FOUR YEAR UNDERGRADUATE (FYUG) PROGRAMME UNDERNATIONAL EDUCATION POLICY 2020

ZOOLOGY

NORTH EASTERN HILL UNIVERSITY

SHILLONG

Preface

The four-year undergraduate program in Zoology offers an enriching educational experience that combines theoretical knowledge with hands-on practical. It is framed to impart students with a comprehensive understanding of the fields of Zoology along with its various disciplines. Throughout the four-year journey, students will engage in a dynamic learning environment facilitated by experienced faculty members. The Department facilities and research opportunities offer students the chance to explore the complexities of various aspects of Zoology firsthand, instilling in them a sense of in-depth responsibility of Zoology and its importance in modern society. Furthermore, the FYUP emphasizes the importance of ethical practices, fostering critical thinking and problem-solving abilities.

Programme Outcomes (POs):

1. Students will understand the importance of Taxonomy and Animal diversity and its significance.
2. Students will about Environmental science and the importance and issues related to environment in present day context.
3. Students will be able to learn about Functional and comparative Anatomy of animals.
4. Students will study about Cell Biology and genetics which will give then an understanding about organisms and the importance of genes and heredity.
5. Students will be imparted with the concept of living system regulated by various biochemical processes and also the role of Immunology in terms of natural defense.
6. Students will understand the concepts of Evolutionary Biology, role of adaptation in organisms, and the various aspects of Animal behavior
7. Students will learn the basic of Aquatic Biology, Wildlife Biology and Conservation Biology
8. Students will gain knowledge on various aspects of parasites and their importance, they will learn the fundamentals of Insects and Entomology, and their importance of animals in Economic Zoology.
9. Students will learn about Developmental Biology and Endocrinology
10. Students will be able to understand various bio-techniques, the application of bioinformatics in biology and the application of Biostatistics in biology.
11. Students will be able to obtain understanding about molecular process in biology and the application of molecular biology in the field of biotechnology
12. Students will undertake Internship and learn how to apply knowledge and skills effectively for analyzing real-world zoological problems, conducting research, and practical applications.

1st Semester

Course Code	Course Title	Credits (Theory)	Credits (Practical)	Total Credits	Total Contact Hours
ZOO-100	Taxonomy and Animal Diversity (Major)	3	1	4	60
ZOO-100	(Minor)	3	1	4	60
MDC-110-119	Any of the available course as notified by the University from time to time	3	0	3	45
AEC-120-129	Any of the available course as notified by the University from time to time	3	0	3	45
SEC-130-139	Any of the available course as notified by the University from time to time	3	0	3	45
VAC-ZOO-140	Environmental Science	3	0	3	45
	Total	**18**	**2**	**20**	**300**

FSC – Fishery Science; MDC – Multi Disciplinary Course; AEC – Ability Enhancement Course; SEC – Skill Enhancement Course; VAC – Value Added Course; VTC - Vocational Education Training Course.

2nd Semester

Course Code	Name of the Paper	Credits (Theory)	Credits (Practical)	Total Credits	Total Contact Hours
ZOO-150	Functional and Comparative anatomy (Major)	3	1	4	60
ZOO-150	(Minor)	3	1	4	60
MDC-160-169	Any of the available course as notified by the University from time to time	3	0	3	45
AEC-170-179	Any of the available course as notified by the University from time to time	3	0	3	45
SEC-180-189	Any of the available course as notified by the University from time to time	3	0	3	45
VAC-190-199	Any of the available course as notified by the University from time to time	3	0	3	45
	Total	**18**	**2**	**20**	**300**

3rd Semester

Course Code	Name of the Paper	Credits (Theory)	Credits (Practical)	Total Credits	Total Contact Hours
ZOO-200	Introductory Cell Biology and Genetics(Major)	3	1	4	75
ZOO-201	Introductory Biochemistry and Immunology(Major)	3	1	4	75
MDC-210-219	Any of the available course as notified by the University from time to time	3	0	3	45
AEC-220-229	Any of the available course as notified by the University from time to time	2	0	2	30
SEC-230-239	Any of the available course as notified by the University from time to time	3	0	3	45
VTC-240-249	Any of the available course as notified by the University from time to time	1	3	4	105
	Total	**15**	**5**	**20**	**375**

4th Semester

Course Code	Name of the Paper	Credits (Theory)	Credits (Practical)	Total Credits	Total Contact Hours
ZOO-250	Evolutionary Biology, Adaptation, and Animal Behaviour (Major)	3	1	4	75
ZOO-251	Aquatic Biology, Wildlife Biology and Conservation Biology (Major)	3	1	4	75
ZOO-252	Ecology and Environmental Biology(Major)	3	1	4	75
ZOO-253	Parasitology, Entomology, and Economic Zoology(Major)	3	1	4	75
VTC-260-269	Any of the available course as notified by the University from time to time	1	3	4	105
	Total	**13**	**7**	**20**	**405**

5th Semester

Course Code	Name of the Paper	Credits (Theory)	Credits (Practical)	Total Credits	Total Contact Hours
ZOO-300	Animal Physiology (Major)	3	1	4	75
ZOO-301	Biochemistry and Immunology (Major)	3	1	4	75
ZOO-302	Introductory Developmental Biology and Endocrinology (Major)	3	1	4	75
ZOO-302	Economic and Applied Zoology (Minor)	3	1	4	75
ZOO-303	Internship	0	4	4	120
	Total	**12**	**8**	**20**	**420**

6th Semester

Course Code	Name of the Paper	Credits (Theory)	Credits (Practical)	Total Credits	Total Contact Hours
ZOO-350	Bio-techniques, Bioinformatics, and Biostatistics (Major)	4	-	4	60
ZOO-351	Cell biology and Genetics (Major)	3	1	4	75
ZOO-352	Developmental Biology and Reproductive Biology (Major)	3	1	4	75
ZOO-353	Molecular Biology and Biotechnology (Major)	3	1	4	75
VTC-360-369	Any of the available course as notified by the University from time to time	1	3	4	105
	Total	**14**	**6**	**20**	**390**

3rd Semester
ZOO-200 INTRODUCTORY CELL BIOLOGY AND GENETICS

Total Credits 4
Total Contact Hours 75
Total Marks = 100

Course objectives:

The course will:

- Explore the structural and functional organization of cell organelles.
- Evaluate the process of cell division, including mitosis and meiosis, in terms of genetic inheritance and variation.
- Examine genetic principles to understand patterns of inheritance and phenotypic variation in populations and information on chromosome structure and dynamics to comprehend the role of genetics in health and disease.

Learning outcomes (LOs):

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

- Differentiate between various cell organelles and explain their functions using appropriate terminology.
- Analyze and interpret data from experiments on mitosis and meiosis.
- Evaluate the impact of chromosomal aberrations on human health and discuss genetic disorders caused by chromosomal anomalies.
- Demonstrate practical skills in laboratory techniques related to cell biology and genetics,

(Theory) **Credits:3**

Contact hours:-45

Unit 1:

Basic structure of prokaryotic and eukaryotic cells.
Ultrastructural characteristics and functions: Plasma membrane, mitochondria, endoplasmic reticulum, golgi complex, ribosomes, centrioles, and lysosomes
Introduction to cytoskeletal components: Microtubules, microfilaments, and intermediate filaments.
Ultrastructural characteristics and functions: Nucleus, nuclear envelope, and nucleolus.

Unit 2:

Chromatin structure and function: Definition and overview; Chromatin structure and function; Euchromatin and heterochromatin; Levels of chromatin organization: Nucleosome, linker DNA and histone proteins, 30-nm fiber, looped domains level, chromosome level.
Chromosome structure: Morphology, including primary constriction, secondary constriction, and satellite bodies. Chromosome classification based on the position of centromeres.
Specialized chromosomes: Structure and function of polytenechromosome and lampbrush chromosome.
Cell cycle phases. Mitosis and meiosis: Stages and biological significance.
Cancer biology: Introduction to cancer and short historical overview; Characteristics

of cancer cells; Differentiation between benign and malignant tumors; Types of cancer- Sarcoma, carcinoma, lymphoma and leukemia; Common carcinogens and their effects.

Unit 3:

Introduction to DNA as genetic material.
Central dogma of molecular biology: Replication, transcription, and translation.
Mendelian genetics: Mendel's experiments and principles of inheritance; Concept of genotype, phenotype, dominance, recessiveness, back cross and test cross. Co-dominance and incomplete dominance; Multiple alleles - ABO Blood groups in humans;
Gene Interactions: Definition of epistasis and types (complementary, supplementary, inhibitory, and duplicate).
Pleiotropy: Effects of single genes on multiple traits
Lethal Genes: Tay-Sachs disease and sickle cell anemia
Chromosomal theory of inheritance.
Linkage: Types of linkage and crossing over.
Chromosomal aberrations: Structural aberrations- Deletion, duplication, inversion, and translocation; Numerical aberrations- Euploidy and aneuploidy.
Sex determination: Chromosomal, genic balance theory, environmental factors.

Unit 4: **(Practical)** **Credit: 1**

(Contact hours :30)

1.Study of cell organelles from model/charts
2. Preparation and study of different stages of mitosis in onion root tip.
3. Preparation (demonstration only) and study of different stages of meiosis from grasshopper testis using permanent slides
4. Study of chromosome types from slides/photographs
5. Preparation and study of polytene chromosomes from Chironomus larva
6. Determination and study of multiple alleles (ABO blood groups in man)
7. Study of phenotypic variations in natural population (at least three characters- rolling tongue, ear lobe, ABO blood groups, Rh blood group, etc.)

