FOUR YEAR UNDERGRADUATE (FYUG) PROGRAMME UNDER NATIONAL EDUCATION POLICY 2020

ZOOLOGY

Academic Council Approval Date: May 21, 2025

NORTH EASTERN HILL UNIVERSITY

SHILLONG

The Curriculum Framework

7th Semester

Course Code	Name of the Paper	Credits (Theory)	Credits (Practical)	Total Credits	Total Contact Hours
ZOO-400	Research Methodology And Research Writing *(For honours and honours with research)*	4	0	4	60
ZOO-401	Advanced Cell Biology And Immunology *(For honours and honours with research)*	3	1	4	75
ZOO-402	Advanced Animal Physiology and Biochemistry *(For honours and honours with research)*	3	1	4	75
ZOO-403	Advanced Genetics and Molecular Biology *(For honours and honours with research)*	3	1	4	75
ZOO-404	Parasites And Human Disease (*Minor - For honours and honours with research*)	4	0	4	60
	Total	**17**	**3**	**20**	**345**

8th Semester

Course Code	Name of the Paper	Credits (Theory)	Credits (Practical)	Total Credits	Total Contact Hours
ZOO-450	Integrative Approaches To Developmental Biology *(For honours and honours with research)*	3	1	4	75
ZOO-451	Freshwater Biology, Wildlife And Conservation Biology (*Minor- For honours and honours with research*)	4	0	4	60
ZOO-452	Research Project/ Dissertation (*For honours with research*)	-	-	12	360
ZOO-453	Laboratory methods in Ecology, Parasitology, Biostatistics and Bioinformatics (*For honours only*)	0	4	4	120
ZOO-454	Experiments in Genetics, Molecular Biology and Biochemistry (*For honours only*)	0	4	4	120
ZOO-455	Ecology, Environmental Biology, and Parasitology (*For honours only*)	4	0	4	60
	Total	**10**	**10**	**20**	**435/495**

Note:

1. For honours only, total credits = 20 credits with a total of 435 contact hours. For honours with research, total credits = 20 credits with a total of 395 contact hours.
2. For student with honours only, paper ZOO-453, ZOO-454, & ZOO-455 is offered in lieu of ZOO-452.

…….

7th Semester

ZOO-400 RESEARCH METHODOLOGY & PROPOSAL WRITING

(Major Course - for honours and honours with research)

Total Credits = 4
Total Contact Hours = 60
Total Marks = 100

Learning objectives:

The course will:

- Introduce advanced molecular biology techniques, including PCR, sequencing, and electrophoresis, for genetic and protein analysis.
- Explain the principles of molecular cloning, protein expression, and chromatography for biochemical investigations.
- Demonstrate spectrophotometry, mass spectrometry, radiolabeling, and imaging techniques for analyzing cellular structures and biomolecules.
- Apply statistical and bioinformatics tools for biological data analysis, including probability distributions, hypothesis testing, and sequence alignment.
- Develop hands-on skills through demonstrations of key molecular and computational techniques in research labs.

Course outcomes (COs):

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

- Apply real-time PCR, sequencing, and array-based techniques for genomic Analyze protein and nucleic acid samples using electrophoresis, chromatography, and spectroscopic methods.
- Interpret immunological assays, including ELISA and Western blotting, for biomolecular detection.
- Evaluate biological datasets using statistical methods and bioinformatics tools for sequence analysis and database management.
- Design and implement experimental workflows integrating molecular biology, biochemical, and computational techniques for research applications.

Theory **Credits: 4**
(Contact hours: 60)

Unit I

Research Problem Identification & Literature Review:

Identification of research problems - Defining a research question and the importance of originality and feasibility.

Literature review - Sources of literature (journals, databases), techniques for critical analysis and synthesis.

Structuring a Research Plan:

Formulation of Research Aims and Objectives - Defining the research aim; Developing specific, measurable, achievable, relevant, and time-bound (SMART) objectives; Aligning objectives with research questions or hypotheses.

Development of a Research Work Plan - Designing a research timeline; Selection and justification of appropriate research methodologies; Anticipating and addressing potential challenges and limitations in the research process.

Research Ethics & Data Integrity:

Ethics in data collection & analysis - Informed consent, privacy, and reproducibility; Avoiding bias and manipulation of data.

Plagiarism and Academic Integrity - Types of plagiarism and tools for plagiarism detection.

Research Outcomes & Publishing:

Research Outcomes & Future Prospects - Communicating findings effectively; Translational impact of research

Journals and Citations - Selecting appropriate journals; Common citation styles; Avoiding predatory journals.

Academic Impact Metrics:

Journal Impact Factor, H-index, and i10-index - Significance and calculation methods; Interpreting Citation Metrics; How citations reflect research impact.

Unit II Nucleic Acid Amplification Techniques:

Real-Time Polymerase Chain Reaction - Principle, components, and mechanism; Applications in gene expression and diagnostics.

Sequencing and Array-Based Techniques:

Whole Genome Sequencing (NGS) - Concept and workflow (Library prep, sequencing, bioinformatics); Platforms - Illumina, PacBio, Oxford nanopore;

DNA Microarray & Methylome Analysis (Illumina Infinium) - Concept of hybridization-based analysis; Applications in genotyping & epigenomics.

RNA Sequencing (RNA-Seq) - Expression profiling, and transcriptomics.

Protein Sequencing - Edman degradation and Mass spectrometry.

Electrophoresis Techniques:

Iso-electrofocusing (Principle & applications in protein charge separation); Pulse-Field Gel Electrophoresis (Mechanism, applications in large DNA fragment separation).

Molecular Cloning & Recombinant Protein Expression:

Basic principles of molecular cloning - Vectors, restriction enzymes, ligation; Cloning in bacterial systems - Selection, transformation, screening; Genomic DNA & cDNA Libraries - Construction and applications.

Expression of recombinant proteins - Expression systems (Bacterial, yeast, and mammalian)

Biochemical analysis techniques:

Tissue processing for chromatography & biochemical analysis - Sample preparation, preservation, extraction methods; Chromatography techniques -

Ion-exchange chromatography, Affinity chromatography, Gel filtration chromatography, High-performance liquid chromatography (HPLC).

Unit III Spectroscopy:

Fluorescence spectroscopy and different types of mass spectrometry.

Crystallography:

X-ray diffraction analysis.

Imaging Techniques:

Visualization of cells and sub-cellular components by fluorescent and electron microscopy (scanning and transmission).

Principles and applications of radiolabeling techniques:

Autoradiography and radioimmunoassay.

Immunological techniques:

Immunodiffusion, enzyme linked immunosorbent assay (ELISA) and Western blotting. Demonstration of relevant techniques in different labs.

Unit IV Basics of Biostatistics:

Measure of Central Tendency - Mean, median, & mode; Significance in biological data interpretation.

Measure of Dispersion - Standard deviation, standard error, coefficient of variation; Applications in experimental biology.

Probability and Distribution - Normal, binomial, and Poisson distribution; Application in biological sampling and genetics.

Hypothesis Testing & Statistical Analysis:

Basics of Hypothesis Testing - Concept of null and alternative hypotheses; Type I and Type II errors, significance level (α), and p-value; Importance of hypothesis testing in biological research.

Tests of Significance - t-test (Comparison of means in biological data); Chi-square test (Genetic linkage, population genetics); ANOVA (Multiple sample comparison in biological experiments).

Simple Correlation and Regression Analysis - Relationship between biological variables; Prediction and modeling.

Introduction to Bioinformatics:

Concept of Biological Databases - NCBI, EBI, DDBJ; Applications in molecular biology research.

Information Retrieval & Sequence Alignment: BLAST - Usage and interpretation of sequence similarity results.

Sequence Data Submission & Management:

Sequence Submission to NCBI - Steps, formats, and importance.

