapatric. Adaptive radiation/ macroevolution (exemplified by Galapagos finches). Origin and evolution of man, Unique hominin characteristics contrasted with primate characteristics, primate phylogeny from *Dryopithecus* leading to *Homo sapiens*, molecular analysis of human origin. Phylogenetic trees, multiple sequence alignment, construction and interpretation of phylogenetic trees.

PRACTICAL

1. Study of equipment used in sample collection.
2. Use of taxonomic keys in identification.
3. Preservation and curation of specimens (Submission of 2 specimens collected and preserved).
4. Study of fossils from models/pictures
5. Study of homology and analogy from suitable specimens
6. Study and verification of Hardy-Weinberg Law by chi-square analysis
7. Demonstration of the role of natural selection and genetic drift in changing allele frequencies using simulation studies
8. Graphical representation and interpretation of data of height/weight of a sample of 100 humans in relation to their age and sex.
9. Construction of phylogenetic trees with the help of bioinformatics tools (Clustal X, Phylip, NJ) and its interpretation.

Suggested Teaching–Learning Methods

Classroom Teaching Methods

- Interactive lectures supported by evolutionary case studies
- ICT-enabled teaching using phylogenetic software, fossil databases, and biodiversity portals
- Concept mapping and evolutionary tree construction exercises
- Group discussions on evolutionary controversies and species concepts
- Student seminars on biodiversity and evolutionary research
- Problem-solving sessions on population genetics
- Taxonomic survey assignments
- Evolutionary case study analyses
- Species inventory preparation
- Literature review and journal discussions
- Mini research projects on local biodiversity
- Studies on DNA barcoding repositories

- Molecular phylogenetic software demonstrations
- Bioinformatics-based sequence alignment exercises
- Online taxonomic catalogues and digital museums
- Evolutionary simulation tools

Suggested Field / Industrial Exposure

Students should be exposed to:

Biodiversity and Taxonomy Centres

- Zoological Survey of India
- Botanical Survey of India
- Natural history museums
- Biodiversity repositories

Wildlife and Conservation Organizations

- Wildlife Institute of India
- State Biodiversity Boards
- Forest Departments
- Wildlife conservation projects

Research Institutions

- Centre for Cellular and Molecular Biology
- Evolutionary biology laboratories
- Molecular taxonomy laboratories
- DNA barcoding centres

Field-Based Exposure

- Biodiversity surveys
- Faunal inventory projects
- Protected area biodiversity monitoring
- Ecological assessment programmes

Suggested Readings:

- ✓ *Principle of Animal Taxonomy; G.G. Simpson. Oxford IBH Publishing Company.*
- ✓ *Elements of Taxonomy. E. Mayer.*
- ✓ *The diversity of life (The College Edition), E.O.Wilson. W.W. Northern & co.*
- ✓ *Theory and Practice of Animal Taxonomy. V.C. Kapoor. Oxford & IBH Publishing Co. Pvt. LTD.*
- ✓ *Advancement in Invertebrate Taxonomy and Biodiversity. Rajeev Gupta. Agrobios International. Campbell, N.A. and Reece J.B (2011). Biology. IX Edition. Pearson, Benjamin,Cummings.*
- ✓ *Rastogi B.B., (2018). Organic Evolution, MedTech; 3rd edition*
- ✓ *B.K. and Hallgrimson, B. (2008). Evolution IV Edition. Jones and Barlett Publishers.*
- ✓ *Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates.*
- ✓ *Ridley, M (2004) Evolution III Edition Blackwell publishing Hall.*
- ✓ *Principles of Taxonomy by Ashok Verma.*
- ✓ *Evolutionary Biology with Practical by Tripurari Mishra.*

Major 2.6 **Credit 04**

2.6 Comparative Anatomy of Vertebrates

Course Objectives

The course is designed to:

- Introduce students to the comparative anatomy and functional organization of vertebrate organ systems.
- Develop understanding of structural adaptations and evolutionary modifications in integumentary, skeletal, digestive, respiratory, circulatory, urinogenital, and nervous systems.
- Explain evolutionary trends in vertebrate morphology and organ system specialization.
- Familiarize students with comparative features of vertebrate sensory organs and receptor systems.
- Provide knowledge of vertebrate adaptations related to feeding, respiration, circulation, excretion, reproduction, and sensory perception.
- Develop analytical and observational skills in comparative anatomy and vertebrate evolution.
- Prepare students for advanced studies and applications in zoology, physiology, biomedical sciences, wildlife biology, and veterinary sciences.