Suggested readings:

1. Alberts, B., Bray, D., Hopkin, K., Johnson, A. D., Lewis, J., Raff, M., & Walter, P. (2015). Essential cell biology. Garland Science.
2. Becker, W. M., Kleinsmith, L. J., & Hardin, J. (2011). Becker's World of the Cell (8th ed.). Pearson Benjamin Cummings.
3. Cooper, G. M. (2007). Cell: A Molecular Approach. Sinauer Associates.
4. Gardener, E. J., Simmons, M. J., & Snustad, D. P. (2005). Principles of Genetics (8th ed.). John Wiley & Sons.
5. Karp, G. (2009). Cell and molecular biology: Concepts and experiments. John Wiley & Sons.
6. Klug, W., Cummings, M., Spencer, C., & Palladino, M. (2012). Concepts of Genetics (10th ed.). Benjamin Cummings.
7. Pierce, B. (2012). Genetics: A conceptual approach (4th ed.). W.H. Freeman.
8. Singh, B. D. (2023). Fundamentals of Genetics (6th ed.). Med Tech Publication.
9. Strickberger, M. W. (1995). Genetics (3rd ed.). Macmillan Publishing Company.

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3rd Semester

ZOO-201 INTRODUCTORY BIOCHEMISTRY AND IMMUNOLOGY

Total Credits 4
Total Contact Hours 75
Total Marks = 100

Course objectives:

The course will:

- Analyze the structural and functional aspects of biomolecules such as carbohydrates, lipids, proteins, DNA, RNA, and vitamins and evaluate mechanisms of enzymatic reactions.
- Study metabolic pathways, catabolism, anabolism, and the role of enzymes
- Explore the fundamentals of immunology.

Learning outcomes:

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

- Identify and perform biochemical tests for the detection of carbohydrates, lipids, and proteins, describe the structure of DNA and RNA, and estimate the concentration of ascorbic acid.
- Investigate the effect of temperature and pH on the activity of human salivary amylase.
- Study lymphoid organ anatomy through charts, models, and videos, Analyze histological sections of spleen, thymus, and lymph nodes ,prepare stained blood films to identify blood cells under the microscope.

(Theory) **Credits 3**

(Contact hours: 45)

Unit 1

Carbohydrates
Monosaccharides: Reducing and non-reducing sugars, Chiral centre, Fischer-Haworth projections (glucose and fructose), anomers.
Disaccharides: glycosidic linkage and examples.
Polysaccharides: Glycogen & Starch and Glycoconjugates - Hyaluronic acid.
Amino acids and proteins
Amino acids: Structure, classification and general properties of α-amino acids; physiological importance of essential and non-essential α-amino acids;
Peptides and proteins: Peptide linkage, dipeptides – Glutathione; Polypeptides – Insulin; Simple and conjugate proteins.
Lipids
Classification, structure and biological importance of lipids; Saturated and un-saturated fatty acids, TAG, phospholipids, glycolipids, and steroids.
Chemical structure of DNA and RNA: Nucleosides, nucleotides and polynucleotides.
Vitamins: Types, sources and functions.

Unit 2

Introduction to Enzymes: Properties of enzymes; Nomenclature and classification; Co-factors, ribozymes, isozymes, proenzymes, and allosteric enzymes.

Enzyme-substrate complex: Lock and key model and induced fit model, role of active sites and catalytic residues in substrate binding and catalysis; Physico-chemical factors affecting enzyme activity.

Metabolism: Catabolism and anabolism, stages of catabolism, compartmentalization of metabolic pathways; Errors in metabolism – phenylketonuria.

Principles of biophysical chemistry: Critical attributes of water that facilitate life. Normality, molarity and molality of solutions; Acids and bases; pH and buffers; Henderson-Hasselbalch equation; Buffers in biological systems.

Stabilizing interaction of proteins and nucleic acid structure: Van der waal's electrostatic interaction, hydrophobic interactions, disulphide bridges, and hydrogen bonding.

Protein structure and levels of organization: Primary, secondary, tertiary, and quaternary structure.

Unit 3

Introduction to immunology: Immunity- types (innate and adaptive, natural and artificial, passive and active, humoral and cell mediated).

Components of innate immunity: Physical barriers (skin, mucous membranes) and chemical barriers (acidic pH, enzymes) in innate immunity; Cellular components-Neutrophils, macrophages, dendritic cells, natural killer (NK) cells, and their roles in innate immune responses.

Adaptive immunity: Introduction to adaptive immunity and its key features-specificity, diversity, memory, and tolerance.

Organs of immune systems; Hematopoiesis; Cells involved in immunity and APCs.

Molecules involved in immunity: Immunoglobulins – basic structure, types and their function; Cytokines – Properties, types and their function; MHC – basic structure, types and their function.

Antigen: Characteristics and types (endogenous and exogenous); Haptens, adjuvants, epitope; Antigenicity and immunogenicity; Factors influencing immunogenicity; antigen - antibody interaction (precipitation, agglutination and complement fixation)

Unit 4 **(Practical)** **Credit 1**

(Contact Hours 30)

1. Detection of Carbohydrates, lipids and proteins (at least three tests)
2. Study of DNA and RNA structure from charts/models/videos
3. Estimation of Ascorbic acid by titration method
4. Study of human salivary amylase activity in relation to temperature
5. Study of human salivary amylase activity in relation to pH
6. Demonstration of lymphoid organs from charts/models/videos
7. Study of sections of spleen, thymus and lymph nodes through slides or photographs.
8. Temporary preparation of stained blood film to study various types of blood cells.

Suggested readings

1. Abbas, A. K., Lichtman, A. H., & Pillai, S. (2019). Basic immunology: Functions and disorders of the immune system (6th ed.). Elsevier India.
2. Berg, J. M., Tymoczko, J. L., & Stryer, L. (2007). Biochemistry (6th ed.). W.H. Freeman and Co.
3. Campbell, M. K., Farrell, S. O., & McDougal, O. M. (2022). Biochemistry. Cengage Learning India Pvt. Ltd.

4. Delves, P. J., Martin, S. J., Burton, D. R., & Roitt, I. M. (2017). Roitt's essential immunology. John Wiley & Sons.
5. Kindt, T. J., Goldsby, R. A., Osborne, B. A., & Kuby, J. (2007). Kuby immunology (6th ed.). W.H. Freeman and Co.
6. McKee, J. R., & McKee, T. (2020). Biochemistry: The molecular basis of life (7th ed.). Oxford University Press USA.
7. Nelson, D. L., & Cox, M. (2017). Lehninger principles of biochemistry: International edition. Macmillan Learning.
8. Voet, D., Voet, J. G., & Pratt, C. W. (2016). Fundamentals of biochemistry: Life at the molecular level (5th ed.). Wiley

4th Semester

ZOO-250 EVOLUTIONARY BIOLOGY, ADAPTATION, AND ANIMAL BEHAVIOUR

Total Credits 4
Total Contact Hours 75
Total Marks = 100

Course objectives:

This course will:

- Explore natural selection, speciation, , human evolutionary history
- Explore adaptation and evolution.
- Examine different types of innate and learned behaviours, complex behaviours and genetic and hormonal influences on behaviour,

Learning outcomes (LOs):

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

- Understand mechanisms like natural selection and patterns like speciation, while exploring human evolutionary history and the evolution of genus *Homo*.
- Understand the concept of adaptation and its importance in evolutionary biology and investigate diverse adaptations to different environments and locomotion types in animals.
- Understand historical perspectives, key figures in ethology, and the nervous system's involvement, innate and learned behaviours.

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

Unit 1

Evolution

Introduction to Evolutionary Biology: Definition of evolution and its significance in biology; Historical context - from Darwin to modern synthesis; The role of evolution as a unifying principle in biology.

Evidence for Evolution: Fossil record and transitional forms; Comparative anatomy and homology; Molecular evidence: DNA, RNA, and protein sequences

Mechanisms of Evolution: Natural selection and adaptation; Genetic drift and gene flow; Mutation and genetic variation. Hardy-Weinberg principle – frequencies of alleles and genotypes.

Patterns of Evolution: Modes of speciation (allopatric, sympatric and parapatric) and species concepts (Morphological species concept, biological species concept, evolutionary species concept); Convergent evolution and evolutionary convergence;

Human Evolution: Overview of human evolutionary history; Evolution of the Genus *Homo*.

Unit 2

Adaptation

Introduction to Adaptation: Definition of adaptation and its importance in evolutionary biology; Mechanisms of adaptation: natural selection, genetic variation, and phenotypic plasticity. Adaptations to Locomotion: Cursorial adaptation-adaptations for running; Fossorial adaptation-adaptations for burrowing; Arboreal

adaptation-adaptations for living in trees;
Adaptations to Physical Environments: Desert adaptation-strategies for coping with arid conditions; Volant adaptation-adaptations for flight; Aquatic adaptation - adaptations for life in water; Cave-dwelling adaptation-adaptations for living in caves; Deep-sea adaptation-adaptations for the deep ocean environment.
Coloration in Animals: Types of coloration- cryptic, warning, and mating coloration; Mechanisms of color production-pigments and structural coloration; Adaptive significance of coloration-camouflage and communication.
Mimicry: Batesian mimicry- mimicry of harmful species by non-harmful species; Müllerian mimicry- mimicry among harmful species; Mimicry as an adaptation for predation, defense, and mate attraction.

Unit 3

Animal Behaviour
Introduction to Animal Behaviour: Overview of the field of animal behaviour; Historical perspectives and key figures in ethology; The four questions about animal behaviour and the zebra finches example; Units of the nervous system.
Development of Behaviour: Innate behaviour - reflexes, kinesis, taxis, instincts, foraging behaviour, and Fixed Action Patterns (FAPs); Learned behaviour - simple, associated, and cognitive learning; Complex behaviour - integration of innate and learned behaviours.
Genetic and Hormonalregulation of behaviour: Genetic influences on behaviour (example- hygienic behaviour honey bee); Hormones and early development of behaviour (specify example). Modes of communication in animals.
Evolution of Behaviour: Adaptiveness of behaviour; Natural selection and behaviour (specify example); Sexual selection-male and female strategies (specify example); Mating systems and their evolutionary significance.

