A combined syllabus for

Four Years Undergraduate Program (FYUGP) &

One year Master Program (FYIMP)

in Zoology

As per instructions of the NEP Implementation Committee, Gauhati University

Prepared by-

Department of Zoology

Gauhati University

BASIC DIVISION OF CREDITS FOR THREE YEAR DEGREE COURSE

Degree with Major / Minor 120 Credits

Core		Common Courses				
Major	Minor	Multi-Disc	AEC	SEC	VAC	Internship
60	24	9	8	9	6 (8)	4 (2)

STRUCTURE OF FOUR YEARS UNDERGRADUATE PROGRAMME (FYUGP) IN ZOOLOGY AS ONE OF THE MAJOR SUBJECTS

Semester	Course Name	Code	Credit
I	**Core A1**: Diversity of Non-chordates	ZLG0100104	3
	Practical		1
II	**Core A2**: Diversity of Chordates	ZLG0200104	3
	Practical		1
III	**Major1**- Principles of Genetics	ZLG0300104	3
	Practical		1
IV (Any one Optional DSE paper)	**Major2**- Animal Taxonomy, Systematics & Biostatistics	ZLG0400104	3
	Practical		1
	Major3-Animal Physiology & Endocrinology	ZLG0400204	3
	Practical		1
	Major4- Principles of Ecology & Evolution	ZLG0400304	3
	Practical		1
	Major5- DSE-Optional I: Comparative Anatomy of Vertebrates	ZLG0400404	3
	Practical		1
	DSE-Optional II: Animal Behaviour and Chronobiology		3
	Practical		1
	DSE-Optional III: Parasitology		3
	Practical		1
V (Any one Optional DSE paper) DSE	**Major6**- Cell Biology	ZLG0500104	3
	Practical		1
	Major7- Fundamentals of Biochemistry	ZLG0500204	3
	Practical		1
	Major8- Entomology & Fisheries	ZLG0500304	3
	Practical		1
	Major9- DSE-Optional I: Immunology	ZLG0500404	3
	Practical		1
	DSE-Optional II: Reproductive Biology		3
	Practical		1
	DSE-Optional III: Developmental Biology		3
	Practical		1
VI (Any one Optional DSE	**Major10**- Wildlife Conservation & Management	ZLG0600104	3
	Practical		1
	Major11-Molecular Biology	ZLG0600204	3
	Practical		1

paper)	**Major12**-Biochemistry of metabolic processes & Regulation	ZLG0600304	3
	Practical		1
	Major13- DSE-Optional I: Computational Biology	ZLG0600404	3
	Practical		1
	DSE-Optional II: Advanced Entomology		3
	Practical		1
	DSE-Optional III: Animal Cell Culture & Genetic Engineering		3
	Practical		1

STRUCTURE OF SYLLABUS FOR FOURTH YEAR OF THE FOUR YEARS UNDEGRADUATE PROGRAM (FYUGP) IN ZOOLOGY UNDER NEP 2020

A. DEGREE WITH HONOURS

or

B. DEGREE WITH HONOURS & RESEARCH

A. FYUGP Degree with honours

Semester	Course Name	Code	Credit
VII	**Major 14:** Advanced Biochemistry	ZLG0700104	3
	Practical		1
	Major 15: Biodiversity Conservation and Applications of Biostatistics	ZLG0700204	3
	Practical		1
	Major 16: Molecular Cytogenetics	ZLG0700304	3
	Practical		1
	Major 17: Immunology and Microbiology	ZLG0700404	3
	Practical		1
	Major 18: Research Methodology/Research Methodology course from MOOCs	ZLG0700504	4
VIII	**Major 19:** Advanced Computational Biology and Instrumentation	ZLG0800104	3
	Practical		1
	Major 20: Cellular Physiology	ZLG0800204	3
	Practical		1
	Major 21: Integrative Biology	ZLG0800304	4
	Major 22: Ecological Science and Environmental Biology	ZLG0800404	3
	Practical		1
	MINI PROJECT	ZLG0800504	4

OR,

B. FYUGP Degree with honours and research

Semester	Course Name	Code	Credit
VII	**Major 14**: Advanced Biochemistry	ZLG0700104	3
	Practical		1
	Major 15: Biodiversity Conservation and Applications of Biostatistics	ZLG0700204	3
	Practical		1
	Major 16: Molecular Cytogenetics	ZLG0700304	3
	Practical		1
	Major 17: Immunology and Microbiology	ZLG0700404	3
	Practical		1
	Major 18: Research Methodology/Research Methodology course from MOOCs	ZLG0700504	4
VIII	**Major 19: RESEARCH/DISSERTATION**	ZLG0800104	16
	Major 20: Compulsory MOOCs course on Bioanalytical techniques	ZLG0800204	4

STRUCTURE OF SYLLABUS FOR FIFTH YEAR OF INTEGRATED MASTER PROGRAM IN ZOOLOGY (FYIMP)/ ONE-YEAR MASTER PROGRAMME IN ZOOLOGY UNDER NEP 2020

Semester	Specialization Name	Code	Credit
IX	**Specialization 1**: Animal Ecology & Wildlife Biology		20
	Specialization 2: Animal Physiology & Biochemistry		20
	Specialization 3: Cell & Molecular Biology		20
	Specialization 4: Entomology		20
	Specialization 5: Fish Biology & Fishery Science		
N.B. ***Details of codes of respective specializations are attached below***			
X	Research	ZLG1000104	16
	Compulsory MOOCs course	ZLG1000204	4

CORE A1
DIVERSITY OF NON-CHORDATES
Code: ZLG0100104
Credit: 3 (T) + 1 (P)

Course Outcomes:

Upon completion of the course, students should be able to:

1. Learn about the importance of systematics, taxonomy and structural organization of animals.
2. Apprehend the diversity of non-chordates living in varied habit and habitats.
3. Understand evolutionary history and relationships of different non-chordates through functional and structural affinities.
4. Analyse the organization, complexity and characteristic features of non-chordates making them familiarize with the morphology and anatomy of representatives of variousanimal phyla.
5. Comprehend the economic importance of non-chordates, their interaction with the environment and role in the ecosystem.

CORE A1
DIVERSITY OF NON-CHORDATES
Code: ZLG0100104
Credit: 3 (T) + 1 (P)

THEORY	Hours
Unit 1: Protista to Pseudocoelomates General characteristics and Classification up to classes of Protista, Porifera, Cnidaria, Ctenophora, Platyhelminthes, Nemathelminthes.	7
Unit 2: Coelomates: Annelida to Echinodermata Evolution of coelom and metamerism General characteristics and Classification up to classes of Annelida, Arthropoda, Mollusca and Echinodermata.	8
Unit 3: Biology of Non-chordates Locomotion and Reproduction in Protista Evolution of symmetry and segmentation of Metazoa Canal system and spicules in sponges Polymorphism in Cnidaria Corals and coral reef formation Parasitic adaptations in helminths- *Fasciola hepatica* and *Wuchereria bancrofti* Excretion in Annelida Vision and respiration in Arthropoda Evolutionary significance of Onychophora Torsion and detorsion in Gastropoda	30

Water vascular system of Echinodermata

DIVERSITY OF NON-CHORDATES

PRACTICAL	Hours
1. Study of the whole mount of *Euglena*, *Amoeba* and *Paramecium* collected from different water sources. 2. Study of minimum of two representatives (specimen/slide/model) of each phylum of non-chordates. 3. Study of larval forms of Arthropoda/Echinodermata 4. T.S. through pharynx, gizzard and typhlosolar intestine of earthworm. 5. To submit a Project Report on life cycle of helminth parasite by students	30

Suggested Readings:

1. Ruppert, E.E. and Barnes, R.D. (2006). Invertebrate Zoology, 8th Edition. Holt Saunders International Edition.
2. Pechenik, J. (2015). Biology of the Invertebrates. 7th Edition, McGraw Hill
3. Schierwater, B. & DeSalle, R. (2021). Invertebrate Zoology: A Tree of Life Approach. 1st edition, CRC Press
4. Jordan, K. and P. S. Verma (2019). Invertebrate Zoology, S. Chand and Co. Ltd.
5. Kotpal, R. L. (2020). Modern text book of Zoology, Invertebrates,12th Edition, Rastogi Publications

CORE A2
DIVERSITY OF CHORDATES
Code: ZLG0200104
Credit: 3 (T) + 1 (P)

Course Outcomes:

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

1. Understand different classes of chordates, level of organization and evolutionary relationship between different subphyla and classes, within and outside the phylum.
2. Study about diversity in animals making students understand about their distinguishing features.
3. Appreciate similarities and differences in life functions among various groups of animals in Phylum Chordata.
4. Comprehend the circulatory, nervous and skeletal system of chordates.
5. Learn about the habit and habitat of chordates in marine, freshwater and terrestrial ecosystems.

CORE A2
DIVERSITY OF CHORDATES
Code: ZLG0200104
Credit: 3 (T) + 1 (P)

THEORY	Hours
Unit 1: Introduction to Chordates Origin of Chordates-Dipleurula concept and Echinoderm theory General characteristics and outline classification	8
Unit 2: Protochordata General characteristics of Hemichordata, Urochordata and Cephalochordata Study of larval forms of protochordates.	7
Unit 3: Euchordata Advanced features of vertebrate over protochordata Overview of axial and appendicular skeleton, Jaw suspensorium, Visceral arches General characteristics and classification of cyclostomes up to class General characteristics of Chondrichthyes and Osteichthyes, classification u pto order. Origin of Tetrapoda General characteristics and classification of Amphibia, Reptilia, Aves and Mammalia up to order	30

Migration in Fishes; Parental care in Amphibia; Biting mechanism in snakes; Archaeopteryx as a connecting link; Flight adaptation in birds; Affinities in Prototheria.

DIVERSITY OF CHORDATES

PRACTICAL	**Hours**
1. Study of museum specimens/ Models - Protochordata (*Balanoglossus, Herdmania, Amphioxus*), Agnatha (*Petromyzon, Myxine*), Fishes (*Scoliodon, Torpedo, Mystus, Heteropneustes, Labeo, Hippocampus, Tetraodon*), Amphibia (*Ichthyophis, Necturus, Bufo, Hyla*), Reptilia (*Chelone, Hemidactylus, Varanus, Chamaeleon, Bungarus, Naja*), Aves (ten different species of birds commonly found in Assam), Mammalia (Bat, common primates, common ungulates, Gangetic River Dolphin). 2. Study of T.S. of *Amphioxus* through pharyngeal, intestinal and caudal regions. 3. Identification key of venomous and non-venomous snakes. 4. PowerPoint presentation on the study of any two vertebrates from two different classes by students.	30

Suggested Readings:

1. Young, J. Z. (2004).The Life of Vertebrates. 3rd Edition. Oxford University press.
2. Pough F. H. & Janis, C. M. (2018). Vertebrate Life. 10th Edition, Sinauer Associates
3. Verma, P. S. & Jordan, E. L. (2013). Chordate Zoology. 14th edition, S. Chand
4. Kotpal, R. L. (2019). Modern text book of zoology: Vertebrates (Z-3). 5th edition, Rastogi Publications

MAJOR 1
PRINCIPLES OF GENETICS
Code: ZLG0300104
Credit: 3 (T) + 1 (P)

Course Outcomes:

Upon completion of the course, students should be able to:

1. Comprehend the basic principles of inheritance.
2. Analyse Mendelian Law and gene interactions leading to development of analytical skills and critical thinking enabling the students to present the conclusion of their findings in a scientific manner.
3. Learn the mechanisms of mutations, the causative agents and the harmful impact of various chemicals and drugs being used in day-to-day life.
4. Apply the knowledge of genetic and environmental basis of sex determination.
5. Understand the importance of genetics for higher order research in future.

MAJOR 1
PRINCIPLES OF GENETICS
Code: ZLG0300104
Credit: 3 (T) + 1 (P)

THEORY	**Hours**
Unit 1: Principles of inheritance, Incomplete dominance and co-dominance; Multiple alleles; Lethal alleles, penetrance and expressivity; Epistasis; Pleiotropy; Sex-linked, sex-influenced and sex-limited characters inheritance and concept of gene. Linkage and crossing over, Cytological basis of crossing over, Recombination frequency as a measure of linkage intensity; Two factor and three factor crosses; Linkage map; coefficient of coincidence and Interference; Gene mapping by Somatic cell hybridization.	15
Unit 2: Gene mutations; Chromosomal abberations – Deletion, duplication, inversion, translocation, aneuploidy and polyploidy; Induced versus spontaneous mutations; Backward and forward mutations; Suppressor mutations; Molecular basis of mutations in relation to UV light and chemical mutagens; Detection of mutations in *Drosophila*: CLB method, attached *X* method.	20
Unit 3: Basis of sex determination: Genetic and environmental; Sex determination in *Drosophila* and human; Mechanism of dosage compensation. Comparison of nuclear and extra nuclear inheritance; Organelle inheritance: Antibiotic resistance in *Chlamydomonas*, Mitochondrial mutations in *Saccharomyces* and human disorders, Infective heredity in *Paramecium*. Maternal effects: Shell coiling in *Limnaea*, pigmentations in *Ephestia*. Polygenic inheritance and Transgressive variation	10

PRINCIPLES OF GENETICS	
Practical	**Hours**
1. To study Mendelian laws and gene interactions and their verification by Chi-square analyses using seeds/beads/*Drosophila*. 2. Study of linkage maps based on data from *Drosophila* crosses. 3. Identification of various mutant types of *Drosophila* (through culture/photomicrograph) 4. Study of human karyotype (normal and abnormal) using photomicrograph. 5. Preparation of polytene chromosomes from *Chironomus/Drosophila* larvae. 6. Preparation of metaphase chromosome from fish/mammal.	30

Suggested Readings:

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). Principles of Genetics. 8th Edition. Wiley India.
2. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. 5th Edition. John Wiley and Sons Inc
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2020). Concepts of Genetics. 10th Edition. Benjamin Cummings.
4. Russell, P. J. (2009). Genetics- A Molecular Approach. 3rd Edition. Benjamin Cummings.
5. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. Introduction to Genetic Analysis. 9th Edition. W. H. Freeman and Co.
6. Tamarin R. H. (2017). Principles of Genetics. Tata McGraw Hill Edition.
7. Brown, T. A. (2023). Genomes 5. 5th edition, CRC Press

MAJOR 2

ANIMAL TAXONOMY, SYSTEMATICS & BIOSTATISTICS

Code: ZLG0400104

Credit: 3 (T) + 1 (P)

Course Outcomes:

Upon completion of the course, the students should be able to :

1. Understand the general principles of taxonomy and systematics
2. Apply the importance of zoological nomenclature and its rules
3. Learn the importance of systematics in biology
4. Evaluate the taxonomic categories and explain the concept of species
5. Apply basic knowledge of phylogeny and understanding of important terminologies to represent phylogenies

MAJOR 2

ANIMAL TAXONOMY, SYSTEMATICS & BIOSTATISTICS

Code: ZLG0400104

Credit: 3 (T) + 1 (P)

THEORY	**Hours**
Unit 1: Animal Systematics	**30**
Introduction to Systematics -Taxonomy vs Systematics; Taxon and Phenon; Contribution of Systematics to biology; Systematics as a profession Taxonomic categories; concepts of species – typological, nominalistic, biological and evolutionary Taxonomic keys – various types; dichotomous nature of keys Taxonomic characters – morphological, behavioural, ecological, and geographical Trends in taxonomy – chemotaxonomy, cytotaxonomy and molecular taxonomy Zoological Nomenclature – ICZN, Principles, functions, and importance of The Code of nomenclature; principle of priority, homonymy and synonymy, principle of typification and use of types for specimens Basics of phylogeny – Characters (ancestral vs. derived), homology and analogy, parallelism and convergence, monophyly, polyphyly, paraphyly; representing phylogenies – Rooted and unrooted phylogenetic trees; clades; Cladograms and Phenograms	
Unit 2: Biostatistics	15
Concept, Importance and Application of Biostatistics Collection and Classification of Statistical data, Frequency distribution, Types of presentation of Statistical data Measures of Central tendency - Mathematical average, Average of position Measures of Partition values	

Measures of Dispersion - Range, Quartile deviation, Mean deviation, Standard deviation, Co-efficient of Variation, Standard errors Testing of Hypothesis; Confidence Intervals; Chi-square test, student's t-test, Analysis of variance. Correlation and Regression

ANIMAL TAXONOMY, SYSTEMATICS & BIOSTATISTICS

PRACTICAL	Hours
1. To identify and distinguish species of insects/ fishes/ amphibians/ reptiles/ birds of NE India using appropriate taxonomic keys. 2. Morphometry and meristic study of insect and fish. 3. Preparation and study of skeleton of fish. 4. Graphical representation of statistical data with the help of computer (e.g., MS-Excel). 5. Calculation of two-sample t-test for a given set of data. 6. Calculation of F value (ANOVA) for a given set of data. 7. Calculation of Karl Pearson's Coefficient of Correlation for a given set of data. 8. Field visit to any Natural History Museum/ Zoo.	30

Suggested Readings:

1. Kapoor, V.C. (2019). Theory and Practice of Animal Taxonomy, 8th Edition, Oxford & IBH Publishing.
2. Simpson, G.G. (2012). Principles of Animal Taxonomy, Scientific Publishers (Indian Edition)
3. Mayr, E. (2022). Principles of Systematic Zoology, United Book Prints (Indian Edition)
4. Wiley, E. O. & Lieberman, B. S. (2011). Phylogenetics: Theory and Practice of Phylogenetic Systematics, Wiley Blackwell
5. Zar, J. H. (1999). Biostatistical Analysis, IV Edition, Pearson Education Inc and Dorling Kindersley Publishing Inc.USA.
6. Antonisamy, B., Christopher S. & Samuel, P. P. (2010). Biostatistics: Principles and Practice. Tata McGraw Hill Education Private Limited, India.
   Pagana,M. & Gavreau, K.(2000).Principles of Biostatistics, Duxberry Press, USA

MAJOR 3

ANIMAL PHYSIOLOGY AND ENDOCRINOLOGY

Code: ZLG0400204

Credit: 3 (T) + 1 (P)

Course Outcomes:

Upon completion of the course, students should be able to:

1. Learn the key concepts of tissues, physiology of organisms and functioning of endocrine glands
2. Understand the principles of normal biological function of the animal body.
3. Apply basic concepts of animal physiology and correlate it with the various histological structures.
4. Analyse the homeostasis in animals in response to changes in their external environment.
5. Evaluate practical related to animal physiology.

MAJOR 3

ANIMAL PHYSIOLOGY AND ENDOCRINOLOGY

Code: ZLG0400204

Credit: 3 (T) + 1 (P)

THEORY	**Hours**
Unit I: Tissues, Functioning of Excitable Tissue (Nerve and Muscle), Digestion and Absorption of Food Types of Tissues; Structure and Function of Epithelial, Connective, Muscular and Nervous Tissues, Generation of Nerve Impulsion and Propagation, Synaptic Transmission and Neurotransmitters. Structure, Kinds and Characteristics of Muscles, Mechanism of Muscle Stimulation and Contraction Neuro - Muscular Junction. Patterns of Digestion and Absorption in Animals, Role of Digestive Enzymes, Digestion, Absorption and Assimilation of Various Food Stuffs.	15
Unit II: Respiratory Physiology, Cardiovascular System and Renal Physiology Respiratory Organs in Different Animals, Transport of Oxygen and Carbon dioxide, Respiratory Pigments. Types and structure of heart, Concepts of Neurogenic and Myogenic Hearts, Cardiac cycle, ECG patterns in Human. Homeostasis and Blood Clot Formation. Functions of Kidney, Types of Nitrogenous Wastes in Different Animal Groups and their Excretion Urea production – Hans Krebs and Kurt Henseleit cycle, Urine Formation.	15
Unit III: Pituitary, Thyroid, Pancreas and Adrenal Glands Structural organization, Hormone secretion and its functions. Pituitary gland and its hypothalamic control.	15

Thyroid and Parathyroid Gland-Structure, function and mechanism of action, Structure of pancreas, Pancreatic hormones, their functions and mechanism of action, Dysfunction and disease of pancreatic hormones,
Structural Organizations of Adrenals, Functions of Cortical and Medullary Hormones and mechanism of action

ANIMAL PHYSIOLOGY AND ENDOCRINOLOGY

PRACTICAL	Hours
1. Preparation of temporary mount of blood cells (blood film preparation), squamous epithelium and striated muscle fibres. 2. Preparation of haemin and haemochromogen crystals. 3. Haemoglobin estimation using Sahli's haemoglobinometer. 4. Determination of ABO Blood group and Rh factor. 5. Study of TLC and DLC in mammalian blood. 6. Study of sickle cell anaemia in human using photomicrograph. 7. Examination and detailed study of permanent histological sections of mammalian Stomach, Duodenum, Liver, Lung, Kidney, Pancreas, Adrenal, Pituitary, Thyroid and Parathyroid.	30

Suggested Readings:

1. Tortora, G.J. and Derrickson, B.H. (2012). Principles of Anatomy and Physiology.XIIIth Edition, John Wiley and Sons, Inc.
2. Hill, R. (2021) Animal Physiology. Sinauer Associates Inc; 5th edition.
3. Widmaier E, Raff H and Strang K. (2013). Vander's Human Physiology: The Mechanism of Body Functions. XIIIth Edition, McGraw-Hill Education.
4. Guyton, A.C. and Hall, J.E. (2011) Textbook of Medical Physiology. XII Edition, Harcourt Asia Pvt. Ltd/ W.B. Saunders Company.
5. Kesar, S. and Vashisht, N. (2007) Experimental Physiology. Heritage Publishers.
6. Prakash, G. (2012) Lab Manual on Blood Analysis and Medical Diagnostics. S. Chand and Company Ltd
7. Cinnamon, V., Regan J., Russo A.F. (2022) Seelay's Anatomy and Physiology. McGraw Hill Education.

MAJOR 4
PRINCIPLES OF ECOLOGY & EVOLUTION
Code: ZLG0400304
Credit: 3 (T) + 1 (P)

Course Outcomes:

Upon completion of the course, students should be able to:

1. Understand key concepts in ecology with emphasis on historical perspective, role of physical factors and concept of limiting factors etc.
2. Define the population characteristics, population dynamics, growth models and interactions.
3. Identify the community characteristics, ecosystem development and climax theories.
4. Distinguish the types of ecosystems, food chains, food webs, energy models, and ecological efficiencies, and the basic principles of ecology in wildlife conservation and management.
5. Evaluate scientific quantitative skills, experimental design, read graphs, and analyse and use information available in scientific literature.