Suggested readings

1. Harris, J. R. (1991). Biological microscopy for biology: A practical approach. IRL Press.
2. Hayat, M. A. (2000). Principles and techniques of electron microscopy: Biological application (4th ed.). Cambridge University Press.
3. Kothari, C. R., & Garg, G. (2019). Research methodology: Methods and techniques (4th ed.). New Age International Publishers.
4. Murad, H., & Atique, M. V. A. (1991). Biological techniques in electron microscopy. CBS Publishers.
5. Nelson, D. L., & Cox, M. M. (2021). Lehninger principles of biochemistry (8th ed.). Prentice Hall.
6. Norman, G. R., & Streiner, D. L. (2014). Biostatistics: The bare essentials (4th ed.). People's Medical Publishing House.
7. Plummer, D. T. (2017). Introduction to practical biochemistry (3rd ed.). Tata McGraw Hill.
8. Stites, D. P., Terr, A. I., & Parslow, T. G. (1994). Basic and clinical immunology. Appleton & Lange.
9. Strachan, T., & Read, A. P. (2019). Human molecular genetics (5th ed.). Garland Science.
10. Triola, M. M., & Roy, J. (2017). Biostatistics for the biological and health sciences (2nd ed.). Pearson.
11. Wilson, K., & Walker, J. (2010). Principles and techniques of biochemistry and molecular biology. Cambridge University Press.

………..

7th Semester

ZOO-401 ADVANCED CELL BIOLOGY AND IMMUNOLOGY

(Minor Course - for honours and honours with research)

Total Credits = 4
Total Contact Hours = 75
Total Marks = 100

Learning objectives:

The course will:

- Explain the molecular composition, structural organization, and functional dynamics of the cell membrane and cytoskeleton.
- Analyze various intracellular transport mechanisms, including membrane transport, protein sorting, and signal transduction pathways.
- Evaluate chromatin organization, epigenetic modifications, and their roles in gene regulation and cellular processes.
- Assess the regulation of the cell cycle, mechanisms of programmed cell death, and molecular basis of cancer development.
- Integrate immunological concepts, including antigen recognition, immune cell activation, and the role of vaccines in immune memory.

Course outcomes (COs):

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

- Differentiate between various membrane transport mechanisms and illustrate the role of transporters like Na^+-K^+ ATPase and GLUTs.
- Interpret the structural and functional significance of cytoskeletal components in maintaining cell shape, motility, and intracellular transport.
- Analyze chromatin remodeling processes and examine the impact of histone modifications on gene expression.
- Critically evaluate the molecular mechanisms of cell cycle regulation, apoptosis, and cancer progression.
- Apply immunological principles to design strategies for disease prevention, including vaccine development and immune response modulation.

Theory **Credits: 3**
(Contact hours: 45)

Unit I Cell Membrane - Composition and Properties:

Molecular Composition and Variability; Asymmetry and Fluidity of the Membrane.

Membrane Transport Mechanisms:

Types of Membrane Transport - Passive vs. Active Transport; Carrier and Channel Proteins; Major Transporters - Na^+-K^+ ATPase, Ca^{2+} Pump, GLUTs, and Aquaporins.

Cytoskeleton - Structural and Functional Dynamics:

Types of Cytoskeletal Components - Microfilaments, Microtubules, Intermediate Filaments; Functions - Cell Shape, Intracellular Transport, and Cell Motility.

Intracellular Protein Sorting and Transport:

Mechanisms of protein targeting and transport to organelles including mitochondria, nucleus, endoplasmic reticulum, golgi complex, and lysosomes.

Cell Junctions and Intercellular Communication:

Types - Tight Junctions, desmosomes, gap junctions; Role in tissue Integrity and Signal Transmission;

Cell Signaling and Signal Transduction Pathways:

Cell Surface Receptors - G-Protein Coupled Receptors (GPCRs) & Enzyme-Linked Receptors; Second Messengers - cAMP, Ca^{2+}, IP_3, DAG; Major Signal Transduction Pathways - G-Protein Linked Pathways, Cytokine-Mediated Pathways, JAK-STAT Pathway.

Unit II Chromatin Organization and Dynamics:

Types of chromatin - Euchromatin vs. heterochromatin; Chemical composition and histones. Molecular organization of nucleosomes; Nucleoplasmin and its role in chromatin assembly; Chromatin condensation mechanisms. Histone modifications - Acetylation, methylation, and phosphorylation; Chromatin remodeling complexes - SWI/SNF, ISWI, INO80.

Cell Cycle and Regulation:

Features and phases of the cell cycle; Regulation of the cell cycle - key regulatory proteins, CDK-Cyclin activity and their role in cell cycle progression and cell cycle checkpoints.

Programmed Cell Death and Cancer Biology:

Apoptosis - Comparison of apoptosis and necrosis; Significance of apoptosis in development and disease; Extrinsic and intrinsic pathways of apoptosis.
Benign and malignant tumors – Characteristic features of malignant cells; Carcinogenesis (Initiation, Promotion, Progression); Genetic and environmental factors influencing carcinogenesis; Role of oncogenes and tumor suppressor genes.

Unit III Antigens and Immune Recognition:

Definition & characteristics: Antigenicity vs. Immunogenicity; Factors affecting immunogenicity; Epitopes and their role in immune responses; Adjuvants - types and mechanisms in enhancing immunogenicity.

T- and B-Cells & their Receptors:

T-cells and B-cells: Development, functions, and activation; T-cell receptor (TCR) and B-cell receptor (BCR) - Structure and signaling.

Immunoglobulins and Antibody Diversity:

Molecular structure of immunoglobulins; classes and functions of immunoglobulins (igG, igA, igM, igE, igD); multigene organization and mechanisms of generation of antibody diversity.

Major Histocompatibility Complex (MHC) and Antigen Presentation:

MHC gene arrangements in mouse and human; Structure and functions of MHC Class I & Class II; role of MHC in antigen presentation to T-cells.

Complement System:

Activation pathways - Classical, alternative, and lectin pathways; Regulation and biological functions of the complement system.

Vaccines and Immunological Memory:

Types of vaccines - Live, killed, subunit, DNA vaccines, mRNA vaccines; characteristic features and mechanisms of vaccine-induced immunity.

Unit IV **(Practical)** **Credits: 1**
(Contact Hours: 30)

1. Preparation and study of mitotic phases in onion root tip cells.
2. Preparation, study and calculation of chiasma frequency and coefficient of terminalization

of meiotic stages in the cells of grasshopper testes.
3. Isolation and staining of mitochondria from liver of commercially available animals.
4. Determination of blood groups in humans and its analysis with reference to cell membrane carbohydrate moieties & antigen-antibody interactions.
5. Study of different cells in blood smears from commercially available animals.
6. Preparation of single cell suspensions from spleen and determination of viability
7. Dissection and histology of lymphoid organs in commercially available animals.
8. Detection, Identification, and Analysis of Antigen-Antibody Interaction Patterns Using Double Radial Immunodiffusion (Ouchterlony Method)

Suggested readings

1. Abbas, A. K., Lichtman, A., & Pillai, S. (2021). Cellular and molecular immunology (10th ed.). Elsevier Publications.
2. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014). Molecular biology of the cell (6th ed.). Garland Publishing.
3. Cooper, G. M. (2018). The cell: A molecular approach (8th ed.). Sinauer Associates Press.
4. Delves, P. J., Martin, S. J., Burton, D. R., & Roitt, I. M. (2017). Roitt’s essential immunology (13th ed.). John Wiley & Sons.
5. Elgert, K. D. (2009). Immunology: Understanding the immune system (2nd ed.). John Wiley.
6. Karp, G., Iwasa, J., & Marshall, W. (2020). Karp’s cell and molecular biology (9th ed.). Wiley.
7. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., & Martin, K. C. (2019). Molecular cell biology (8th ed.). W. H. Freeman and Company.
8. Murphy, K., & Weaver, C. (2017). Janeway’s immunobiology (9th ed.). Garland Science, Taylor & Francis Group.
9. Peakman, M. (2010). Basic and clinical immunology (2nd ed.). Churchill Livingstone.
10. Punt, J., Stranford, S., Jones, P., & Owen, J. (2019). Kuby immunology (8th ed.). W. H. Freeman and Company.