Unit 4 **(Practical)** **Credit :1**

(Contact Hours 30)

1. To utilize anatomical, embryological, and paleontological evidence demonstrated through charts and models.
2. To investigate the evolutionary progression of amniotes through examination of skull morphology, distinguishing between anapsids, diapsids, and synapsids, facilitated by charts and models.
3. To understand and explore -the evolutionary history of horses through phylogenetic analysis, illustrated with charts and models.
4. Fossil identification- to recognize and categorize different fossil specimens.
5. Application and calculation of allelic and genotypic frequencies utilizing the Hardy-Weinberg principle.
6. To study adaptive modifications of bird beaks, emphasizing their functional significance and evolutionary implications.
7. Submission of a photographic record showcasing animal adaptations, particularly focusing on coloration and mimicry.
8. To study the behavioural observation on animal behaviour and distinguishing between innate and learned behaviours, with a focus on identifying behavioural patterns.
9. Examination of communication signals across different species, including examples and functions, to understand the role of communication in animal behaviour and evolution.
10. To study geotactic behaviour in earthworm.
11. To study the phytotaxis in insect larvae.

Suggested readings:

1. Adhikari, S., & Sinha, A. K. (2016). Fundamentals of biology of animals. Kolkata, India: New Central Book Agency.
2. Arumugam, N. (2019). Organic evolution. Saras Publication.
3. Dugatkin, L. A. (2014). Principles of animal behaviour (Third edition). United Kingdom: W. W. Norton.
4. Futuyma, D. (2013). Evolution. United States: Sinauer.
5. Goodenough, J., McGuire, B., &Jakob, E. (2010). Perspectives on animal behaviour. United Kingdom: Wiley.
6. Hall, B. K., Hallgrímsson, B., &Strickberger, M. W. (2014). Strickberger's evolution. United States: Jones & Bartlett Learning.
7. Herron, J. C., & Freeman, S. (2014). Evolutionary analysis. United Kingdom: Pearson.
8. Mandal, F. B. (2015). Textbook of animal behaviour. India: PHI Learning Private Limited.
9. Manning, A., & Dawkins, M. S. (2012). An introduction to animal behaviour. United Kingdom: Cambridge University Press.
10. Rastogi, V. B. (2018). Organic evolution (3rd ed.). MedTech.
11. Ridley, M. (2009). Evolution. United Kingdom: Wiley.

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4th Semester

ZOO-251 AQUATIC, WILDLIFE AND CONSERVATION BIOLOGY

Total Credits 4
Total Contact Hours 75
Total Marks = 100

Course objectives:

The course will:

- To understand aquatic environments, the structural and functional roles of their biota and to differentiate between lentic and lotic freshwater ecosystems.
- Explore estuarine and marine ecosystems.
- Gain insights into the significance of wildlife, identify threats, and recognize the necessity for wildlife conservation and management.

Learning outcomes (LOs):

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

- Understand the importance of aquatic environments and their biota.
- Understand about the importance of estuarine and marine ecosystems and their communities.
- Gain an insight into wildlife, threats to wildlife, and conservation and management.
- Appreciate the wildlife conservation efforts through in situ and ex situ conservation and have an understanding about different international and national policies for wildlife conservation.

(Theory) **Credits : 3**

(Contact hours: 45)

Unit 1 Introduction to limnology: Definition and history; Physicochemical characteristics of freshwater environments (Physical – Light, temperature, turbidity and depth; Chemical – Oxygen, carbon dioxide, pH, biogenic salts and organic matter).
Inland waters and their types – Lentic and lotic; Zonation of lakes and ponds; Formation, classification and thermal stratification of lakes; Classification of ponds. Lotic habitats; River continuum concept. Flora and fauna of lentic and lotic habitats (Plankton, neuston, nekton, periphyton/aufwuchs, benthos).

Unit 2 Physicochemical characteristics of marine ecosystem: (Physical – Light, temperature, pressure, tides; Chemical – Salinity, O2, CO2, pH, inorganic and organic matter).Classification and stratification of marine environment; Marine communities.
Estuaries – Types and estuarine biota.

Unit 3 Wildlife: Definition, economic importance of wild life, threats to biodiversity and causes of wildlife depletion; Keystone, flagship and umbrella species; Biodiversity hotspots. IUCN Red Data Book and Red List categories and criteria.
Wildlife conservation – Definition, need for wildlife conservation. Types of conservation – In situcorridors and their types. National Wildlife Action Plan 2017-2031; Wildlife Protection Amendment Act, 2006.conservation (National park, Wildlife sanctuaries, Biosphere reserves); Ex situ conservation (Botanical gardens, Zoological gardens, Germplasm banks); Introduction to Animal

Unit 4 **(Practical)** **Credit 1**

(Contact Hours 30)

1. Estimation of dissolved oxygen in water samples (lentic and lotic).
2. Estimation of free CO2 in water samples (lentic and lotic).
3. Estimation of total alkalinity in water samples (lentic and lotic).
4. Estimation of total hardness in water samples (lentic and lotic).
5. Estimation of calcium and magnesium hardness of water samples (lentic and lotic).
6. Determination of pH, Specific conductivity and TDS of water samples.
7. Qualitative study of plankton from freshwater.
8. Quantitative study of plankton from freshwater.
9. Analysis of community similarities and species diversity indices.
10. Field visit to any in-situ/ ex-situ conservation sites.

Suggested readings:

1. Dobson, M., &Frid, C. (2008). Ecology of aquatic systems. Oxford University Press.
2. Dodds, W. K. (2002). Freshwater ecology: Concepts and environmental applications. Elsevier.
3. Fryxell, J. M., Sinclair, A. R., &Caughley, G. (2014). Wildlife ecology, conservation, and management. John Wiley & Sons.
4. Levinton, J. S. (2008). Marine biology: Function, biodiversity, ecology. Springer-Verlag New York Inc.
5. Michael, P. (1986). Ecological methods for field and laboratory investigations. Tata McGraw-Hill India.
6. Saha, G. K., &Mazumdar, S. (2017). Wildlife biology: An Indian perspective. PHI Learning.
7. Singh, S. K. (2020). Textbook of wildlife management (3rd ed.). CBS Publisher.
8. Van Dyke, F. (2008). Conservation biology: Foundations, concepts, applications. Springer Science & Business Media.
9. Wetzel, R. G. (2001). Limnology: Lake and river ecosystems. Gulf Professional Publishing.
10. Wetzel, R. G., & Likens, G. E. (2010). Limnological analyses. Springer-Verlag New York Inc.

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4th Semester

ZOO-252 ECOLOGY AND ENVIRONMENTAL BIOLOGY

Total Credits 4
Total Contact Hours 75
Total Marks = 100

Course objectives:

The course will:

- Explore concepts of Ecology, abiotic and biotic factors, ecological interactions, and biogeochemical cycles, ecosystem functioning and ecological principles.
- Develop understanding of Environment and foster appreciation for significant contemporary environmental issues and problems, such as environmental degradation caused by anthropogenic activities and pollution.
- Encourage students to critically analyze ecological and environmental problems

Learning outcomes (LOs):

On completion of the course, students will be able to

- Understand concepts of Ecology, and recognize its significance in understanding the natural world.
- Describe the levels of organization in the Biosphere, and analyze the structural and functional components of ecosystems, including trophic relationships and energy flow..
- Evaluate the impact of biotic and abiotic factors on ecological systems
  Understand environmental concerns such as pollution, habitat destruction, and climate change.

(Theory) **Credits 3**

(Contact hours: 45)

Unit 1

Ecology: Concepts, subdivisions, scope and importance.
Levels of organization in the biosphere.
Ecosystem: Structure and function (components and trophic level); Food chains, food web. Trophic Relationships- Ecological pyramids, productivity, energy flow. Laws of limiting factors, Liebig's law of minimum and maximum, Shelford's law of tolerance.
Ecological factors: Biotic and Abiotic; Morphological and physiological adaptations to light and temperature. Biogeochemical Cycles (Nitrogen, Carbon and Phosphorus Cycle);
Salient features of terrestrial ecosystem; Ecotones and the edge effect; k-selection & r-selection.

Unit 2

Population and Community
Characteristics of population; Density, natality, mortality, life tables, fecundity tables; Survivorship curves, age ratio, sex ratio, dispersal and dispersion.
Population Growth: exponential and logistic growth, growth curve; Regulation of population density.
Community: characteristics, structure and composition. Species richness and species diversity. Ecological succession (causes, types, process); Interspecific and intra specific species interactions; Ecological niche; Terrestrial biomes.

Unit 3

Environmental concerns

Environmental Pollution - Air, Water, Land, Radioactive pollution (causes, sources, consequences and management), Acid rain.

Biological indicators, Biomagnification. Anthropogenic activity on the environment; Ozone depletion. Greenhouse effect, global warming and climate change.

Natural resources: Renewable and non-renewable and their management. Sustainable development: Concept and strategies

Ecotoxicology: Definition, toxicity effects, classification of toxicants and application of toxicology.

Unit 4 **(Practical)** **Credit 1**

(Contact Hours 30)

1. Study of soil texture from at least two ecosystems.
2. Estimation of temperature, conductivity and pH of different soil samples.
3. Estimation of primary productivity of a pond by light and dark bottle method.
4. Estimation of phosphate in soil samples.
5. Study of population distribution in relation to biotic and abiotic factors.
6. Simple random sampling of a natural population using the quadrat method and the calculation of population density, relative abundance, frequency, species richness, species diversity and evenness.
7. Comparative study of terrestrial/aquatic fauna in a polluted and unpolluted site.
8. Study of behavioural response to environmental stress (temperature stress on housefly).
9. Analysis of air quality of different sites to assess and compare pollution levels using simulated data.

Suggested readings

1. Beeby, A., & Brennan, M. A. (2008). First ecology - Ecological principles and environmental issues (3rd ed.). Oxford University Press, India.
2. Cain, M. L., Bowman, W. D., & Hacker, S. D. (2011). Ecology (2nd ed.). Sinauer Associates, Inc. Publishers.
3. Kendeigh, F. C. (1984). Ecology with special reference to animal and man. Prentice Hall Inc.
4. Kormondy, E. J. (1996). Concepts of ecology (4th ed.). Prentice Hall of India Pvt. Ltd.
5. Michael, P. (1986). Ecological methods for field and laboratory investigations. Tata McGraw-Hill India.
6. Odum, E. P., & Barrett, G. W. (2006). Fundamentals of ecology (5th ed.). Cengage Learning India.
7. Sharma, P. D. (1990). Ecology and environment. Rastogi Publications.
8. Shyam, D., & Rosencranz, A. (2001). Environmental law and policy in India. Oxford University Press.
9. Smith, T. M., & Smith, R. L. (2014). Elements of ecology (8th ed.). Pearson Education India.
10. Stiling, P. D. (2012). Ecology companion site: Global insights and investigations. McGraw Hill Education.