MAJOR 4
PRINCIPLES OF ECOLOGY & EVOLUTION
Code: ZLG0400304
Credit: 3 (T) + 1 (P)

THEORY	Hours
Unit 1: Introduction to Ecology and Ecosystem Basic concept of Ecology and Ecosystem, Autecology, Synecology, Level of organization, Study of physical factors, Laws of limiting factors, Structural components of Ecosystem, Functional attributes of Ecosystem-Trophic structure, food chain, food web, Energy flow, Ecological Pyramids, Ecological Efficiencies; Types of Ecosystems with examples.	12
Unit 2: Population and community ecology Definition, Unitary and Modular populations, Population attributes-Abundance, Density, Natality and Mortality, Life table and survivorship curve, Dispersion, Dispersal, Age distribution, Sex ratio, Biotic potential and Environmental resistance, Population growth form-Exponential and Logistic; Population regulation-density dependent and independent factors. Population interactions, Gauss's principle; Definition of Community, Community Characteristics, Community Structure, Ecological succession and types, Theories pertaining to climax community Ecotone and Edge effect.	17
Unit 3: Evolution Origin of life - From chemogeny to biogeny, Experimental evidences, RNA world Evolutionary perspectives – Pre-Darwinian concepts, Darwinism vs Neo-Darwinism	16

Paleontological evidences of evolution, Geological timescale
Natural selection – concept of fitness, selection coefficient, kin selection, sexual selection
Population genetics - Hardy-Weinberg Law (statement and derivation), concept of gene flow, arrival of the fittest – sources of variations and role in evolution, Genetic Drift (Founder's and Bottleneck effect), Role of migration and mutation in changing allelic frequencies
Evolution of Horse

PRINCIPLES OF ECOLOGY & EVOLUTION

PRACTICAL	**Hours**
1. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided 2. Determination of population density by quadrat method and calculation of Shannon-Weiner diversity index in a natural/hypothetical community. 3. Study of an aquatic ecosystem: phytoplankton and zooplankton, measurement of temperature, turbidity/penetration of light, determination of pH, and dissolved oxygen content (Winkler's method), free CO_2 4. Study of fossils from models/pictures 5. Study of homology and analogy from suitable specimens/models 6. Study and verification of Hardy-Weinberg Law by Chi-square analysis 7. Report on a visit to National Park/Biodiversity Park/Wildlife sanctuary	30

Suggested Readings:

1. Colinvaux, P.A. (1973). Ecology. 2nd Edition. John Wiley and Sons Inc.
2. Krebs, C. J. (2001). Ecology. 6th Edition. Benjamin Cummings.
3. Odum, E.P. (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole
4. Smith, R. L., Smith, T.M. (2000). Ecology and field biology Harper and Row publisher
5. Ricklefs, R.E. (2000). Ecology. V Edition. Chiron Pres
6. Hall B.K. & Hallgrimsson B. (2013). Strickberger's Evolution. 5th Edition, Jones and Bartlett Publishers, Inc.
7. Futuyama, D. J. (2017). Evolution. 4th Edition, Sinauer Associates
8. Ridley, M. (2020). Evolution. 2nd edition (South Asia Edition), Oxford University Press.

MAJOR 5-DSE-Optional I
COMPARATIVE ANATOMY OF VERTEBRATES
Code: ZLG0400404
Credit: 3 (T) + 1 (P)

Course Outcomes:

Upon completion of the course, students should be able to:

1. Understand the pattern of vertebrate evolution, organization and functions of various systems.
2. Compare the integument and skeletal components, their functions and modifications in different classes of vertebrates.
3. Comprehend the evolution of heart, modification in aortic arches, structure of respiratory organs used in aquatic, terrestrial and aerial vertebrates; and digestive system and its anatomical specializations with respect to different diets and feeding habits.
4. Learn the evolution of brain, sense organs and excretory organsto a complex, highly evolved form in mammals;
5. Analyze and critically evaluate the structure and functions of vertebrate systems, which helps them to discern the developmental, functional and evolutionary history of vertebrate species.

MAJOR 5-DSE-Optional I
COMPARATIVE ANATOMY OF VERTEBRATES
Code: ZLG0400404
Credit: 3 (T) + 1 (P)

THEORY	Hours
Unit 1: Integumentary System-Structure, functions and derivatives of integument Skeletal System-Overview of axial and appendicular skeleton, Jaw suspensorium, Visceral arches. Digestive System-Alimentary canals and associated glands, dentition.	15
Unit 2: Respiratory System-Skin, gills, lungs and air sacs; Accessory respiratory organs. Circulatory System-General plan of circulation, evolution of heart and aortic arches. Urinogenital System-Succession of kidney, Evolution of urinogenital duct	20
Unit 3: Nervous System-Comparative account of brain, Autonomic nervous system, Spinal cord, Cranial nerves in mammals. Sense Organs-Classification of receptors; Brief account of visual and auditory receptors in man	10

COMPARATIVE ANATOMY OF VERTEBRATES

PRACTICAL	Hours
1. Study of placoid, cycloid and ctenoid scales through permanent slides/photographs 2. Study of disarticulated skeleton of Frog/Fowl/Rabbit 3. Study of Carapace and plastron of turtle/tortoise 4. Study of Mammalian skulls: One herbivorous and one carnivorous animal 5. Project on comparative structure of any two organs (heart, lung, kidney, eye, and ear)	30

Suggested Readings:

1. Kardong, K.V. (2005) Vertebrates' Comparative Anatomy, Function and Evolution. IV Edition. McGraw-Hill Higher Education
2. Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-Hill Companies
3. Hilderbrand, M and Gaslow, G.E. Analysis of Vertebrate Structure, John Wiley and Sons
4. Walter, H.E. and Sayles, L.P. Biology of Vertebrates, Khosla Publishing House

MAJOR 5-DSE-Optional II
ANIMAL BEHAVIOUR AND CHRONOBIOLOGY
Code: ZLG0400404
Credit: 3 (T) + 1 (P)

Course Outcomes:

After the completion of this course, the students should be able to:

1. Recognize various profiles of behavioural biologists and their contributions to the field of animal behaviour
2. Interpret basic concepts and terms related to causes and patterns of behaviour, and chronobiology.
3. Classify animal orientation and navigation, and different biological rhythms.
4. Understand the social nature of animals and communication among individuals of animal societies.
5. Evaluate and apply scientific methods of studying animal behaviour, and circadian functions in human.

MAJOR 5-DSE-Optional II
ANIMAL BEHAVIOUR AND CHRONOBIOLOGY
Code: ZLG0400404
Credit: 3 (T) + 1 (P)

THEORY	Hours
Unit 1: Introduction to Animal Behaviour Origin and history of ethology - Brief profiles of Karl Von Frish, Ivan Pavlov, Konrad Lorenz, Niko Tinbergen, and their contributions to the field of animal behaviour; Proximate and ultimate causes of behaviour; Patterns of behaviour - instinct vs. learned behaviour; Animal orientation - Taxis vs. Kinesis; Navigation; Methods of studying behaviour.	20
Unit 2: Social Behaviour Animal Communication - Dance Language in honey bees; Eusocial organization - honey bee, termite, and ant; Schooling behaviour in fishes; Social behaviour in monkeys.	10
Unit 3: Chronobiology Historical developments; biological oscillations - concept of average, amplitude, phase and period. Biological timekeeping - adaptive significance and importance; Biological rhythms - types and characteristics; Environmental zeitgebers; photoperiod and regulation of seasonal reproduction of vertebrates; role of melatonin in daily sleep-wake cycle.	15

ANIMAL BEHAVIOUR AND CHRONOBIOLOGY

Practical	Hours
1. To study nest and nesting habits of birds/social insects 2. To study geotaxis behaviour in earthworm. 3. To study scan and focal animal sampling in wetland birds/mammals. 4. To study circadian function in human with special reference to body temperature. 5. To study behavioural activities of animals in home/backyard garden and prepare a short report by student.	30

Suggested Readings:

1. Manning, A. & Dawkins, M. S. (2012). An Introduction to Animal Behaviour. Cambridge University Press, 6th edition.
2. Barnard, C. (2003). Animal Behaviour: Mechanism, Development, Function and Evolution. Pearson, 1st edition.
3. Lehner, P. N. (1996). Handbook of Ethological Methods. Cambridge University Press, 2nd edition
4. Kumar, V. (2017). Biological Timekeeping: Clocks, Rhythms and Behaviour. Springer, 1st edition

MAJOR 5-DSE-Optional III
PARASITOLOGY
Code: ZLG0400404
Credit: 3 (T) + 1 (P)

Course Outcomes:

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

1. Identify the variation among parasites, parasitic invasion with special reference to medical and agricultural aspects.
2. Compare and contrast the stages of the life cycle of parasites and their respective infective stages.
3. Value the use some of parasites as possible biocontrol agents.
4. Infer the possible scopes of the subject including research and applied aspects.
5. Develop skills and realize significance of diagnosis of parasitic attack and treatment of host.

MAJOR 5-DSE-Optional III
PARASITOLOGY
Code: ZLG0400404
Credit: 3 (T) + 1 (P)

THEORY	Hours
Unit 1: Brief introduction of Parasitism; Parasite, Parasitoid and Vectors; Host-parasite relationship; types of parasites and hosts; evolution of parasitism Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Trypanosoma gambiense*, *Leishmania donovani* and *Plasmodium vivax*	12
Unit 2: Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Schistosoma haematobium*, *Taenia solium* and *Hymenolepis nana.* Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity of *Ascaris lumbricoides*, *Ancylostoma duodenale*, *Wuchereria bancrofti* and *Trichinella spiralis*	21
Unit 3: Biology, importance and control of ticks, mites, *Pediculus humanus* (Head and Body louse), *Xenopsylla cheopis* and *Cimex lectularius* A brief account of parasitic vertebrates – Candiru and Vampire bat	12

PARASITOLOGY

Practical	Hours
1. Study of life stages of *Entamoeba histolytica*, *Giardia intestinalis*, *Trypanosoma gambiense*, *Leishmania donovani* and *Plasmodium vivax* through permanent slides/photographs.	30

2. Study of adult and life stages of *Fasciolopsis haepatica, Schistosoma haematobium, Taenia solium* and *Hymenolepis nana* through permanent slides/photographs.
3. Study of adult and life stages of *Ascaris lumbricoides, Ancylostoma duodenale, Wuchereria bancrofti* and *Trichinella spiralis* through permanent slides/microphotographs.
4. Study and preparation of report of any two common protozoan/ helminth/ arthropod parasites
5. Study of *Pediculus humanus* (Head louse and Body louse), *Xenopsylla cheopis* and *Cimex lectularius* through permanent slides/ photographs.
6. Study of nematode/cestode parasites from fish or intestine of Poultry bird
7. Submission of at least two arthropod parasites.

Suggested readings:

1. Chernin, J. (2000). Parasitology. Taylor & Francis Group.
2. Arora, D. R and Arora, B. B. (2018) Medical Parasitology. 5th Edition, CBS Publications and Distributors Pvt Ltd
3. Noble, E.R. and Noble, G.A. (1982) Parasitology: The Biology of Animal Parasites. 5th Edition, Lea & Febiger
4. Ahmed, N., Dawson, M., Smith, C. and Wood, Ed. (2007) Biology of Disease. Taylor and Francis Group
5. Taylor, M. A., Coop, R. L., & Wall, R. L. (2016). Veterinary Parasitology. 4th edition, Wiley Blackwell
6. Loker, E. S. & Hofkin, B. V. (2015). Parasitology – A conceptual approach. Taylor & Francis Group

MAJOR 6
CELL BIOLOGY
Code: ZLG0500104
Credit: 3 (T) + 1 (P)

Course Outcomes:

Upon completion of the course, students should to be able to:

1. Identify different cell types.
2. Infer about the composition of cells and cellular compartments and detail study about the functioning of these organelles.
3. Interpret cellular energetics and concept of protein sorting
4. Compare and contrast different levels of DNA packaging within the cells and the types of chromosomes.
5. Define cellular growth and division, communication among different cells and mode of cellular homeostasis by apoptosis and necrosis.

MAJOR 6
CELL BIOLOGY
Code: ZLG0500104
Credit: 3 (T) + 1 (P)

THEORY	**Hours**
Unit 1 **Over view of Cells**: Prokaryotic and Eukaryotic cells, Virus, Viroids, Mycoplasma, Prions. **Plasma Membrane:** Various models of plasma membrane structure, Transport across membranes: Active and Passive transport, Facilitated transport, Types of transporters **Cell junctions:** Structure and functions of Tight junctions, Desmosomes, Gap junctions **Endomembrane System**: Structure and Functions of Endoplasmic Reticulum, Golgi Apparatus and Lysosomes	15
Unit 2 **Mitochondria:** Structure, Semi-autonomous nature, Endosymbiotic hypothesis, Mitochondrial Respiratory Chain, Chemi-osmotic hypothesis **Peroxisomes:** Structure and functions **Cytoskeleton**: Structure and Functions of Microtubules, Microfilaments and Intermediate filaments, Cillia and flagella **Nucleus**: Structure of Nucleus (Nuclear envelope, Nuclear pore complex, Nucleolus)	15
Unit 3 **Chromosomes:** Giant chromosome (Polytene and lampbrush), Types of eukaryotic chromosomes based on centromeres, Euchromatin and Hetrochromatin, DNA packaging within the nucleus (nucleosome model) **Cell Division**: Mitosis, Meiosis, Cell cycle and its regulation **Cell to Cell communications:** Types of signalling molecules, Cell surface	15

receptors and its types, second messengers, Mechanism of signal transductions of peptide and steroid hormones.

Cell Deaths: Necrosis and apoptosis, significance of apoptosis in cellular homeostasis, Mechanism of apoptosis

CELL BIOLOGY

Practical	**Hours**
1. Preparation of temporary stained squash of onion root tip to study various stages of mitosis **2.** Study of various stages of meiosis in testis (Grasshopper/Cockroaches/Mice/Rat). **3.** Preparation of permanent slide to show the presence of Barr body in human female blood cells/cheek cells. **4.** Preparation of permanent slide of blood and study of different types of blood cells **5.** Preparation of histological slides from tissues as liver, Lung, Stomach, Intestine, Kidney, Pancreas, Testes and Ovary. **6.** Preparation of permanent slide for cytochemical demonstration of a. DNA by Feulgen reaction b. Mucopolysaccharides and Glycogen by PAS reaction c. Proteins by Mercuro bromophenol blue/FastGreen d. Lipid by Sudan black B	30

Suggested Readings:

1. Cooper, G. M. (2018). 8th Edition. The cell: A molecular approach. Massachusetts, USA: Sinauer Associates. ISBN-13:978-1605357072
2. Alberts, B et al. (2014). 6th edition. Molecular Biology of the Cell. W. W. Norton & Company. ISBN-13 : 978-0815345244
3. Lodish H et al. (2003). 5th Revised edition. Molecular Cell Biology. W.H.Freeman & Co Ltd; ISBN13 : 978-0716743668
4. Hardin, J. Bertoni, G. P. Kleinsmith, L.J. and Becker, W.M. (2016). 9th Edition. The world of the cell. San Francisco, USA: Benjamin Cummings Publishers, ISBN-13: 978 -0321934925.
5. Karp, G. (2019). 9th Edition. Cell and molecular biology: New Jersey, USA: Wiley Publishers. ISBN-978—1-119-59816-9

MAJOR 7
FUNDAMENTALS OF BIOCHEMISTRY
Code: ZLG0500204
Credit: 3 (T) + 1 (P)

Course Outcomes:

Upon completion of this course, students should be able to:

1. Identify and define the basic principle, structure and function of biomolecules like carbohydrates, proteins and nucleic acids.
2. Interpret the role of these molecules in the functioning of animal systems.
3. Relate the characteristics, kinetics, regulation and inhibition of enzymes.
4. Describ the biochemical system of the body.
5. Apply and develop practical skills isolate, identify and quantify different functional groups present in these molecules.

MAJOR 7
FUNDAMENTALS OF BIOCHEMISTRY
Code: ZLG0500204
Credit: 3 (T) + 1 (P)

THEORY	**Hours**
Unit1: Carbohydrates and Lipids Carbohydrates: Structure and Biological importance: Monosaccharides, Disaccharides, Polysaccharides and Glycoconjugates Lipids: Structure and Significance: Physiologically important saturated and unsaturated fatty acids, Tri-acylglycerols, Phospholipids, Glycolipids, Steroids	15
Unit 2: Amino Acids, Proteins and Nucleic Acids Amino acids: Structure, Classification and General properties of α- amino acids; Physiological importance of essential and non-essential α- amino acids. Proteins: Bonds stabilizing protein structure; Levels of organization in proteins; Denaturation; Introduction to simple and conjugate proteins. Nucleic Acids: Structure: Purines and pyrimidines, Nucleosides, Nucleotides, Nucleic acids Cot Curves: Base pairing, Denaturation and Renaturation of DNA. Types of DNA and RNA, Complementarity of DNA**.**	15

FUNDAMENTALS OF BIOCHEMISTRY

Practical	**Hours**
1. Qualitative tests of functional groups in carbohydrates, proteins and lipids. 2. To determine the iodine number of given oil/fat. 3. Estimation of a reducing sugar in a given sample. 4. To find the pKa value of acetic acid. 5. To study the activity of Salivary Amylase and Determination of Amylase Number. 6. To study the absorption spectrum of proteins and DNA.	30

7. Demonstration of proteins separation by SDS-PAGE.

Suggested Readings:

1. Cox, M.M and Nelson, D.L. (2008). Lehninger's Principles of Biochemistry, V Edition, W.H. Freeman and Co., NewYork.
2. Berg,J.M.,Tymoczko,J.L.andStryer,L.(2007).Biochemistry,VIEdition,
3. W.H. Freeman and Co., New York. Murray,R.K.,Bender,D.A.,Botham,K.M.,Kennelly,P.J.,Rodwell.
4. V.W.and Well, P.A. (2009). Harper's Illustrated Biochemistry, XXVIII Edition, International Edition, The McGraw- Hill CompaniesInc.
5. Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd.,U.K.
6. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2008). Molecular Biology of the Gene, VI Edition, Cold Spring Harbor Lab. Press, PearsonPub.
7. Das M, Dutta A and Kalita A (2022). Advanced Biochemistry. Kalyani Publications.

MAJOR 8
ENTOMOLOGY AND FISHERIES
Code: ZLG0500304
Credit: 3 (T) + 1 (P)

Course Outcomes:

Upon completion of the course, the students should be able to:

1. Identify and classify the diversity of insects and fishes based on their morphological characters
2. Interpret the body design and plan of insects and fishes in a simpler form.
3. Categorize the common vectors of human diseases and common phytophagous pests
4. Compare and contrast capture and culture fisheries resources of India
5. Appraise the importance of fish as a model organism in research and develop skills on induced breeding of Indian Major Carps, soil and water quality in aquaculture.

MAJOR 8
ENTOMOLOGY AND FISHERIES
Code: ZLG0500304
Credit: 3 (T) + 1 (P)

THEORY	Hours
Unit 1: **General Features of Insects**, Classification of insects up to orders, causes of success of insects on earth, role of insects in pollination, Basic concept on collection, preservation and culture techniques of insects **General Morphology of insects** -compound Eyes, antennae, Mouth parts and legs. Structure of integument. Molting and metamorphosis. **Insects as Vectors & Pest**: Insects as mechanical and biological vectors of pathogens and parasites, Common insect vectors (Aedes, Culex, Anopheles, Phlebotomus, Musca domestica), Insects as plant pests.	23
Unit 2: **Introduction to fish** - General description of a fish; Account of systematic classification of freshwater teleosts of NE India (up to Order) **Morphology and Physiology** - Types of fins and their modifications; Locomotion in fishes; Types of Scales; Structure and functions of Gills, basic mechanism of gas exchange; Swim Bladder - types, role in Respiration and buoyancy; Osmoregulation in Elasmobranchs; Electric organs	09
Unit 3: **Capture Fisheries** - Inland Capture Fisheries resources of India; marine fisheries; Fishing crafts and Gears; Application of remote sensing and GIS in fisheries; Fisheries rules and regulations; Climate change and its impact on fisheries; Fishery by-products **Culture fisheries** - Extensive, semi-intensive and intensive culture of fish; Pen and cage culture; Polyculture; Composite fish culture; Brood stock management; Induced breeding of Indian Major Carps; Management of	13

hatcheries; Role of soil and water quality in aquaculture
Fish in research - Transgenic fish, Zebrafish as a model organism in research

ENTOMOLOGY AND FISHERIES

Practical	Hours
1. Study of different types of mouth parts/ antenna of insects through slides/specimens.	30
2. Study of insect vectors through permanent slides or photographs or model: *Aedes*, *Culex*, *Anopheles*, *Pediculus*, *Cimex*, *Phlebotomus* (sand fly), and *Musca domestica* (house fly).	
3. Preparation of project report on any one vector and diseases transmitted by the vector (*Aedes/Culex/Anopheles*/ lice/ bed bug, sand fly/ house fly).	
4. Identification of insects belonging to different orders, common insect pest of paddy, tea, stored grain, citrus and sugarcane.	
5. Classification and characterization of commercially important food and ornamental fishes of NE India.	
6. Study of different types of indigenous/locally available fishing gears.	
7. Estimation and interpretation of pH of pond soil; dissolved oxygen (D.O.) and free carbon dioxide (fCO_2) in pond water.	
8. Dissection and display of Pituitary Gland of Indian Major Carp.	
9. Demonstration of induced breeding of IMCs (video)	

Suggested Readings:

1. Pradhan, S. (1969). Insect Pests of Crops. National Book Trust, India Book House.
2. Atwal, A.S. (1993) Agricultural pest of India and South East Asia. Kalyani Pub., New Delhi.
3. Chapman, R. F. The Insects: Structure and Function. Cambridge University Press, UK
4. S. Hill. (2005) Agricultural Insect pests of the tropics and their management, Cambridge University press.
5. Pedigo L. P. (2002). Entomology and Pest Management, Prentice Hall Publication
6. Tembhare, D.B. Modern Entomology
7. David, B.V. and Ananthakrishnan (2004). General and Applied Entomology.
8. Bone, Q. & Moore, R. H. (2008). Biology of Fishes. 3rd edition, Taylor & Francis
9. Evans, D. H., Claiborne, J. B. & Curie, S. (2014). The Physiology of Fishes. 4th edition, CRC Press
10. Handbook of Fisheries and Aquaculture (2013). Published by the Indian Council of Agricultural Research, New Delhi
11. Khanna, S. S. & Singh, H. R. (2014). Textbook of Fish Biology and Fisheries. 3rd edition, Narendra Publishing House
12. Jayaram, K. C. (2010). The Freshwater Fishes of the Indian Region. 2nd edition, Narendra Publishing House
13. Vishwanath, W. (2021). Freshwater Fishes of the Eastern Himalayas. 1st edition, Elsevier

MAJOR 9 (DSE-Optional I)
IMMUNOLOGY
Code: ZLG0500404
Credit: 3 (T) + 1 (P)

Course Outcomes:

Upon completion of the course, students shpuld be able to:

1. Define the various types of cells and organs of the immune system.
2. Compare and contrast the antigens, antibodies and their interactions.
3. Interpret the functioning of the immune system.
4. Summarize the role of vaccines in preventing diseases.
5. Design experiments related to immunological functioning in mammals.

MAJOR 9 (DSE-Optional I)
IMMUNOLOGY
Code: ZLG0500404
Credit: 3 (T) + 1 (P)

THEORY	Hours
Unit 1: Cells and Organs of the Immune System Introduction to basic concepts of immunology; components of immune system; principles of innate and adaptive immune system. Haematopoiesis, Cells of immune system and organs (primary and secondary lymphoid organs) of the immune system	15
Unit 2: Antigens and Antibodies Basic properties of antigens, B and T cell epitopes, haptens and adjuvants. Structure, classes and function of antibodies, monoclonal antibodies, antigen antibody interactions as tools for research and diagnosis	20
Unit 3: Working of the immune system and Vaccines Structure and functions of MHC, exogenous and endogenous pathways of antigen presentation and processing, basic properties and functions of cytokines, Complement system: Components and pathways. General introduction to vaccines, various types of vaccines.	10

IMMUNOLOGY

Practical	Hours
1. Histological study of spleen, thymus and lymph nodes through slides/ photographs. 2. Preparation of stained blood film to study various types of blood cells.	30

3. ABO blood group and Rh factor determination.
4. Demonstration of - a) ELISA; b) Immunoelectrophoresis
5. Isolation of lymphocytes from blood.

Suggested Readings:

1. Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J (2006). Immunology, VI Edition. W.H. Freeman and Company.
2. David, M., Jonathan, B., David, R. B. and Ivan R. (2006). Immunology, VII Edition, Mosby, Elsevier Publication.
3. Abbas, K. Abul and Lechtman H. Andrew (2003.) Cellular and Molecular Immunology. V Edition. Saunders Publication.

MAJOR 9 (DSE-Optional II)
REPRODUCTIVE BIOLOGY
Code: ZLG0500404
Credit: 3 (T) + 1 (P)

Course Outcomes:

Upon completion of the course, students should be able to:

1. Identify the processes of reproductive endocrinology in mammals.
2. Interpret the functional anatomy of male and female reproductive systems in mammals.
3. Describe various hormones involved in the process of reproduction and also the roles that they perform in the body.
4. Develop practical skills related to understanding the reproductive biology in mammals.
5. Perform further studies on the topics related to reproductive biology.