………..

7th Semester

ZOO-402 **ADVANCE ANIMAL PHYSIOLOGY AND BIOCHEMISTRY**

(Major Course - for honours and honours with research)

Total Credits = 4
Total Contact Hours = 75
Total Marks = 100

Learning objectives:

The course will:

- Provide an in-depth understanding of physiological integration and adaptive strategies in animals, emphasizing concepts such as allostasis, stress responses, and environmental adaptations.
- Explore the complex regulatory roles of gut microbiota, neurotransmitter systems, and osmoregulatory mechanisms in maintaining physiological homeostasis across taxa.
- Illustrate metabolic regulation and biosynthesis of carbohydrates, lipids, nucleotides, and amino acids.
- Examine enzyme mechanisms, kinetics, and coenzyme functions in biochemical pathways.
- Evaluate energy transduction processes and the role of electron carriers in metabolism.

Course outcomes (COs):

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

- Critically analyze and compare allostatic and homeostatic mechanisms in stress physiology and extreme environmental adaptations in diverse animal groups.
- Evaluate the integrative roles of gut microbiota and neuroendocrine signaling in regulating metabolic, behavioral, and immune responses in mammals.
- Analyze metabolic pathways and predict regulatory points in biosynthesis and degradation of biomolecules.
- Apply enzyme kinetics principles to interpret reaction mechanisms and metabolic control.
- Critically assess energy transduction systems and explain the role of coenzymes and electron carriers in cellular metabolism.

Theory **Credits: 3**
(Contact hours: 45)

Unit I

Allostasis and Physiological Integration: Concept of allostasis vs. homeostasis in modern physiology. Neuroendocrine integration in adaptive physiological responses with reference to stress physiology.

Gut Microbiome and Metabolic Regulation: Role of the gut microbiota in mammalian digestion and immune modulation. Interaction between microbiome and host metabolism, obesity, and behavior.

Adaptations to Hypoxia and Extreme Environments: Physiological mechanisms in high-altitude mammals and birds. Diving physiology in marine mammals: oxygen storage, bradycardia, and blood flow adjustments.

Neurotransmitter Systems and Synaptic Plasticity: Neurotransmitter classification, synthesis, and receptor diversity. Ionotropic vs. metabotropic receptors. Mechanisms of long-term potentiation and depression.

Osmoregulation in Extreme Environments: Strategies in desert mammals, marine fish, and amphibians. Hormonal control (ADH, aldosterone) in osmoregulation.

Comparative Nitrogen Excretion Strategies: Evolutionary relevance of ammonotelic, ureotelic, and uricotelic excretion. Trade-offs between water conservation and nitrogen elimination.

Unit II Metabolic Regulation and Biosynthesis of Biomolecules:

Regulation of Carbohydrate Metabolism (Glycogen and glucose); Glyoxylate cycle; Biosynthesis of TAG, Phospholipids and cholesterol; Oxidation of unsaturated fatty acids. Biosynthesis and degradation of purine and pyrimidine Nucleotides; Biosynthesis of amino acids (Glutamine, tryptophan and histidine); Structure and biosynthesis of vitamin D.

Unit III Enzyme Mechanisms, Coenzymes, and Energy Transduction:

Enzymes: Allosteric enzymes – Properties, modes of action and models of allosterism (sequential and double displacement); Enzyme kinetics: Kinetics of allosteric enzymes, bi-substrate and multi-substrates reactions including calculations; Co-enzymes (NAD+, FAD+, CoA and PLP) – structure and role in metabolism; structure and role of electron transducing carriers (CoQ, Fe-S centres, copper centres, Cytochromes), phosphate group transfers and ATP.

Unit IV **(Practical)** **Credits: 1**
(Contact Hours: 30)

1. RBC and WBC count in human/animal blood.
2. Hb concentration in human/animal blood
3. Measurement of blood pressure under different physiological conditions.
4. Determination of the rate of oxygen consumption by a fish.
5. Preparation of phosphate and acetate buffers of different pH.
6. Estimation of casein in milk.
7. Estimation of glycogen content in liver of fish/goat.
8. Estimation of ascorbic acid in tomato, lemon and milk for the purpose of comparison.
9. Estimation of amino acids using ninhydrin reagent.
10. Estimation of inorganic phosphate by Fiske-Subbarow method.
11. To study the effect of pH and time on Enzyme activity.

Suggested readings

1. Berg, J. M., Tymoczko, J. L., & Stryer, L. (2007). Biochemistry (6th ed.). W.H. Freeman and Co.
2. Campbell, M. K., Farrell, S. O., & McDougal, O. M. (2022). Biochemistry. Cengage Learning India Pvt. Ltd.
3. Eckert, R., & Randall, D. (2015). Animal physiology: Mechanisms & adaptations (5th ed.). CBS Publishers & Distributors.
4. Hill, R. W., Wyse, G. A., & Anderson, M. (2016). Animal Physiology (4th ed.). Sinauer Associates.
5. McKee, J. R., & McKee, T. (2020). Biochemistry: The molecular basis of life (7th ed.). Oxford University Press USA.
6. Moyes, C. D., & Schulte, P. M. (2006). Principles of animal physiology. Pearson Benjamin Cummings.
7. Nelson, D. L., & Cox, M. (2017). Lehninger principles of biochemistry: International edition. Macmillan Learning.
8. Norris, D. O., & Carr, J. A. (2013). Vertebrate Endocrinology (5th ed.). Academic Press.
9. Prosser, C. L. (1991). Comparative animal physiology. Saunders.

10. Sherwood, L., Klandorf, H., & Yancey, P. H. (2012). Animal physiology: From genes to organisms (2nd ed.). Cengage Learning.
11. Voet, D., Voet, J. G., & Pratt, C. W. (2016). Fundamentals of biochemistry: Life at the molecular level (5th ed.). Wiley
12. Widmaier, E. P., Raff, H., & Strang, K. T. (2019). Vander's Human Physiology (15th ed.). McGraw-Hill.
13. William, B., M.D. (2008). Carpenter animal physiology (New rev. ed.). Kessinger Publishing Co.
14. Witherspoon, J. D. (2001). Human physiology. Harper & Row.

………..

7th Semester

ZOO-403 ADVANCED GENETICS AND MOLECULAR BIOLOGY

(Major Course - for honours and honours with research)

Total Credits = 4
Total Contact Hours = 75
Total Marks = 100

Learning objectives:

The course will:

- Enable students to understand and critically evaluate mechanisms of gene regulation in prokaryotes and eukaryotes, including operon models, translational control, and gene alterations.
- Provide in-depth insights into RNA splicing mechanisms and epigenetic regulatory pathways that influence gene expression at the molecular level.
- Provide students with a comprehensive understanding of classical and molecular principles of human genetics, including inheritance patterns, pedigree analysis, and applications of the human genome project.
- Introduce students to advanced molecular technologies such as genome editing, transgenic animal models, and therapeutic applications including gene therapy and RNA-based interventions.
- Examine the molecular genetics of cancer, including oncogenes, tumor suppressor genes, and therapeutic strategies.

Course outcomes (COs):

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

- Analyze and compare regulatory mechanisms such as the tryptophan operon, feedback inhibition, and gene rearrangement strategies in immune function.
- Evaluate the molecular basis and functional consequences of RNA splicing and epigenetic modifications like DNA methylation and histone acetylation on gene expression.
- Construct and interpret human pedigrees to deduce inheritance patterns and genetic risks.
- Critically evaluate genome editing approaches such as CRISPR/Cas9 and assess their application in generating transgenic animal models and designing gene therapy strategies.
- Analyze the role of epigenetic modifications in gene regulation and predict their implications in diseases like cancer.