Course Outcomes (COs)

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

CO1: Describe the structure, functions, and evolutionary modifications of vertebrate integumentary and skeletal systems.

CO2: Explain comparative organization and adaptations of digestive and respiratory systems in vertebrates.

CO3: Interpret evolutionary trends in circulatory systems, heart organization, aortic arches, kidneys, and urinogenital ducts.

CO4: Describe comparative anatomy of vertebrate nervous systems, brain organization, spinal cord, and cranial nerves.

CO5: Explain the structure and functions of vertebrate sensory receptors including visual, auditory, chemo-, and mechanoreceptors.

CO6: Analyze adaptive and evolutionary significance of vertebrate organ systems in relation to habitat and functional specialization.

CO7: Develop observational, analytical, and diagrammatic skills relevant to vertebrate anatomy, physiology, and comparative zoology.

Course Structure

UNIT I

Integumentary & Skeletal System: Structure, functions and derivatives of integument (Scale, claw, nail, hair, feather and dentition). Axial and appendicular skeleton, Jaw suspensorium, Visceral arches.

UNIT II

Digestive & Respiratory System

Alimentary canal and associated glands; Respiration through Skin, gills, lungs and air sacs; Accessory respiratory organs.

UNIT III

Circulatory and Urinogenital system

General plan of circulation, evolution of heart and aortic arches; Succession of kidney, Evolution of urinogenital ducts, Types of mammalian uteri.

UNIT IV

Nervous System & Sense Organs

Comparative account of brain; Nervous system, Spinal cord, Cranial nerves in mammals. Classification of receptors: Brief account of visual and auditory receptors in man. Chemo and mechano-receptors

PRACTICAL

1. Study of placoid, cycloid and ctenoid scales through permanent slides/photographs
2. Disarticulated skeleton of Frog, Varanus, Fowl, Rabbit.
3. Carapace and plastron of turtle /tortoise (Photographs, charts etc).
4. Mammalian skulls: One herbivorous and one carnivorous animal.
5. Study of structure of any two organs (heart, lung, kidney, eye and ear) through ICT tools.
6. Project report submission on Integumentary derivatives.

Classroom Teaching Methods

- Interactive lectures using comparative anatomical illustrations
- Comparative morphology-based discussions
- Evolutionary trend analysis using diagrams and flowcharts
- ICT-enabled teaching with 3D anatomical models and animations
- Case-based discussion on vertebrate adaptations
- Student seminars and group presentations
- Dissection demonstrations and virtual dissection tools
- Assignment-based learning
- Comparative anatomy chart preparation
- Mini-projects on vertebrate evolution and adaptation
- Flipped classroom and peer-learning activities
- Zoological museum-based learning
- Digital vertebrate anatomy resources and virtual simulations
- Comparative phylogenetic analysis tools
- Online anatomical atlases and databases

- Multimedia learning modules on vertebrate systems
- Evolutionary modelling and organ system comparison

Suggested Field / Industrial Exposure

Students may undergo educational visits/training at:

- University zoological museums
- Regional Museum of Natural History
- Biodiversity conservation centres
- Zoological Survey of India Museum, Gopalpur
- Chilika Development Authority Museum, Barkul
- Wildlife Institute of India
- Indian Veterinary Research Institute
- Veterinary anatomy laboratories
- Biomedical and physiology laboratories

Industrial Exposure Components

- Museum preservation and specimen preparation units
- Histology and anatomical preparation laboratories
- Biomedical instrumentation facilities
- Wildlife rehabilitation and conservation centres

Suggested Readings:

- ✓ *Kardong, K.V. (2005) Vertebrates' Comparative Anatomy, Function and Evolution.IV Edition. McGraw-Hill Higher Education*
- ✓ *Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. IXEdition. The McGraw-Hill Companies*
- ✓ *R. K. Saxena and Sumitra Saxena (2016). Comparative Anatomy of Vertebrates2nd edition.*
- ✓ *Hilderbrand, M and Gaslow G.E. Analysis of Vertebrate tructure, JohnWiley and Sons*
- ✓ *Walter, H.E. and Sayles, L.P; Biology of Vertebrates, Khosla Publishing House*

MDC-2 **Credit -03**

Bio-resource Technologies & Bio-products

UNIT-I

Bio resources- natural and anthropogenic; importance of bio-resources and their utilization. Natural bioresources: agricultural, forestry and aquatic biomass. Biomass availability, production and food security, nonedible biomass characteristics. Anthropogenic bio-resources: Organic wastes-domestic and industrial; characteristics of municipal sewage / sludge and industrial sludges.

UNIT-II

Conversion processes: biochemical, thermo-chemical and physico-chemical conversion processes Biochemical processes: Microbial anaerobic and aerobic processes, enzymatic processes; fermentation for alcohols and acids; penicillin and other therapeutic products. Production of single cell protein (SCP); bio-pulping, bio gasification.

UNIT-III

Thermo-chemical processes: pyrolysis (coke and pyro-oils), oxidation-combustion, gasification (downdraft, updraft and fixed bed gasification, fluidized bed and entrained bed gasification). Various methods of manufacture of activated carbons

UNIT-IV

Biofuels, biomaterials, specialty chemicals (gylcol, acetic acid and downstream chemicals), anhydrous alcoholsethanol and butanol; biodiesel, bio-aviation turbine fuel (BATF). Physico-chemical processes: Pretreatment, steam/acid/alkali hydrolysis, effect of temperature on hydrolysis

Suggested Reading:

- ✓ *Tripathi, G., "Bioresource Technology", CBS Publications (2002).*
- ✓ *Pandey, A., "Concise Encyclopaedia of Bioresource Technology", CRC Press (2004).*
- ✓ *Shuler, M., Kargi, F., "Bioprocess Engineering, Basic Concept", Prentice Hall of India Pvt. Ltd. (2004)*

SEC -2 **Credit -03**

Marine Biotechnology

Unit I

Marine Biotechnology - An Introduction, Marine Ecosystem and its Functions, Chemical Oceanography, Sedimentation, Marine microbiology, Values of Marine Biodiversity, Importance of costal aquaculture, Mariculture, Induced Breeding in Fish, Culture of Shrimps and Marine Macroalgae – Seaweeds, Culture of Live Feed Organisms, Bio-floc technology, aquaponics

Unit II

Classification of marine environment. Diseases of Fish and Shrimp, Diagnosis of Diseases of Fish and Shrimp, Chromosomal Manipulation in Fish, Transgenic Fish, Aquatic Vaccines, Probiotics in Aquaculture, Fish feed technology.

Unit III

Bio-communication in oceans, Microbe-microbe interaction, Quorum sensing, Marine biomass and productivity, Biogeochemical processes- Nutrient Cycling, Carbon, Sulphur, Phosphorus and Iron nitrogen cycle, marine pollution

Unit IV

Cryopreservation in Fishery Sciences, Biofouling, Marine Bioremediation, Marine By-products, Marine Pharmaceuticals, Marine Natural Products and their Applications, Marine Protein, Food preservation and processing, Packing.

Suggested Reading

- ✓ *Aquaculture –Principles and Practices, 1990 – TVR Pillay, Fishing Nets Boooks.*
- ✓ *Aquaculture Biotechnology, First edition, 2012, Eds. Garth L. Fletcher and Mathew L Rise, Wiley-Blackwell publication*
- ✓ *Aquaculture Biotechnology, V. Ramachandran, 2013, Black Prints 4. Marine Biology – An ecological approach, 1988 – James W. Nybken, Harper Collins publication*