MAJOR 9 (DSE-Optional II)
REPRODUCTIVE BIOLOGY
Code: ZLG0500404
Credit: 3 (T) + 1 (P)

THEORY	Hours
Unit 1: Reproductive Endocrinology Gonadal hormones and mechanism of hormone action, steroids, glycoprotein hormones and prostaglandins, hypothalamo–hypophyseal–gonadal axis, regulation of gonadotrophin secretion in male and female; Reproductive System: Development and differentiation of gonads, genital ducts, external genitalia, mechanism of sex differentiation.	15
Unit 2: Functional anatomy of male reproduction Outline and histological study of male reproductive system in rat and human; Testis: Cellular functions, germ cell, system cell renewal Spermatogenesis: kinetics and hormonal regulation; Androgen synthesis and metabolism; Epididymal function and sperm maturation; Accessory glands functions; Sperm transportation in male tract	20
Unit 3: Functional anatomy of female reproduction Outline and histological of female reproductive system in rat and human;	10

Ovary: folliculogenesis, ovulation, corpus luteum formation and regression; Steroidogenesis and secretion of ovarian hormones; Reproductive cycles (rat and human) and their regulation, changes in the female tract; Fertilization, implantation and pregnancy in mammals

REPRODUCTIVE BIOLOGY
Credit: 3 (T) + 1 (P)

Practical	**Hours**
1. Study of estrous cycle in rat/mice.	30
2. Study of histological sections from photomicrographs/ permanent slides of rat/human: testis, epididymis and accessory glands of male reproductive systems.	
3. Study of histological sections from photomicrographs/ permanent slides of sections of ovary, fallopian tube, uterus (proliferative and secretory stages), cervix and vagina.	
4. Total sperm count and determination of sperm motility in mammal	

Suggested Readings:

1. Austin, C.R. and Short, R.V. Reproduction in Mammals. Cambridge University Press.
2. Degroot, L.J. andJameson, J.L. (eds). Endocrinology. W.B. Saunders and Company.
3. Knobil, E. et al.(eds). The Physiology of Reproduction. Raven Press Ltd.
4. Hatcher, R.A. et al. The Essentials of Contraceptive Technology. Population Information Programme.
5. Johnson, M.H. (2018). Essential Reproduction, Wiley-Blackwell, 8th Edition
6. Zarrow, M. (1964). Experimental Endocrinology-A source book of basic techniques, Elsevier, 1st Edition

MAJOR 9 (DSE-Optional III)
DEVELOPMENTAL BIOLOGY
Code: ZLG0500404
Credit: 3 (T) + 1 (P)

Course Outcomes:

Upon completion of the course, students should be able to:

1. Define the role of mitosis and meiosis cell division, cellular differentiation during gametogenesis.
2. Interpret how fertilization happens and the factors that affect fertilization event.
3. Correlate the basic embryonic development and organogenesis.
4. Compare the role different hormones and of cellular signalling during development through metamorphosis and teratogenesis.
5. Appraise the importance of IVF, amniocentesis and embryonic stem cells.

MAJOR 9 (DSE-Optional III)
DEVELOPMENTAL BIOLOGY
Code: ZLG0500404
Credit: 3 (T) + 1 (P)

THEORY	Hours
Unit 1: **Gametogenesis:** Spermatogenesis and Oogenesis Type of animal eggs, egg membrane and vitellogenesis, **Fertilization:** External and internal fertilization**,** sperm-egg interactions, biochemical events, post-fertilizations events. **Parthenogenesis**: Natural haploid, diploid and cyclic parthenogenesis. Artificial stimulus for parthenogenesis and its significance.	15
Unit 2: Planes and patterns of cleavage; Types of Blastula; Embryonic induction and Organizer, Fate map construction in frog and chick. **Organogenesis:** Development of heart and eye in vertebrates Development of chick embryo up to three germ layer formation. Extra embryonic membranes in bird and mammal.	15
Unit 3: **Placenta:** Types, function and physiology **Metamorphosis: types of metamorphosis, metamorphic changes**, hormonal regulations of metamorphosis in insects and amphibians. **Teratogenesis:** Teratogenic agents and their effects on embryonic development In vitro fertilization, Embryonic Stem cell (ESC), Amniocentesis.	15

DEVELOPMENTAL BIOLOGY

Practical	Hours
1. **Collection and study of different type of eggs** 2. **Examination of gametes of frog/rat/mice:** Sperm and ova through permanent slides or photomicrographs. 3. **Study of developmental stages of Frog:** Whole mounts and sections through permanent slides of cleavage stages, blastula, gastrula, neurula, tail bud stage, tadpole external and internal gill stages. 4. **Study of developmental stages of Chick embryo:** Whole mounts of chick through permanent slides (Hamburger and Hamilton Stages): Stage 3 (Intermediate Streak, 13 hours), Stage 4 (Definitive Streak, 18 hours), Stage 5 (Head Process, 21 hours), Stage 7 (24 hours), Stage 8 (28 hours), Stage10 (33 hours), Stage 11 (40 hours), Stage 13 (48 hours), Stage 19 (72 hours) and Stage 24 (96 hours) of incubation 5. **Study of different types of placenta**: Histological sections through permanent slides or photomicrographs.	30

Suggested Readings:

1. Gilbert, Scott F. *Developmental Biology*. 7th ed. Sunderland, MA: Sinauer Associates, 2003. ISBN: 9780878932580.
2. Wolpert, Lewis. *Principles of Development.* 2nd ed. New York, NY: Oxford University Press, 2001. ISBN: 9780198792918.
3. Kalthoff, Klaus. *Analysis of Biological Development*. 2nd ed. Boston, MA: McGraw-Hill, 2001. ISBN: 0071180788.
4. Slack, J. M. W. *Essential Developmental Biology*. Malden, MA: Blackwell Science, 2001. ISBN: 9780632052332.
5. Bier, Ethan. *The Coiled Spring: How Life Begins*. Plainview, NY: Cold Spring Harbor Laboratory Press, 2000. ISBN 9780879695637.
6. Gerhart, John, and Marc Kirschner. *Cells, Embryos, and Evolution: Toward a Cellular and Developmental Understanding of Phenotypic Variation and Evolutionary Adaptability*. Malden, MA: Blackwell Science, 1997. ISBN: 9780865425743.
7. Russo, V. E. A., et al., eds. *Development: Genetics, Epigenetics, and Environmental Regulation*. New York, NY: Springer, 1999. ISBN: 9783540627548.
8. Arias, Alfonso Martinez, and Alison Stewart. *Molecular Principles of Animal Development.* New York, NY: Oxford University Press, 2002. ISBN: 9780198792840.
9. Rao, Mahendra S., and Marcus Jacobson, eds. *Developmental Neurobiology*. 4th ed. New York, NY: Springer-Verlag, 2005. ISBN: 9780306483301.

MAJOR 10
WILDLIFE CONSERVATION AND MANAGEMENT
Code: ZLG0600104
Credit: 3 (T) + 1 (P)

Course Outcomes:

Upon completion of the course, students should be able to:

1. Define key concepts such as wildlife, wildlife conservation and conservation ethics.
2. Explain the values and importance of wildlife.
3. Describe the biological and ecological basis of wildlife management.
4. Analyze the relationship between wildlife habitat ecology and its management.
5. Develop a comprehensive wildlife management plan addressing key issues.

MAJOR 10
WILDLIFE CONSERVATION AND MANAGEMENT
Code: ZLG0600104
Credit: 3 (T) + 1 (P)

THEORY	**Hours**
Unit 1: Introduction to Wildlife Concepts of wildlife, wildlife definition, wildlife conservation, history of wildlife, and conservation ethics. Values and importance of wildlife; Causes of depletion of wildlife in India; Wildlife habitat ecology and its management; Biological and ecological basis of wildlife management. Conservation vs. preservation, Wildlife population survey	13
Unit 2: Wildlife Ecology and Management Concepts pertaining to wildlife population, density, types of density, natality, mortality sex ratio and age structure, population growth patterns and concept of carrying capacity; Habitat management of wildlife in a forested and aquatic ecosystem, the definition of wildlife cover and cover characteristics. Wildlife habitat succession and management; Restoration of degraded habitats, Concepts of GIS and Remote sensing and their utility in wildlife habitat management.	16
Unit 3: Wildlife Protected Area and Management Concepts of protected areas, wildlife protected areas in India; Protected area network, National Parks, Sanctuaries, Man and Biosphere Reserve, Ecological sensitive zones, Conservation reserves, Community reserves, Secret Groves. Concepts of elephant and tiger reserves, Ramsar sites; Recent challenges of the management of Tiger reserves and Ramsar sites. Concepts and management of renewable natural resources and wildlife's welfare factors.	16

WILDLIFE CONSERVATION AND MANAGEMENT

Practicals	Hours
1. Identification of flora (Common plant species associated with wildlife) and fauna (Mammals, Birds, Herpetofauna, and Butterflies)	30
2. Demonstration and applicability of basic equipment needed for wildlife studies (Compass, Range finder, GPS, Camera Traps).	
3. Demonstrations of field study techniques: line transect and quadrate sampling.	
4. Importance of indirect evidences in wildlife survey and its identification [Animal Footprints (Pug mark & hoof mark), Animal Droppings (Scat, Dung, Pellet), Other animal signs, Antlers, Nests of birds]	
Animal trail survey or trail monitoring, use of plaster of Paris for wildlife survey (for the indirect survey).	

Suggested Readings

1. Caughly, G. and Sinclair, A. R. E. (1994). Wildlife Ecology and Management. Blackwell Scientific Publications, 1-334pp.
2. Shekhar, S. Kolipaka, (2014). A Field Guide to Tracks & Signs of Indian Wildlife. 1-385pp.
3. Sinclair, A.R. E., John M. Frysell, and Graeme Caughley (2006). Wildlife Ecology, Conservation, and Management, Blackwell Publishing, 1-463, pp.
4. Raj, M. (2012). Wildlife Ecology and Management (With special reference to Northeast India). Assam Book Depot, Panbazar, Guwahati-1, 1-294pp.
5. Berwick S. H. and Saharia, V. B. (1995). Development of International principles of Wildlife Research and Management (Asian and American approaches). Oxford University Press, Delhi, Bombay, Madras. 1-481. pp.
6. Vivek Menon, (2014). Indian mammals, A Field Guide.Hachetta Book Publishing India Pvt. Ltd.4th and 5th Floor Corporate centre, Plot No. 94, Sector 44, Gurgoan, 122001, India.
7. Hunter M. L., Gibbs, J. B. and Sterling, E. J. (2008). Problem-Solving Conservation Biology and Wildlife Management: Exercise for class, Field and laboratory, Blackwell Publishing.
8. Southerland, W. J. (2000). The conservation handbook: Research management and Policy. Blackwell Sciences.
9. Bookhout, T. A. (1996). Research and management techniques for wildlife and habitats, 5th edition. The Wildlife Society, Allen Press.
10. Woodroffe, R., Thirgood, S. and Rabinowitz, A. (2005). People and Wildlife, Conflict or Co-existence? Cambridge University.

MAJOR 11
MOLECULAR BIOLOGY
Code: ZLG0600204
Credit: 3 (T) + 1 (P)

Course Outcomes:

Upon completion of the course, students should be able to:

1. Explain the mechanisms of DNA replication in prokaryotes and eukaryotes.
2. Describe post-translational modifications and RNA processing, including splicing and alternative splicing.
3. Apply knowledge of transcription and translation mechanisms to interpret experimental data.
4. Compare and contrast gene regulation mechanisms in prokaryotes and eukaryotes.
5. Perform isolation of DNA from tissues and its qualitative analysis using agarose gel electrophoresis.

MAJOR 11
MOLECULAR BIOLOGY
Code: ZLG0600204
Credit: 3 (T) + 1 (P)

THEORY	**Hours**
Unit 1: Nucleic Acids: Structure and types of DNA and RNA, Watson and Crick model of DNA. DNA Replication: Enzymes used in DNA Replication, DNA Replication in prokaryotes and eukaryotes, mechanism of DNA replication, Semi-conservative, bidirectional and semi-discontinuous replication, Telomere and replication of telomeres	15
Unit 2: Transcription: RNA polymerase structure and transcriptional Unit, mechanism of transcription in prokaryotes and eukaryotes Post Transcriptional Modifications and Processing of Eukaryotic RNA: Split genes: concept of introns and exons, splicing mechanism and alternative splicing Translation: Genetic code, Degeneracy of the genetic code and Wobble Hypothesis; aminoacyl tRNA synthetases and charging of tRNA; Proteins involved in initiation, elongation and termination of polypeptide chain; Mechanism of translation, Inhibitors of protein synthesis	15

Unit 3: Regulation of gene expression: Operon concept, Transcription regulation in prokaryotes (lac operon and tryptophan operon) Transcription regulation in eukaryotes: Activators, repressors, enhancers, silencer elements; Gene silencing and Genetic imprinting. DNA Damage and Repair Mechanisms RNA interference	15

MOLECULAR BIOLOGY

Practical	**Hours**
1. Study of Polytene chromosomes from Chironomous / Drosophila larvae **2.** Preparation of metaphase chromosome from the bone marrow of mice **3.** Quantitative estimation DNA using colorimeter (Diphenylamine reagent) **4.** Quantitative estimation of RNA using Orcinol reaction **5.** Isolation of DNA from tissues and qualitative analysis by agarose gel electrophoresis. **6.** Study and interpretation of electron micrographs/ photograph showing: DNA replication, Transcription and Split genes	30

Suggested Readings:

1. Cooper, G. M. (2018). 8th Edition. The cell: A molecular approach. Massachusetts, USA: Sinauer Associates. ISBN-13:978-1605357072
2. Alberts, B et al. (2014). 6th edition. Molecular Biology of the Cell. W. W. Norton & Company. ISBN-13 : 978-0815345244
3. Lodish H et al. (2003). 5th Revised edition. Molecular Cell Biology. W.H.Freeman & Co Ltd; ISBN13 : 978-0716743668
4. Karp, G. (2019). 9th Edition. Cell and molecular biology: New Jersey, USA: Wiley Publishers. ISBN-978—1-119-59816-9
5. Brown, T. A. (2020). 8thEdition. Gene cloning and DNA analysis: An introduction. New York, USA: John Wiley and Sons, ISBN-13: 978-1119640783.

MAJOR 12
BIOCHEMISTRY OF METABOLIC PROCESSES AND REGULATION
Code: ZLG0600304
Credit: 3 (T) + 1 (P)

Course Outcomes:

Upon completion of the course, students should be able to:

1. Define the principles of catabolic and anabolic processes.
2. Describe carbohydrate, protein and lipid metabolism and correlate it practical observations.
3. Explain the process of energy production in the body.
4. Perform analysis related to metabolic processes.
5. Interpret the assay results to understand enzyme activity levels.

MAJOR 12
BIOCHEMISTRY OF METABOLIC PROCESSES AND REGULATION
Code: ZLG0600304
Credit: 3 (T) + 1 (P)

THEORY	Hours
Unit 1: Overview of Metabolism Catabolism vs. Anabolism, ATP as "Energy Currency of cell"; coupled reactions; Use of reducing equivalents and cofactors.	15
Unit 2: Carbohydrate Metabolism and Oxidative Phosphorylation Sequence of reactions and regulation of glycolysis, Citric acid cycle, Phosphate pentose pathway, Gluconeogenesis, Glycogenolysis and Glycogenesis Redox systems; Mitochondrial respiratory chain, Inhibitors and un-couplers of Electron Transport System	20
Unit 3: Lipid and Protein Metabolism β-oxidation and omega-oxidation of saturated fatty acids with even and odd number of carbon atoms; Ketogenesis Catabolism of amino acids: Transamination, Deamination, Urea cycle.	10

BIOCHEMISTRY OF METABOLIC PROCESSES AND REGULATION

Practical	Hours
1. Estimation of total protein in given solutions by Lowry'smethod.	30
2. Extraction of lipids from insect.	
3. Spectrophotometric analysis of lipids using Sulpho-Phospho-Vaniline.	
4. Detection of SGOT and SGPT in serum/tissue	
5. To perform the Acid and Alkaline phosphatase assay from serum/tissue.	
6. Determination of Urea in Urine sample.	

Suggested Readings:

1. Cox, M.M and Nelson, D.L. (2008). Lehninger Principles of Biochemistry, V Edition, W.H. Freeman and Co., NewYork.
2. Berg,J.M.,Tymoczko,J.L.andStryer,L.(2007).Biochemistry,VIEdition, W.H. Freeman and Co., New York.
3. Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). Harper's Illustrated Biochemistry, XXVIII Edition, International Edition, The McGraw-Hill CompaniesInc.
4. Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd.,U.K.

MAJOR 13 (DSE-Optional I)
COMPUTATIONAL BIOLOGY
Code: ZLG0600404
Credit: 3 (T) + 1 (P)

Course Outcomes:

Upon completion of the course, the students should be able to:

1. Identify primary, secondary and composite biological databases.
2. Recall sequence submission tools and various sequence file formats.
3. Explain the methods of sequence alignment, similarity, identity and homology of sequences.
4. Develop a workflow for performing and interpreting multiple sequence alignments and phylogenetic analysis.
5. Design and execute a comprehensive bioinformatics project involving sequence retrieval, alignment and phylogenetic analysis.

MAJOR 13 (DSE-Optional I)
COMPUTATIONAL BIOLOGY
Code: ZLG0600404
Credit: 3 (T) + 1 (P)

THEORY	**Hours**
Unit I: Introduction to Bioinformatics and Biological Databases Importance, Goal, Scope; Genomics, Transcriptomics, Systems Biology, Functional Genomics, Metabolomics, Molecular Phylogeny; Applications and Limitations of Bioinformatics, Introduction to biological databases; Primary, secondary and composite databases; Nucleic acid databases (GenBank, DDBJ, EMBL and NDB); Protein databases (PIR, SWISS-PROT, TrEMBL, PDB); Metabolic pathway database (KEGG, EcoCyc, and MetaCyc); Small molecule databases (PubChem, Drug Bank, ZINC, CSD)	15
Unit 2: Sequence submission tools (BankIt, Sequin, Webin); Sequence file format (flat file, FASTA, GCG, EMBL, Clustal, Phylip, Swiss-Prot); Sequence annotation; Data retrieval systems (SRS, Entrez)	15
Unit 3: Basic Concepts of Sequence Alignment and Applications of Bioinformatics Scoring Matrices (PAM, BLOSUM), Methods of Alignment (Dot matrix, Dynamic Programming, BLAST and FASTA); Local and global alignment, pair wise and multiple sequence alignments; Similarity, identity and homology of sequences. Structural Bioinformatics (3-D protein, PDB), Drug discovery method (Basic concepts)	15

COMPUTATIONAL BIOLOGY

Practical	Hours
1. Retrieval of sequence data from Entrez, gene expression from GEO, structural data of protein using PDB, motif information of protein using Prosite. 2. Primer Designing 3. Perform pair-wise alignment of sequences (BLAST) and interpret the output. 4. Perform multiple sequence alignment using MEGA 5. Phylogenetic analysis using PHYLIP (rooted and unrooted).	30

Suggested Readings:

1. Ghosh Z and Mallick B. (2008). Bioinformatics:
2. Principles and Applications, Oxford UniversityPress.
3. Pevsner J. (2009). Bioinformatics and Functional Genomics, II Edition, Wiley Blackwell.
4. Zvelebil,MarketaandBaumO.Jeremy(2008).Understanding Bioinformatics, Garland Science, Taylor and Francis Group,USA.

MAJOR 13 (DSE-Optional II)
ADVANCE ENTOMOLOGY
Code: ZLG0600404
Credit: 3 (T) + 1 (P)

Course Outcomes:

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

1. Understand the basic physiological systems of Insects
2. Develop basic concept on pest and pest control strategies.
3. Recall concept on common insect pest of crops and stored grains
4. Describe the idea on life history of the beneficial insects
5. Develop knowledge on the diverse applications of insect products.

MAJOR 13 (DSE-Optional II)
ADVANCE ENTOMOLOGY
Code: ZLG0600404
Credit: 3 (T) + 1 (P)

THEORY	Hours
Unit 1: Insect physiology Physiological systems of insects- Digestive System, Excretory System, Circulatory System, Respiratory System, Reproductive System, and Nervous system	30
Unit 2: Pest and pest control Definition of pest, types of pests according to damage (sub economic, occasional, perennial), concept of economic injury level, economic threshold level, pest resurgence, secondary pest outbreak, cultural control, biological control of pest, pheromonal control of pest. Life history and control of following plant pests: Agricultural pests (*Papilio demoleus, Leucinodes orbonalis, Spodoptera litura*); Stored grain pests (*Callosobruchus chinensis, Sitophilus oryzae*), Tea pest (*Helopeltis theivora, Buzura suppressaria*), Paddy pest (*Dicladispa armigera, Leptocorisa* sp.), Host-plant selection by phytophagous insects	08
Unit 3: Beneficial insects Life history of two silk producing insects in North East India. Life history of lac insects. Applications of lac, silk and honey.	07

ADVANCE ENTOMOLOGY

Practical	Hours
1. Collection, preservation, identification of common phytophagous pest 2. Submission of life cycle of silkworm/ lac insects 3. Dissection of digestive and nervous system of cockroach/ grasshopper 4. Study on biological agents- (identification, classification and significance): pathogens, parasites, predators 5. Visit to field and prepare a report (agriculture/ sericulture/ apiculture/ lac culture field)	30

Suggested Readings:

1. Pradhan, S. (1969). Insect Pests of Crops. National Book Trust, India Book House.
2. Atwal, A.S. (1993) Agricultural pest of India and South East Asia. Kalyani Pub., New Delhi.
3. Chapman, R. F. The Insects: Structure and Function. Cambridge University Press, UK
4. Dennis, S. Hill. (2005) Agricultural Insect pests of the tropics and their management, Cambridge University press.
5. Pedigo L. P. (2002). Entomology and Pest Management, Prentice Hall Publication
6. Tembhare, D.B. Modern Entomology, Himalaya Publishing House.
7. David, B.V. and Ananthakrishnan (2004). General and Applied Entomology. McGraw Hill India.
8. Ghosh, M.R. (1995). Concepts of Insect Control. New Age International Limited, New Delhi.
9. Srivastava, K.P. (1996) A Textbook of Applied Entomology. Kalyani Publisher.
10. Nation, J.L. (2008). Insect Physiology and Biochemistry. CRC Press, New York

MAJOR 13 (DSE-Optional III)
ANIMAL CELL CULTURE AND GENETIC ENGINEERING
Code: ZLG0600404
Credit: 3 (T) + 1 (P)

Course Outcomes:

Upon completion of the course, students should be able to:

1. Define basic cell culture techniques and key concepts that are used in isolation and culture of animal cells.
2. Develop basic understanding of the modern robust techniques with wide applications (such as PCR, DNA sequencing, DNA fingerprinting, DNA microarrray and blotting techniques.
3. Understand the importance of gene cloning in biotechnology and utilization of different cloning vectors such as plasmids and bacteriophages.
4. Explain the importance of construction of genomic libraries
5. Analyse the specialized screening methods to identify gene of interest.