Theory **Credits: 3**
(Contact hours: 45)

Unit I Regulation of Genes in Prokaryotes and Eukaryotes:

General aspects of Regulation- The tryptophan operon, relative positions of promoters and operators, regulation of translation, regulation of the synthesis of ribosomes; Unregulated changes in gene expression, feedback Inhibition.

Regulatory strategies in Eukaryotes: Gene alteration (Gene loss, gene amplification, gene rearrangement: the joining of coding sequences in the immune system).

RNA Splicing: tRNA, rRNA precursors; Splicing without protein enzyme;

Epigenetics and Gene Regulation:

Introduction to Epigenetics (concept and definition). Molecular basis of epigenetics - DNA methylation & Histone modifications (acetylation & phosphorylation); Role of DNA methylation in gene expression regulation.

Unit II Human Genetics - Classical and Molecular Approaches:

History of Human Genetics. Pedigree Construction and Analysis. Patterns of Inheritance: Autosomal - Dominant and recessive. Sex-linked - Dominant and recessive; Sex-limited and sex-influenced traits. Human Genome and its Applications (Human Genome Project).

Functional Genomics and Genome Editing:

Generation of Transgenic Animals - Knock-in and Knock-out Models, Microinjection, and ES Cell Transformation. Genome Editing - CRISPR/Cas9 System.

Gene Therapy and RNA-based Therapeutics:

Gene Therapy - Introduction, Somatic and Germline Gene Therapy, *In vivo, Ex vivo,* and *In vitro* Gene Therapy. Transgenic Animal Models for Gene Therapy.

Unit III Genetics of Cancer:

Oncogenes and their role in cancer: Retroviral oncogenes – Discovery and significance; Proto-oncogenes – Normal functions and how mutations lead to cancer; Oncogenes in human cancer – Examples and mechanisms.

Introduction to tumor suppressor genes (TSGs) - Definition & contrast with oncogenes. Characteristics & functions of TSGs - General mechanisms of tumor suppression (Cell cycle control, apoptosis, DNA repair, senescence).

Key TSGs products and their functions: Role of p53 protein in DNA repair, apoptosis, and cell cycle arrest; regulation of the G1/S checkpoint by the retinoblastoma (Rb) protein and its control over E2F transcription factors.

Interplay Between Oncogenes & Tumor Suppressor Genes in Cancer Development: How TSG loss cooperates with oncogene activation.

Tumor Viruses and Their Role in Cancer:

Mechanisms of viral-induced cancer – Integration and oncogene activation; Examples of tumor viruses - Hepatitis B viruses (HBV) and liver cancer, Papilloma viruses and cervical cancer, SV40, polyomaviruses, adenoviruses, herpes viruses, and retroviruses.

Epigenetic Basis of Cancer:

DNA Methylation and cancer; Histone Acetylation & Deacetylation in cancers - Role of HATs & HDACs.

Gene Therapy for Cancer:

Concept of cancer gene therapy – Strategies & challenges; RNA-DNA Chimera in Cancer therapy – Mechanism & applications; Viral vaccines for cancer Therapy – HPV vaccine and oncolytic viruses.

Unit IV **(Practical)** **Credits: 1**
(Contact Hours: 30)

1. Analyze inheritance patterns of traits across generations using pedigree charts.
2. Laboratory handling, maintenance, culture preparation and study of the life cycle of *Drosophila melanogaster.*
3. Study of Drosophila mutants using charts/models/specimens
4. Preparation of giant polytene chromosomes from salivary glands of Drosophila/Chironomus larvae
5. Genomic DNA isolation from animal tissue or virtual simulation
6. Agarose Gel preparation and electrophoresis of DNA using kit or virtual simulation
7. Restriction enzyme digestion of genomic DNA using restriction digestion kit or virtual simulation
8. Demonstration of PCR using kit or virtual simulation.

Suggested readings

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). Molecular biology of the cell (6th ed.). Garland Science.
2. Allis, C. D., Jenuwein, T., & Reinberg, D. (Eds.). (2015). Epigenetics (2nd ed.). Cold Spring Harbor Laboratory Press.
3. Armstrong, L. (2021). Epigenetics (2nd ed.). Garland Science.
4. Ashburner, M. (1989). Drosophila: A laboratory manual. Cold Spring Harbor Laboratory Press.
5. Brown, T. A. (2016). Genomes (4th ed.). Garland Science.
6. Cooper, G. M., & Hausman, R. E. (2018). The cell: A molecular approach. Oxford University Press.
7. Kakar, S., & Singh, R. (2022). Genome Editing: Technologies and Applications (1st ed.). Springer.
8. Krebs, J. E., Goldstein, E. S., & Kilpatrick, S. T. (2022). Lewin's genes XII (12th ed.). Jones & Bartlett Learning.
9. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., & Martin, K. C. (2021). Molecular cell biology (9th ed.).
10. Nussbaum, R. L., McInnes, R. R., & Willard, H. F. (2021). Thompson & Thompson Genetics in Medicine (9th ed.). Elsevier.
11. Pecorino, L. (2016). Molecular biology of cancer: Mechanisms, targets, and therapeutics (4th ed.). Oxford University Press.
12. Strachan, T., & Read, A. P. (2018). Human Molecular Genetics (5th ed.). Garland Science.
13. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. (2014). Molecular biology of the gene (7th ed.). Pearson Education.
14. Weinberg, R. A. (2014). The biology of cancer (2nd ed.). Garland Science.

………..

7th Semester

ZOO-404 PARASITES AND HUMAN DISEASE

(Minor Course - for honours and honours with research)

Total Credits = 4
Total Contact Hours = 60
Total Marks = 100

Learning objectives:

The course will:

- Introduce students to the principles of parasitism and host-parasite relationships, emphasizing their ecological and public health significance.
- Enable students to classify and describe major protozoan, helminthic, and arthropod parasites of medico-veterinary importance, including their life cycles, transmission, and control.
- Equip students to analyze host immune responses and parasite immune-evasion mechanisms, emphasizing protozoan and helminthic interactions.
- Explore zoonotic parasitic diseases and emerging threats due to climate change, fostering understanding of integrated control and One Health strategies.

Course outcomes (COs):

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

- Define and differentiate types of parasitism and explain their relevance in ecology and disease epidemiology.
- Illustrate the morphology and life cycles of key protozoan and helminth parasites, and analyze their pathogenic mechanisms.
- Evaluate the role of host immunity and parasite evasion strategies in disease persistence and transmission.
- Critically assess zoonotic transmission dynamics and propose integrated vector control and climate-adaptive strategies for parasite management.

Theory **Credits: 4**
(Contact hours: 60)

Unit I Introduction to Parasitism and Host-Parasite Relationships

Overview of Parasitism:

Parasitism - Definition, significance in ecology and human health. Types of parasitism (obligate, facultative, ecto-parasites, and endo-parasites). Comparison of parasitism with mutualism and commensalism.

Host-Parasite Relationships:

Key terms - Host, definitive host, intermediate host, paratenic host, vector, zoonosis. Reservoirs of infection and epidemiological significance. Co-evolution of parasites and their hosts.

Protozoan Parasites:

Plasmodium sp.- Morphology and life cycle of *Plasmodium vivax.* Pathogenicity and clinical features of malaria. Diagnosis, treatment, and emerging drug resistance. Morphology and life cycle of *Entamoeba histolytica*- Pathogenicity, diagnosis, and treatment.

Unit II Helminth parasites and Their Adaptations

Overview of helminths:

Classification of helminths - Trematodes, cestodes, and nematodes. General adaptations for parasitism (morphological, physiological, and behavioral).