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4th Semester

ZOO-253 PARASITOLOGY, ENTOMOLOGY, AND ECONOMIC ZOOLOGY

Total Credits 4
Total Contact Hours 75
Total Marks = 100

Course objectives:

The course will:

- Provide an understanding of parasitism and parasite-host relationship.
- Study of the morphology, life cycle, epidemiology, and pathogenicity of protozoan and helminth parasite. Importance and control of arthropod parasite and insect vectors.
- Study of the morphology and physiological structures of insect.
- Understand economic zoology through practices of apiculture, sericulture and pisciculture.

Learning outcomes (LOs):

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

- Understand parasitism and the relationship between parasite and host with morphology, life cycle, epidemiology, and pathogenicity of protozoan and helminth parasite.
- Understand the importance and control of arthropod parasite and insect vectors.
- To study and identify insects up-to their orders, their morphology and physiology
- To understand the economic importance of beekeeping, and learn about types of silkworms

(Theory) **Credits 3**

(Contact hours: 45)

Unit 1

Introduction to Parasitism and Host-Parasite relationships.
Overview of parasitism: An introduction to the concept of parasitism and its significance in ecology and human health. Host-Parasite Relationship: Exploration of key terms including host, definitive host, intermediate host, symbiosis, commensalism, reservoir, and zoonosis, elucidating the intricate interactions between parasites and their hosts.
Protozoan Parasites: Study of life cycle and pathogenicity of *Plasmodium* sp.
Helminth Parasites: Study of morphology, life cycle and pathogenicity including *Ancylostomaduodenale* (Nematoda) and *Fasciolagigantica (*Platyhelminthes). Analysis of the morphological and physiological adaptations of helminth parasites, highlighting their evolutionary strategies for survival and reproduction.
Arthropod Parasites: Study of the biology, significance, and management of head lice (*Pediculushumanuscapatis*) infestations, emphasizing their impact on human health and strategies for control.
Insect Vectors: Examination of the medical importance and control measures for insect vectors such as *Anopheles,Culex,* and *Aedes* mosquitoes, focusing on their role in transmitting human diseases and approaches to mitigate vector-borne illnesses.

Unit 2

Introduction to entomology

Overview, history, and importance: Overview of entomology as a scientific discipline; Historical developments in entomology; Importance of insects in ecosystems, agriculture, and human health.

Insect classification: Introduction to insect taxonomy; General features of insects and classification up to orders;

External insect anatomy and physiology (Cockroach): External features including head (eyes, vision, types of antennae), mouthparts, thorax (wings, wing articulation), types of legs, abdominal appendages, and genitalia;

Internal anatomy and physiology of insect body systems (Cockroach): Introduction to - muscles and locomotion, nervous system and co-ordination, endocrine system and the function of hormones, circulatory system, tracheal system and gas exchange, digestion and nutrition, excretory system and waste disposal, reproductive system, and insect senses.

Insect development & metamorphosis: Introduction to life history stages (egg, larval, pupal, and adult); Introduction to ametabolous, hemimetabolous, holometabolous type of metamorphosis.

Ecology of insects: Introduction to habitat types and adaptations; Overview of insects' roles in ecosystems.

Beneficial insects: Overview of pollinators, natural enemies, and decomposers. Detrimental insects: Introduction to agricultural pests, disease vectors, and household insects. Insects and their impact on human society.

Unit 3

Apiculture

Species of Honey bees, life history and social organization; Traditional and modern bee hive, bee keeping equipment. Economic importance of beekeeping.

Sericulture

Introduction, definition, history and present status of sericulture in India; Types of silkworms and their distribution (Mulberry, Muga, Tasar, Eri and Oak silkworms). Life cycle of *Bombyxmori*. Methods of sericulture, composition of silk and economic importance of sericulture.

Pisciculture:

Introduction and economic importance of pisciculture, present status, problems and scope of fish farming in India. Composite fish culture and Integrated fish farming (Paddy-cum fish farming, Poultry-cum fish farming); Status of inland culture and captured fisheries in India. Scientific fish farming: induced breeding in fishes. Common cultivable fishes (major carps).

Unit 4 **(Practical)** **Credit 1**

(Contact Hours 30)

1. Study of parasites from permanent slides/photographs (*Plasmodium* sp., *Ancylostomaduodenale*, *Fasciolagigantica, Pediculushumanus*)
2. Permanent mount preparation of helminth parasites from fowl intestine.
3. Study of *Anopheles*, *Culex*, and *Aedes* from permanent slides/photographs.
4. Study of mouth parts, antennae, wings, legs of an insect from slides/photographs
5. Mounting of the mouth parts/legs/wings of an insect.
6. Mounting of mosquito larvae
7. Study of different castes of honey bee.
8. Study of life cycle of *Bombyxmori*.
9. Identification on important culturable fishes in India: Indian major carps and exotic carps.
10. Morphometric and meristic measurement of fish.
11. Field visit and submission of project report on a visit to any fish farm/ sericulture farm/apiary unit.

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. Netherlands: Elsevier Science.
3. Chapman, R. F., Simpson, S. J., & Douglas, A. E. (2013). The insects: Structure and function. United Kingdom: Cambridge University Press.
4. Chatterjee, K. D., & Chatterjee, D. (2019). Parasitology, protozoology and helminthology. CBS. New Delhi.
5. Cheng, T. C. (2012). General parasitology. United Kingdom: Elsevier Science.
6. Gullan, P. J., & Cranston, P. S. (2010). The insects: An outline of entomology. Germany: Wiley.
7. Gunn, A., & Pitt, S. J. (2012). Parasitology: An integrated approach. United Kingdom: Wiley.
8. Gupta, S. K., & Gupta, P. C. (2006). General and applied ichthyology: Fish and fisheries. India: S. Chand Limited.
9. Integrated pest management concepts and approaches (3rd ed.). (2022). Author: G.S. Dhaliwal, Ramesh Arora. Kalyani Publishers.
10. Jayaram, K. C. (2008). Fundamentals of fish taxonomy (Reprint ed.). Narendra Publishing House.
11. Lagler, K. F. (1977). Ichthyology. United States: Wiley.
12. Lucius, R., Loos-Frank, B., Lane, R. P., Poulin, R., Roberts, C., &Grencis, R. K. (2017). The biology of parasites. Germany: Wiley.
13. Marquardt, W. C., Demaree, R. S., & Grieve, R. B. (2000). Parasitology and vector biology. United Kingdom: Academic Press.
14. Modern parasitology: A textbook of parasitology. (2009). Germany: Wiley.
15. Paniker, C. K. J., & Ghosh, S. (2017). Paniker's textbook of medical parasitology. India: Jaypee Brothers Medical Publishers Pvt. Limited.
16. Rahman, A. (2023). Textbook of entomology (1st ed.). Indian Council of Agricultural Research.
17. Smyth, J. D., & Wakelin, D. (1994). Introduction to animal parasitology. United Kingdom: Cambridge University Press

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5th Semester

ZOO-300 ANIMAL PHYSIOLOGY

Total Credits 4
Total Contact Hours 75
Total Marks = 100

Course objectives:

- Introduce students to major physiological systems, emphasizing functions and interrelationships and examine homeostasis and its significance.
- Explore the anatomical structure and physiological functions of mammalian digestive and excretory systems and examine osmoregulation across different environments.
- Delve into the comprehensive study of cardiac and pulmonary physiology, encompassing the structure and function of the heart and anatomy of the lung including the processes of gas exchange in both lungs and gills.
- Explore the intricacies of physiological processes governing animal movement and coordination by delving into nervous system and muscular system physiology.

Learning outcomes (LOs):

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

- Demonstrate a comprehensive understanding of major physiological systems in animals, describe the hierarchical levels of organization in animals, and evaluate the significance of homeostasis in maintaining internal stability.
- Analyze the anatomy and functions of the mammalian digestive tract and the excretory system, and finally to compare osmoregulation mechanisms in fish.
- Describe the structure and function of the heart and understand the regulatory mechanisms involved in blood pressure and cardiac output control.
- Identify the structural and functional components of neurons, understand nerve impulse generation and transmission, and synaptic transmission in the nervous system.

(Theory) **Credits 3**

(Contact hours: 45)

Unit 1

Overview of physiological systems: Introduction to major physiological systems; Levels of organization in animals; Homeostasis and its significance.

Physiology of the mammalian digestive system and metabolism: Overview of digestive tract anatomy and functions; Nutrient absorption and metabolism; Disease - Causes and characteristics of gastritis and irritable bowel syndrome.

Physiology of the mammalian excretory system: Overview of the structures and organs comprising the excretory system; Functional anatomy of the kidneys.

Mammalian renal physiology: Urine formation and concentration; Regulation of water balance; Excretion of metabolic wastes. Disease - Causes and characteristics of urinary tract infection.

Osmoregulation in fish.