MAJOR 13 (DSE-Optional III)
ANIMAL CELL CULTURE AND GENETIC ENGINEERING
Code: ZLG0600404
Credit: 3 (T) + 1 (P)

THEORY	**Hours**
Unit 1: Basic requirement of animal cell culture, cell culture media Basic techniques of cell culture, Development of primary cell cultures: cell separation, harvesting and maintenance of cell lines; Transformation and differentiation of cell cultures, Types of cell culture: monolayer, suspension, Measurement of viability and parameters of growth. Cell culture Bioassays: Cell proliferation assays	15
Unit 2: Polymerase Chain Reaction DNA sequencing: Sanger's method, Next generation sequencing Southern, Northern and Western blotting DNA Finger Printing and DNA microarray,	15
Unit 3: Basic concept of gene cloning, Restriction enzymes and DNA modifying enzymes. Cloning vectors: Plasmids, Lambda Bacteriophage, M13, YAC and Expression vectors (characteristics). Cell Transformation techniques: Calcium chloride method, electroporation and biolistic method. Construction of genomic and cDNA libraries and screening by colony and plaque hybridization	15

ANIMAL CELL CULTURE AND GENETIC ENGINEERING

Practical	Hours
1. Genomic DNA isolation from E. coli **2.** Plasmid DNA isolation (pUC 18/19) from E. coli **3.** Demonstration of Restriction digestion of Plasmid/Lambda DNA. **4.** To demonstrate following techniques: (Optional) Southern/ Northern/Western blotting (Any one) PCR DNA fingerprinting DNA Sequencing (Sanger's Method) **5.** Project report on animal cell culture OR on a visit to any biotechnology Institute	30

Suggested Readings:

1. Freshney, R. Ian Culture of Animal Cells: A Manual of Basic Technique, 4th Edition ISBN 13: 9780471348894
2. Leslie Wilson, Paul Matsudaira, (1998), Animal Cell Culture Methods, eBook ISBN: 9780080859552
3. Cooper, G. M. (2018). 8th Edition. The cell: A molecular approach. Massachusetts, USA: Sinauer Associates. ISBN-13:978-1605357072
4. Alberts, B et al. (2014). 6th edition. Molecular Biology of the Cell. W. W. Norton & Company. ISBN-13 : 978-0815345244
5. Lodish H et al. (2003). 5th Revised edition. Molecular Cell Biology. W.H.Freeman & Co Ltd; ISBN13 : 978-0716743668
6. Karp, G. (2019). 9th Edition. Cell and molecular biology: New Jersey, USA: Wiley Publishers. ISBN-978—1-119-59816-9
7. Brown, T. A. (2020). 8thEdition. Gene cloning and DNA analysis: An introduction. New York, USA: John Wiley and Sons, ISBN-13: 978-1119640783.
8. Cantor, C. R. and Smith, C. L. (2004). 1st Edition. Genomics: The science and technology behind the human genome project. New York, USA: John Wiley and Sons. ISBN-13: 978-0471461869.
9. Old, R. W. and Primrose, S. B. (1994). 7th Edition. Principles of Gene Manipulation: an Introduction to Genetic Engineering. Boston: Wiley. ISBN-13: 978-0632037124.
10. Joseph Sambrook, E.F. Fritsch, T. Maniatis. (1989). 2nd Edition. Molecular Cloning: A Laboratory Manual. New York, USA: Cold Spring Harbor Laboratory. Press ISBN- 978-0879693732.
11. Glick, B. R. and Patten, C. L. (2022). 6thEdition. Molecular Biotechnology: Principles and Applications of Recombinant DNA. USA: ASM press, ISBN-13: 978-1683673668.
12. Primrose, S. B. and Twyman, R. B. (2014). 7th Edition. Principles of Gene Manipulation and Genomics. New York, USA: John Wiley and Sons. ISBN-13: 978-1118653883.
13. Green, M. R. and Sambrook, J. (2012). 4th Edition. Molecular Cloning: A Laboratory Manual (three-volume set). New York, USA: Cold Spring Harbor Laboratory Press ISBN-13: 978- 1936113422

FOURTH YEAR: SEMESTER VII

(Common for both Degree with Honours and Degree with Honours & Research)

MAJOR 14
ADVANCED BIOCHEMISTRY
Code: ZLG0700104
Credit: 3 (T) + 1 (P)

Course Outcomes:

Upon completion of course, the students should be able to:

1. Apply knowledge and solve the problem of biogenetics
2. Analyze the concepts of protein structure and solve the problem of protein chemistry.
3. Understand the concept of Enzyme kinetics.
4. Analyze the concept of enzyme regulation.
5. Analyze the concept of nucleic acid structure and Transcriptional Regulation and Gene Expression

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ADVANCED BIOCHEMISTRY
Code: ZLG0700104
Credit: 3 (T) + 1(P)

THEORY	**Hours**
Unit 1:	22

1. Energy rich compound, role of ATP/ADP cycle in transfer of high energy phosphate
2. Important respiratory complex of ATP synthesis and oxidative phosphorylation, chemiosmotic hypothesis
3. Secondary structure: α-helix, β-pleated sheet & bends, Prediction of secondary structure, Ramachandran plot
4. Tertiary structure: Forces stabilizing tertiary structure, Domains and motifs, Quaternary Structure of proteins.
5. Michaelis-Menten equation and plot. Linear kinetic plots: Lineweaver Burk, Hanes Wolf, Edie Hofstee, Eadie Scatchard plot, Importance of Kcat/km, Kinetics of Zero and first order reaction, Calculations on enzyme kinetics, multi-substrate reactions: Random sequential, Ordered, Ping-pong (double reciprocal) mechanism
6. Regulation: Allosterism, covalent modifications and regulation by proteolytic cleavage

Unit 2:	23

1. Hexose monophosphate shunt pathway and its significance; synthesis of fatty acids.
2. Intermediary metabolism: inter-conversion between lipids, carbohydrate and proteins.
3. Amino acid: Structure and chemistry of amino acid, Amino acid catabolism: Transamination, Transdeamination and oxidative deamination.
4. Nucleic acids: Structure, folding motifs, conformational flexibility, and supercoiling,
5. Transcriptional Regulation and Gene Expression: regulatory interplay between transcription factors: regulatory DNA sequences (promoters, enhancers, locus control regions) /general transcription machinery/transcription factors: cell-specific and ubiquitous regulatory factors/ mechanistic aspects of transcription activation / chromatin, histones, DNA methylation /gene regulatory networks/transcription factors in health and disease/ transcription factors as the final integrators of signaling cascades.

ADVANCED BIOCHEMISTRY	
PRACTICAL	**Hours**
1. Extraction of biomolecules (carbohydrates, proteins, lipids) from fish liver. 2. Estimation of protein extracted from fish liver by Biuret/Lowry/Bradford method. 3. Estimation of glycogen extracted from fish liver by Anthrone reagent method. 4. Estimation of blood glucose by Folin-Wu method. 5. Effect of substrate concentration on enzyme activity and determination of Km and Vmax by plotting Michaelis-Menten and LB plot. 6. Determination of Pka & PI value of glycine using Titration method. 7. Separation of protein by SDS PAGE 8. Amplification DNA by PCR using Thermal cycler.	30

Suggested Readings:

1. Text book of Biochemistry by Lippincott
2. Harper's Illustrated Biochemistry
3. Text Book of Biochemistry by Lehninger
4. Clinical Biochemistry by Varley
5. Text Book of Biochemistry by Vasudevan
6. Text Book of Biochemistry by Styrer
7. Text Book of Biochemistry by Voet and Voet
8. Text Book of Biochemistry by Garret and Gisham

MAJOR 15

BIODIVERSITY CONSERVATION AND APPLICATION OF BIOSTATISTICS

Code: ZLG0700204

Credit: 3 (T) + 1 (P)

Course Outcomes:

Upon completion of course, the students should be able to:

1. Recall key concepts and definitions related to biodiversity conservation and biostatistics and identify different data collection methods and types of sampling techniques used in statistical investigations.
2. Explain the principles and theories behind biodiversity conservation and statistical analysis.
3. Apply statistical methods to analyze biodiversity data and propose conservation strategies.
4. Interpret biodiversity data and evaluate the effectiveness of conservation measures.
5. Critically assess the impact of population pressure, urbanization and climate change on biodiversity.

BIODIVERSITY CONSERVATION AND APPLICATION OF BIOSTATISTICS

Code: ZLG0700204

Credit: 3 (T) + 1(P)

THEORY	**Hours**
Unit 1: BIODIVERSITY CONSERVATION	22

1. Concept and history of biodiversity, Components of Biodiversity (Genetic, Organismal and Ecological), Biological disciplines of Biodiversity, Characterization of biodiversity on different scales.
2. Biodiversity in different levels (Country, Global, Regional).
3. Magnitude and distribution of Biodiversity, Values of Biodiversity.
4. Methods and tools for biodiversity conservation (ex-situ, in-situ, Restoration and Rehabilitation, Sustainable land use practices).
5. Priority setting: Criteria for conservation; Conservation status and problems of fresh water fishes in NE India.
6. Challenges in Biodiversity Conservation: Impacts of population pressure, land use changes and urbanization on biodiversity; Impact of climate Change on biodiversity loss, public health and disease dynamics.
7. Integrating gender perspectives in biodiversity conservation.
8. Legal instruments for biological diversity conservation.

Unit 2: APPLICATIONS OF BIOSTATISTICS	23

1. Biostatistics and its application; Statistical investigation: Data collection methods (Census survey and sample survey) and types of sampling.
2. Measures of Central Tendency and Dispersion: Quartile, Deciles and percentiles; Absolute measures (standard deviation and variance) and Relative measure (co-efficient of variation) of Dispersion; Standard error; Theory of Estimation, Confidence limit.
3. Probability and Theoretical Distribution: Probability Theory; Theoretical Distribution: Binomial, poison and normal distributions, Skewness, Kurtosis and Moments.
4. Correlation analysis: Types of Correlation, Methods of measuring correlation, Properties of Correlation Coefficient; Regression analysis: Linear and Nonlinear Regression, regression lines, regression equation, regression Coefficients, Properties

of regression coefficients.

5. Statistical hypothesis; Z Test; T- Test; F- Test and Analysis of Variance: One way classification and Two -way classification.
6. Chi-square test; Kruskal-Wallis or H test; Man-Whitney U test.

BIODIVERSITY CONSERVATION AND APPLICATION OF BIOSTATISTICS	
PRACTICAL	**Hours**
1. Identification of regionally available vertebrates (Mammals, Birds, Herpetofauna, and Fishes) in Field /Laboratory. 2. Identification of regionally available invertebrates (Arachnida/Lepidoptera) in Field/Laboratory. 3. Activity budgeting of free living and free ranging animals (bird/mammal). 4. Graphical representation of hypothetical or collected biodiversity data. 5. Calculation of Standard deviation, Variance, Standard error, Coefficient of variation from hypothetical or collected biodiversity data. 6. Analysis of Karl Pearson correlation Coefficient, Spearman Correlation coefficient, T-test using equal variance, paired sample t-test, ANOVA, chi-square test, Kruskal Wallis test, Man-Whitney U test from biodiversity data manually or by using computer operated statistical software (SPSS, R Programming etc.).	30

Suggested Readings:

1. Chainy, G. B. N., Mishra, G. and Mohanty, P. K. 2008. *Biostatistics Theory and Applications*, Kalyani Publishers, Ludhiana-New Deli, 353pp.
2. Satguru Prasad, 2020. *Elements of Biostatistics*, Rastogi Publications.314pp.
3. Gupta, S. P. 2022. *Statistical Methods*, Published by Sultan Chand & Sons. 46th Edition
4. P. N. Arora, & Malhan, P. K. 1998. *Biostatistics*. Himalaya Publishing House. 447pp.
5. Gaston, K and Spicer, J. I. 2004. *Biodiversity An Introduction*, Second edition, Blackwell Publishing, 191pp.
6. Heywood, H. and Gardner, K. 2003. Global *Biodiversity Assessment*, (eds), UNEP publisher, 1140pp.

MAJOR 16
MOLECULAR CYTOGENETICS
Code: ZLG0700304
Credit: 3 (T) + 1 (P)

Course Outcomes:

Upon completion of course, the students should be able to:

1. Define chromatin and its role in DNA packaging.
2. Identify different types of chromosome banding techniques and explain their principles.
3. Explain the molecular basis of chromosomal abnormalities and diseases.
4. Apply karyotyping techniques to analyze and interpret karyotypes.
5. Explain the molecular mechanisms of mutations caused by base analogs and alkylating agents

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MOLECULAR CYTOGENETICS
Code: ZLG0700304
Credit: 3 (T) + 1(P)

THEORY	**Hours**

Unit 1: 15

1. Chromatin structure and chromosome organization, packaging of DNA in chromatin, histones and non-histone proteins, nucleosome and higher-level organization.
2. Metaphase chromosome, centromere and kinetochore, structure and functions of telomere, holocentric chromosomes and supernumerary chromosomes, chromosomal domains (matrix, loop domains) and their functional significance, heterochromatin and euchromatin.
3. Functional states of chromatin and alterations in chromatin organization, structural and functional organization of interphase nucleus.

Unit 2: 15

1. Karyotyping: Classic karyotype, spectral karyotype (SKY technique), digital karyotyping, types of chromosome banding, FISH technique and its applications, principles, and applications of comparative genomic hybridization (CGH).
2. Genetics and cancer: molecular basis of chromosomal abnormalities and diseases, chromosomal anomalies in malignancy (chronic myeloid leukaemia, Burkitt's lymphoma, retinoblastoma, and Wilm's tumor).
3. History of organization, goals and values of human genome project, organization, and distribution of human genes.

Unit 3: 15

1. Types of mutations (Sponteneous & Induced, Base substitutions and frameshifts - Transitions, Transversions, gain in function, loss in function, Neutral mutations)
2. Molecular mechanism of mutations (Base analogs, alkylating agents)
3. Detection of mutations: Dominant lethal test, Sex-linked recessive lethal test, II-III translocations, Ame's test, P-mediated mutagenesis
4. Cytogenetic effects of ionizing and nonionizing radiations
5. Linkage and construction of genetic maps: Cytogenetic and linkage maps, Two- and three-point cross in *Drosophila*; RFLP mapping

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MOLECULAR CYTOGENETICS

PRACTICALS	Hours
1. Study of Barr body using buccal smear of human 2. Preparation and study of metaphase chromosomes from mouse bone marrow/fish. 3. Chromosome banding (C- and G-banding). 4. Preparation of human karyotype and study of chromosomal aberrations with respect to number, translocation, deletion etc., from the pictures provided. 5. Study of morphology and mutants of *Drosophila melanogaster* 6. Temporary squash preparation of polytene chromosomes from salivary glands of *Drosophila*/*Chironomous* larvae. 7. Demonstration of telomere and centromere using FISH technology	30

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. Rooney, D. E., & Czepulkowski, B. H. (2013). Human Cytogenetics: Constitutional Analysis (4th ed.). Oxford University Press.
3. Lewin, B., Krebs, J. E., & Goldstein, E. S. (2000). Genes IX. Jones and Bartlett Publishers.
4. Vogel, F., & Motulsky, A. G. (2010). Human Genetics: Problems and Approaches (4th ed.). Springer Science & Business Media.
5. T. A Brown. Genomes, 5th Edition, CRC Press.

MAJOR 17
IMMUNOLOGY & MICROBIOLOGY
Code: ZLG0700404
Credit: 3 (T) + 1 (P)

Course Outcomes:

Upon completion of course, the students should be able to:

1.Explain the concepts of antigens, antigenicity and immunogenicity
2. Compare and contrast the micro and macro structures of lymphoid organs.
3. Create a classification of Ig classes and types.
4. Define and differentiate between Bacteria, Archea, Viruses, Algae, Fungi and Protists.
5. Evaluate the impact of different microbial species on human health and the environment.

IMMUNOLOGY & MICROBIOLOGY
Code: ZLG0700404
Credit: 3 (T) + 1(P)

THEORY	**Hours**
Unit 1: Immunology (2 credits)	30
1. Innate and acquired immunity: Cells and molecules involved in innate and adaptive immunity, antigens, antigenicity, and immunogenicity. 2. Cells of the immune system: Types of cells and their subsets responsible for immune response- WBC, macrophages, dendritic cells, B cells, T cells and NK cells. 3. Basic concept of B- and T-cell antigen receptors, and CD markers. 4. Lymphoid organs: primary and secondary lymphoid organs and their functions, their micro and macro structures, vascular and lymphatic connections. 5. Immunoglobulins: Structure and domain of Ig molecule, Ig classes and types; Myeloma protein, monoclonal antibody, Ig superfamily 6. Antigen-antibody reaction: antibody affinity and avidity, cross reactivity, agglutination reaction, precipitation reaction.	
Unit 2: Microbiology (1 credit)	15
1. Diversity of Bacteria, Archaea, Viruses, Algae, Fungi and Protists. 2. Microbial modes of Pathogenicity: Portals of entry of microbes; Invasiveness and Toxigenicity. 3. Bacterial growth characteristic: basic requirements of growth; types of culture media; concept of generation time; phases of growth; measurement of growth; pure culture techniques. 4. Microbes and human welfare: Microbial products; Microbial biocontrol; microbial sewage water treatment.	

IMMUNOLOGY & MICROBIOLOGY

PRACTICALS	**Hours**
1. Dissection and histology of lymphoid organs in rat/mouse. 2. Differential WBC count in mammalian blood. 3. Quantitative analysis of antigens by precipitation reactions in gels: Single radial immunodiffusion (SRID). 4. Indirect ELISA technique.	30

5. Preparation and study of whole mount of ciliates.
6. Demonstration on techniques of isolation of bacteria and preparation of pure culture.
7. Bacterial colony count.
8. Gram staining and identification of bacteria.

Suggested Readings:

1. Jenni Punt, Sharon Stranford, Patricia Jones, Judith A Owen (2018). *Kuby Immunology*. 8th ed., WH Freeman [ISBN: 978-1319114701].
2. Abul Abbas, Andrew H Lichtman, Shiv Pillai (2017). *Cellular and Molecular Immunology*. 10th ed., South Asia Edition, Elsevier [ISBN: 978-8131248928].
3. Subhash C Parija (2012). *Textbook of Microbiology and Immunology*. 2nd ed., Elsevier [ISBN: 978-81-312-2810-4].
4. Michael T. Madigan, John M. Martinko, David A. Stahl, David P. Clark (2012). *Brock Biology of Microorganisms*. 13th ed, Pearson [ISBN 10: 0-321-64963-X (Student edition)].
5. Prescott, Harley, Klein (2002). *Microbiology*. 5th ed, The McGraw−Hill Companies [ISBN: 0-07-282905-2].
6. Gerard J. Tortora, Berdell R. Funke, Christine L. Case (2013). *Microbiology - An Introduction*. 11th ed., Pearson [ISBN 10: 0-321-73360-6; ISBN 13: 978-0-321-73360-3 (Student edition)].

MAJOR 18
RESEARCH METHODOLOGY
Code: ZLG0700504
Credit: 04

Course Outcomes:

Upon completion of course, the students should be able to:

1. Understand the basics of performing research in science
2. Create and develop the concepts of designing a research plan
3. Comprehend the important data collection, analyses and report writing
4. Identify the importance of ethics in research
5. Develop skills to write a research report

RESEARCH METHODOLOGY
Code: ZLG0700504
Credit: 04

THEORY	**Hours**
Unit 1: Foundation of Research	05
1. Meaning, Objectives, Motivation: Research Methods vs Methodology 2. Types of Research: Analytical vs Descriptive, Quantitative vs Qualitative, Basic vs Applied	
Unit 2: Research Design	10
1. Need for research design: Features of good design, Important concepts related to good design- Observation and Facts, Prediction and Explanation, Development of Models. Developing a research plan: Problem identification, Experimentation, 2. Determining experimental and sample designs	
Unit 3: Data Collection, Analysis and Report Writing	**15**
1. Observation and Collection of Data-Methods of data collection- Sampling Methods, Data Processing and Analysis Strategies, Technical Reports and Thesis writing, Preparation of Tables and Bibliography. Data Presentation using digital technology	
Unit 4: Ethical Issues	**15**
1. Intellectual property Rights, Commercialization, Copy Right, Royalty, Patent law, 2. Plagiarism, Citation, Acknowledgement, Record keeping, organizing data, organizing the lab space. 3. Chemical, Radioactive and Biological safety: Possible hazards and precautionary measures; do and don'ts upon exposure.	
Unit 5: Writing	**15**
1. Communication of Research Results and Inferences 2. Scientific writing (including Language proficiency), State-of-the-art scientific literature comprehension, Art and ethics of writing research report/paper, writing of an abstract for scientific community and public. 3. Skills of making PowerPoint presentations, Art of web-meeting interaction; presentations using latest video-meeting modes. Letter writing and official correspondence.	

Suggested Readings:

1. Anthony, M, Graziano, A.M. and Raulin, M.L. 2009. *Research Methods: A Process of Inquiry*, Allyn and Bacon.
2. Walliman, N. 2011. *Research Methods- The Basics*. Taylor and Francis, London, New York.
3. Wadhera, B.L. 2002. *Law Relating to Patents, Trade Marks, Copyright Designs and Geographical Indications*, Universal Law publishing
4. Kothari, C. R. 2009. *Research Methodology*, New Age International
5. Coley, S.M. and Scheinberg, C.A. 1990. *Proposal writing*, Stage Publications.

NOTE:

- Students can opt for a **Research Methodology course from MOOCs** as an alternative of the above to acquire the Credits

FOURTH YEAR: EIGHTH (VIII) SEMESTER
(Only for Degree with Honours)

MAJOR 19
ADVANCED COMPUTATIONAL BIOLOGY, BIOTECHNIQUES AND INSTRUMENTATION
Code: ZLG0800104
Credit: 3 (T) + 1 (P)

Course Outcomes:
Upon completion of course, the students should be able to:

1. Demonstrate different biological databases and tools.
2. Apply algorithms for searching the biological databases.
3. Categorize sequence alignment methods.
4. Implement phylogenetic tree construction algorithms.
5. Predict gene and protein secondary structure.

ADVANCED COMPUTATIONAL BIOLOGY, BIOTECHNIQUES AND INSTRUMENTATION
Code: ZLG0800104
Credit: 3 (T) + 1(P)

THEORY	**Hours**
Unit 1:	23

1. Molecular phylogeny and evolution: Properties and types of phylogenetic trees; Tree building methods- Distance based: UPGMA (Unweighted pair group method using arithmetic mean), Neighbour-joining, minimum evolution methods; Character-based: Maximum Parsimony, Maximum Likelihood.
2. Theoretical aspects of sequence analysis. Needleman-Wunsch and Smith-Waterman methods of global and local alignments for a pair of sequences.
3. Computational tools and methods for prediction of protein secondary and tertiary structures. Description of machine learning methods for secondary structures.
4. Homology modelling, fold recognition and ab initio methods for tertiary structure prediction.
5. Introduction to Bioinformatics approaches in drug discovery. Application of Molecular docking and Pharmacokinetics studies.
6. Overview of protein-protein and protein-ligand interactions (use of Cluspro and Autodock).

Unit 2:	22

1. Histochemical and Immunotechniques: Antibody generation, Detection of molecules using ELISA, RIA, western blot, immunoprecipitation, flowcytometry and immunofluorescence microscopy, detection of molecules in living cells, in situ localization by techniques such as FISH and GISH. C
2. Biophysical Method: Molecular analysis using UV/visible, fluorescence, IR spectroscopy.
3. Radiolabelling techniques: Detection and measurement of different types of radioisotopes normally used in biology, incorporation of radioisotopes in biological

tissues and cells, molecular imaging of radioactive material, safety guidelines.

4. Microscopic techniques: Visualization of cells and subcellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells, scanning and transmission microscopes, different fixation and staining techniques for EM, freeze-etch and freezefracture methods for EM, Fluorescent and confocal microscopy

ADVANCED COMPUTATIONAL BIOLOGY, BIOTECHNIQUES AND INSTRUMENTATION

PRACTICAL	**Hours**
1. Data mining for sequence analysis	30
2. Finding possible genes in a given nucleotide sequence (ORF finder)	
3. Prediction and validation of protein structure using homology modelling approach (use of Swiss model)	
4. Calculating the distance between the ligand and a particular amino acid (using PYMOL). Visualizing the secondary structure of a protein (using PYMOL)	
5. Construction of phylogenetic tree using MEGA software for given set of sequences	
5. Determination of binding modes of a given ligand in the active site of a protein (use of Autodock)	
6. Visit to advanced laboratory and prepare a report on sophisticated instruments.	