Trematode parasites:

Fasciola gigantica - Morphology and life cycle; Pathogenicity, clinical features, and diagnosis. Role of freshwater snails as intermediate hosts. Zoonotic significance and control measures.

Cestode parasites:

Taenia solium - Morphology and life cycle; Pathogenicity, clinical features, diagnosis, and control measures.

Nematode parasites:

Ascaris lumbricoides - Morphology, life cycle, and pathogenicity. Clinical manifestations and epidemiology of round worm infection. Diagnosis, treatment, and prevention.

Unit III Arthropod Parasites, Insect Vectors, and Disease Transmission

Arthropod parasites:

Pediculus humanus capitis - Biology and life cycle of head lice. Epidemiology and transmission dynamics. Public health significance and treatment strategies.

Insect vectors and disease transmission:

Mosquito vectors and human diseases – *Anopheles* (Malaria transmission, vector control strategies), *Culex* (Role in filariasis), and viral diseases (West Nile virus, Japanese encephalitis); *Aedes* (Dengue, chikungunya, Zika virus transmission). Integrated vector management (biological, chemical, and genetic control methods).

Control Strategies for Vector-Borne Diseases:

Use of insecticides and larvicides. Biological control - Predatory fish, bacteria-based larvicides. Genetically modified mosquitoes for vector control. Impact of environmental changes on vector distribution and disease prevalence.

Unit IV Host-Parasite Interactions and Environmental Impact:

Host Specificity in Parasitism - Concepts and definitions; Kinds of specificity (ecological, phylogenetic, behavioral); Factors influencing host specificity.

Zoonotic Parasitic Diseases and Their Control:

Transmission dynamics of zoonotic parasites; One Health approach for zoonotic disease control; Case study - *Toxoplasma gondii*.

Immunity Against Parasitic Infections:

Immune responses against different parasitic groups - Protozoa (*Plasmodium*), Trematodes (*Schistosoma*), Intestinal nematodes (Ascaris).
Immune-Evasive Strategies of Parasites - Antigenic variation (Trypanosomes) and Immunosuppression (Filarial worms).

Impact of Climate Change on Parasitism and Disease Control:

Climate-driven changes in parasite distribution; Emerging parasitic threats due to global warming.

Suggested readings

1. Awasthi, V. B. (2016). Introduction to general and applied entomology (3rd ed.). Scientific Publishers.
2. Bogitsh, B. J., Carter, C. E., & Oeltmann, T. N. (2005). Human parasitology. Elsevier Science.
3. Chatterjee, K. D., & Chatterjee, D. (2019). Parasitology, protozoology and helminthology. CBS Publishers.
4. Cheng, T. C. (2012). General parasitology. Elsevier Science.
5. Gunn, A., & Pitt, S. J. (2012). Parasitology: An integrated approach. Wiley.
6. Lucius, R., Loos-Frank, B., Lane, R. P., Poulin, R., Roberts, C., & Grencis, R. K. (2017). The biology of parasites. Wiley.
7. Marquardt, W. C., Demaree, R. S., & Grieve, R. B. (2000). Parasitology and vector biology. Academic Press.
8. Modern parasitology: A textbook of parasitology. (2009). Wiley.
9. Paniker, C. K. J., & Ghosh, S. (2017). Paniker's textbook of medical parasitology. Jaypee Brothers Medical Publishers Pvt. Limited.
10. Smyth, J. D., & Wakelin, D. (1994). Introduction to animal parasitology. Cambridge University Press.

………..

8th Semester

ZOO-450 INTEGRATIVE APPROACHES TO DEVELOPMENTAL BIOLOGY

(Major Course - for honours and honours with research)

Total Credits = 4
Total Contact Hours = 75
Total Marks = 100

Learning objectives:

The course will:

- Provide an understanding of the molecular and cellular mechanisms of development, including cell signaling, induction, competence, and differentiation.
- Explore the processes involved in early developmental stages, such as fertilization, cleavage, gastrulation, and axis formation in various model organisms.
- Describe the development of specific organs and systems, including the vertebrate brain, somites, limbs, muscles, and bones, with a focus on morphogenesis and organogenesis.
- Help to gain practical knowledge through hands-on experiments and histological techniques, such as studying regeneration, chick embryo development, cell death, and in vitro development.

Course outcomes (COs):

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

- Gain a comprehensive understanding of the molecular and cellular mechanisms involved in development, including cell signaling pathways and cellular interactions that govern differentiation and morphogenesis.
- Acquire practical skills in experimental techniques, such as whole mount preparation, histological studies, and in vitro culture of embryos, to investigate developmental processes.
- Develop the ability to analyze and interpret regeneration processes in model organisms (e.g., *Planaria*, *Hydra*, tadpoles) and study cell death pathways in developmental contexts, such as in chick embryos.
- Integrate knowledge from various species (e.g., *Drosophila*, amphibian and chick embryos) to understand key concepts of developmental biology, such as pattern formation, axis development, and organogenesis.

Theory **Credits: 3**
(Contact hours: 45)

Unit I Cell-to-cell communication in development:

Induction and competence (Cascades of induction, instructive and permissive interactions, epithelial-mesenchymal interactions).

Paracrine factors - Overview of fibroblast growth factors, Hedgehog family, Wnt family, TGF-beta superfamily.

Signal Transduction Pathways in Development:

RTK pathway, SMAD pathway, JAK-STAT pathway, Wnt pathway, Hedgehog pathway. Juxtacrine signaling - Notch signaling pathway; Cell death pathways.

Stem cells:

Definition, characteristics and types of stem cells (Totipotent, pluripotent, multipotent, unipotent); Applications in tissue engineering and regenerative medicine.

Unit II Internal fertilization and the block to polyspermy in mammals.

Early Development in Drosophila:

Cleavage, blastulation, gastrulation, and axis formation (Maternal-effect genes and axis formation).

Cell Commitment and Specification in Development:

Types of specification (Autonomous, conditional, and syncytial specification); Mechanisms of cell fate determination (with example of regulatory genes and a signaling pathways).

Axis and Pattern Formation in Amphibians:

Spemann-Mangold organizer and gastrulation movements (Nieuwkoop center & BMP inhibitors); Molecular mechanisms in axis formation (Wnt signaling, Organizer induction, DV polarity).

Unit III Morphogenesis and organogenesis:

Development of the vertebrate brain.

Somites and their derivatives.

Osteogenesis: The development of bones.

Myogenesis: The development of muscles.

Development of the tetrapod limb: Formation of the limb bud, generation of the proximal-distal axis, anterior-posterior axis, dorsal-ventral axis, coordination of the three axes, and formation of digits.

Regeneration of the salamander limb.

Unit IV **(Practical)** **Credits: 1**
(Contact Hours: 30)

1. Study of the regeneration of *Planaria*/*Hydra*/tail of tadpoles.
2. Study of various stages of w.m of chick embryo according to Hamburger and Hamilton, 1951 staging.
3. Study of histological sections of early developmental stages of the chick embryo.
4. Preparation of a whole mount of the chick embryo and identification of developmental stages.
5. Alizarin red staining for skeletal visualization in fish.
6. Study of cell death in chick embryos using vital stains (Neutral Red).
7. Study of the development of chick embryos in vitro.

Suggested readings

1. Balinsky, B. I. (1981). An introduction to embryology (5th ed.). Holt-Saunders and International Editions.
2. Carlson, B. M. (2007). Foundations of embryology (6th ed.). Tata McGraw-Hill Publishers.
3. Ericson, B. L. W., Carl, A., & Jeffrey, W. R. (1997). Developmental biology. Saunders College Publications.
4. Gilbert, S. F., & Barresi, M. J. F. (2018). Developmental biology (11th ed.). Sinauer Associates Inc. Publishers.
5. Kalthoff, K. (2001). Analysis of biological development (2nd ed.). McGraw-Hill Publishers.
6. New, D. A. T. (1966). The culture of vertebrate embryos. Logos Press Limited.
7. Shi, Y. B. (2000). Amphibian metamorphosis: From morphology to molecular biology. John Wiley & Sons, Inc.
8. Subramoniam, T. (2002). Developmental biology. Narosa Publishing House.
9. Tuan, R. S., & Lo, C. W. (1984). Developmental biology protocols (Vols. I–III). Humana Press.
10. Wolpert, L., Tickle, C., & Martinez, A. (2019). Principles of development (6th ed.). Oxford University Press.

