A Syllabus of

Four-Years Undergraduate Program (FYUGP)

in

ZOOLOGY

As per instructions of the NEP Implementation Committee, Gauhati University

Prepared by-

Department of Zoology
Gauhati University

GENERAL CURRICULAR STRUCTURE
of
FIRST 3 YEARS (WITH MAJOR) OF FYUGP

Total "CREDITS" to be acquired by a student (including MAJOR + MINOR + SEC/VAC/MDC/AEC + Internship) in the first 03-year period = 120 credits

"MAJOR" courses to be opted by a student in the period of 03 years = 11

Semester-1			Semester-2		
Type	**Course**	**Credit**	**Type**	**Course**	**Credit**
Major	Major-1	4	Major	Major-2	4
Minor	Minor-1	4	Minor	Minor-2	4
SEC	SEC-1 (Major oriented)*	3	SEC	SEC-2 (Major oriented)*	3
AEC	AEC-1	4	AEC	AEC-2	4
MDC	MDC-1	3	MDC	MDC-2	3
VAC	VAC-1	2	VAC	VAC-2	2
TOTAL		**20**	**TOTAL**		**20**

Semester-3			Semester-4		
Type	**Course**	**Credit**	**Type**	**Course**	**Credit**
Major	Major-3	4	Major	Major-5	4
	Major-4	4		Major-6	4
Minor	Minor-3	4		Major-7	4
SEC	SEC-3 #	3		Major-8	4
MDC	MDC-3	3	Minor	Minor-4	4
VAC	VAC-3	2			
TOTAL		**20**	**TOTAL**		**20**

Semester-5			Semester-6		
Type	**Course**	**Credit**	**Type**	**Course**	**Credit**
Major	Major-9	4	Major	Major-12	4
	Major-10	4		Major-13	4
	Major-11	4		Major-14	4
Minor	Minor-5	4		Major-15	4
Internship		4	Minor	Minor-6	4
TOTAL		**20**	**TOTAL**		**20**

NOTE
Boxes indicate the number of MAJOR courses for <u>ONE SUBJECT as MAJOR</u> per Semester

COURSE STRUCTURE OF THE FIRST THREE YEARS OF FYUGP WITH ZOOLOGY AS ONE OF THE MAJOR SUBJECTS

Semester	Course Name	Code	Credit
1	**Major-1** Diversity of Non-chordates	ZLG0100104	3
	Practical		1
2	**Major-2** Diversity of Chordates	ZLG0200104	3
	Practical		1
3	**Major-3** Basic Genetics (To be adopted from SWAYAM)	ZLG0300104	4
	Practical		
	Major-4 Entomology & Fisheries	ZLG0300204	3
	Practical		1
4 **(Any one of the Optional DSE papers to be opted)**	**Major-5** Animal Taxonomy, Systematics & Biostatistics	ZLG0400104	3
	Practical		1
	Major-6 Animal Physiology & Endocrinology	ZLG0400204	3
	Practical		1
	Major-7 Fundamentals of Ecology (To be adopted from SWAYAM)	ZLG0400304	4
	Practical		
	Major-8 *DSE-I*: Comparative Anatomy of Vertebrates	ZLG0400404 (DSE-I/ DSE-II/ DSE-III)	3
	Practical		1
	DSE-II: Animal Behaviour and Chronobiology		3
	Practical		1
	DSE-III: Parasitology		3
	Practical		1
5 **(Any one**	**Major-9** Cell Biology	ZLG0500104	3

of the Optional DSE papers to be opted)	Practical		1
	Major-10 Fundamentals of Biochemistry	ZLG0500204	3
	Practical		1
	Major-11 *DSE-I*: Immunology (To be adopted from SWAYAM)	ZLG0500304 (DSE-I/ DSE-II/ DSE-III)	4
	Practical		
	DSE-II: Reproductive Biology		3
	Practical		1
	DSE-III: Developmental Biology		3
	Practical		1
6 (**Any one of the Optional DSE papers to be opted**)	**Major-12** Wildlife Conservation & Management	ZLG0600104	3
	Practical		1
	Major-13 Molecular Biology	ZLG0600204	3
	Practical		1
	Major-14 Biochemistry of metabolic processes & Regulation	ZLG0600304	3
	Practical		1
	Major-15 *DSE-I*: Fundamentals of Bioinformatics (To be adopted from SWAYAM)	ZLG0600404 (DSE-I/ DSE-II/ DSE-III)	4
	Practical		
	DSE-II: Advanced Entomology		3
	Practical		1
	DSE-III: Animal Cell Culture & Genetic Engineering		3
	Practical		1

GENERAL CURRICULAR STRUCTURE OF THE FOURTH YEAR OF FYUGP WITH ZOOLOGY AS MAJOR

The fourth year comprises of two optional types of degrees –

A. DEGREE WITH HONOURS
Or,
B. DEGREE WITH HONOURS & RESEARCH

A. FYUGP with Honours

Semester	Course level	Course work (CORE*)	Research component/Project	Total Credits
7	400	4 courses with 4 credits each (4 x 4 =16)	Research Methodology with 4 credits	20
8	400	4 courses with 4 credits each (4 x 4 =16)	"One seminar/project-based course & presentation" with 4 credits	20