Suggested Readings:

1. Bioinformatics, Sequence and Genome analysis. Second Ed. By David W. Mount
2. Bioinformatics and Functional genomics. Third Ed. By Jonathan Pevsner
3. Biotechniques by P. Ponmurugan; B. Ganagadhara Prabhu
4. Wilson And Walker's Principles And Techniques Of Biochemistry And Molecular Biology

MAJOR 20
CELLULAR PHYSIOLOGY
Code: ZLG0800204
Credit: 3 (T) + 1 (P)

Course Outcomes:

Upon completion of course, the students should be able to:

1. Learn cellular and molecular bases of physiological processes including cellular homeostasis, signal transduction, water transport, membrane potentials, cellular excitability, synaptic transmission and plasticity, and neuromuscular function.
2. Interpret how animal cell membranes are structured and how solutes and water are moved across membranes in and out of cells
3. Differentiate between different types of ion channels and other membrane proteins that permit movement of ions across cell membranes
4. Predict directions of ion flux across membranes
5. Define the changes in membrane voltage associated with action potentials in multiple cell types and distinguish between the ionic basis of different types of action potentials

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CELLULAR PHYSIOLOGY
Code: ZLG0800204
Credit: 3 (T) + 1(P)

THEORY	**Hours**
Unit 1:	15
1. Bio membranes: Basic concept and Structural organization with special reference to erythrocyte membrane structure; concept of micelles and liposome. 2. Transport across biological membranes: Active vs passive transport, types and molecular structures of transporters, role of membrane transporters in regulation of physiological process. 3. Role of cytomembrane in health and diseases with special reference to lipid peroxidation.	
Unit 2:	15
1. Signal hypothesis and protein sorting within the subcellular compartment. 2. Glycosylation of proteins within GERL. 3. Role of coated vesicles in protein trafficking; endocytosis and exocytosis.	
Unit 3:	15
1. Cell-to-cell signaling, signaling molecules. 2. Hormones and their receptors, cell surface receptors and signal transduction pathways, second messengers. 3. Membrane potential and nerve impulse transmission, neurotransmitters, and synaptic neurotransmission.	

CELLULAR PHYSIOLOGY	
PRACTICAL	**Hours**
1. Study of the effect of hypotonic, isotonic and hypertonic solution on isolated erythrocytes. 2. Isolation of hepatocytes and histochemical staining of Golgi complex. 3. Estimation of lipid peroxidation in tissues homogenates. 4. Estimation of acetylcholinesterase activity. 5. Histological preparation of adrenal glands to demonstrate cellular organization of adrenal cortex and medulla. 6. Histological preparation of thyroid gland. 7. Microscopic examination of phagocytosis and exocytosis in tetrahymena. 8. Study on the effect of hormones on reproductive organs.	30

Suggested Readings:

1. Hardin J. *Becker's The World of the Cell*. Any Edition ISBN-10: 0321716027 | ISBN-13:
2. 978-0321716026
3. Cooper, G. M. (2018). 8th Edition. *The cell: A molecular approach*. Massachusetts, USA: Sinauer Associates. ISBN-13:978-1605357072
4. Alberts, B et al. (2014). 6th edition. *Molecular Biology of the Cell*. W. W. Norton & Company. ISBN 13: 978-0815345244
5. Lodish H et al. (2003). 5th Revised edition. *Molecular Cell Biology*. W.H.Freeman & Co
6. Ltd; ISBN13: 978-0716743668
7. Karp, G. (2019). 9th Edition. *Cell and molecular biology*, New Jersey, USA: Wiley Publishers. ISBN-978—1-119-59816-9
8. Brown, T. A. (2020). 8thEdition. *Gene cloning and DNA analysis: An introduction*. New
9. York, USA: John Wiley and Sons, ISBN-13: 978-1119640783.

MAJOR 21
INTEGRATIVE BIOLOGY
Code: ZLG0800304
Credit: 4 (T)

Course Outcomes:

Upon completion of course, the students should be able to:

1. Define the structure of atoms and molecules.
2. Explain the role of hormones and their receptors.
3. Analyze signal transduction pathways involving second messengers.
4. Assess the effectiveness of different gene mapping methods.
5. Define concepts like neutral evolution, molecular divergence and molecular clocks.

INTEGRATIVE BIOLOGY
Code: ZLG0800304
Credit: 4 (T)

THEORY	**Hours**
1. Molecules and their interactions: Structures of atoms, molecules, chemical bonds; stabilizing interactions (Van der Waal's, Electrostatic, Hydrogen bonding, Hydrophobic interactions, etc.).	60
2. Cell signaling: Hormones and their receptors; signaling through G-protein coupled receptors; signal transduction pathways: secondary messengers and regulation of signaling pathways; bacterial chemotaxis and quorum sensing.	
3. RNA interference: History, molecular mechanisms and applications of antisense RNA, microRNA, siRNA, and ribozymes.	
4. Cellular communication: Regulation of hematopoiesis; neurotransmission and its regulation.	
5. Gene mapping methods: Linkage maps, tetrad analysis; mapping by using somatic somatic cell hybrids.	
6. Generation of genomic and cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors.	
7. Molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems; expression of recombinant proteins using bacterial and animal vectors.	
8. *In vitro* mutagenesis and deletion techniques, gene knock out in bacterial and eukaryotic organisms.	
9. RFLP, RAPD and AFLP techniques.	
10. Human genetics: Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.	
11. Quantitative genetics: Polygenic inheritance, heritability, and its measurements; QTL mapping.	
12. Recombination: Homologous and non-homologous recombination including transposition, site-specific recombination.	
13. Concepts of neutral evolution, molecular divergence, and molecular clocks; origin of new genes; gene duplication and divergence.	

Suggested Readings:

1. Molecular Cell Biology by Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Angelika Amon, and Matthew P. Scott
2. Molecular Cloning: A Laboratory Manual" by Joseph Sambrook and David W. Russell
3. Essential Cell Biology" by Bruce Alberts, Dennis Bray, Karen Hopkin, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter
4. Wilson And Walkers Principles and Techniques of Biochemistry and Molecular Biology 8Ed, Cambridge university press
5. Gene cloning and DNA analysis: an introduction, 8th edition, by T. A. Brown.
6. Fundamentals Molecular Biology by Lizabeth A. Allison, John Wiley & Sons.
7. Genomes, 5th Edition by T. A Brown, CRC Press.

MAJOR 22
ECOLOGICAL SCIENCE AND ENVIRONMENTAL BIOLOGY
Code: ZLG0800404
Credit: 3 (T) + 1 (P)

Course Outcomes:

Upon completion of course, the students should be able to:

1. Understand key concepts and principles in ecology and environmental science, the interrelationship between different components of ecosystems, and the impacts of human activities on the environment.
2. Apply theoretical knowledge to analyse real-world environmental issues and propose solutions for mitigation and conservation.
3. Evaluate the dynamics of populations, communities, and biogeochemical cycles in various ecosystems.
4. Integrating knowledge from multiple disciplines to develop holistic approaches to environmental management and biodiversity conservation.
5. Assess the effectiveness of environmental regulations, policies, and conservation strategies in addressing global environmental challenges.

ECOLOGICAL SCIENCE AND ENVIRONMENTAL BIOLOGY
Code: ZLG0800404
Credit: 4 (T)

THEORY	**Hours**
Unit 1: Ecological Science	**25**

1. Ecosystem Structures and Biomes: Introduction to major aquatic (Freshwater and Marine) and terrestrial Ecosystems; Overview of terrestrial biomes.
2. Productivity and Stability: Concepts of productivity, Primary and secondary productivity, measurements of productivity in ecosystems; Homeostasis of the ecosystem
3. Energy Flow and Trophic Dynamics: Energy flow between trophic level, Energy Flow Models, Lindeman's Trophic dynamics concept; Efficiency of energy transfer: Trophic, Consumption, Assimilation & production efficiency; Trophic Cascades: Aquatic and terrestrial trophic cascade
4. Food web Patterns and Measurements: Description of food web structures and patterns in the Ecosystem, Techniques for creating schematic representation of food web, Interpretation of food web diagrams and their components.
5. Population Ecology: Population Fluctuation; Cyclic Oscillations in Population
6. Dynamics; Concepts of Carrying capacity and Allee principles of aggregation and refugia; Metapopulation Dynamics.
7. Community Ecology: Biotic Community concepts and organization; Relative Density, Frequencies, and Dominance in Communities, Stability concept.
8. Niche concept and types, Niche width, overlap and separation; Resource partitioning and competitive exclusion, Character displacement.
9. Life History Strategies: K-selection and r-selection.

Unit 2: Environmental Biology	20

1. Environmental Issues and Regulations: Overview of key environmental issues: pollution, habitat loss, climate change; Analysis of environmental regulations and policies; Approaches to biodiversity management and conservation
2. Environmental concerns and Global Impact: greenhouse effects, global warming; effects of environmental pollution on ecosystem and human health; Mitigation strategies for addressing environmental concerns.
3. Human and Environment Interaction: Anthropogenic impact on the environment and biodiversity, Environmental Impact Assessment (EIA).
4. Environmental Monitoring and Documentation: Principles and methods of environmental monitoring; Importance of documentation in environmental management.
5. Divers of Biodiversity Changes: Identification of major drivers of biodiversity changes; Case studies on the impacts of habitat destruction, climate change, and invasive species on biodiversity.
6. Waste management and Control: Phases of Waste management: generation, collection, treatment, disposal; Strategies for sustainable waste management and pollution control.

ECOLOGICAL SCIENCE AND ENVIRONMENTAL BIOLOGY

PRACTICAL	Hours
1. Visit nearby freshwater/terrestrial ecosystems to observe aquatic/ terrestrial biota and prepare species lists, their abundance, and data on species interactions along with photographic evidence. 2. Identify and classify faunal species in different terrestrial and aquatic ecosystems. 2. Conduct field measurements of abiotic factors such as soil temperature/moisture/ light intensity/pH/ N/ P/ K /organic caron etc. in terrestrial ecosystems. Analyse and compare the data in different sampling areas. 3. Determination of species diversity indices: Shannon-Weiner Index, Similarity and Dissimilarity index, Association index, and Community Dominance Index in a natural ecosystem. 4. Visit natural ecosystems such as grasslands or forests to observe complex interactions between plant and animal biota, encompassing both predator-prey dynamics and construct a comprehensive food web diagram based on the collected information. 5. Use GIS mapping to visualize and quantify human-environment interactions, such as deforestation, built-up areas, wetland destruction, etc.	30

Suggested Readings:

- Odum, E. P. 1985.Fundamental of Ecology, W. B. Saunders Company Ltd. Philadelphia, London, ISBN 0-7216-6941-7. 574pp.
- Dash, M. C. 2005. Fundamentals of Ecology, Tata Mcgraw-Hill Publishing Company, ISBN 0-07-042147-1. 525pp.
- Krebs, C. J. Ecology.1985. Harper International Edition, ISB 0-06-350391-3, 800pp.
- Odum, E. P. and Barret G. W. 2009. Fundamental of Ecology. Published by Cengage Learning India Private Ltd. 418 F. I. E. Patparganj, New Delhi-110092. 598pp.

FOURTH YEAR: EIGHTH (VIII) SEMESTER

(Only for Degree with Honours & Research)

Major 19 **RESEARCH/DISSERTATION** **Code: ZLG0800104** **Credit: 16**
Major 20 **Compulsory MOOCs course on Bioanalytical techniques** **Code: ZLG0800204** **Credit: 4**

SYLLABUS FOR FIFTH YEAR OF INTEGRATED MASTER PROGRAM IN ZOOLOGY/
ONE-YEAR MASTER PROGRAMME IN ZOOLOGY [UNDER NEP 2020]

Specialization: ANIMAL ECOLOGY AND WILDLIFE BIOLOGY

Semester	Course Name	Code	Credit
IX	Ecosystem Functions and Stability	ZLG0900104	3
	Practical		1
	Wildlife and Wildlife Habitat Relations	ZLG0900204	3
	Practical		1
	Wildlife population ecology and methods	ZLG0900304	3
	Practical		1
	Wildlife Conservation	ZLG0900404	3
	Practical		1
	Wildlife Management &Management practices	ZLG0900504	3
	Practical		1
X	Dissertation	ZLG1000104	16
	Compulsory MOOCs course	ZLG1000204	4

SPECIALIZATION: ANIMAL ECOLOGY AND WILDLIFE BIOLOGY
COURSE TITLE: ECOSYSTEM FUNCTIONS AND STABILITY
Code: ZLG0900104
Credits: 3 (T) + 1 (P)

Course Outcomes:

1. Demonstrate an understanding of fundamental ecological concepts, including ecosystem productivity, nutrient cycling, and trophic dynamics.
2. Apply ecological principles to analyze and assess the functioning of ecosystems in realworld scenarios.
3. Synthesize information from diverse sources to evaluate the effectiveness of ecosystem management strategies in promoting sustainability and resilience.
4. Develop critical thinking skills by analyzing complex ecological issues and proposing evidence-based solutions.
5. Communicate ecological concepts and findings through written reports, oral presentations, and collaborative projects.

ECOSYSTEM FUNCTIONS AND STABILITY

Theory (3 Credit)

Unit-I: Ecosystem Function (Credits 2) **Total Contact hours: 23**

Natural and Artificial ecosystems, Concept of Ecological footprint; Productivity, Productivity and biodiversity; Energy flow Models, Energy partitioning in food chain and food web, trophic structure and ecological pyramid; Ecosystem energetics; Nutrient cycling, Nutrient Pools and exchange; Restoration ecology and its relevance to present context.

Fundamental and realized Niche, Quantification of Niche breadth and niche overlap, Niche partitioning, Niche segregation, Niche Relationship and community structures, Guild concept, Ecological equivalents, Parallel niche, Competitive Displacement, Principles of co-existence.

Unit-II: 2 Ecosystem Stability (Credits 2) **Total contact hours: 22**

Stability concept, Types of Stability; Resistance and resilience stability, Relationship of Species Diversity and Stability, Stability of their steady state and Influence of random perturbations on population; Two views of community organization: Equilibrium Hypothesis, Non-equilibrium Hypothesis and Intermediate disturbance hypothesis. Keystone species,

Strategy of Ecosystem development, Models of succession, Climax concept, Ecosystem maturity and role of Natural selection, Relevance of Ecosystem development theory to human ecology

Ecological Principles of Management, Role of Ecologist in the management of Natural Ecosystem, Management Techniques, Significance of Planning of Ecosystem Management, Ecological Risk Assessment in terrestrial and Aquatic ecosystem and planning and strategies.

Practical (1 credit) **Total hours: 30**

1. Identification and study of pioneer plant species in the process of primary/secondary succession.
2. Pattern of seed dispersals in pioneer stages of ecosystem succession taking animals as dispersal agents.
3. Conduct surveys to measure biodiversity, measures of species richness and evenness (Shannon Wiener Index (H′), Margalefs' D Index, Simpsons' D Index , Evenness or Equitability index)
4. Quantification of Niche overlap and Niche breadth using appropriate methods.
5. Field survey of degraded ecosystem and collect data on threat factors affecting the ecosystems and provide probable measures for protection.

Suggested Readings:

1. Fundamentals of Ecology by Eugene P. Odum
2. Principles of Terrestrial Ecosystem Ecology by F. Stuart Chapin, Pamela A. Matson, and Harold A. Mooney
3. Growth and Development: Ecosystems Phenomenology by Robert E. Ulanowicz
4. Biogeochemistry: An Analysis of Global Change by William H. Schlesinger and Emily S. Bernhardt
5. Restoration Ecology: Repairing the Earth's Ecosystems in the New Millennium by Richard J. Hobbs and James A. Harris
6. Resilience and Stability of Ecological Systems by C. S. Holling (1973)
7. The Diversity-Stability Debate by Kevin S. McCann (2000)
8. Diversity in Tropical Rain Forests and Coral Reefs by Joseph H. Connell (1978)
9. What is Ecosystem Management? by R. Edward Grumbine (1994)

SPECIALIZATION: ANIMAL ECOLOGY AND WILDLIFE BIOLOGY
COURSE TITLE: WILDLIFE AND WILDLIFE HABITAT RELATIONS
Code: ZLG0900204
Credits: 3 (T) + 1 (P)

Course Outcomes:

1. Demonstrate an understanding of the characteristics, compositions, and distribution of different types of wildlife habitats, including grasslands, wetlands, and forests in India and Northeast India.
2. Apply various habitat assessment techniques to evaluate wildlife habitats and assess their suitability for different species.
3. Analyze the relationships between wildlife and their habitats and the impact of habitat fragmentation and climate change on wildlife species.
4. Evaluate the effectiveness of conservation strategies in mitigating habitat loss and preserving wildlife species, including the role of wetlands in biodiversity conservation and the ecological role of different wildlife habitats.
5. Effectively communicate habitat conservation principles and strategies through written reports, oral presentations, and discussions

WILDLIFE AND WILDLIFE HABITAT RELATIONS
Theory (3 Credits)

UNIT-I: Wildlife Habitat **Contact Hours: 23**

Grassland Ecosystem: Characteristics, Compositions and distribution in India and NE India; Wetlands: Definition, Ramsar Convention and criteria for inclusion, formation and types; Forest types in NE Region, Dominance species composition in different Forest types (Tropical, Temperate and Alpine forest); Canopy openness, closed Canopy and Open canopy forests; High altitudes habitat of wildlife and wildlife species compositions; Wildlife Habitat Assessment methods: Community Dominance Index (CDI), Canopy Area Coverage, Foliage Height Diversity (FHD), Similarity and Dissimilarity index and Association index; Changing patterns of environmental gradients of light, temperature and humidity in degraded forest and its impact on wildlife.

Unit II: Wildlife Habitat Relations **Contact hours: 27**

Succession of Wildlife Habitat within the Wildlife Sanctuaries and National parks of Assam (KNP, ONP, NNP, MNP & PWLS), Implication of habitat Succession in wildlife habitat; Forest fragmentation & wildlife habitat loss, Gap formation and their impact on wildlife, Gap dynamics; impact of climate changes on wildlife species; Island Factor and its relationship with present day wildlife conservation networks; Habitat utilization pattern of Rhino, Elephant, Greater Adjutant Stork, Hoolock Gibbon, Golden Langur and Tiger; Habitat selections, theory of habitat selections, Evolution of habitat preferences; Loss of wetland habitat and its relation to wildlife species. Ecological Role of Wetlands in Biodiversity conservation.

Practical (1 Credit) **Contact hours:30**

1. Collect and analyze vegetation / animal data to calculate Community Dominance Index (CDI), Association Index, Similarity & Dissimilarity Index
2. Plant community analysis: Vegetation sampling using quadrate method.
3. Basics of wildlife habitat map preparation using GIS and Remote Sensing techniques.
4. Studies on biodiversity of aquatic and terrestrial ecosystem: Data collection, compilation, and analysis.
5. Measurement of solar radiation using Lux meter.
6. Studies on physical characteristics of soil, measurement of soil temperature and pH.
7. Types of pollinating animal biota in grassland, scrubland and forest habitat, and comparative study of species involved in pollination among these habitats.

Suggested readings:

1. Fundamentals of Ecology by Eugene P. Odum
2. Grasslands of the World by Victor Squires
3. Wetlands by William J. Mitsch and James G. Gosselink
4. Forest Types of India by H.G. Champion and S.K. Seth
5. Ecological Census Techniques: A Handbook by William J. Sutherland
6. Tropical Forest Ecology: A View from Barro Colorado Island by Egbert G. Leigh Jr.
7. Ecological Succession: Theory and Practice by D.C. Glenn-Lewin and R.K. Peet
8. Forest Fragmentation: Wildlife and Management Implications by J.A. Bissonette
9. Climate Change and Wildlife Conservation in North America by J.L. Root and S.H. Schneider
10. The Theory of Island Biogeography by Robert H. MacArthur and Edward O. Wilson

Specialization: Animal Ecology and Wildlife Biology
Course Title: Wildlife population ecology and methods
Code: ZLG0900304
Credits: 3 (T) + 1 (P)

Course Outcomes:

1. Demonstrate an understanding of the characteristics of wildlife populations, and vital statistics such as life tables and reproductive values.
2. Apply concepts of carrying capacity, dispersal, and migration to analyze wildlife population dynamics and health.
3. Evaluate different sampling design methods used in wildlife studies and understand their importance in obtaining representative data.
4. Apply statistical analysis techniques to analyze wildlife data and test hypotheses related to population ecology.
5. Demonstrate proficiency in various wildlife study methods, including mist netting, radio telemetry, census techniques, and modern census techniques for different wildlife species.

WILDLIFE POPULATION ECOLOGY AND METHODS
Theory (credit:3)

Unit-I: Wildlife Population Ecology **Contact Hours: 23**

Wildlife Population Characteristics; Characteristics and types of Carrying Capacity, Carrying capacity of wildlife habitat and wildlife population sizes, Sign of wildlife habitat and carrying capacity and population health; wildlife population dispersal and three modes of population dispersal, Evolutionary advantages of dispersal; Ecological density vs crude density; life table and life table construction (Preparation); Causes of Migration, Migratory routes of birds associated with NE India, study of bird migration and local movement pattern using mist nets and plastic colour banding and metallic rings; Home range: Importance of Home range in species conservation, Territoriality among Mammals and Birds.

Unit-II: Wildlife Study Methods **Contract hours: 22**

Methods of Samplings & Sampling Design, Why Sampling design has been done prior to any study and its importance, differences between simple Random and stratified random samplings and systematic random samplings, Terrestrial vegetation studies for Wildlife habitat; Statistical analysis of wildlife data using computer software and circular statistics; Occupational survey methods and its necessity for the study of large vertebrates; research designed and statistical approach for hypothesis testing; Wildlife Population Survey methods: Importance and Direct and Indirect wildlife census or survey methods, Mist netting, Radio telemetry techniques, Modern Census Techniques of Rhino, Tiger, Elephant**,** Migratory and residential birds, terrestrial birds; Survey of Herpetofauna, butterflies, spiders & other invertebrates.

Practicals (1 credit) **Contact hours: 30**

1. Direct methods of wildlife census: (i) Line transact (ii) Point transact.
2. Estimating the home range of mammals/ birds using radio telemetry/ grid methods and minimum convex polygon (MCP) methods in Laboratory from data sheets.
3. Census of Residential, Migratory and Terrestrial birds using appropriate methods and data analysis.
4. Measure habitat parameters: species composition, canopy area coverage and foliage height diversity using standard protocols.
5. Identification of food plant species of both birds and mammals.
6. Biostatistical Applications: Null Hypothesis Significance Test (t-test, ANOVA etc.), Circular statistics, biological interpretation of statistical results.
7. Survey and document the diversity of herpetofauna, butterflies, spiders, and other invertebrates in a local area using established methods.

Suggested readings:

1. **Population Ecology: First Principles** by John H. Vandermeer and Deborah E. Goldberg
2. **Essentials of Conservation Biology** by Richard B. Primack
3. **Bird Migration: A General Survey** by Peter Berthold
4. **Wildlife Ecology, Conservation, and Management** by Anthony R.E. Sinclair, John M.
5. **The Ecology of Bird Communities** by John A. Wiens
6. **Research and Management Techniques for Wildlife and Habitats** by Theodore A. Bookhout
7. **Biostatistical Analysis** by Jerrold H. Zar
8. **Wildlife Study Design** by Michael L. Morrison, Bruce G. Marcot, and William M. Mannan
9. **Telemetry Techniques: A User Guide** edited by Robert Kenward
10. **Monitoring Animal Populations and Their Habitats: A Practitioner's Guide** by Brenda McComb

Specialization: Animal Ecology and Wildlife Biology
Course Title: Wildlife Conservation
Code: ZLG0900404
Credits: 3 (T) + 1 (P)

Course Outcomes:

1. Demonstrate an understanding of umbrella, flagship, and edge species and their importance in species conservation.
2. Able to apply concepts such as wildlife corridors, metapopulation dynamics, and island biogeography to develop conservation strategies for protecting wildlife habitats and populations.
3. Evaluate wildlife conservation practices based on attributes, criteria, and values.
4. Demonstrate proficiency in modern conservation techniques such as camera trapping, microchips and radio collars and understand their applications in wildlife conservation.
5. Synthesize knowledge of biodiversity conservation, conservation practices in the Northeast region, and global biodiversity hotspots to develop comprehensive conservation plans.