Unit 2

Physiology of the mammalian cardiovascular system: Structure and function of the heart; Blood - composition and functions; Erythropoiesis; Structure and function of hemoglobin; Cardiac cycle, cardiac output and its regulation; Regulation of blood pressure; Blood coagulation factors and mechanism, Kallikrein-kinin system; blood

groups - ABO and Rh; Disease - Causes and characteristics of anemia and Stroke.
Physiology of the mammalian respiratory system: Respiratory structures including the lungs, trachea, and alveoli; Mechanism of breathing, respiratory volumes and capacities; Gas exchange mechanisms in lungs. Transport of oxygen and carbon dioxide in blood; Oxygen dissociation curve and factors influencing it; Regulation of respiration – nervous and chemical; Disease - Causes and characteristics (Asthma and chronic obstructive pulmonary diseases - COPD)

Unit 3

Physiology of the mammalian nervous system: Structure and function of neurons; Generation and transmission of nerve impulses (myelinated and non-myelinated neurons); Structure of the synapse and synaptic transmission (electrical and chemical). Types of neurotransmitters; Disease - Causes and characteristics (Dementia, Alzheimer's, Parkinson's)
Physiology of the mammalian muscular system: Overview of muscle tissue types (skeletal, smooth, cardiac); Structural features of the skeletal muscles. Mechanism of muscle Contraction - the sliding filament theory and molecular mechanisms of muscle contraction; Neuromuscular junction and motor control; Disease - Causes and characteristics (muscular dystrophy)

Unit 4 **(Practical)** **Credit 1**

(Contact Hours 30)

1. Examination of muscle tissue morphology using permanent slides or visual aids.
2. Analysis of neuron diversity through observation of various neuron types on permanent slides or visual aids.
3. Enumeration of RBCs in human blood.
4. Enumeration of WBCs in human blood.
5. Preparation of haemin crystals derived from human blood.
6. Quantification of hemoglobin levels in human blood utilizing Sahli's method.
7. Evaluation of blood clotting time in human blood samples.
8. Assessment of blood pressure variations before and after physical exertion to understand cardiovascular responses.
9. Identification of ABO and Rh blood groups to comprehend blood compatibility principles and transfusion significance.
10. Measurement of blood hemoglobin saturation (SpO2) using an oximeter to investigate factors influencing oxygen saturation, such as altitude, exercise, and respiratory conditions.

Suggested readings

1. Arumugam, N., &Mariakuttikan, A. (2019). Animal physiology. Saras Publication.
2. Eckert, R., & Randall, D. (1987). Animal physiology. CBS Publishers and Distributors.
3. Hill, R. W., Wyse, G. A., & Anderson, M. (2012). Animal physiology (3rd ed.). Sinauer Associates Inc.
4. Moyes, C. D., & Schulte, P. M. (2013). Principles of animal physiology (2nd ed.). Pearson Education India.
5. Prosser, C. L. (1991). Comparative animal physiology. W.B. Saunders & Company.
6. Rastogi, S. C. (2019). Essentials of animal physiology (4th ed.). New Age International.
7. Randall, D., & Burggren, W. (2001). Eckert animal physiology (5th ed.). W. H. Freeman.
8. Schmidt-Nielson, K. (2002). Animal physiology. Prentice Hall India Ltd.
9. Sebastian, M. M. (n.d.). Animal physiology. Dona Publications.
10. Sherwood, L., Klandorf, H., &Yanchey, P. (2010). Textbook of animal physiology. Cengage Learning India.
11. Verma, P. S., Tyagi, B. S., & Agarwal, V. K. (2000). Animal physiology. S Chand & Co.

5th Semester

ZOO-301 BIOCHEMISTRY AND IMMUNOLOGY

Total Credits 4
Total Contact Hours 75
Total Marks = 100

Course objectives:

This course will:

- Explain the energetics and mechanisms of enzyme catalysis, including binding energy, activation energy, and transition state dynamics. Derive the Michaelis-Menten equation and interpret enzyme kinetics
- Explore enzyme regulation mechanisms, encompassing allosteric regulation, covalent modification, and inhibition strategies.
- Describe metabolic pathways, including carbohydrate, amino acid, and lipid metabolism, as well as concepts of bioenergetics and thermodynamics.
- Analyze the roles of immune cells, antigen presentation pathways, and the complement system in immunity. Discuss immunoglobulin diversity, immune disorders, and vaccination strategies.

Learning outcomes (LOs):

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

- Demonstrate understanding of enzyme energetics, including binding energy, activation energy, and transition state dynamics, and analyze mechanisms of enzyme catalysis using various catalytic strategies.
- Evaluate enzyme regulation mechanisms, including allosteric regulation and covalent modification, and analyze the impact of enzyme inhibition on metabolic pathways.
- Analyze metabolic pathways involved in carbohydrate, protein, and lipid metabolism, and explain concepts of bioenergetics and thermodynamics, including redox potential and Gibbs-Free energy.
- Investigate immune cell functions, including B and T cell receptor interactions, antigen presentation pathways, and complement system activation, and discuss immunoglobulin diversity, immune disorders, and vaccination strategies for active, passive, and herd immunity.

(Theory) **Credits 3**

(Contact hours: 45)

Unit I

Enzymes: Energetics of enzyme catalyzed reaction-Binding energy, activation energy and transition state; Mechanism of enzyme catalysis (acid-base catalysis, covalent catalysis, metal ion catalysis, proximity and orientation catalysis);
Enzyme kinetics: Derivation of Michaelis-Menten equation and calculations; Line-weaver – Burk plot; Significance of Km; Enzyme regulation – Allosteric regulation and covalent modification; Enzyme inhibition.
Carbohydrate metabolism: Glycolysis; Citric acid cycle; Hexose monophosphate shunt; Gluconeogenesis; Glycogenolysis and glycogenesis.

Unit II Protein metabolism-catabolism of amino acids: Transamination, deamination, and urea cycle; Fate of C-skeleton of glucogenic and ketogenic amino acids; Glucose-Alanine cycle.
Lipid metabolism: B-oxidation of saturated fatty acids with even and odd number of carbon atoms and their regulation;
Ketogenesis; Biosynthesis of palmitic acid.
Bioenergetics and Thermodynamics: Redox potential, Gibbs-free energy, enthalpy (H), entropy (S); Mitochondrial Electron Transport System, Inhibitors and un-couplers of Electron Transport System; Oxidative Phosphorylation.

Unit III B Cell and T Cell: Receptors, activation and differentiation.
APC: Presenting and processing (endogenous and exogenous pathway); Complement system: Introduction and function of the complement system; Classical pathway.
Basic idea of immunoglobulin diversity: Multi gene organization and mechanism of generation of antibody diversity; Immune system disorder: Hypersensitivity – types and classification (Gell and Coomb's); Autoimmunity (Rheumatoid arthritis); Immunodeficiency – Primary (SCID) and secondary (AIDS).
Introduction to vaccines: Types of vaccines (Natural, live-attenuated, inactivated, toxoid, polysaccharide vaccines, Nucleic acids); Immunization – Active, passive and herd immunity.

Unit IV **(Practical)** **Credit 1**

(Contact Hours 30)

1. Estimation of glucose by anthrone reagent
2. Estimation of protein by Lowry/Biuret/Bradford method
3. Study of effect of substrate concentration on urease enzyme
4. Qualitative analysis of nitrogen wastes – Ammonia, urea and uric acid
5. Plotting and graphical interpretation of enzyme inhibition plots
6. Preparation of blood smear to study different types of WBCs.
7. ABO and Rh blood group antigen determination by agglutination reaction.
8. Demonstration of Antigen antibody interaction in vitro: Double radial immune-diffusion in Agarose gel.
9. Virtual demonstration of Immunoelectrophoresis.

Suggested readings:

1. Abbas, A. K., Lichtman, A. H., & Pillai, S. (2019). Basic Immunology: Functions and Disorders of the Immune System, 6e: Sae-E-Book. Elsevier India.
2. Berg, J. M., Tymoczko, J. L., &Stryer, L. (2007). Biochemistry (6th ed.). W.H. Freeman and Co.
3. Campbell, M. K., Farrell, S. O., & McDougal, O. M. (2022). Biochemistry. Cengage Learning India Pvt. Ltd.
4. Delves, P. J., Martin, S. J., Burton, D. R., &Roitt, I. M. (2017). Roitt's essential immunology. John Wiley & Sons.
5. Kindt, T. J., Goldsby, R. A., Osborne, B. A., &Kuby, J. (2007). Kuby Immunology (6th ed.). W.H. Freeman and Co.
6. McKee, T., & McKee, J. R. (2016). Biochemistry: The molecular basis of life, international edition.
7. Nelson, D. L., Cox, M. (2017). Lehninger Principles of Biochemistry: International Edition. United Kingdom: Macmillan Learning.
8. Voet, D., Voet, J. G., & Pratt, C. W. (2016). Fundamentals of Biochemistry: Life at the Molecular Level (5th ed.). Wiley.

5th Semester

ZOO-302 INTRODUCTORY DEVELOPMENTAL BIOLOGY AND ENDOCRINOLOGY (MAJOR)

Total Credits 4
Total Contact Hours 75
Total Marks = 100

Course objectives:

The course will:

- Provide a comprehensive understanding of human endocrine and neuro-endocrine glands, including their structure, function, and hormone biosynthesis processes,role of hormones in maintaining homeostasis, and highlight the implications of hormonal imbalances in causing various diseases and metabolic disorders
- Explore neuro-endocrine system in insects, and its significance in regulating physiological and behavioural aspects crucial for survival.
- Examine human reproduction in detail, reproductive cycles in mammals, infertility issues, and the impact of reproductive health technologies and contraception.

Learning outcomes (LOs):

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

1. Understand the principles of the endocrine system and hormone characteristics. Recognize the vital role of the endocrine system in maintaining internal balance and its collaboration with the nervous system.
2. Analyze hormone action mechanisms and their regulation and understand how the endocrine system controls physiological functions and contributes to disease development.
3. Explore the neuroendocrine system in insects and its impact on their physiology, metamorphosis, and behaviour.
4. Analyze reproductive organ structure and function, including hormonal regulation in reproductive cycles. Evaluate infertility diagnosis and treatments

(Theory) **Credits 3**

(Contact hours: 45)

Unit I

Definition and scope of developmental biology.
Spermatogenesis - Process of spermatogenesis, structure of the sperm and hormonal control; Oogenesis - Oocyte development, folliculogenesis, and hormonal control; Types and classification of eggs based on the amount and distribution of yolk.
Fertilization: External and internal fertilization mechanisms; Block to polyspermy - mechanisms and significance; Parthenogenesis.
Cleavage - Planes and types;
Blastulation: Blastula formation in frog.
Morphogenetic movements: Epiboly, invagination, ingression, involution, and delamination.
Gastrulation in Frog: Cellular events and formation of germ layers.
Gastrulation in chick embryos: Primitive streak formation, cell migration, and axial specification.
Larval forms in Crustacea and the ecological significance of larval forms.

