

# Semester -I

Moham  
29.7.2028

29.7.26

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### **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*

## 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.

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### **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 Units (CRR, 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. 9<sup>th</sup> edition. Pearson Education Limited
- ✓ Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott's Microbiology. 9<sup>th</sup> Edition. McGraw Hill International.
- ✓ Atlas RM. (1997). Principles of Microbiology. 2<sup>nd</sup> edition. WM. T. Brown Publishers.
- ✓ Pelczar MJ, Chan ECS and Krieg NR.(1993). Microbiology. 5<sup>th</sup> edition. McGraw Hill Book Company.
- ✓ Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5<sup>th</sup> edition. McMillan.

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**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
- Preparation 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

## 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

- 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 Research (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, 5<sup>th</sup> Edition, 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.

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### 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 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

**AEC Paper I**  
**English: Business Communication**

**Credits: 4**

| S. No | Modules                                                           | Outcomes                                                                                                                                                                                                     |
|-------|-------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.    | <b>English Language and Communication: Introduction</b>           | <ul style="list-style-type: none"><li>• Communication, its Importance and Factors</li><li>• Types of Communication</li><li>• Verbal and Non-verbal Communication</li><li>• Styles of Communication</li></ul> |
| 2     | <b>English Language and Communication: Listening and Speaking</b> | <ul style="list-style-type: none"><li>• Types of Listening</li><li>• Speaking to communicate effectively</li><li>• Style of speaking in Various Situations</li><li>• English Pronunciation</li></ul>         |
| 3     | <b>English Language and Communication: Reading and Writing</b>    | <ul style="list-style-type: none"><li>• Reading methods and techniques.</li><li>• Reading texts to Understand meaning</li><li>• Writing Process</li><li>• Writing short and Long texts</li></ul>             |
| 4     | <b>English Language and Communication: Grammar and Vocabulary</b> | <ul style="list-style-type: none"><li>• Grammar</li><li>• Sentence structure</li><li>• Functions of Language</li></ul>                                                                                       |

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

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India as a mega diversity nation. Hot spots of biodiversity, Threats to biodiversity. Endangered and endemic species of India. Conservation of biodiversity. In Situ and Ex-situ 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 Lightning)
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

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## Semester - II

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**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  $K_m$  and  $V_{max}$ , 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 Approaches Assignment-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**

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**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

- 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, 9<sup>th</sup> 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: 9781281104493.
- ✓ DeRobertis E. D. P. (2017) Cell and Molecular Biology 8<sup>th</sup> 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. 8<sup>th</sup> Edition. WH Freeman. ISBN: 10-1464183392. 13-978-1464183393
- ✓ Becker W. M., Kleinsmith L.J., Hardin J, Berton 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, 4<sup>th</sup> 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*

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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**

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## 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).

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- 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, VI Edition. 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)).*

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## **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:

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## AEC Paper II

### English: Word and Presentation skill

Credits: 4

| S. No | Modules                    | Outcomes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------|----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.    | <b>Basic Communication</b> | <ul style="list-style-type: none"><li>• Explain:<ul style="list-style-type: none"><li>○ Structures in present and present continuous tense</li><li>○ Structures in past &amp; past continuous tense</li><li>○ Structure in present perfect &amp; present perfect continuous tense</li><li>○ Structures in future tense</li><li>○ Modals: helping verbs</li><li>○ Prepositions</li><li>○ Idioms</li></ul></li><li>• Practice speech on a given topic.</li><li>• Practice Extempore speech</li></ul> |
| 2     | <b>Communication</b>       | <ul style="list-style-type: none"><li>• Describe communication.</li><li>• Describe the Process of communication.</li><li>• Discuss the Importance of communication</li><li>• Explain various Types of communication.</li><li>• Demonstrate Useful Phrases for Everyday Use</li><li>• Explain the technique of Asking Questions</li></ul>                                                                                                                                                           |
| 3     | <b>Hotel English</b>       | <ul style="list-style-type: none"><li>• Describe the Essential qualities of a good speaker.</li><li>• Discuss Speech improvement- pronunciation.</li><li>• Explain the importance of Stress in speech.</li><li>• Describe Intonation and modulation.</li><li>• Describe Common phonetics- difficulties</li></ul>                                                                                                                                                                                   |

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## Semester - III

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## 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:**  $\beta$ -oxidation and omega -oxidation of saturated fatty acids with even and odd number of carbon 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 of Electron 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  $\text{CO}_2$  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

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**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

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- 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. Daniel: *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.

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## 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

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## 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.

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### 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*. 7<sup>th</sup> Edition. Wiley-Blackwell. ISBN: 978-1-405-13544-3
- ✓ Richard J. Reece (2003) *Analysis of Genes and Genomes*. 8<sup>th</sup> 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). *Recombinant DNA- Genes and Genomes- A Short 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

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## 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:

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**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.

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### **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-Hill Publishers.*
- *Verma PS and Agrawal VK, Chordata Embryology (2010) (S Chand Publication).*

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## 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, fecal 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 handling 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, 6<sup>th</sup> Edition, 2017, Elsevier.*
- ✓ *David E. Bruns, Edward R. Ashwood, Carl A. Burtis, Fundamentals of Molecular Diagnostics, 1<sup>st</sup> Edition, Elsevier.*

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## 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.

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## **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

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## 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.

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## Major 1.15

### 1.15 Environment Impact Assessment & Toxicology

Credit 04

#### 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

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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*

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**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, curation, 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

- 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; 3<sup>rd</sup> 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.

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## 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
- 20/11/2020 20/11/2020 20/11/2020

**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 (glycol, acetic acid and downstream chemicals), anhydrous alcohol, ethanol 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)

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