WILDLIFE CONSERVATION

Unit-I: Wildlife Conservation **Contact hours: 23**

Key species in Conservation: Keystone and Umbrella species, Flagship species and edge species, Importance of Umbrella and flagship species in conservation; Contribution of Wildlife in GNP; Distribution of Large Cats, Elephant, Rhino, Swamp Deer, Asiatic Wild Buffalos, Hoolock Gibbon and Globally endangered birds of NE Region; Conservation needs; Identifying land for Nature Reserve, SLOSS debate, Wildlife Corridors, conservation prospects of urban wildlife and strategies. Metapopulation and metapopulation dynamics, concept of Island biogeography, Mammalian biogeography of Assam and India, Endemic and restricted species and species conservation.

Unit-II: Conservation Practices **Contact hours: 22**

Principles of wildlife management; Conservationist Preservationist and Conservationist Utilizationist; Wildlife Conservation Evaluation: Attributes, Criteria and Values; IUCN Criteria of Threatened Wildlife; Conservation and Preservation; Biodiversity and types of diversity, importance of biodiversity Conservation, Prospects of biodiversity in economic development, biodiversity & human livelihood, Global biodiversity hot spots; DNA Finger Printing, Genetic Depression; Protected area network and Wildlife Conservation Practices in NE Region; Reintroduction and Translocation, In-situ and Ex-situ conservation; Modern conservation tools: Camera trapping, Radio Collar Micro Chips, (PTT/ NTT), Scat and Dung analysis.

Practicals (1 Credit) **Contact Hours: 30**

1. Make a list of endemic species of Assam and NE India based on available published literature.
2. Use of Compass and GPS in transact laying, monitoring, and tracking wildlife and mapping wildlife corridor.
3. Setting up and monitoring camera traps to study wildlife existence and behaviour of wildlife.
4. Scat and Dung Analysis to know the food habits of wild animals.
5. Mist Netting study of birds, followed by data recording.
6. Introduction to various statistical packages: Statistical analysis of ecological data using Excel, SPSS and R.
7. Advanced ecological methods: Occupancy modelling, Species Distribution Modelling

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Suggested Readings:

1. Conservation Biology: Foundations, Concepts, Applications by Fred Van Dyke
2. Wildlife Conservation in a Changing Climate by Jedediah F. Brodie, Eric Post, and Daniel F. Doak
3. The Biology of Island Floras by David Bramwell and Juli Caujapé-Castells
4. Mammals of South Asia: Volume Two by John R. Mallon and Prachi Thatte
5. The SLOSS Debate: Assessing the Role of Single Large or Several Small Reserves by Graham, J., & Sherman, P.
6. Wildlife Management and Conservation: Contemporary Principles and Practices by Paul R. Krausman and James W. Cain III
7. Principles of Conservation Biology by Martha J. Groom, Gary K. Meffe, and C. Ronald Carroll
8. Biodiversity and Conservation by Michael J. Jeffries
9. Techniques for Wildlife Investigations and Management by Nova J. Silvy
10. Reintroduction Biology: Integrating Science and Management by John G. Ewen, Doug P. Armstrong, Kevin A. Parker, and Philip J. Seddon

Specialization: Animal Ecology and Wildlife Biology
Course Title: Wildlife Management &Management practices
Code: ZLG0900504
Credits: 3 (T) + 1 (P)

Course Outcomes:
Students will be able to**:**

1. Understand and interpret key wildlife protection laws and international treaties.
2. Analyze the principles and objectives of wildlife management in different habitats.
3. Critically assess the effectiveness of conservation breeding programs and evaluate the impacts of human activities on wildlife and devise mitigation strategies.
4. Design and implement management practices based on species ecological requirement.
5. Develop sustainable ecotourism models that benefit both wildlife and local communities.

WILDLIFE MANAGEMENT &MANAGEMENT PRACTICES
THEORY

Unit I: Wildlife Management **Contract hours: 23**

Wildlife legislation and policy: Wildlife Protection (Act)1972, Wetland (Act) 2016, Biodiversity (Act) 2002, **CITES**; Wildlife Crime: Issues and preventive measures; Conservation Breeding: Economics, Breeding species in Captivity, Effective Population size, Genetic Management in Captivity; Cryopreservation and DNA bar coding: Importance and techniques; Molecular aspects: wildlife management and forensic application; Role of Zoo in species Conservation; Definition of wildlife, Wildlife conservation model and management objectives, management of wildlife based on habitat and species carrying capacity; Human-Wildlife conflict: Impact on human life and livelihoods; Ecotourism: community-based tourism in Northeast India (NER); Biological basis of wildlife management; Effects of flood in wildlife habitat and its control, Effects of competition with introduced species in the protected area and its impact.

Unit II: Ecological Association &Wildlife Management **Contact hours: 22**

Reasons of wildlife Taxonomic Diversity in NE Region, Historical evidences of species colonization in NE India; Utilitarian Values of Wildlife and species management; Pivotal linkages in ecosystems, Wild mammal groups, Linkage of Primates in Tropical ecosystem functioning; Importance of Wetland and Forests of NE region as complementary Habitat for Birds and Mammals; Key Wildlife areas: Wildlife species composition in Kaziranga and Manas, Dehang- Debang and Namdapha NP; Side effect of Pest Control, Effects of Invasive predators on wildlife and habitat; Species Extinction: Estimating the risk of extinction, Quantifying risk of extinction, catastrophic digesters, species colonization vs species extinction.

Practicals (1 Credit) **Contact Hours: 30**

1. Identification of mammals, birds, lizards, snakes and butterflies, in the natural habitats.
2. Identification of vertebrate wildlife species using indirect evidence (Scat, Dung, Pug marks,
3. etc.) in the field and laboratory.
4. Study on interactions of wildlife with invasive species present in nearby areas, including data collection and analysis.
5. Make a report based on field survey to identify nearby human-wildlife conflict and propose potential mitigation measures.
6. Field trip to a local wildlife area to conduct habitat assessment and species documentation.
7. Development and submission of research project proposal to be carried out in next semester.

Suggested readings:

1. **Wildlife Protection Act, 1972, Biodiversity Act, 2002, and Wetland (Conservation and Management) Rules, 2010**
2. **International Wildlife Trade: A CITES Sourcebook** by Rosalind Reeve
3. **Wildlife Forensics: Methods and Applications** by Jane E. Huffman and John R. Wallace
4. **Genetics for Captive Breeding Programs** by Richard Frankham, Jonathan D. Ballou, and David A. Briscoe
5. **Zoo Conservation Biology** by John E. Fa and Stephan M. Funk
6. **Human-Wildlife Conflict: Complexity in the Marine Environment** by Robert M. Entman and Susan Joy Hassol
7. **The Ecology of Tropical East Asia** by Richard Corlett
8. **Biodiversity of Northeast India: Status and Conservation** by N. Choudhury and P.K. Singh
9. **Wildlife Ecology and Management** by Eric G. Bolen and William L. Robinson

SYLLABUS FOR FIFTH YEAR OF INTEGRATED MASTER PROGRAM IN ZOOLOGY/ ONE-YEAR MASTER PROGRAMME IN ZOOLOGY [UNDER NEP 2020]

Specialization: ANIMAL PHYSIOLOGY AND BIOCHEMISTRY

Semester	Course Name	Code	Credit
IX	Biochemistry and Proteomics	ZLG0900104	3
	Practical		1
	Enzymology, natural product chemistry and drug discovery	ZLG0900204	3
	Practical		1
	Animal Physiology and Metabolic Disorder	ZLG0900304	3
	Practical		1
	Molecular Endocrinology and Reproductive Biology	ZLG0900404	3
	Practical		1
	Immunology	ZLG0900504	3
	Practical		1
X	Dissertation	ZLG1000104	16
	Compulsory MOOCs course	ZLG1000204	4

Code: ZLG0900104
BIOCHEMISTRY AND PROTEOMICS
Credit:3+1

Course Outcomes:

Upon completion of the course, students should be able to:

1. Understand and applying the knowledge for sample preparation mass spectorometry, CD spectroscopy, NMR and Xray crystallography workflow for elucidation of protein structures.
2. Explain the Post-translational processing of protein, Translational Control and Post-translational Protein Modification
3. Elucidate the concept of protein structures.
4. Explain the mechanism of lipid transport, lippid and Nucleotide metaboloism
5. Understand and analyze the concept of Transcriptional Regulation and Gene Expression

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Code: ZLG0900104
BIOCHEMISTRY AND PROTEOMICS

Credit:3 (T)

THEORY	**Hours**

UNIT I: BIOCHEMISTRY 45

1. Futile cycle and anapleortic reaction
2. **Lipids:** Cholesterol: Biosynthesis and degradation. Lipid transport and storage. Biosynthesis of eicosanoids: Prostaglandins and leucotrienes . Biosynthesis and degradation of porphyrin and heme.
3. **Nucleotides :** Biosynthesis and regulation of purine and pyrimidine nucleotides, Catabolism of purines and pyrimidines
4. **Transcriptional Regulation and Gene Expression**: regulatory interplay between transcription factors: regulatory DNA sequences (promoters, enhancers, locus control regions) /general transcription machinery/transcription factors: cell-specific and ubiquitous regulatory factors/ mechanistic aspects of transcription activation / chromatin, histones, DNA methylation /gene regulatory networks /transcription factors in health and disease/ transcription factors as the final integrators of signaling cascades
5. **Structure, Processing, Trafficking and Function of RNA**: chemistry and structure of RNA/ major lectures of cellular RNAs (mRNAs, tRNAs, rRNAs, snRNAs, and the newly discovered small regulatory RNAs/pre-mRNA processing with emphasis on splicing and polyadenylation/ biogenesis of tRNA and rRNA/biochemistry and function of RNA interference (RNAi) and microRNAs/ RNA trafficking in the cell/ RNA quality control and RNA degradation/regulated mRNA translation during development/ RNA-protein interactions and major lectures of ribonucleoprotein particles; RNA granules and bodies /evolution of RNAs: the RNA world.

UNIT II: PROTEOMICS:

1. Peptide bond, geometry and parameters; Backbone geometry and parameters, side chain geometry and parameters, Ramachandran plot. Primary, secondary, tertiary and quaternary structures. Protein structure stabilizing forces hydrogen bond, electrostatic bond or salt bridges; hydrophobic forces. Protein folding, dynamics and thermodynamics. Protein: from gene to function. Protein and diseases. Some important proteins in cellular functions.

2. Post-translational processing of protein, Translational Control and Post-translational Protein Modification: the translational control: codons and frame shifting, attenuation, phosphorylation, and transformation/the role of translational control in the regulation of cell growth and differentiation.

3. Protein cloning, expression and purification. Protein chromatography systems and purification procedures HPLC, FPLC etc. Bioinformatics of protein sequences sequence analysis, comparison, alignment etc. Mass spectrometry introduction to mass spectroscopy, gel mass spectroscopy, LC-MS, LC-MS-MS, MALDI-TOF . Protein NMR, FTIR Raman, CD. Protein crystallography.

BIOCHEMISTRY AND PROTEOMICS
Credit: 1 (P)

PRACTICAL	**Hours**
1. Estimation of tissue protein by Bradford method.	30
2. Estimation of total free amino acid by using Ninhydrin reagent.	
3. Estimation of lipid content in tissue by SULFO-PHSOPHO-VANILLIN method	
4. Isolation of RNA and cDNA synthesis	
5. To analyse the expression of beta actin mRNA by qPCR	
6. SDS-PAGE analysis of tissue proteins.	
7. Determination of Acid Value of Fats and Oils	
8. Visit to Advanced Laboratory and prepare a field report.	

Suggested Readings:

1. Principles of Biochemistry by Lehningers
2. Biochemistry by Voet & Voet
3. Biochemistry by Harper
4. Biochemistry by Garret & Grisham
5. Introduction to Proteomics by Daniel C. Liebler
6. A textbooks of Proteins 7 Proteomics by C. Subramaniam & N. Hazare
7. Proteomics Introduction to Methods & Application by Kraj & Silberring

Code: ZLG0900204
Enzymology, natural product chemistry and drug discovery
Credit:3+1

Course Outcomes:

Upon completion of the course, students should be able to:

1. Describe and use the equations of enzyme kinetics
2. Describe the methods used in in enzyme kinetics
3. Applying the principle of Enzyme- enzyme interaction, protein ligand binding in solving problems
4. Analyzing the view of techniques for studying Enzyme assay.
5. Describe the methods of isolation purigfication and characterization of simple chemical constituents from natural sources

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Code: ZLG0900204
Enzymology, natural product chemistry and drug discovery
Credit:3 (T)

THEORY	**Hours**
UNIT I: ENZYMOLOGY	45

1. Mechanism of enzyme action, general mechanistic principle , Techniques for studying mechanism of action Factors associated with catalytic efficiency, proximity, orientation and distortion of strain Collision and transition state theories, significance of activation energy
2. Qualitative description of concerted and sequential models, Negative cooperativity Half site reactivity, Kinetics of allosteric enzymes.
3. Enzyme- enzyme interaction, protein ligand binding, Measurement analysis of binding isotherm, cooperativity, Hill and Scatchard plots
4. Isolation, crystallization and purification of enzymes Test of homogeneity of enzyme preparation, methods of enzyme analysis. Detailed view of techniques for studying enzyme assay. Chemical modification of active site groups Chymotrypsin, Lysozyme, RNase, Carboxypeptidase, GPDH, Aldolase, alcohol dehydrogenase a
5. Zymogens and their activation (proteaseses and prothrombin). Isozymes :Multiple forms of enzymes with special reference to lactate dehydrogenase Multienzyme complexes, Ribozymes
6. Enzyme technology**:** Methods for large scale production of enzymes, immobilized enzymes and their comparison with soluble enzymes Methods of immobilization of enzymes, immobilized enzyme reactors. Thermal stability and catalytic efficiency of enzyme, site directed mutagenesis and enzyme engineering-selected examples
7.

UNIT II: Natural Products and Drug Discovery

1. Occurance, isolation, chemistry and biosynthesis of mono-, sesqui- and di-terpenoids, flavonoids and alkaloids.

2. Free radicals and Antioxidants: important free radicals in living systems, sources, chemistry and reactivity of important free radicals in biological systems, natural antioxidants of different classes. In vitro Methods: free radical determination by ESR methods, impact of singlet and triplet oxygen (importance of reactive oxygen species) in radical formation in biological systems.

3. Steroids & Saponins: sources, biological significance and structure elucidation of saponins; and of steroids ergosterol, stigmasterol, β- sitosterol and diosgenin, squalene biosynthesis.

4. Classical and non-classical H-bonding, importance of non-covalent interactions in molecular recognition, introduction of QSAR, drug - receptor interactions, physiochemical empirical and nonempirical parameters, 2D-QSAR approaches, 3D-QSAR approaches, 4D-QSAR and higher approaches, statistical methods in modeling, model validation, application of QSAR in drug discovery.

Enzymology, natural product chemistry and drug discovery
Credit: 1 (P)

PRACTICAL	**Hours**
1. Determination of amylase activity and calculation of amylase number. 2. Study of effect of time on arginase activity by calorimetric method and assay of arginase enzyme by spectrophotometric method. 3. To study the effect of temperature on arginase activity. 4. To study the effect of P^H on Arginase activity. 5. Determination of inhibitor constant (ki) for L-Orinithine against Arginase enzyme by LB plot. 6. To Estimate the total phenol content in plant extracts. 7. To estimate the total antioxidant(ABTS and DPPH) activity of plant extract. 8. To estimate total flavonoid contents in plant extract.	30

Suggested Readings:

1. Enzymology by Devsene
2. Fundamentals of Enzymology by Nicolas & Lewis
3. Enzymes: Biochemistry, Biotechnology, Clinical Chemistry" by Palmer T and P L Bonner
4. Applications of Enzyme Biotechnology byKelly, Jeffrey W., Baldwin, Thomas O. (Eds.)
5. Nature of Enzymes by L. Foster
6. Keith Wilson and John Walker.2006.Principles and Techniques of Biochemistry and Molecular Biology 6th edition .Cambridge University Press New York,pp.571-594
7. Lubert Stryer.2007. Biochemistry 6th Edition W.H. Freeman, and Company. New York
8. Enzymology by Price
9. Natural Products and drug Discovery by S.C. Mandal.

Code: ZLG0900304
ANIMAL PHYSIOLOGY AND METABOLIC DISORDER
Credit:3+1

Course Outcomes:

Upon completion of the course, students should be able to:

1. Developed, understanding and applying the concept of blood vascular system, cardiovascular system and physiology of respiration.
2. Familiarize the students with nervous systems, excretory systems and physiology of muscles for analyzing the concept of system physiology.
3. Outline the main steps in the metabolism of fatty acids, proteins, and carbohydrates and the principles of their regulation.
4. Identify the specific pathways which are disturbed in various metabolic diseases and link them to the disease symptoms and presentation.
5. Compare and contrast modern approaches to treatment of inherited and acquired metabolic diseases.

Code: ZLG0900304
ANIMAL PHYSIOLOGY AND METABOLIC DISORDER
Credit:3 (T)

THEORY **Hours**

UNIT I: ANIMAL PHYSIOLOGY 45

1. **Blood and circulation** - Blood corpuscles, haemopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, haemoglobin, immunity, hemostasis.
2. **Cardiovascular System:** Comparative anatomy of heart structure, myogenic heart, specialized tissue, ECG – its principle and significance, cardiac cycle, heart as a pump, blood pressure, neural and chemical regulation of all above.
3. **Respiratory system** - Comparison of respiration in different species, anatomical considerations, transport of gases, exchange of gases, waste elimination, neural and chemical regulation of respiration.
4. **Nervous system** - Neurons, action potential, gross neuro-anatomy of the brain and spinal cord, central and peripheral nervous system, neural control of muscle tone and posture.
5. **Sense organs** - Vision, hearing and tactile response.
6. **Excretory system** - Comparative physiology of excretion, kidney, urine formation, urine concentration, waste elimination, micturition, regulation of water balance, blood volume, blood pressure, electrolyte balance, acid-base balance
7. **Physiology of movement and locomotion**: Biochemistry of contractile proteins, Sources of energy for muscle contraction, Sliding filament theory Excitation of contraction and mechanism of regulation of contraction by calcium Mechanism of relaxation
8. **Adaptational Physiology**: Adaptations to temperature variations, molecular mechanisms of adaptations. Endothermy and Ectothermy. Extremophiles varieties and their adaptations. Mechanisms of body

temperature regulation, Hypoxia and oxygen therapy, Dyspnea, Periodic breathing, Respiratory buffering. High altitude: decreased pressure of gas, hypoxic effects, mountain sickness and acclimatization, Osmoregulation in aquatic and terrestrial environments

UNIT II: METABOLIC DISORDER

1. **Introduction** To Metabolism & Bioenergetics, Signal Transduction in Metabolism, Mitochondrial structure & Function, Mitochondrial Diseases, Lipid Metabolism, Atherosclerosis, Clinical Correlation: Atherosclerosis

2. **Lysosomal Storage Diseases I,** Lysosomal Storage Diseases II, Role of pH in Cell Physiology and Pathophysiology I, Role of pH in Cell Physiology and Pathophysiology II and Review I, Glycogen Storage Diseases I, Glycogen Storage Diseases II

3. **Diabetes Mellitus -** Molecular Mechanisms, Diabetes Mellitus - Strategies for Treatment and Prevention I, Diabetes Mellitus - Strategies for Treatment and Prevention II, Obesity - Molecular Mechanisms, Obesity – Interventions, Diseases of Amino Acid Metabolism I, Diseases of Amino Acid Metabolism II, Alcohol Dependence - Molecular Mechanisms, Alcohol Dependence - Disease Manifestations and Interventions, Principles of Gene Therapies and Stem Cell Therapies. Recombinant protein Production

ANIMAL PHYSIOLOGY AND METABOLIC DISORDER
Credit: 1 (P)

PRACTICAL	**Hours**
1. Measurement of human electrocardiogram (ECG) using the biopac system 2. Measuring of blood pressure using sphygmomanometer 3. Measuring the respiratory function using spirometer 4. Analyzing CO2 content of exhaled air with the Müller's method 5. Determination of blood glucose level by Folin-Wu method. 6. Photometric determination of hemoglobin in blood sample 7. Determination of blood clotting and erythrocyte sedimentation rate 8. Induction of diabetes in rodent model by injecting Streptozotocin 9. Isolation of mitochondria, measurement of ROS and membrane potential from isolated mitochondria in normal and disease condition.	30

Suggested readings:

1. Medical Physiology by Ganong
2. Medical Physiology by Guyton
3. Human physiology by C. C. Chatterjee
4. Animal Physiology by Hill, Cavanaugh & Anderson
5. Lieberman, Michael and Pete, Alisa. Marks' Basic Medical Biochemistry: A Clinical Approach. 6th Edition, Wolters Kluwer (LWW), 2022

Code: ZLG0900404
MOLECULAR ENDOCRINOLOGY AND REPRODUCTIVE BIOLOGY
Credit: 3 + 1

Course Outcomes:

Upon completion of the course, students should be able to:

1. Understand the major areas of molecular endocrinology and undelying pathologies of endocrine diseases.
2. Applying the concept of molecular mechanism of hormone action and include a description of the main hormones receptors and their signal transduction pathways.
3. Describe the structures of the organs of the reproductive systems in males and females and how these relate to their functions.
4. Demonstrate an understanding of hormonal control, the process of sexual differentiation and explain some of the disorders.
5. Distinguish between the main stages of embryonic fetal and neonatal development.

Paper- ZLG0900404
MOLECULAR ENDOCRINOLOGY AND REPRODUCTIVE BIOLOGY
Credit:3 (T)

THEORY	**Hours**
	45

UNIT I: MOLECULAR ENDOCRINOLOGY

1. **Chemical nature of hormones**: Amino acid derived hormones, peptide hormones, Glyco-protein hormones, Steroid hormones, Biosynthesis of peptide hormones, transcriptional and post-transcriptional modifications, Biosynthesis and secretion of thyroid hormones, thyroid hormone disorders, mechanism of action of peptide hormones , concept of second messengers- cAMP, cGMP, Ca^{++}, IP3, DAG, NO, signal transduction mechanism, mechanism of action of steroid hormones, cross talk concept.
2. **Hormonal regulation of metabolism**: Role of insulin & glucagon in regulation of carbohydrate metabolism, metabolic regulatory hormones in lipid and protein metabolism, gastrointestinal hormones and their role in regulation of metabolic activity, endocrine regulation of calcium and phosphate homeostasis in mammals.
3. **Genetic basis of hormonal disorders**: General principle and classification of hormonal disorders, genetic basis of growth hormone disorder, genetic basis of PCOS, sequence-specific DNA binding receptor proteins, nuclear receptor proteins, cytosolic receptor proteins,

cell surface receptor proteins, their role in gene transcription, cell differentiation and cell proliferation, regulatory substances- eicosanoids, growth factors, thymus gland & kinins.