Unit II Overview of the endocrine system - Definition, classification and transport of hormones.
Structure, functions and disorders of endocrine glands - Hypothalamus, pituitary, pineal, thyroid, parathyroid, pancreas, adrenals, testis, & ovary;
Introduction to neuroendocrine system in insects.

Unit III Basic concepts of hormone feedback mechanisms (positive & negative);
Hormones of gastrointestinal tract; Placental hormones; Lactation and its regulation.
Pheromones – Definition, types and functions of pheromones.
Biosynthesis of thyroid hormones.
Mechanism of hormone action - Peptide/protein hormones and steroid hormones.

Unit IV **(Practical)** **Credit 1**

(Contact Hours 30)

1. Study of types of eggs in vertebrates.
2. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula.
3. Study of whole mounts/sections of developmental stages of chick through permanent slides (Hamburger and Hamilton Stages) (at least 4 stages).
4. Preparation of permanent mounts of larval forms (mosquito, mysis, Nauplius)
5. Observations of the location, gross morphology, and key features of endocrine glands in human using charts/models.
6. Study of sections of mammalian endocrine glands - Pineal, Pituitary, Thyroid, Parathyroid, Pancreas, Adrenal, Testis and Ovary.
7. Dissection and display of pituitary gland and gonads in a teleost.
8. Study of endocrine disorders by analyzing fictional patient profiles (at least two): Identify symptoms related to hormonal imbalances or glandular abnormalities, and propose potential underlying causes.
9. Virtual Demonstration: Castration and Ovariectomy Techniques in Rats.

Suggested readings:

1. Arora, R., & Grover, A. (2018). Developmental Biology: Principles and Concepts (1st ed.). R. Chand & Company.
2. Balinsky, B. I., & Fabian, B. C. (2006). An Introduction to Embryology (8th ed.). International Thompson Computer Press.
3. Bertino, A., & Lowenstein, D. (Eds.). (2018). Principles of Endocrinology and Hormone Action. Springer International Publishing AG.
4. Carlson, B. M. (2007). Foundations of Embryology (6th ed.). Tata McGraw-Hill Publishers.
5. Gilbert, S. F. (2010). Developmental Biology (9th ed.). Sinauer Associates, Inc. Publishers.
6. Hadley, M. E. (2006). Endocrinology. India: Pearson Education.
7. Jameson, J. L. (Ed.). (2017). Endocrinology (4th ed.). Harrisons McGraw Hill Publishers.
8. Jones, R. E., & Lopez, K. H. (2013). Human Reproductive Biology. Netherlands: Elsevier Science.
9. Kalthoff, K. (2001). Analysis of Biological Development (2nd ed.). McGraw Hill Publishers.
10. Knobil and Neill's Physiology of Reproduction. (2014). Netherlands: Elsevier Science.
11. Norman, A. W., &Litwack, G. (2014). Hormones. United States: Elsevier Science.

12. Norris, D. O., & Carr, J. A. (2013). Vertebrate Endocrinology. United Kingdom: Elsevier Science.
13. Slack, J. M. W. (2013). Essential Developmental Biology (3rd ed.). Wiley-Blackwell.
14. Wolpert, L. (2002). Principles of Development (2nd ed.). Oxford University Press.

5th Semester

ZOO-302 ECONOMIC ZOOLOGY AND APPLIED ZOOLOGY (MINOR)

Total Credits 4
Total Contact Hours 75
Total Marks = 100

Course objectives:

This course will:

- Provide an in-depth understanding of apiculture , sericulture , aquaculture and pisciculture and its economic importance
- Discuss the principles and practices of Integrated Pest Management and its importance in modern pest management.
- Understand aspects of animal husbandry and explore poultry farming principles, techniques and its economic significance

Learning outcomes (LOs):

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

- Develop a comprehensive understanding of apiculture, including biology of honey bee and significance of both traditional and modern beekeeping techniques and equipment.
- Acquire knowledge about aquaculture and pisciculturre principles, methods, and economic importance.
- Understand the principles and practices of Integrated Pest Management and its significance in modern pest management strategies.
- Explore different facets of animal husbandry and poultry farming principles and methods including their economic importance.

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

Unit I Apiculture: Species of Honey bees; Life history and social organization; Traditional and modern bee hive; Economic importance of beekeeping; Bee keeping equipment.
Sericulture: Introduction: definition, history and present status of sericulture in India; Types of silkworms and their distribution (mulberry, muga, tasar, eri and oak silkworms);Life cycle of Bombyxmori; Methods of sericulture, composition of silk and economic importance of sericulture.

Unit II Aquaculture: Introduction to Aquaculture - Definition, history, and significance of aquaculture; Types of aquaculture systems (ponds, tanks, cages, raceways) and facilities; Freshwater Aquaculture - Prawn culture; Mariculture: Oyster culture.
Pisciculture: Introduction and economic importance of pisciculture; present status, problems and scope of fish farming in India. Composite fish culture and Integrated fish farming (Paddy- cum fish farming, poultry- cum fish farming); Status of inland culture and captured fisheries in India. Scientific fish farming: induced breeding in fishes. Common culturable fishes (major carps).

Unit III Integrated Pest Management: Integrated pest management principles and importance in modern agriculture and pest control. Physical, chemical, hormonal, and biological control of Pest management.
Animal Husbandry: Preservation and artificial insemination in cattle; Induction of early puberty and synchronization of estrus in cattle.
Poultry Farming: Principles of poultry breeding, management of breeding stock and broilers, Processing and preservation of eggs.

Unit IV **(Practical)** **Credit 1**

(Contact Hours 30)

1. Study of different castes of honey bee
2. Study of life cycle of *Bombyxmori*.
3. Preparation of permanent mount of insect wings.
4. Morphometric and meristic measurement of fish.
5. Identification on important culturable fishes in India: Indian and exotic major carps.
6. Setup and maintenance of freshwater aquarium
7. Virtual demonstration of Induced breeding method in fishes
8. Virtual demonstration of artificial insemination in cattle
9. Documentation of different Integrated Pest Management methods (Physical/Chemical/Hormonal/Biological Control)
10. Visit to poultry farm/fish farm and submission of field report

Suggested readings:

1. Ahsan, J. (2010). A Hand Book On Economic Zoology. S. Chand & Co.
2. Arora, R., & Dhaliwal, G. S. (2022). Integrated pest management concepts. Kalyani Publishers.
3. Dholakia, A. D. (2004). Fisheries and aquatic resources of India. Daya Publishing House.
4. Jaiswal, V., &Jaiswal, K. (2022). Economic Zoology. PHI Learning.
5. Jayaram, K. C. (2009). Fundamentals of fish taxonomy. Narendra Publishing House.
6. Jhingran, V. G. (1997). Fish and fisheries of India (3rd edition). Hindustan Publishing Corporation.
7. Pandey, K., & Shukla, J. P. (2018). Fish and fisheries (Z-56). Rastogi Publications.
8. Pathak, N., & Moglekar, H. S. (2022). Recent updates in Indian fisheries sector. Narendra Publishing House.
9. Ravindranathan, K.R. (2013). A Text Book of Economic Zoology. Saujanya Books.
10. Shukla, G.S. (2016). Economic Zoology. Rastogi Publications.

ZOO-303 **Internship (Zoology)**

Total credits: 4
(Contact hours: 120)
Total marks: 100

Course Objectives:

The internship will:

- Apply and refine knowledge by integrating classroom learning with real-world zoological scenarios for deeper understanding.
- Develop professional skills essential for zoology careers, including critical thinking, communication, collaboration, problem-solving, and adaptability.
- Explore diverse zoological fields and potential career paths such as research, conservation, wildlife management, and animal behavior.

Course Outcomes:

After completion of the internship, the student will be able to:

- Apply knowledge and skills effectively for analyzing real-world zoological problems, conducting research, and practical applications.
- Develop professional skills in critical thinking, communication, collaboration, and adaptability for success in zoology careers.
- Explore diverse career paths in zoology to make informed decisions about future endeavors.

Total Credits 4

(Contact hours 120)

Sl.No	Evaluation of Interns	Marks distribution	Credits
1	Field work /Experiments	50	2
2	Internship Report	25	1
3	Presentation and Viva.	25	1
Total		**100**	**4**

Suggested Readings:

1. Aniket Singh. (2018). The complete book of internships in India: Intern abroad this summer. Notion Press, Incorporated.
2. Woodard, E. (2015). The ultimate guide to internships: 100 steps to get a great internship and thrive in it. Allworth Press.
3. McLachlan, J. E., & Hess, P. F. (2015). Get an internship and make the most of it: Practical information for high school and community college students. Rowman & Littlefield Publishers.
4. Green, M. E. (1997). Internship success: Real-world, step-by-step advice on getting the most out of internships. VGM Career Horizons.
5. Khoury, R. J., & Selby, J. (2021). How to intern successfully: Insights and actions to optimize your experience. Waterside Productions.
6. Shindell, R. (2019). Total internship management supervisor's handbook: A manager's guide to delivering an amazing internship experience. Intern Bridge, Incorporated.
7. Labor, S. L. (2020). Student internship success workbook (Supervisor's guide): 20+ Lessons and activities for student intern career readiness. Independently published.

6th Semester

ZOO-350 BIOLOGICAL TECHNIQUES, BIOINFORMATICS AND BIOSTATISTICS

Total Credits 4
Total Contact Hours 75
Total Marks = 100

Course objectives:

The course will:

- Explore principles and applications of various microscopes
- Understand principles and applications of centrifugation, chromatography, colorimetry and spectrophotometry and pH meter.
- Introduce the fundamentals of biostatistics
- Familiarize students with bioinformatics

Learning outcomes (LOs):

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

- Analyze microscopy techniques for interpreting biological samples, evaluate the principles and applications of centrifugation, chromatography, and gel electrophoresis for separating biological components.
- Utilize colorimetryand spectrophotometry to quantify the concentration of biological molecules.
- Assess the importance of statistics in biology for precise data analysis
- Understand the importance of bioinformatics in modern biology and its impact on research, including the use of computational tools for analyzing biological data.