………..

8th Semester

ZOO-451 AQUATIC BIOLOGY AND BIODIVERSITY

(Minor Course - for honours and honours with research)

Total Credits = 4
Total Contact Hours = 60
Total Marks = 100

Learning objectives:

The course will:

- Introduce fundamental concepts of limnology, including the classification and ecological significance of lentic and lotic ecosystems.
- Explain the physical and chemical limiting factors influencing freshwater habitats and their impact on aquatic biodiversity.
- Describe the diversity of flora and fauna in freshwater ecosystems and their ecological roles.
- Analyze the importance of wildlife conservation, threats to biodiversity, and conservation strategies at local, national, and global levels.
- Examine wildlife conservation laws, international organizations, and regulations governing wildlife trade and protection.

Course outcomes (COs):

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

- Differentiate between lentic and lotic ecosystems and classify water bodies based on their origin, stratification, and ecological characteristics.
- Evaluate the impact of physical and chemical factors on freshwater biodiversity and ecosystem functioning.
- Identify key aquatic organisms (plankton, nekton, benthos) and assess their ecological significance.
- Discuss wildlife conservation approaches, including in situ and ex situ conservation, and their effectiveness in biodiversity protection.
- Interpret wildlife protection laws and analyze the role of organizations like IUCN, WWF, and national agencies in conservation efforts.

Theory **Credits: 4**
(Contact hours: 60)

Unit I

Foundations of Limnology:

Definition, scope, and significance of limnology; Interdisciplinary nature of limnology (linkages with ecology, hydrology, and geoscience).

Classification and Types of Inland Waters:

Freshwater, brackish and saline systems.
Lentic ecosystems (lakes, ponds, reservoirs) - Definitions and characteristics.
Lotic ecosystems (streams, rivers) - definitions and hydrological features.
Functional differences between lentic and lotic systems.

Physical Limiting Factors in Freshwater Ecosystems:

Light, Temperature, density and buoyancy, turbidity and transparency, and depth.

Chemical Limiting Factors:

Dissolved oxygen (DO), carbon dioxide (CO_2), pH and alkalinity, nutrients (Biogenic salts), and organic matter.

Zonation and Typology of Lentic Systems:

Zonation of lakes and ponds; Origin and classification of lakes (tectonic, glacial, volcanic, fluvial, artificial); Types of ponds (ephemeral, semi-permanent, permanent); Stratification and mixing regimes (Dimictic, monomictic, polymictic, and meromictic).

Structure and Function of Lotic Ecosystems:

Stream order and flow regime - Gradient, substrate, and flow variability.
River Continuum Concept (RCC) - Changes in energy sources, biota, and ecosystem processes along the river course.

Biotic Communities in lakes and rivers.

Unit II

Marine Environment – Physical and chemical properties:

Physical parameters - Light attenuation and depth zones, temperature gradients, ocean pressure, waves, tides, and currents (thermohaline and wind-driven circulation).
Chemical parameters - Salinity gradients and halocline, gas solubility (O_2 and CO_2), pH buffering systems, ocean acidification.
Productivity and Nutrients - Macronutrients (N, P, Si), micronutrients (Fe), upwelling systems, oligotrophic vs. eutrophic regions.

Stratification and Zonation in Marine Realms:

Vertical Stratification - Epipelagic to hadopelagic (with hydrography and biotic adaptations).
Benthic Zones - Intertidal, continental shelf, abyssal plain, hydrothermal vent and cold seep habitats.
Horizontal Zonation - Littoral, neritic, oceanic zones

Marine Biodiversity and Ecological Communities:

Major Marine Biota – Plankton, Nekton, and Benthos,

Functional Communities:

Coral reefs - structure, symbiosis, bleaching threats; Kelp forests and seagrass beds; Open-ocean pelagic systems; Deep-sea ecosystems - adaptations and energy dynamics.
Feeding Relationships: Trophic levels, food webs, detritus-based vs. grazing-based systems.

Modern Perspectives in Marine Ecology:

Climate Change Impacts - Warming, acidification, sea-level rise, deoxygenation.
Marine Protected Areas (MPAs) and conservation strategies.

Unit III

Introduction to Biodiversity:

Defining biodiversity - levels (genetic, species, ecosystem); Biodiversity vs. species richness; Functional and phylogenetic diversity.

Measuring Biodiversity:

Species richness, evenness, abundance; Diversity indices (Shannon, Simpson); Sampling methods and biases; Estimating total biodiversity (global estimates, uncertainty).

Mapping Biodiversity:

Purpose and significance of mapping biodiversity; Issues of spatial and temporal scale; Patterns - biodiversity hotspots vs. coldspots; Gradients in biodiversity (latitudinal, altitudinal, depth); Congruence and surrogacy in biodiversity mapping.

Values of Biodiversity:

Direct-use value - food, fuel, medicine, materials; Indirect-use value - ecosystem services (pollination, water purification, climate regulation); Non-use values - aesthetic, cultural, ethical; Biodiversity and resilience.

Unit IV

Human Impacts on Biodiversity:

Historical vs. current extinction rates (6th mass extinction); Species extinction - patterns and causes; Genetic erosion - consequences for adaptation and resilience.

Threats to biodiversity - habitat loss, fragmentation, invasive species, pollution, overexploitation, and climate change.
The Anthropocene and biodiversity.

Maintaining Biodiversity:

Introduction to the Convention on Biological Diversity (CBD); Objectives and principles of the CBD.
General measures for conservation and sustainable use; Identification and monitoring mechanisms.
In-situ conservation - Protected Areas, indigenous community reserves; Ex-situ conservation - zoological parks, botanical gardens, sacred forests, gene banks, seed banks.
Sustainable use of biodiversity - ecosystem approaches and resource management.
Incentive-based conservation - payments for ecosystem services, community-based conservation.

National and international responses - Aichi Targets, Post-2020 Global Biodiversity Framework.

Suggested readings

1. Castro, P., & Huber, M. E. (2019). Marine biology (12th ed.). McGraw-Hill Education.
2. Dobson, M., & Frid, C. (2008). Ecology of aquatic systems. Oxford University Press.
3. Dodds, W. K. (2002). Freshwater ecology: Concepts and environmental applications. Elsevier.
4. Fryxell, J. M., Sinclair, A. R., & Caughley, G. (2014). Wildlife ecology, conservation, and management. John Wiley & Sons.
5. Gaston, K. J., & Spicer, J. I. (2004). Biodiversity: An Introduction (2nd ed.). Blackwell Publishing.
6. Jones, I. D., & Smol, J. P. (Eds.). (2023). Wetzel's limnology: Lake and river ecosystems (4th ed.). Elsevier Academic Press.
7. Kaiser, M. J., Attrill, M. J., Jennings, S., Thomas, D. N., Barnes, D. K. A., Brierley, A. S., ... & Kaartokallio, H. (2020). Marine ecology: Processes, systems, and impacts (3rd ed.). Oxford University Press.
8. Levinton, J.S. (2020). Marine Biology: Function, Biodiversity, Ecology. Oxford Univ. Press.
9. Primack, R. B. (2014). Essentials of Conservation Biology (6th ed.). Sinauer Associates.
10. Saha, G. K., & Mazumdar, S. (2017). Wildlife biology: An Indian perspective. PHI Learning.
11. Singh, S. K. (2020). Textbook of wildlife management (3rd ed.). CBS Publishers.
12. Van Dyke, F. (2008). Conservation biology: Foundations, concepts, applications. Springer Science & Business Media.
13. Wetzel, R. G., & Likens, G. E. (2010). Limnological analyses. Springer-Verlag New York Inc.