UNIT II : Reproductive Biology

1. Introduction to reproductive strategies in animal Kingdom: Reproductive strategies, uni-sexuality and bisexuality, sex reversal.
2. **Reproductive system in human beings**: Male and female reproductive system, follicular development and ovulation, secondary sexual characteristics in male and female, gametogenesis.
3. Pregnancy, gestation, placentation, parturition and lactation Gestation, parturition, foetal membranes, classification of placenta.
4. **Reproductive cycles in mammals**: Estrous and menstrual cycles and hormonal control.
5. **Reproductive technologies**: Infertility and its causes, infertility management, semen collection and storage, artificial insemination and surrogacy.
6. **In vitro fertilization and embryo transfer:** In vitro fertilization, cryopreservation of embryos and test tube babies. Assistant Reproductive Technologies: hormone replacement therapy, GIFT, ZIFT, ICSI, TET, oocyte and embryo donation.
7. **Prenatal diagnosis**: Different methods, reasons, female foeticide issues. Fertility control: Reasons, chemical and hormonal control methods, surgical contraception, sterilization, removal of gonads and uterus, abortion. , Environmental estrogens, Endocrine disruptors

MOLECULAR ENDOCRINOLOGY AND REPRODUCTIVE BIOLOGY

PRACTICAL	**Hours**
1. 1. Study of estrous cycle in rat/ mice	30
2. To study Sperms count and motility in mice	
3. Histological study of testis, ovary, pancreas, pituitary, adrenal, thyroid and para thyroid in mammals.	
4. Visit to IVF laboratory and prepare report on it.	
5. Histology of male and female genital organs and endocrine glands in normal and pathology condition.	
6. Eosin Nigrosin stain for live and dead spermatozoa	

Suggested readings:

1. Molecular Endocrinology by Franklyn F. Bolander
2. Harrison's Endocrinology

3. Molecular Endocrinology Methods and Protocol by Thomas E. Curie.
4. Essential Reproduction by Markin & Johnson
5. Human Reproductive biology by Jones & Lopez
6. Human Reproductive Biology by Richard E. Jones

Code: ZLG0900504
IMMUNOLOGY
Credit:3 + 1

Course Outcomes:

Upon completion of the course, students should be able to:

1. Outline compare and contrast the key mechanisms and cellular players of adaptive immunity.
2. Outline the key events and cellular player in antigen presentation and MHC complexes.
3. Applying the principles governing vaccination and mechanisms of protection against infectious diseases
4. Elucidate the genetic basis of immunological diversity and generation of adaptive immune responses.
5. Explain the basis of immunological tolerance autoimmunity and transplantation.

Code: ZLG0900504
IMMUNOLOGY
Credit:3 (T)

THEORY	**Hours**
	45

UNIT 1.

1. Complement system: classical and alternate pathways of complement activation
2. Complement and inflammation, formation of membrane attack complex
3. Cytokine structure and function, cytokine receptor, Cytokine and immune response
4. Genetic Basis of Ab Structure
5. Genetic organization of MHC, role of MHC in activation of T lymphocyte, Association of diseases with MHC haplotypes
6. The T and B Cell Receptor: Structure and Genetic Basis, Antibody-Mediated Reactions, Cell-Mediated Reactions

UNIT 2

1.Immunology of HIV Infection
2.Infection and Immunity
3. Immune Regulation & Tolerance
4.Autoimmunity
5.Immunology of Cancer
6.Immunoprophylaxis (Vaccines) & Immunotherapy, Transplantation immunology, Modern Antibody therapy

IMMUNOLOGY Credit: 1 (P)	
PRACTICAL	**Hours**
1. Dissection localization and study of lymphoid organs in RAT 2. Widal's test 3. Purifiation of IgG from plasma using Protein A Sepharose affinity chromatography 4. Perform Western blot of protein. 5. Demonstration of Immunohistochemistry 6. Study of various types of immune reaction in vitro.	30

Suggested Readings:

1. Kuby Immunology by Punt, Stranford, Jones &Owen
2. Cellular and Molecular Immunology by Abbas
3. Roitt's essential Immunology by Delves, Martin, Burton & Roitt.

SYLLABUS FOR FIFTH YEAR OF INTEGRATED MASTER PROGRAM IN ZOOLOGY/
ONE-YEAR MASTER PROGRAMME IN ZOOLOGY [UNDER NEP 2020]

Specialization: CELL AND MOLECULAR BIOLOGY

Semester	Course Name	Code	Credit
IX	Molecular Approach to Cellular Functions	ZLG0900104	3
	Practical		1
	Molecular Basis of Human Diseases	ZLG0900204	3
	Practical		1
	Advanced Immunology	ZLG0900304	3
	Practical		1
	Genetic engineering and recombinant DNA	ZLG0900404	3
	Practical		1
	Genomics and Proteomics	ZLG0900504	3
	Practical		1
X	Dissertation	ZLG1000104	16
	Compulsory MOOCs course	ZLG1000204	4

Code: ZLG0900104
Course title: Molecular Approach to Cellular Functions
Credit:3 (T) +1(P)

Course Outcomes:

Upon completion of the course, students should be able to:

1. Recall the basic differences between transcription in prokaryotic and eukaryotic cells.
2. Explain the mechanics of DNA replication in prokaryotes and eukaryotes, including the role of accessory proteins.
3. Demonstrate how transcription factors regulate gene expression in eukaryotic cells.
4. Explain the processes involved in different DNA damage repair mechanisms.
5. Develop an experimental plan to study the effects of a specific gene mutation on cell cycle progression.

Molecular Approach to Cellular Functions
Credit:3

THEORY	**Hours**
UNIT 1 DNA replication: Basic idea of prokaryotic and eukaryotic DNA replication- mechanics of DNA replication, enzymes and accessory proteins involved in DNA replication. Transcription: An overview of in prokaryotic and eukaryotic cells, Post transcriptional modification in RNA, Transcriptional and post transcriptional control of Gene expression Gene silencing: Concept, mechanism and applications **UNIT 2** Cell cycle: Genetics of cell cycle: genetic regulation of cell division in yeasts and eukaryotes; molecular basis of cellular checkpoints. Apoptosis and necrosis: Differences between apoptosis and necrosis, mechanism of apoptotic cell death, biomarker of apoptotic detection in cell/tissues Autophagy: Concept, mechanism and significance of autophagy **UNIT 3** Gene mutation and chromosomal aberration Type of DNA damage: spontaneous hydrolysis and deamination, alkylation, oxidation, radiation, base analogs and intercalating agents DNA damage repair mechanism: direct reversal, base excision, nucleotide excision, mismatch repair and recombinational repairs, Detection of DNA damage in single cells.	45

Molecular Approach to Cellular Functions
Credit: 1

PRACTICAL	Hours
1. Preparation of single cell suspension and study of cell viability.	30
2. Study of different stages of cell cycle	
3. Study of different stage of mitosis and meiosis	
4. Study of chromosomal aberration and micronucleus (MN) as indicator of genotoxicity	
5. Study of morphological features of apoptotic and necrotic cells.	
6. Tunnel assay to detect apoptosis in single cell/tissues.	
7. Demonstration of single cell gel electrophoresis (Comet assay) to detect DNA fragmentation	

Suggested Readings:

1. Medical Physiology, 3rd ed., Boron and Boulpaep, Elsevier ISBN 9781455743773
2. Marieb EN, Human Anatomy & Physiology, Any Edition ISBN-10: 0321695984 | ISBN-13: 978-0321695987 RECOMMENDED TEXTS:
3. Hardin j. Becker's The World of the Cell. Any Edition ISBN-10: 0321716027 | ISBN-13: 978-0321716026
4. Cooper, G. M. (2018). 8th Edition. The cell: A molecular approach. Massachusetts, USA: Sinauer Associates. ISBN-13:978-1605357072
5. Alberts, B et al. (2014). 6th edition. Molecular Biology of the Cell. W. W. Norton & Company. ISBN-13 : 978-0815345244
6. Lodish H et al. (2003). 5th Revised edition. Molecular Cell Biology. W.H.Freeman & Co Ltd; ISBN13 : 978-0716743668
7. Karp, G. (2019). 9th Edition. Cell and molecular biology: New Jersey, USA: Wiley Publishers. ISBN-978—1-119-59816-9
8. Brown, T. A. (2020). 8thEdition. Gene cloning and DNA analysis: An introduction. New York, USA: John Wiley and Sons, ISBN-13: 978-1119640783.

Code: ZLG0900204
Course title: Molecular Basis of Human Diseases
Credit:3 (T) +1(P)

Course Outcomes:

Upon completion of the course, students should be able to:

1. Describe the pathophysiology of Alzheimer's, Parkinson's, and dementia.
2. Apply knowledge of normal and cancer stem cells to research and therapeutic contexts.
3. Explain the genetic basis and clinical manifestations of thalassemia and cystic fibrosis.
4. Describe the cellular and molecular basis of aging and the factors that contribute to it.
5. Recall the histological characteristics of normal and pathological tissues.

Molecular Basis of Human Diseases
Credit: 3 (T)

THEORY	**Hours**
UNIT 1 Blood pressure and its regulation, hypertension and mechanism of drug action Atherosclerosis and coronary heart disease Diabetes mellitus: types, causes and therapeutic approaches Thalassemia and cystic fibrosis Pathophysiology of neurological diseases (Alzheimer, Parkinson and Dementia)	45
UNIT 2 Cancer: monoclonal origin; differences between normal and cancer cell; cell transformation and factors for cell proliferation; concepts of oncogenes and their role in cancer, tumour suppressor and apoptotic genes; chromosomal basis of cancer. Ageing: Cellular basis of aging; causes of aging; oxidative damage; genetic instability; mitochondrial genome damage; genetic aging programme.	
UNIT 3 Introduction to stem cells, basic principles and methodologies, classification of stem cells Normal stem cells: hematopoietic stem cells, mesenchymal stem cells, cardiac stem cells. Embryonic stem cells (ESC), Identification and characterization of pluripotent stem cells in animal and humans; sources of pluripotent cells – blastocysts, parthenogenesis, nuclear transfer, iPSCs. Cancer stem cells: Historical perspective, isolation and characterization of cancer stem cells. Stem cell based regenerative therapy for various diseases (neurodegenerative, retinal, leukemia, heart).	

Molecular Basis of Human Diseases

(Credit: 1)

PRACTICAL	**Hours**
9. Induction of diabetes and Glucose tolerance test in animal model	30
10. Study of histological slides of normal and diabetic pancreas	
11. Induction of Alzheimer disease in animal model	
12. Study of histological slides of brain for the presence of amyloid plaques	
13. Histological Study of atherosclerotic plaques and identification of foam cells in pathological condition.	
14. Study of different types of cancer using histopathological slides	

Suggested Readings:

1. Medical Physiology, 3rd ed., Boron and Boulpaep, Elsevier ISBN 9781455743773
2. Coleman, W. B., & Tsongalis, G. J. (2017, November 9). Molecular Pathology: The Molecular Basis of Human Diseases. ISBN-10-0128027614
3. Epstein, R. J. (2003, January 1). Human Molecular Biology: An Introduction to the Molecular Basis of Health & Disease. ISBN-10-052164481X
4. Dean, M. (2017, September 13). From Gene to Therapy: Understanding Human Disease through Genetics. ISBN-10-1615047719
5. Das, U. N. (2011, April 2). Molecular Basis of Health and Disease. ISBN-10-94007913X
6. Epstein, C. J., Erickson, R. P., & Wynshaw-Boris, A. J. (2004, January 1). Inborn Errors of Development. ISBN-10-0195306910
7. Marieb EN, Human Anatomy & Physiology, Any Edition ISBN-10: 0321695984 | ISBN-13: 978-0321695987 RECOMMENDED TEXTS:

Code: ZLG0900304
Course title: Advanced Immunology
Credit:3 (T) +1(P)

Course Outcomes:

Upon completion of the course, students should be able to:

1. Recall the structure and classes of immunoglobulins.
2. Describe the complement system and its pathways.
3. Explain the processes of B and T cell maturation and activation.
4. Use knowledge of immunodeficiency disorders to explain their impact on immune function.
5. Assess the impact of hypersensitivity reactions on health and disease management.

Advanced Immunology
Credit:3

THEORY	**Hours**
UNIT 1 Innate and acquired immunity: components and characteristic features, kinetics of primary and secondary immune responses; Cells of the immune system (WBC, macrophages, dendritic cells, B, T and NK cells; Basic concept of B and T cell antigen receptors and CD markers), Immune-globulins: Structure and classes, subclasses and types; Generation of Antibody diversity; V(D)J recombination in antibody; Allotypic and Isotypic determinants, monoclonal antibody, Myeloma protein. Complement system: Complement component; Functions of Complement system; Pathways of complement activation classical, alternate and lectin pathway, formation of membrane attack complex. **UNIT 2** B-cell development, maturation, activation, differentiation and role in immunological response; B-cell receptors; rearrangement in B-cell Receptor; Immunological tolerance; Clonal selection theory; Humoral immune responses. T Cell development, maturation, activation, differentiation and role in immunological response; T cell receptors; diversity generation in T cell receptors; Thymic selection of T cell; T-cell mediated cyto-toxicity. MHC molecules: Basic Structure and subclasses; antigen processing and presentation: Endogenous and Exogenous pathways. Cytokines and chemokine in immune response. **UNIT 3** Immunodeficiency disorders: Primary and secondary immunodeficiency; Important examples of immunodeficiency diseases. Hypersensitivity reactions: Types and basic mechanism; Allergy and anaphylaxis. Autoimmunity: self-reactive antibody and auto-immune response; some important examples of autoimmune diseases in human; Transplantation immunology: Types of transplant, Recognition of alloantigens,	45

Pattern of graft rejection.
Cancer: Tumor antigen, Host response to tumors; tumor immunity, immunotherapy in Cancer.

Advanced Immunology

Credit: 1

PRACTICAL	**Hours**
10. Preparation of blood smear and identification and percentage quantification of different types WBC.	30
11. Total RBC and WBC count in blood sample using haemocytometer.	
12. Identification of blood groups to demonstrate antigen-antibody reactions by haemo-agglutination reaction.	
13. Preparation of single cell suspension from mouse Spleen, staining and counting of viable splenocytes.	
14. Histological observation of T-cell and B-cell specific zones in spleen and thymus.	
15. Isolation of peritoneal macrophages and study of phagocytosis	
16. Immunodiffusion assay for detection and quantification of antigen and antibody.	

Suggested readings:

1. Punt, J., Stranford, S., Jones, P., & Owen, J. (2018, October 16). Kuby Immunology. ISBN-10-1319114709
2. Abbas, A. K., Lichtman, A. H. H., & Pillai, S. (2019, April 10). Basic Immunology. ISBN-10-8131248917
3. Abbas, A. K., Lichtman, A. H., & Pillai, S. (2015, January 1). Cellular and Molecular Immunology. ISBN-10-1416023895
4. Delves, P. J., Martin, S. J., Burton, D. R., & Roitt, I. M. (2017, January 17). Roitt's Essential Immunology. ISBN-10-1118415779
5. Paul, W. E. (2012, December 3). Fundamental Immunology. ISBN-10-9781451117837

Code: ZLG0900404
Course title: Genetic engineering and recombinant DNA
Credit:3 (T) +1(P)

Course Outcomes:

Upon completion of the course, students should be able to:

1. Recall the methods of transformation and transfection.
2. Describe the molecular mechanisms of antisense RNA, microRNA, siRNA, and ribozymes.
3. Identify the techniques used for DNA footprinting and fingerprinting.
4. Explain the principles behind each molecular techniques and its applications in genetic engineering.
5. Assess the role of marker and reporter genes in the identification of successful cloning events.

Genetic engineering and recombinant DNA
Credit:3 (T)

THEORY	**Hours**
UNIT 1 Basic of Genetic Engineering: Gene manipulation tools for molecular cloning, Restriction enzymes their types, cohesive and blunt end ligation, linkers, adaptors, homopolymeric tailing. Gene Cloning Vectors: Plasmids, bacteriophages, cloning in M13 Vectors, phagemids, Lambda vectors; insertion and replacement vectors, Cosmid vectors, Artificial chromosome vectors (YACs, BACs), Animal virus derived vectors-Sv-40, retroviral vectors, Expression vectors Transformation, transfection: chemical and physical methods, Marker gene and reporter gene in selection of recombinant DNA **UNIT 2** Northern blot, in situ hybridization, Rnase protection assay, RTPCR. Western blot, in situ analysis, ELISA, protein gel electrophoresis RNA interference: History, molecular mechanisms and applications of antisense RNA, microRNA, siRNA, and ribozymes. Somatic cell hybridization Genome editing, CRSIPR based genome editing and application of genome editing **UNIT 3** Basis of DNA footprinting and fingerprinting RFLP and RAPD techniques Genetically modified organism (GMO) and transgenic mice Gene knockout mice: Procedure of creation and application	45

Genetic engineering and recombinant DNA
Credit: 1

PRACTICAL	Hours
1. Determination of DNA & RNA purity 2. Determination of G+C percentage rate & Melting temperature 3. Measurement of DNA GC% ratio by melting curve analysis 4. Isolation of DNA from different animal tissues 5. Preparation of a standard curve and estimation of DNA using DPA method 6. Separation of DNA using agarose gel electrophoresis 7. Isolation of mitochondrial DNA from animal tissues 8. Restriction digestion of mitochondrial DNA/Plasmid DNA/DNA fragments 9. Demonstration of ELISA and Western blotting technique 10. Isolation and quantification of total RNA from animal tissues	30

Suggested readings:

1. Sandhya Mitra, Genetic Engineering: Principle and Practices, (2017) 2nd edition , ISBN: 978-9339203535
2. Nicholl, D. S. T. (2023, February 28). An Introduction to Genetic Engineering. ISBN-10-1009180606
3. Gupta, P. K. (2008, January 1). Molecular Biology and Genetic Engineering. ISBN-10-8171337198
4. Watson, J. D., Gilman, M., Witkowski, J., & Zoller, M. (1994, January 1). Recombinant DNA. ISBN-10-0716722828
5. Yount, L. (2004, January 1). Biotechnology and Genetic Engineering. ISBN-10-0816072175
6. Nair, A. (2010, December 1). Principles of Biochemistry and Genetic Engineering. ISBN-10-9789380386324

Code: ZLG0900504
Course title: Genomics and Proteomics
Credit:3 (T) +1(P)

Course Outcomes:

Upon completion of the course, students should be able to:

1. Define the different levels of protein structure.
2. Describe the methods for identifying and classifying organisms using molecular markers.
3. Explain different methodology of DNA sequencing of genomes.
4. Assess the impact of meta-genomics in environmental and biomedical studies.
5. Identify the steps for accessing a biological database and retrieving a gene sequence.

Genomics and Proteomics
Credit:3

THEORY	**Hours**
UNIT 1 Proteins and Proteome: Protein Chemistry: primary, secondary, tertiary and quaternary levels of protein structure; Concept of subunit, motifs and domains; DNA binding Motif; Protein-Protein interaction; Important examples of Protein structure and their functions; convergent and divergent evolution of protein structure and functions. Isoelectric focussing, 2D gel electrophoresis, enzymatic digestion of protein and peptide fingerprinting, **UNIT 2** Genome organisation: Prokaryotic and Eukaryotic genome organization: Mitochondrial DNA, Protein-DNA interactions in genome; Genome complexity: C-value paradox; Genome mapping: methods of gene mapping, restriction mapping, linkage mapping. Sequencing of genomes: methodology of DNA sequencing: Sanger Sequencing, Next generation sequencing, Pyro-sequencing, potential challenges; Contiguous DNA sequence: Reads, contig and scaffold, Contig assembly; Chromosome walking and characterization of Chromosome; Site-specific recombinase technique: Cre-loxp system. **UNIT 3** DNA libraries: Construction of DNA libraries: Genomic DNA library, cDNA library; Clonal selection techniques; Transfection techniques; Application of DNA libraries in biomedical science; Human Genome Project. Comparative Genomics: Meta-genomics: techniques and application; Identification and classification of organisms using molecular marker- 16s rRNA typing, Dominant and co-dominant molecular markers; Orthologous and	45

Paralogous gene; utilization of genome to understand evolution.

Genomics and Proteomics
Credit: 1

PRACTICAL	**Hours**
	30

1. To retrieve a gene sequence from biological database and perform BLAST to observe percentage homology.
2. Study of protein and drug interaction using bioinformatics
3. To design a primer for a given gene sequence using BLAST software.
4. To isolate genomic DNA from tissue and amplify DNA sample using PCR.
5. To separate DNA using agarose gel electrophoresis.
6. To isolate and quantification of total proteins from a biological sample.
7. To separate proteins using SDS gel electrophoresis.

Suggested Readings:

1. Campbell, A. M., & Heyer, L. J. (2007, January 1). Discovering Genomics, Proteomics, and Bioinformatics. ISBN-10-9788131715598
2. Jolles, P., & Jörnvall, H. (2013, March 11). Proteomics in Functional Genomics. ISBN-10-8184890753
3. Thangadurai, D., & Sangeetha, J. (2015, June 9). Genomics and Proteomics. ISBN-10-1774635372
4. Saraswathy, N., & Ramalingam, P. (2011, July 1). Concepts and Techniques in Genomics and Proteomics. ISBN-13-978-1907568107
5. Malkoff, C. (2016, May 31). Functional Genomics and Proteomics. ISBN-10-1682861228

SYLLABUS FOR FIFTH YEAR OF INTEGRATED MASTER PROGRAM IN ZOOLOGY/ ONE-YEAR MASTER PROGRAMME IN ZOOLOGY [UNDER NEP 2020]

Specialization: ENTOMOLOGY

Semester	Course Name	Code	Credit
IX	Insect Structure & Function	ZLG0900104	3
	Practical		1
	Insect Ecology	ZLG0900204	3
	Practical		1
	Insect Physiology	ZLG0900304	3
	Practical		1
	Agricultural and Forest Entomology and Pest Control	ZLG0900404	3
	Practical		1
	Medical, Veterinary and Forensic Entomology	ZLG0900504	3
	Practical		1
X	Dissertation	ZLG1000104	16
	Compulsory MOOCs course	ZLG1000204	4

Code: ZLG0900104
Course title: Insect Structure & Function
Credit:3 (T)+1(P)

Course Outcomes:

Upon completion of the course, students should be able to:

1. Define the basic parts of an insect's body and their functions.
2. Apply their knowledge of insect anatomy to identify different insect species.
3. Analyze the relationship between insect anatomy and behavior.
4. Evaluate the importance of insects in ecosystems and human society.
5. Create a model or diagram illustrating the anatomy of an insect and its functions.

Insect Structure & Function
Credit:3

THEORY	**Hours**
1. Structure of insect head, thorax and abdomen, insect integument 2. Type of mouthparts, antennae, legs and their modifications & function 3. Wings, wing structure, venations and wing coupling. 4. Insect eye:-structure & function. 5.Receptor organs in insects (Chemo receptors, mechanoreceptors and Photoreceptors) 6. Sound and light producing organs in insects.	45

Insect Structure & Function
Credit:1

PRACTICAL	**Hours**
9. Study of different types of mouth parts 10. Study of different types of antennae 11. Study of different types of legs 12. Study of different types of wings 13. Preparation of arolium, empodium and pollen basket 14. Study of male and female external genitalia of cockroach	30

Suggested Readings:

i. General Entomology by S.W. Frost. Narendra Publishing House, New Delhi.

ii. General Textbook of Entomologyby Walter Scott Patton and Alwen M. Evans. Akashdeep Publishing House, Delhi.

iii. The Insects Structure and Function by R.F. Chapman. Cambridge University Press. Unted Kingdom.

iv. Modern Entomology by D.B.Tembhare. Himalaya Publishing House. Mumbai.

v. A handbook for the Identification of Insects of Medical Importance by J. Smart, K. Jordon and R.J. Whittick. Biotech Books, Delhi.

Code: ZLG0900204
Course title: Insect Ecology
Credit:3 (T)+1(P)
Credit:3

Course Outcomes:

Upon completion of the course, students should be able to:

1. Define key concepts related to the dynamics of insect population and factors influencing their abundance.
2. Explain the importance of environmental factors as regulator of insect population.
3. Apply their knowledge of surveillance and sampling techniques to collect data from field and analyze and interpretation.
4. Develop concepts on morphological and physiological adaptation of insects that help insects to adopt different habitats.
5. Explain the impact of climatic changes on insect communities.