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

Unit I

Introduction to Bio-techniques;
Microscopy: Principles and applications of light microscopy, dark field microscopy, phase contrast microscopy, fluorescence microscopy, and electron microscopy (SEM and TEM).
Centrifugation: Principle, types and applications.
Chromatography: General Principle of chromatography. Principle and applications of TLC and HPLC.
Colorimetry and spectrophotometry: Beer-Lambert's law; Principle and applications of colorimeter and UV-Vis spectrophotometer.
pH meter: Principles and application; Measurement of pH.
Gel Electrophoresis: Principle and applications of Agarose gel electrophoresis and SDS-PAGE.

Unit II

Introduction to biostatistics: Overview of the meaning of statistics; necessity of statistics; statistics in biology; limitations of statistics.
Measurement and sampling concepts: Populations, samples and observations; The sampling unit; Random sampling; Independence; Statistics and parameters; Descriptive and inferential statistics; Parametric and non-parametric statistics.
Processing data: Scales of measurement-the nominal scale, ordinal scale, interval scale, and the ratio scale; Derived variables; Precision of observations; Precision of data; Frequency table; Aggregating frequency classes; Frequency distribution

of count observations; Dispersion; Bivariate data.
Presenting data: Dot plot or line plot, bar graph, histogram, frequency polygon and frequency curve, scattergram (scatter plot), pie graph.
Measurement of central tendency: Mean, median and mode; Relationship between the mean, median and mode.
Measuring variability: Variability, the range; The standard deviation, calculating the standard deviation, calculating the standard deviation from grouped data; Variance; An alternative formula for calculating the variance and standard deviation; obtaining the standard deviation; variance and the sum of squares; degrees of freedom; the coefficient of variation (CV).

Unit III

Overview of bioinformatics: Definition, scope, and significance in biology.
Biological databases: Types of databases (e.g., sequence, structure, functional) and their importance.
Tools and resources: Introduction to commonly used bioinformatics tools (BLAST (Basic Local Alignment Search Tool), Clustal Omega, NCBI Entrez, & UCSC Genome Browser) and databases (GenBank, NCBI Gene, UniProt).
Introduction to sequence analysis: Basics of DNA, RNA, and protein sequences.
Sequence alignment: Pairwise and multiple sequence alignment, algorithms (e.g., Needleman-Wunsch, Smith-Waterman), and applications.
Introduction to phylogenetics: Basics of evolutionary relationships, phylogenetic trees, and evolutionary models.

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

1. Calibrate the pH meter using standard buffers, immerse the electrode into the solution, and record the pH reading.
2. Preparation and determination of pH of Solutions.
3. Separation of amino acids from paper chromatography
4. Demonstration of agarose gel electrophoresis of DNA
5. Determination of Concentration of a Colored Solution using a colorimeter.
6. Conduct a small survey to demonstrate sampling from a population.
7. Study of random sampling using dice or random number generator and compare random and non-random sampling methods.
8. Calculate mean, median, and mode for given datasets.
9. Create dot plot, bar graph, histogram, and scatter plot sample data.
10. Explore the following databases - GenBank and Protein Data Bank
11. Preform hands-on activity on using BLAST for sequence retrieval and analysis
12. Conduct multiple sequence alignment using software like Clustal Omega.

Suggested readings:

1. 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.
2. Daniel, W. W., & Cross, C. L. (2014). Biostatistics: Basic concepts and methodology for the health sciences. Wiley.
3. Fowler, J., Cohen, L., & Jarvis, P. (2013). Practical statistics for field biology. Wiley.
4. Lesk, A. (2014). Introduction to bioinformatics. OUP Oxford.
5. Plummer, M., & Plummer, D. T. (2001). Introduction to practical biochemistry. Tata McGraw Hill Publishing Company.
6. Rao, P. S. S. S., & Richard, J. (2012). Introduction to biostatistics and research methods. PHI Learning.
7. Sadasivam, S., &Manickam, A. (2007). Biochemical methods. New Age International

(P) Limited.

8. Tripathi, T (2023) Introduction to Spectroscopic Methods. Astral International (P) Ltd, New Delhi. ISBN: 978-93-5461-699-0
9. Tripathi, T.(2024) Chromatography and Centrifugation Methods: A Beginner's Handbook. Astral International (P) Ltd, New Delhi. ISBN: 978-93-5461-731-7
10. Tripathi, T.(2024) Electrophoresis and Immunology Methods: A Beginner's Handbook. Astral International (P) Ltd, New Delhi.
11. Wilson, D. B., & Walker, J. M. (2018). Principles and techniques of biochemistry and molecular biology. Cambridge University Press.
12. Xiong, J. (2006). Essential bioinformatics. Cambridge University Press.

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6th Semester

ZOO-351 CELL BIOLOGY AND GENETICS

Total Credits 4
Total Contact Hours 75
Total Marks = 100

Course objectives:

The course will:

- Develop an in-depth understanding of the structure and function of membrane systems and chromosome structure and functions, including chromosomal organization and genetic material packaging.
- Understand cell cycle, division, and signal transduction.
- Explore genetic principles including linkage, crossing over, mutations, and karyotyping, alongside concepts of extra chromosomal inheritance, microbial genetics, and transposons in genetic research.

Learning outcomes (LOs):

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

- Explore and understand the intricacies of cellular interactions, adhesion mechanisms, endomembrane system functions (particularly protein transport), and the importance of endocytosis and exocytosis processes.
- Analyze the structure and enzyme functions of peroxisomes and comprehend the diversity of DNA and RNA, including regulatory RNAs.
- Evaluate cell cycle regulation mechanisms, signal transduction pathways, and mechanisms related to cellular senescence and programmed cell death.

(Theory) **Credits 3**

(Contact hours: 45)

Unit I

Cell-cell interaction: Cell junctions- Tight junctions, desmosomes, gap junctions; cell adhesion molecules.
Functions of endomembrane system: Protein targeting, sorting, transport.
Endocytosis - phagocytosis, pinocytosis, and receptor-mediated endocytosis. Exocytosis-constitutive exocytosis and regulated exocytosis.
Membrane transport: Passive transport- simple diffusion and facilitated diffusion; Active transport: uniport, symport, &antiport.
Peroxisome: Structure, enzymes and functions.
DNA and RNA: Watson and Crick model of DNA structure; Forms of DNA (A, B, &Z form); Types and functions: mRNA, tRNA, rRNA, snRNA, miRNA, siRNA&lncRNA.
Regulation of cell cycle: Cell cycle checkpoints; Cyclins and cyclin-dependent kinases (CDKs); Regulation of cyclin-CDK complexes.
Regulation of mitotic spindle formation: Microtubule dynamics and motor proteins.
Cytokinesis: Mechanisms of contractile ring formation and cleavage furrow ingression.
Structure and function of the synaptonemal complex. Chiasma formation.
Signal transduction: Intracellular signaling and cell surface receptors, via G-protein linked receptors.
Cell senescence and Cell death: Cellular features of Senescence - spontaneous and induced; Programmed cell death: Understanding the mechanism and significance.

Unit II

Linkage: cis and trans arrangement of genes; Linkage group in Drosophila and man. Crossing over – Types and mechanism of crossing over; Interference and coincidence; Factors affecting linkage and crossing over; significance of linkage and crossing over; Recombination frequency as a measure of linkage intensity

Linkage Map: Three-point crosses in Drosophila and construction of linkage maps.

Types of gene mutations. Detection of mutations in Drosophila - ClB method & attached X method; Mutagens: Physical and chemical mutagens. Molecular basis of spontaneous and induced mutations.

Genetic disorders: Hemophilia and phenylketonuria.

Dosage compensation and Lyon's hypothesis; X-inactivation

Unit III

Extra-nuclear inheritance: Characteristic features of cytoplasmic inheritance; Kappa particles in Paramecium; Sigma factor in Drosophila; Shell coiling in snail.

Sex-linked inheritance in Drosophila (eye color) and man (color blindness).Non-disjunction of sex chromosome in Drosophila.

Human Cytogenetics: Normal human karyotype (Male & Female); Clinical features and karyotype of syndromes - Down, Turner, and Klinefelter. Sex determination in man.

Characteristics of polygenic traits; Polygenic traits vs. single-gene traits; Examples of polygenic trait in humans - skin color.

Introduction to bacterial genetic transfer mechanisms: Overview of bacterial genetic transfer; Importance in bacterial evolution and adaptation; Comparison of vertical vs. horizontal gene transfer; Brief introduction to conjugation, transformation, and transduction; Historical background and key experiments leading to the discovery of these mechanisms.

Introduction to transposable elements: Definition, historical background and discovery of TEs; Classification of TEs based on mechanism of transposition; Examples of transposons – IS elements in bacteria and Ty elements in yeast.

Unit IV **(Practical)** **Credit 1**

(Contact Hours 30)

1. Preparation and study of sex-chromatin (Barr body) in human buccal cells.
2. Preparation and identification of meiotic stages from grasshopper testis.
3. Study of different forms of DNA (A, B, and Z forms) from charts/models/videos sources.
4. Study of different types of RNA (mRNA, tRNA, and rRNA) from charts/models/videos sources.
5. Study of different types of cell junctions (tight junctions, desmosomes, gap junctions) from photomicrographs.
6. Karyotyping and preparation of a karyogram of normal human chromosomal complement from supplied photographic plates.
7. Karyotyping and preparation of a karyogramofchromosomal complement of Down/Turner/Klinefelter syndromes from supplied photographic plates.
8. Identification of mutant variety of Drosophila from charts/models/videos sources.
9. Preparation, study and calculation of chiasma frequency and coefficient of terminalization of meiotic stages in the cells of grasshopper testes.

Suggested readings:

1. Alberts, B. (2017). Molecular biology of the cell. W.W. Norton.
2. Alberts, B., Bray, D., Hopkin, K., Johnson, A. D., Lewis, J., Raff, M., ...& Walter, P. (2015). Essential cell biology. Garland Science.
3. Brown, T. A. (2012). Introduction to genetics: A molecular approach. CRC Press.