………..

8th Semester

ZOO-452 **Research Project / Dissertation**

(Major Course - for honours with research)

Total Credits = 12
Total Contact Hours = 360
Total Marks = 100

1. Identification of the research problem, writing of synopsis proposal, presentation of the synopsis: (Credits: 3)
2. Dissertation: (Credits: 5)
3. Presentation of dissertation and Viva voce: (Credits: 4)

……….

8th Semester

ZOO-453 **LABORATORY METHODS IN ECOLOGY, PARASITOLOGY, BIOSTATISTICS AND BIOINFORMATICS**

(Major Course - for honours only)

Total Credits = 4
Total Contact Hours = 120
Total Marks = 100

Learning objectives:

The course will:

- Train students in ecological field and laboratory techniques for analyzing soil characteristics and ecosystem productivity.
- Develop skills for identifying and examining parasitic protozoans and helminths of medical and veterinary importance using microscopy and permanent preparations.
- Impart proficiency in statistical analysis using software tools to interpret biological data through descriptive and inferential methods.
- Introduce students to bioinformatics tools and databases to retrieve, align, and analyze molecular data relevant to zoological species.

Course outcomes (COs):

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

- Analyze ecological samples to determine moisture, organic content, and primary productivity using standard lab techniques.
- Identify and distinguish key morphological features of protozoan and helminth parasites and prepare diagnostic blood smears for microscopic analysis.
- Compute statistical parameters (mean, SD, t-tests, ANOVA) and interpret biological significance using Excel/SPSS or equivalent software.
- Retrieve and analyze molecular sequence data using NCBI tools and BLAST, and evaluate annotation and species identity based on alignment metrics.

Practical **Credits: 4**
(Contact hours: 120)

Unit I

1. Determination of Moisture Content of soil samples by the Oven Drying Method
2. Determination of organic Matter in soil using the Walkley -Black method (Titration and Colorimetric Method).
3. Analysis of primary productivity in a freshwater ecosystem.
4. Study of protozoan and helminth parasites of medico-veterinary importance from permanent preparations/Charts: *Entamoeba*, *Leishmania*, life history stages of liver fluke (Redia and Cercaria), tape worm (bladder worm), and blood flukes.
5. Preparation of thin and thick blood smears of fish for detection of blood protozoans.
6. Study of permanent blood films depicting haemoflagellates, haemosporidia, microfilarae.
7. Exploration and study of helminthic infections in locally slaughtered vertebrate hosts: poultry, pigs and goats.
8. Introduction to standard statistical package like MS Excel/SPSS/any other appropriate software.
9. Compute the mean, median, and mode using raw or simulated biological data and provide the biological interpretation of the results.
10. Calculate SD, SE, and CV using raw or simulated biological data and provide the biological interpretation of the results.

11. Create various kinds of graphical representation of the data (like boxplots, histograms, scatter plots etc), using raw or simulated biological data through software package like MS Excel/SPSS or any appropriate software.
12. Perform independent and paired t-tests and interpret biological significance of results, using raw or simulated data.
13. Conduct a One-Way ANOVA using raw or simulated data and use the Post-hoc Tukey test.
14. Calculate Pearson correlation coefficient from a raw or simulated data. Plot the scatter diagram.
15. Explore NCBI's taxonomy browser using some selected zoological species and perform searches on GenBank, RefSeq, and Protein databases for the selected species. Record the gene/protein entries for a particular gene/protein in different taxa. Compare annotation features across databases.
16. Perform sequence retrieval & alignment using nucleotide BLAST (BLASTn) with a query COI sequence from pisces or reptilia. Interpret max score, query coverage, identity %. Identify closest species match and possible misidentifications.

Note: The Statistical experiments can be carried out using any standard statistical package like MS Excel/SPSS/any other appropriate software

Suggested readings

1. APHA. (2017). Standard methods for the examination of water and wastewater (23rd ed.). Washington, D.C.: American Public Health Association.
2. Baxevanis, A. D., & Ouellette, B. F. F. (2009). Bioinformatics: A practical guide to the analysis of genes and proteins (3rd ed.). Wiley India Pvt. Limited.
3. Daniel, W. W., & Cross, C. L. (2014). Biostatistics: Basic concepts and methodology for
4. Garcia, L. S. (2007). Diagnostic medical parasitology (5th ed.). Washington, DC: ASM Press.
5. Lesk, A. (2014). Introduction to bioinformatics. OUP Oxford.
6. Michael, P. (1986). Ecological methods for field and laboratory investigations. Tata McGraw-Hill India.
7. Rao, P. S. S. S., & Richard, J. (2012). Introduction to biostatistics and research methods. PHI Learning.
8. Roberts, L. S., & Janovy, J. (2013). Foundations of parasitology (9th ed.). New York: McGraw-Hill.
9. Taylor, M. A., Coop, R. L., & Wall, R. L. (2016). Veterinary parasitology (4th ed.). Oxford: Wiley-Blackwell.
10. the health sciences. Wiley.
11. Wetzel, R. G., & Likens, G. E. (2010). Limnological analyses. Springer-Verlag New York Inc.
12. Xiong, J. (2006). Essential bioinformatics. Cambridge University Press.

..……..

8th Semester

ZOO-454 **EXPERIMENTS IN GENETICS, MOLECULAR BIOLOGY AND BIOCHEMISTRY**

(Major Course - for honours only)

Total Credits = 4
Total Contact Hours = 120
Total Marks = 100

Learning objectives:

The course will:

- Provide students with practical exposure to cytogenetic techniques, including mitosis, meiosis, and chromatin studies, to reinforce cellular and chromosomal concepts.
- Train students in classical and molecular genetic analysis, including chromosome mapping, gene linkage studies, and Hardy-Weinberg equilibrium testing.
- Develop students' competencies in modern molecular biology tools such as PCR, DNA profiling, and restriction digestion.
- Equip students with biochemical analytical skills through the study of enzyme kinetics, inhibition patterns, and separation techniques like chromatography.
- Promote scientific reasoning and data analysis skills by using simulated and raw data to draw conclusions on genotypic frequencies, paternity, and radiation-induced chromosomal aberrations.

Course outcomes (COs):

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

- Perform cytological experiments such as root tip squashes and testis smear preparations to identify mitotic and meiotic stages and calculate mitotic index.
- Construct genetic maps and determine gene order using 3-point test cross data, and analyze chromosomal aberrations induced by radiation.
- Evaluate genotypic and allelic frequencies in populations, apply the Hardy-Weinberg principle, and use the Chi-square test to assess genetic equilibrium.
- Demonstrate molecular diagnostic techniques including PCR and DNA fingerprinting, and interpret STR profiles for paternity or identity analysis.
- Analyze enzyme activity through kinetic parameters (Km and Vmax), investigate competitive inhibition, and apply chromatographic methods to separate biomolecules like proteins and lipids.