Insect Ecology
Credit:3

THEORY	**Hours**
1. Dynamics of insect life system-determinants of insect abundance, population change, birth rate, Death rate, Movements, 2. Effect of environment on insect development-- effect of light, temperature & humidity. 3. Basic concept of surveillance and sampling of insect 4. Adaptation of insects- Aquatic, Terrestrial, soil. 5. Impact of climate change on insect communities 6. Insect behavior: chemotropism, thigmotropism, hydrotropism, rheotropism, anemotropism, phototropism, thermotropism, geotropism, instinct. Protective behavior: mimicry. Behavioural defence, chemical defence. 7. Insect associations: Passive insect association, active associations, estivating aggregation, protective aggregation, swarming aggregation, sleeping aggregation, dissociation, social aggregations.	45

Insect Ecology
Credit:1

PRACTICAL	**Hours**
15. Identification of aquatic insects with specific adaptive characteristics. 16. Identification of terrestrial insects with specific adaptive characteristics 17. Identification of boring insects with specific adaptive characteristics 18. Study of aggregation behaviour of any social insect 19. Report preparation on impact of climate change in any insect. 20. To study any tropic behaviour of a model insect 21. Sampling of terrestrial insects by using quadrate method	30

22. Study of locally available mimicking insects
23. Study on the insect catching/collecting devices for aquatic, terrestrial and aerial insects.

Suggested Readings:

i. Insect Ecology, Behaviour, Populations & Communities by P.W. Price; R.F. Denno; M.D. Eubanks; D.L.Finke & I.Kaplan. Cambridge University Press.
ii. A Textbook of Forest Entomology by T.V.Sathe. Daya Publishing House, Delhi.
iii. The Ecology and Control of the Forest Insects of India and the neighbouring countries by C.F.C. Beeson. Shiva Offset Press, Dehra Dun.
iv. The Insects An Outline of Entomology by P.J. Gullan & P.S. Cranston. Blackwell Publishing.

Code: ZLG0900304
Course title: Insect Physiology
Credit:3 (T)+1(P)

Course Outcomes:

Upon completion of the course, students should be able to:

1. Define and describe the influence of the exoskeleton on physiological functions of insects.
2. Discuss the hormonal and neuronal regulatory systems.
3. Demonstrate the communication and sensory system of insects.
4. Apply knowledge gained in the course for designing experiments in insects.
5. Evaluate the significance of diapause, growth, and metamorphosis in the life cycle of insects.

Insect Physiology
Credit:3

THEORY	Hours
1. **Digestive System**: Different parts of alimentary canal their origin and histology, salivary glands, physiology of digestion and absorption 2. **Respiratory system**: General organization of respiratory system, classification of respiratory system, Respiration in terrestrial insects - different types of spiracles and their structure, opening and closing mechanism of spiracles, trachea and tracheoles, air sacs, ventilation of tracheal system, mechanism of gaseous exchange, Respiration in aquatic insects, physiology of gill and plastron respiration,, respiration in parasitic insects 3. **Circulatory system**: Diaphragms and sinuses, doral vessel, accessory pulsatory organs, blood circulation, chemical composition of haemolymph, different type of haemocytes and their functions 4. **Nervous system** : Structure and type of neurons, Central nervous system-basic plan, gross anatomy and microanatomy of brain and ganglion, sympathetic nervous system, nerve impulse transmission **5. Reproductive system**: male and female reproductive system, spermatogenesis, oogenesis. Hormonal control of reproduction in male and female insects. **6. Excretory system** : basic and cryptonephredial system, Malpighian tubules, accessory organs of excretion, metabolic pathways of formation of uric acid and ammonia, elimination of uric acid by malpighian tubules.	45

Insect Physiology
Credit:1

PRACTICAL	Hours
17. Dissection & display of male & female reproductive system of cockroach 18. Bacterial chamber of termite 19. Study of pharyngeal, labial and thoracic salivary glands of Honey bee 20. Detection of chitin in insect cuticle 21. Estimation of protein from haemolymph of insect.	30

22. Histological study of foregut, midgut and hindgut of insect.
23. Dissection of nervous system of cockroach/grasshopper
24. Study of different types of haemocytes of insects

Suggested readings:

1. Insect Biochemistry and Physiology by J.L. Nation. CRC Press.
2. The Insects Structure and Function by R.F. Chapman. Cambridge University Press. Unted Kingdom.
3. General Entomology by S.W. Frost. Narendra Publishing House, New Delhi.
4. General Textbook of Entomologyby Walter Scott Patton and Alwen M. Evans. Akashdeep Publishing House, Delhi.

Code: ZLG0900404
Course title: Agricultural and Forest Entomology and Pest Control
Credit:3 (T)+1(P)

Course Outcomes:

Upon completion of the course, students should be able to:

1. Knowledge on major pests of rice, vegetables, tea, jute, pulses, and stored grains, including their classification up to family level, life history, nature of damage, and control measures.
2. Idea about the different pest control strategies most importantly basis of classification and mode of action of chemical insecticides.
3. Apply their knowledge of pest life cycles and symptoms of damage to adopt appropriate control strategies for specific pests.
4. Knowledge on the economic impact of pest damage on crops and forests, and decision making.
5. Practical knowledge on the impact of insecticides upon exposure to insect pests and studying successful case studies.

Agricultural and Forest Entomology and Pest Control
Credit:3

THEORY	**Hours**
1. Major pests of rice, vegetables, tea, jute and pulses – classification upto family, life history, nature and damage and control (two each). 2. **Stored grain pests** : *Sitophilus oryzae*, *Tribolium castaneum*, , *Sitotroga cerellela*, *Callobruchus chinensis*, life history and control. 3. **Forest insects**: defoliators, borers and suckers of Teak, Sal, Gamari, classification upto family, life history and control (two each). 4. **Primary control measures**: Physical, Mechanical, Cultural and Legislative measures. Chemical control: Classification and mode of action of important insecticides, insecticide toxicity to humans, drawbacks of chemical control, Insect resistance to pesticides, Fumigants- Pheromonal control. **5. Biological and Genetic control** : use of parasites, parasitoids, predators and pathogenic organisms, sterile insect technique, lethal mutations, inherited sterility, cytoplasmic incompatibility. **6. Pest management**: Economic decision levels for pest populations- Concept of economic injury level, Economic threshold, concept of integrated pest management (IPM)**.**	45

Agricultural and Forest Entomology and Pest Control Credit:1	
PRACTICAL	**Hours**
1. Study of insect collection and preservation technique 2. Collection and identification of pests of rice, vegetables, pulses, tea, jute and stored grains 3. Study and identification of forest pest. 4. Determination of sublethal dose of insecticides using any common pest 5. Study of life stages of any economically important insects 6. Preparation of report on case study of IPM/ Preparation of a report on case study of sterile insect technique **7.** Study of the effect of any chemical insecticide on acetylcholinesterase enzyme of insect	30

Suggested readings:

1. General Entomology by S.W. Frost. Narendra Publishing House, New Delhi.
2. General Textbook of Entomologyby Walter Scott Patton and Alwen M. Evans. Akashdeep Publishing House, Delhi.
3. A handbook for the Identification of Insects of Medical Importance by J. Smart, K. Jordon and R.J. Whittick. Biotech Books, Delhi
4. Toxicology of Inseticides by F.Matsumura. Plenum Press, New York and London.

Code: ZLG0900504
Course title: Medical, Veterinary and Forensic Entomology
Credit:3 (T)+1(P)

Course Outcomes:

Upon completion of the course, students should be able to:

1. Discuss the mechanisms behind host choice and location adopted by the hematophagous insects.
2. Apply their knowledge of hematophagous insect biology and behavior to develop control strategies for medical and veterinary pests.
3. Analyze the vector-parasite relationship and the strategies parasites use to contact vectors.
4. Evaluate the public health significance of major vector-borne diseases transmitted by mosquitoes, ticks, and other hematophagous insects.
5. Knowledge on the importance of insects in forensic science as clue for determining cause and time of death.

Medical, Veterinary and Forensic Entomology
Credit:3

THEORY	**Hours**
1. Hematophagy, Evolution of the blood sucking habit, Host choice, Host location, anti-haemostatic and anti-pain factors in saliva, phagostimulants, gonotrophic concordance 2. Mosquito (*Aedes, Culex, Anopheles, Toxorynchus*) Taxonomy, Biology and Behaviour . Major vector borne diseases 3. Vector-parasite relationship, Parasite strategies for contacting a vector, Vector immune mechanisms 4. Public health importance of Mites, Ticks 5. Myiasis and myasis causing flies 6. Veterinary pests : Horsefly, stable fly, screw worm, nose fly, cattle blood sucking louse, life history and control 7. Forensic entomology: - Lifecycles of Calliphora and Sarcophaga, determination of date and causes of death	45

Medical, Veterinary and Forensic Entomology
Credit:1

PRACTICAL	**Hours**
1. Identification of common mosquito species 2. Study of the mouth parts of male and female mosquitoes 3. Study and identification of forensic insect 4. Study and identification of common veterinary pest	30

5. Study of the life cycle of common mosquito species (*Aedes/Culex/Anopheles/ Toxorhynchus*)
6. Study of life stages of common mites and ticks

Suggested Readings:

i. A handbook for the Identification of Insects of Medical Importance by J. Smart, K. Jordon and R.J. Whittick. Biotech Books, Delhi.
ii. The Biology of Blood-sucking in insects by M.Lehane. Cambridge University Press, UK.
iii. Medical and Veterinary Entomology By G. Mullen & L. Durden (Edt.). Academic Press.
iv. The Insects An Outline of Entomology by P.J. Gullan & P.S. Cranston. Blackwell Publishing

SYLLABUS FOR FIFTH YEAR OF INTEGRATED MASTER PROGRAM IN ZOOLOGY/ ONE-YEAR MASTER PROGRAMME IN ZOOLOGY [UNDER NEP 2020]

Specialization: FISH BIOLOGY & FISHERY SCIENCE

Semester	Course Name	Code	Credit
IX	Systematics of Finfish	ZLG0900104	3
	Practical		1
	Physiology of Finfish	ZLG0900204	3
	Practical		1
	Fisheries Science	ZLG0900304	3
	Practical		1
	Freshwater Aquaculture	ZLG0900404	3
	Practical		1
	Fish Disease and Health Management	ZLG0900504	3
	Practical		1
X	Dissertation	ZLG1000104	16
	Compulsory MOOCs course	ZLG1000204	4

SYSTEMATICS OF FINFISH

Code: ZLG0900104

Credit: 3 (T) + 1 (P)

Course Outcomes:

1. Classify and interpret the methods of identification and classification of fishes.
2. Compare and contrast the transition from classical approaches to modern trends of fish taxonomy.
3. Infer and assess the conservation status and distribution of freshwater fish diversity of NE India
4. Estimate and apply the various methods of fish phylogenetics.
5. Apply the concept of fish systematics in conservation.

SYSTEMATICS OF FINFISH

Credit: 3 (T) + 1(P)

THEORY	**Hours**
1. Northeast India as a global hotspot of freshwater biodiversity – overview of origin and evolution of freshwater finfishes of the Eastern Himalayas; status and distribution of fishes in major river basins of NE India. 2. Classification of Indian Freshwater Teleost up to families. 3. Classical taxonomy – morphological characters (colour patterns, shape, anatomy, etc.), morphometry and meristic, and taxonomic keys to identify common Indian freshwater families of fishes. 4. Fish skeleton as a tool in fish taxonomy. 5. Modern trends in taxonomy – utility of DNA barcoding and karyology in taxonomic study of fishes. 6. Concepts and methods applied to construct and interpret fish phylogenies.	45

SYSTEMATICS OF FINFISH

PRACTICAL	**Hours**
1. Identification and characterization up to family of representative freshwater finfish species of NE India (carp/catfish/murrel/perch/loach/featherback/eel/river shad). 2. Comparative biometric assessment using Morphometry and Meristics for identification of representatives of at least two different freshwater fish families of NE India. 3. Osteological preparation and submission of a report highlighting a comparison of various components of the skeleton to distinguish any two common fish genera of NE India. 4. Utility of internal anatomy for identifying fishes – dissection and visualization of gut coiling pattern and swim bladder in representative Cypriniform fishes. 5. Microscopic analyses of lips and associated structures to distinguish	30

fish species of atleast two different families.

6. Preparation of a taxonomic key to distinguish atleast five fish species under any one family using appropriate taxonomic characters.
7. Construction and interpretation of phylogeny of fish species with morphological/molecular characters using appropriate software.

Suggested Readings:

- *Ichthyology*, 2nd Edition; by Lagler, Bardach, Miller and Passino; Wiley [ISBN: 978-0-471-51166-3]
- *The Diversity of Fishes*: *Biology, Evolution, and Ecology*, 2nd Edition; by Collete, Bowen, Helfman and Facey; Wiley [ISBN: 978-1-119-10328-8]
- *Freshwater Fishes of the Eastern Himalayas*, 1st edition, by W. Vishwanath; Elsevier [ISBN: 9780128233917]
- *Inland fishes of India and adjacent countries*, Vol. I and II; by Talwar and Jhingran; Oxford-IBH Publishing Co. Pvt. Ltd. [ISBN: 978-9061911630]
- *Fundamentals of Fish Taxonomy* by Jayaram; Narendra Publishing House [ISBN: 9788185375700]
- *The Freshwater fishes of the Indian Region*, 2nd edition, by Jayaram; Narendra Publishing House [ISBN: 9788190795210]

PHYSIOLOGY OF FINFISH

Code: ZLG0900204

Credit: 3 (T) + 1 (P)

Course Outcomes:

1. Identify and explain the detailed physiology and anatomy of a fish.
2. Interpret the role and mechanism of various organs and organ systems of a fish.
3. Infer the concepts of genetics applicable to aquaculture and fisheries.
4. Utilize the basic knowledge of fish endocrinology.
5. Interpret and associate the scope of physiology in higher studies/research

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PHYSIOLOGY OF FINFISH

Credit: 3 (T) + 1(P)

THEORY	**Hours 45**
1. Physiology of digestion in teleost — Digestive system: anatomical differentiation and modifications; feeding adaptations in fishes.	
2. Respiratory system — Gill structure, Mechanism of respiration, Counter-current principle, Exchange of gases.	
3. Physiological adaptation in air breathing fishes - Accessory respiratory organs – types, structure and functions.	
4. Excretion — Excretion of nitrogenous wastes, Urea cycle.	
5. Nervous system – brain and cranial nerves.	
6. Sensory system – lateral-line sensory organ.	
7. Principles of osmoregulation in Freshwater and Marine Teleosts — Processes and functional aspects.	
8. Endocrine system — Hypothalamo-hypophysial system; Functional morphology of Pituitary gland; structure and function of Thyroid and Pancreas; Caudal neurosecretory system and its hormones.	
9. Reproductive system – spermatogenesis; oogenesis; vitellogenesis; hormones of reproduction.	

PHYSIOLOGY OF FINFISH

PRACTICAL	**Hours**
1. Dissection and display of digestive system of different groups of herbivorous, carnivorous and omnivorous fishes.	30
2. Dissection and visualization of types of gill-rakers in different groups of finfish.	
3. Calculation of relative length of gut (RLG) and interpretation of feeding habit.	
4. Preparation of T.S. of different regions of the alimentary canal and identification of different cell types in digestion.	
5. Dissection and display of Weberian apparatus, Urinogenital system	

(male/female), and brain and cranial nerves - V, VII, IX, X.

6. Preparation and submission of permanent slides of endocrine organs of fishes.

Suggested Readings:

- *Ichthyology*, 2nd Edition; by Lagler, Bardach, Miller and Passino; Wiley [ISBN: 978-0-471-51166-3]
- *Handbook of Fisheries and Aquaculture*, 2nd edition; by ICAR [ISBN: 9788171641062]
- *Textbook of Fish Biology and Fisheries*, 3rd edition; by Khanna and Singh [ISBN: 9384337129]
- *The Physiology of Fishes*, 5th edition; Eds.: Suzanne Currie, David H. Evans; CRC Press [ISBN: 9780367477554]
- *Fish Endocrinology* (2 volumes); by Reinecke, Zaccone and Kapoor; CRC Press [ISBN 9780367412890]
- *Fish Endocrinology*, First Edition; by Hadwin; Random Publications [ISBN: 9386314568].

FISHERIES SCIENCE

Code: ZLG0900304

Credit: 3 (T) + 1 (P)

Course Outcomes:

1. Interpret and analyse the importance and scope of fisheries in the country
2. Compare and contrast the prospects and problems of fisheries in the Indian context
3. Outline the basic principles and processes of post-harvest technology of Indian fisheries
4. Estimate and apply the various indices of fish growth and diversity analyses
5. Explain and relate the basic concepts of fish stock assessments

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FISHERIES SCIENCE

Credit: 3 (T) + 1(P)

THEORY	**Hours 45**
Unit 1: Capture fisheries (2.5 credit)	**25**
1. Inland capture fisheries resources of India – major types and their contribution towards the Indian economy; overview of fisheries statistics in the Indian context. 2. Fish and fisheries of River Brahmaputra 3. Floodplain wetland (*beel*) fisheries resources, problems and management strategies 4. Marine pelagic fisheries – sardine and mackerel 5. Estuarine fisheries resources of India – major fish resources; problems of Indian estuarine fisheries	
Unit 2: Study of fish population (1 credit)	**15**
1. Concept of absolute and relative growth; growth rate and ageing. 2. Stock assessment and management — Concept of stock in fisheries; methods of stock composition analysis. Morphological and genetic markers in stocks. 3. Indices in fisheries science – length-weight relationships; condition factor; relative condition factor; fecundity. 4. Marking and tagging of fish.	
Unit 3: Post-harvest technology (0.5 credit)	**05**
1. Principle, importance and methods of fish preservation - Refrigeration vs freezing, freeze drying, drying, salting, smoking, canning, pickling, fermentation. 2. Fishery bi-products, their production and utilization - liver oils, Body oils, Fish meal, Fish flour, Fish Silage, Fish protein, Fish guano, Icinglass.	

FISHERIES SCIENCE

PRACTICAL	**Hours**
1. Estimation and interpretation of length-weight relationship and condition factor of locally available freshwater fish species. 2. Estimation of fecundity.	30

3. Estimation and interpretation of hepatosomatic and gonadosomatic indices.
4. Analysis and interpretation of gut content using appropriate indices viz., fullness of gut, Index of preponderance.
5. Age estimation through study of hard parts – scales/vertebrae/otoliths.
6. Presentation of case studies on impact of climate change in fisheries.
7. Field visit to nearest fish landing centre and report submission of species landings analysis.

Suggested Readings:

- *Ichthyology*, 2nd Edition; by Lagler, Bardach, Miller and Passino; Wiley
- *Handbook of Fisheries and Aquaculture,* 2nd edition; by Indian Council of Agricultural Research, New Delhi
- *Textbook of Fish Biology and Fisheries*, 3rd edition; by Khanna and Singh
- *Manual of Finfish Biology*; by Venkataramanujam and Ramanathan; Oxford and IBH publishing Co. pvt. Ltd.
- *Methods for the Assessment of Fish Production in Freshwaters*; by Ricker; Blackwell, Oxford and IBH.
- *Stock assessment of tropical marine fishes*; by Vivekanandan; Indian Council of Agricultural Research, New Delhi.

FRESHWATER AQUACULTURE

Code: ZLG0900404

Credit: 3 (T) + 1 (P)

Course Outcomes:

1. Infer and apply the various methods and techniques of scientific fish farming.
2. Identify and classify the different systems of aquaculture.
3. Interpret the scientific management of different species in aquaculture.
4. Associate the importance of nutrition for feed and health management in aquaculture.
5. Outline and apply the basic knowledge of aquarium keeping

FRESHWATER AQUACULTURE

Credit: 3 (T) + 1(P)

THEORY	**Hours 45**
Unit 1: Aquaculture Technology (1 credit)	**15**
1. Natural and Induced breeding technology – physical and chemical agents; brood stock management: nutritional requirements; captive rearing and maturation of carps, catfishes, mahseers and air-breathing fishes. 2. Sewage-fed culture; cage and pen culture; raceway culture; BioFloc; RAS. 3. Aquarium keeping — Design and construction of aquaria; species-wise aquarium size requirements; heating, lighting, aeration and filtration arrangements; common aquarium plants and their propagation. Maintenance of natural colour of finfishes in aquarium.	
Unit 2: Aquaculture Nutrition (1 credit)	**15**
1. Nutritional requirements in aquaculture — Protein, carbohydrate, fats, vitamins and minerals. 2. Feed formulation — General principles, different steps of feed formulation, classification of feed ingredients. 3. Larval nutrition — Importance of live feed and artificial feed, Different types of feed available for larvae.	
Unit 3: Modern Aquaculture (1 credit)	**15**
1. Water quality management in aquaculture systems. 2. Genetics in aquaculture: GIFT technology; selective breeding of finfish: scope and application in aquaculture; selection approaches; Jayanti Rohu. 3. Stock improvement: sex-reversal, Hybridization, Gynogenesis, hybrid vigour, introgression.	

FRESHWATER AQUACULTURE

PRACTICAL	Hours
1. Identification of commercially important indigenous and exotic carps	30
2. Identification of indigenous and exotic ornamental fishes	
3. Identification of common aquarium plants	
4. Induced breeding of carp/catfish using synthetic hormones	
5. Identification and classification of developmental stages from egg to larva of IMCs	
6. Estimation of water and soil quality parameters – soil organic carbon, pH; water hardness; alkalinity; Calcium and magnesium content.	
7. Visit to a local food/ornamental fish farm and report preparation	

Suggested Readings:

- *Handbook of Fisheries and Aquaculture*, 2nd edition; by Indian Council of Agricultural Research
- *Textbook of Fish Biology and Fisheries*, 3rd edition; by Khanna and Singh
- *Manual of Finfish Biology*; by Venkataramanujam and Ramanathan; Oxford and IBH publishing Co. pvt. Ltd.
- *New technologies in aquaculture - Improving production efficiency, quality and environmental management*; by Burnell and Allan; CRC Press
- *Selective breeding in aquaculture: An introduction*; by Gjedrem and Baranski; Springer
- *Induced fish breeding – a practical guide for hatcheries*; by Chattopadhyay; Elsevier

FISH DISEASE AND HEALTH MANAGEMENT

Code: ZLG0900504

Credit: 3 (T) + 1 (P)

Course Outcomes:

1. Identify and locate the various kinds of diseases of fish.
2. Classify the important fish pathogens in finfish aquaculture systems.
3. Associate and apply the basic knowledge of prophylaxes in aquaculture.
4. Infer and analyze the harmful effects of algal blooms and toxins in aquaculture.
5. Classify and apply the utilities of nutraceuticals in aquaculture

FISH DISEASE AND HEALTH MANAGEMENT

Credit: 3 (T) + 1(P)

THEORY	**Hours 45**
Unit 1: Fish disease (2 credit)	**23**
1. Diseases of fishes: Bacterial, Fungal, Viral diseases of finfish in farm ponds, natural waters; nutritional disorders and environmental diseases. 2. Disease diagnostics tools: Histopathological methods; Immunoassay; Biochemical assay; Serological techniques; basics of virological techniques. 3. Isolation and culture of pathogenic bacteria of finfish. 4. Fish parasites: types and symptoms caused.	
Unit 2: Health Management (2 credit)	**22**
1. Harmful algal bloom and microbial toxins in aquaculture. 2. Sanitation in aquaculture systems. 3. Control of diseases: Control measures; Herbal therapeutants; guidelines on use and disuse of antibiotics in aquaculture. 4. Types and importance of nutraceuticals as natural immunobiotics for disease control.	

FISH DISEASE AND HEALTH MANAGEMENT

PRACTICAL	**Hours**
1. Identification of disease conditions in cultivable finfish. 2. Colony count of bacteria from prepared agar plates. 3. Identification of finfish parasites 4. Histopathological examination of liver, kidney and gills 5. Demonstration of methods of isolation and culture of pathogenic bacteria of finfish. 6. Preparation of blood smear for DLC.	30

Suggested Readings:

- *Handbook of Fisheries and Aquaculture,* 2nd edition; by Indian Council of Agricultural Research
- *Textbook of Fish Biology and Fisheries*, 3rd edition; by Khanna and Singh
- *Fish disease: diagnosis and treatment*; by Noga; Iowa State Press
- *Fish Pathology*; by Roberts; W. B. Saunders

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