4. Clark, D. P., &Pazdernik, N. J. (2012). Molecular biology. Elsevier.
5. Gardner, M. J., Simmons, M. J., &Snustad, D. P. (2006). Principles of genetics (8th ed.). Retrieved from books.google.co.in
6. Geoffrey, M., Cooper, H., & Robert, E. (2018). Cell: A molecular approach. Oxford University Press.
7. Klug, W. S., Cummings, M. R., Spencer, C. A., &Palladino, M. A. (2014). Concepts of genetics. Pearson.
8. Klug, W., Cummings, M., Spencer, C., &Palladino, M. (2012). Concepts of Genetics (10th ed.). Benjamin Cummings.
9. Pierce, B. A. (2012). Genetics: A conceptual approach. Macmillan.
10. Singh, B. D. (2023). Fundamentals of Genetics (6th ed.). Med Tech Publication.
11. Snustad, D. P., & Simmons, M. J. (2015). Principles of genetics. John Wiley & Sons.
12. Strickberger, M. W. (1995). Genetics (3rd ed.). Macmillan Publishing Company.

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6th Semester

ZOO-352 DEVELOPMENTAL BIOLOGY AND REPRODUCTIVE BIOLOGY

Total Credits 4
Total Contact Hours 75
Total Marks = 100

Course objectives:

The course will:

- Provide in-depth knowledge of developmental processes from embryonic to post-embryonic stages.
- Introduce model organisms like frogs and chicks to study various aspects of development, including morphogenetic movements.
- Analyze developmental errors and their implications for human health.

Learning outcomes (LOs):

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

- Understand the events leading to the formation of multicellular organisms from a single fertilized egg.
- Acquire knowledge of cellular processes, molecular mechanisms, and general patterns of embryogenesis and morphogenesis and organ formation.
- Evaluate the importance of techniques like in-vitro fertilization for human welfare.

(Theory) **Credits 3**

(Contact hours: 45)

Unit I

Fate Maps and cell Lineages: Overview of fate mapping techniques; Fate maps in frog and chick embryos.
Embryonic induction and organizer concept: Principles of embryonic induction; Role of the organizer in embryonic patterning and axis formation.
Cell aggregation and differentiation in Dictyostelium: Life cycle and developmental stages of Dictyostelium; Cell-cell communication and differentiation during aggregation.
Organogenesis: Development of the vertebrate eye.

Unit II

Metamorphosis in insects; Hormonal regulation of insect metamorphosis.
Metamorphosis in frogs: Morphological and physiological changes during tadpole-to-frog transition; Hormonal regulation of frog metamorphosis.
General account of regeneration in invertebrate and vertebrate groups. Modes of regeneration- Epimorphosis in planaria, morphallaxis in hydra and compensatory regeneration in liver.
Extra-embryonic membranes in chick. Placentation and types of placenta in mammals.
Teratogenesis and developmental birth defects. Theories of ageing.

Unit III

Anatomy of the human male and female reproductive systems.
Reproductive cycles: Estrous and menstrual in mammals.
Infertility in male and female: Causes and diagnosis;
Assisted Reproductive Technology - In vitro fertilization and embryo transfer technology.
Contraceptive methods for males and females.Sexually transmitted diseases (HIV/AIDS): Causes, modes of transmission, treatment and prevention.

Unit IV

(Practical) **Credit 1**

(Contact Hours 30)

1. Observation of the development of a chick embryo using the window method.
2. Permanent preparation of whole mount of Chick embryo.
3. Study of metamorphosis in amphibia (using charts/models).
4. Study of regeneration in *Hydra*/*Planaria*/tadpole tail.
5. Virtual Demonstration: Hans Spemann experiment on embryonic induction.
6. Observation of the location, gross anatomy, and key features of female and male reproductive systems from charts/models.
7. Study of modern contraceptive devices from charts and models.
8. Virtual Demonstration: *In vitro* fertilization and embryo transfer technology.
9. Microtomy of chick embryo.

Suggested readings:

1. Arora, R., & Grover, A. (2018). Developmental biology: Principles and concepts (1st ed.). R. Chand & Company
2. Balinsky, B. I., & Fabian, B. C. (2006). An introduction to embryology (8th ed.). International Thompson Computer Press.
3. Carlson, B. M. (2007). Foundations of embryology (6th ed.). Tata McGraw-Hill Publishers.
4. Gilbert, S. F. (2010). Developmental biology (9th ed.). Sinauer Associates, Inc. Publishers.
5. Jangir, O. P. (2018). Developmental biology: A manual. Agrobios.
6. Kalthoff, K. (2001). Analysis of biological development (2nd ed.). McGraw Hill Publishers.
7. Knight, J., & Mari-Beffa, M. (Eds.). (2011). Key experiments in practical developmental biology. Cambridge University Press.
8. Oxford University Press. (2003). A practical guide to developmental biology. Melissa Ann Gibbs.
9. Slack, J. M. W. (2013). Essential developmental biology (3rd ed.). Wiley-Blackwell.
10. Wolpert, L. (2002). Principles of development (2nd ed.). Oxford University Press.

6th Semester

ZOO-353 MOLECULAR BIOLOGY AND GENETIC ENGINEERING

Total Credits 4
Total Contact Hours 75
Total Marks = 100

Course objectives:

The course will:

- Explain the process of translation in prokaryotes, including initiation, elongation, and termination, utilizing the genetic code to synthesize proteins.
- Analyze the molecular components and machinery involved in translation, such as ribosomes, transfer RNA (tRNA), messenger RNA (mRNA), initiation factors, elongation factors, and release factors.
- Evaluate the mechanisms of translational regulation in prokaryotic cells, including the role of riboswitches, regulatory RNA molecules, and translational repression/activation by proteins.

Learning outcomes (LOs):

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

- Recognize and classify diverse genome organizations in viruses, bacteria, and eukaryotes, understanding their structural and functional implications.
- Understand the central dogma of molecular biology and the intricate process of DNA replication, transcription, and translation in prokaryotes and their importance living organisms.
- Appraise gene mutations and mutagenic agents, assessing their effects on DNA structure and function, and discussing mechanisms of recombination and DNA repair.
- Apply basic techniques in molecular biology, to manipulate, analyze, and study DNA molecules, while evaluating ethical considerations and biosafety regulations in genetic engineering practices.

(Theory) **Credits 3**

(Contact hours: 45)

Unit I

Genome organization in viruses, bacteria, human, and mitochondria.
Central dogma of molecular biology.
DNA Replication in prokaryotes: Meselson and Stahl experiment; Overview of the enzymes and proteins involved in DNA replication; The initiation, elongation and termination phase of DNA replication. Comparison between prokaryotic and eukaryotic replication
Characteristics of the genetic code.
Transcription in prokaryotes: Components of the transcriptional machinery in prokaryotes, including RNA polymerase and accessory proteins; Mechanisms involved in transcription initiation, elongation and termination. Comparison between prokaryotic and eukaryotic transcription.
Translation in prokaryotes: Components of the translation machinery in prokaryotes; Mechanisms involved in translation initiation, elongation and termination in prokaryotic cell. Comparison between prokaryotic and eukaryotic translation.

Unit II

The modern concept of the gene: promoter region, transcription start site, transcribed region, exons, introns, polyadenylation signal, terminator region, regulatory elements, transcription factor binding sites, enhancers and silencers.
Split genes and splicing mechanism; Overlapping genes.
Regulation of gene expression in prokaryotes: The lac operon.
Causes of mutation: spontaneous replication errors, spontaneous chemical changes, chemically induced mutations and radiation induced mutations.
DNA repair: Mismatch repair, SOS repair system, direct repair, base and nucleotide excision repair, and double-strand break repair in eukaryotes.

Unit III

Introduction to genetic engineering: principles and applications.
Introduction to common enzymes used in molecular cloning: Restriction enzymes, DNA ligase, DNA polymerase, alkaline phosphatase, exonucleases, and reverse transcriptase.
Cloning vectors: Properties of a vector; Plasmid, cosmid, lambda phage; Shuttle vectors. Expression vectors.
Fundamental process of molecular cloning with bacterial vectors: Isolation of DNA fragment; Selection of cloning vector; Insertion of DNA fragment into vector; Transformation; election and screening; Propagation and amplification; Expression and analysis.
Techniques: Basics of PCR and southern blotting
Introduction to genomic library and cDNA library: construction and applications.
Forensic DNA analysis: Principles and applications of DNA fingerprinting.
Introduction to ethical issues and biosafety regulations.

Unit IV **(Practical)** **Credits 1**

(Contact Hours 30)

1. Study of clover leaf structure of RNA, double helical structure of DNA, genome organization of a dsDNA virus, dsRNA virus, bacteriophage, *E. coli*, from charts/models/visual aids
2. Estimation of DNA using Diphenylamine reagent.
3. Estimation of RNA using Orcinol reagent.
4. Virtual demonstration of Polymerase Chain Reaction.
5. Virtual demonstration of Southern blotting.
6. Extraction of DNA from goat liver and estimation of DNA using spectrophotometer.
7. Virtually manipulate DNA models or sequences to introduce various types of mutations, including substitutions, insertions, and deletions, and subsequently analyze the potential effects on protein function.
8. Analyse simulated DNA profiles from different individuals and interpret the banding patterns for applications like paternity testing or forensics.

Suggested readings

1. Alberts, B. (2017). Molecular biology of the cell. W.W. Norton.
2. Brown, T. A. (2006). Genomes 3. Taylor & Francis Group.
3. Brown, T. A. (2012). Introduction to genetics: A molecular approach. CRC Press.
4. Brown, T. A. (2016). Gene cloning and DNA analysis: An introduction. Wiley.
5. Clark, D. P., & Pazdernik, N. J. (2012). Molecular biology. Elsevier.
6. Geoffrey, M., Cooper, H., & Robert, E. (2018). Cell: A molecular approach. Oxford University Press.
7. Klug, W. S., Cummings, M. R., Spencer, C. A., & Palladino, M. A. (2014). Concepts of genetics. Pearson.
8. Pierce, B. A. (2012). Genetics: A conceptual approach. Macmillan.
9. Primrose, S. B., & Twyman, R. (2006). Principles of gene manipulation and genomics. Wiley.
10. Strachan, T., & Read, A. (2018). Human molecular genetics. CRC Press.

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