Practical **Credits: 4**
(Contact hours: 120)

Unit I

1. Preparation of onion root tip squash and determination of mitotic index.
2. Preparation and study of sex chromatin from human buccal cells.
3. Chromosome mapping with linked genes by the determination of map distances and gene order from a 3-point cross genetic data.
4. Study of Radiation-induced chromosomal aberrations from slides/images.
5. Calculation of Genotypic and allelic frequencies in a population from raw or simulated data.
6. Test the Hardy-Weinberg equilibrium using raw or simulated data of allele frequencies from a population. Calculate expected genotypic frequencies. Perform Chi-square Test for goodness-of-fit.
7. DNA Profiling using raw or simulated STR Markers data from different individuals to determine paternity of a subject.
8. Restriction enzyme digestion of genomic DNA using restriction digestion kit or

virtual simulation

9. Demonstration of PCR using kit or virtual simulation.
10. Studying enzyme kinetics: Determination of Km (Michaelis constant) and Vmax (maximum reaction velocity) using Urease enzyme.
11. Study of Competitive Inhibition of Urease by Thiourea and Determination of Inhibition Constant (Ki)
12. Gel filtration chromatography using protein mixture or dye
13. Separation of lipids using Thin Layer Chromatography (TLC)

Suggested readings

1. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014). Molecular biology of the cell (6th ed.). Garland Science.
2. Boyer, R. F. (2000). Modern experimental biochemistry (3rd ed.). Pearson Education.
3. Brown, T. A. (2016). Gene cloning and DNA analysis: An introduction (7th ed.). Wiley-Blackwell.
4. Gardner, E. J., Simmons, M. J., & Snustad, D. P. (2008). Principles of genetics (8th ed.). Wiley.
5. Green, M. R., & Sambrook, J. (2012). Molecular cloning: A laboratory manual (4th ed.). Cold Spring Harbor Laboratory Press.
6. Griffiths, A. J. F., Wessler, S. R., Carroll, S. B., & Doebley, J. (2020). Introduction to genetic analysis (12th ed.). Macmillan.
7. Hedrick, P. W. (2011). Genetics of populations (4th ed.). Jones & Bartlett Learning.
8. Nelson, D. L., & Cox, M. M. (2021). Lehninger principles of biochemistry (8th ed.). Macmillan.
9. Plummer, D. T. (2017). An introduction to practical biochemistry (3rd ed.). McGraw-Hill Education.
10. Segel, I. H. (1993). Enzyme kinetics: Behavior and analysis of rapid equilibrium and steady-state enzyme systems. Wiley.
11. Wilson, K., & Walker, J. (2018). Principles and techniques of biochemistry and molecular biology (8th ed.). Cambridge University Press

………..

8th Semester

ZOO-455 ECOLOGY, ENVIRONMENTAL BIOLOGY, AND PARASITOLOGY

(Major Course - for honours only)

Total Credits = 4
Total Contact Hours = 60
Total Marks = 100

Learning objectives:

The course will:

- Provide students with a comprehensive understanding of population dynamics, community structure, and ecological interactions across ecosystems.
- Develop students' analytical skills in interpreting ecological succession, species interactions, and niche concepts using classical and modern ecological principles.
- Equip students with the ability to evaluate environmental challenges including pollution, climate change, and the sustainable use of resources, integrating global and local perspectives.
- Introduce students to the biology, transmission, pathogenesis, and control of protozoan and helminthic parasites of human importance.
- Train students to critically assess host-parasite interactions and the influence of climate and immunity on parasite biology, with emphasis on zoonoses and One Health approaches.

Course outcomes (COs):

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

- Analyze population growth patterns, interpret age pyramids, and distinguish between r- and K-strategies in population regulation.
- Differentiate types of ecological interactions, explain the principles of succession, and assess community characteristics using quantitative measures.
- Evaluate the causes and consequences of air, water, and soil pollution, and suggest sustainable solutions including renewable energy and resource conservation.
- Describe life cycles, pathogenesis, and control strategies for major protozoan and helminthic parasites, and interpret public health implications of zoonotic parasitic diseases.
- Assess immune responses to different parasitic groups, evaluate parasite immune evasion strategies, and analyze the impact of climate change on parasite distribution and disease emergence.

Theory **Credits: 4**
(Contact hours: 60)

Unit I Population and Community Ecology:

Population attributes: Density, natality, mortality, age distribution and age pyramids, growth curves, biotic potential, factors regulating population size; r- and k- strategies.

Biotic community concept; Community characteristics - species richness and species diversity, relative abundance, dominance, equitability and carrying capacity; ecological niche - types, Gause's principle of competitive exclusion.

Interactions among organisms - intraspecific and interspecific interactions.

Ecological succession – Types; General process of succession; Examples of succession - Hydrosere and heterotrophic succession; Climax concept in succession.

Unit II Environmental Challenges and Sustainable Solutions:

Environmental Pollution - Air, water, and soil pollution (sources, consequences, and, management); Greenhouse effect, global warming and climate change; Ozone layer depletion; Acid rain.

Types of natural resources-renewable and non- renewable and their conservation.

Non–conventional energy sources: Solar, wind, hydel, biomass and geothermal energy.

Sustainable eco-development. Environmental impact and risk assessment.

Unit III

Protozoan Parasites: Pathogenesis, diagnosis, and treatment of key protozoan diseases - Chagas disease (*Trypanosoma cruzi*), human african trypanosomiasis (Sleeping Sickness), and Leishmaniasis.

Helminthic parasites and their impact:

Life cycle, pathogenesis, epidemiology, and control of - Liver flukes (*Dicrocoelium*), the Blood flukes (*Schistosoma* spp.).

Life cycle, hydatid disease, and public health significance of *Echinococcus* spp.

Life cycle, pathogenesis, and control strategies of *Ancylostoma* sp.; life cycle and pathogenesis of *Wuchereria bancrofti*.

Unit IV

Host-Parasite Interactions and Environmental Impact:

Host Specificity in Parasitism - Concepts and definitions; Kinds of specificity (ecological, phylogenetic, behavioral); Factors influencing host specificity.

Zoonotic Parasitic Diseases and Their Control: Transmission dynamics of zoonotic parasites; One Health approach for zoonotic disease control; Case study - *Toxoplasma gondii*.

Immunity Against Parasitic Infections - Immune responses against different parasitic groups - Protozoa (*Plasmodium*), Trematodes (*Schistosoma*), Intestinal nematodes (Ascaris). Immune-Evasive Strategies of Parasites - Antigenic variation (Trypanosomes) and Immunosuppression (Filarial worms).

Impact of Climate Change on Parasitism and Disease Control - Climate-driven changes in parasite distribution; Emerging parasitic threats due to global warming.

Suggested readings

1. Begon, M., & Townsend, C. R. (2020). Ecology: From individuals to ecosystems (5th ed.). John Wiley & Sons Inc.
2. Cain, M. L., Bowman, W. D., & Hacker, S. D. (2011). Ecology (2nd ed.). Sinauer Associates, Inc. Publishers.
3. Michael, P. (1986). Ecological methods for field and laboratory investigations. Tata McGraw-Hill India.
4. Odum, E. P., & Barrett, G. W. (2006). Fundamentals of ecology (5th ed.). Cengage Learning India.
5. Sharma, P. D. (1990). Ecology and environment. Rastogi Publications.
6. Smith, T. M., & Smith, R. L. (2014). Elements of ecology (8th ed.). Pearson Education India.
7. Stiling, P. D. (2012). Ecology companion site: Global insights and investigations. McGraw Hill Education.
8. Bogitsh, B. J., Carter, C. E., & Oeltmann, T. N. (2018). Human parasitology (5th ed.). Academic Press.
9. Cox, F. E. G. (2009). Modern parasitology: A textbook of parasitology (2nd ed.). Wiley-Blackwell.
10. Loker, E. S., & Hofkin, B. V. (2022). Parasitology: A conceptual approach (2nd ed.). CRC Press.
11. Roberts, L. S., Nadler, S., Schmidt, G. D., & Janovy, J. (2013). Foundations of parasitology (9th ed.). McGraw-Hill Higher Education.
12. Smyth, J. D., & Wakelin, D. (2001). Introduction to animal parasitology (3rd ed.). Cambridge University Press.
13. Sood, R. (2020). Textbook of human parasitology: Protozoology and helminthology. CBS Publishers & Distributors Pvt. Ltd.
14. Zeibig, E. (2012). Clinical parasitology: A practical approach (2nd ed.). Saunders.

………