OR,

B. FYUGP Honours with Research

Semester	Course level	Course work (CORE*)	Research component/Project	Total Credits
7	400	4 courses with 4 credits each (4 x 4 =16)	Research Methodology with 4 credits	20
8	400	Dissertation with 16 credits	"One seminar-based course/presentation" with 4 credits	20

*CORE courses can comprise either compulsory, or compulsory + elective courses

COURSE STRUCTURE OF SYLLABUS FOR THE FOURTH YEAR OF FYUGP WITH ZOOLOGY AS MAJOR

A. **FYUGP Degree with honours**

Semester	Course Name	Code	Credit
7	**Major-16** Advanced Biochemistry	ZLG0700104	3
	Practical		1
	Major-17 Biodiversity Conservation and Applications of Biostatistics	ZLG0700204	3
	Practical		1
	Major-18 Molecular Cytogenetics	ZLG0700304	3
	Practical		1
	Major-19 Evolution and Microbiology	ZLG0700404	3
	Practical		1
	Major-20 Research Methodology (To be adopted from SWAYAM)	ZLG0700504	4
8	**Major-21** Advanced Computational Biology and Instrumentation	ZLG0800104	3
	Practical		1
	Major-22 Cellular Physiology	ZLG0800204	3
	Practical		1
	Major-23 Data Analysis for Biologists (To be adopted from SWAYAM)	ZLG0800304	2
	Practical		2
	Major-24 Ecological Science and Environmental Biology	ZLG0800404	3
	Practical		1
	Major-25 **MINI PROJECT** (with compulsory Seminar presentation)	ZLG0800504	4

OR,

B. **FYUGP Degree Honours with Research**

Semester	Course Name	Code	Credit
7	**Major-16** Advanced Biochemistry	ZLG0700104	3
	Practical		1
	Major-17 Biodiversity Conservation and Applications of Biostatistics	ZLG0700204	3
	Practical		1
	Major-18 Molecular Cytogenetics	ZLG0700304	3
	Practical		1
	Major-19 Evolution and Microbiology	ZLG0700404	3
	Practical		1
	Major-20 Research Methodology (To be adopted from SWAYAM)	ZLG0700504	4
8	**Major-21** **RESEARCH/DISSERTATION**	ZLG0800104	16
	Major-22 Seminar presentation based on Dissertation	ZLG0800204	4

SEMESTER I

MAJOR-1
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 various animal phyla.
5. Comprehend the economic importance of non-chordates, their interaction with the environment and role in the ecosystem.

MAJOR-1
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	30

Vision and respiration in Arthropoda
Evolutionary significance of Onychophora
Torsion and detorsion in Gastropoda
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

SEMESTER II

MAJOR-2
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.

MAJOR-2
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	30

Mammalia up to order 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

SEMESTER III

MAJOR-3
BASIC GENETICS
Code: ZLG0300104
Credit: 3(T) + 1(P)

TO BE ADOPTED FROM SWAYAM

By Prof. Richa Arya, Prof. Madhu G Tapadia, Prof. J K Roy (retired); Banaras Hindu University

Course Outcomes:
Upon completion of the course, students should be able to:
The course provides a fundamental understanding of heredity and variation principles. It covers basic Mendelian genetics, extensions of Mendelian concepts, and cytoplasmic inheritance. Students will learn how genetic information is transmitted in eukaryotes and prokaryotes, the interactions of genes within biological systems, and the molecular basis of these processes. Additionally, the course explores the role of chromosomes in determining sex and discusses various chromosomal anomalies that can impact human development.

Course Layout:

Week 1: Elements Of Heredity and Variations
1. Historical Background and Mendel's Laws of Inheritance: Part 1
2. Historical Background and Mendel's Laws of Inheritance: Part 2
3. Understanding Mendel's Data: Methods & Applications (Probability, Product Rule, Sum Rule, Binomial Expansion and Factorial)
4. Understanding Mendel's Data: Methods & Applications (Punnet Square, Forked Line Method, Statistical Test to Analyse Data)
5. Chromosomal Basis of Inheritance (Post Mendel's laws, chromosome behaviour during meiosis, theory by Sutton and Boveri, Work of Morgan and team)

Week 2: Extension of Mendelism
1. Dominance Relationships, Multiple Allelism
2. Multiple Allelism, Conditional Alleles, Lethal Alleles
3. Pleiotropy, Phenocopy, Polygeny
4. Epistasis
5. Gene Interaction

Week 3: Various Ways to Determine Sex and Inheritance of Sexual Traits
1. Discovery of Sex Chromosomes: From History to Systems
(XX/XY system in *Drosophila* and Human)
2. Discovery of Sex Chromosomes: From History to Systems (XX/XO, ZZ/ZW, haploidy/diploidy)
3. Environmental and Hormonal control of sex determination
4. Sex Influenced, Sex-Limited and Sex-Linked Traits
5. Dosage Compensation in *Drosophila* and Human

Week 4: Different Types of Inheritance Patterns
1. Quantitative Inheritance
2. Quantitative Inheritance (Cont.)
3. Extra nuclear inheritance
4. Infective Inheritance
5. Maternal Inheritance

Week 5: Gene Mutations
1. Spontaneous Mutations
2. Induced Mutations
3. Molecular basis of mutations
4. Detections of mutations, Ames test, ClB technique, Nutritional Mutations in *Neurospora*
5. DNA repair mechanisms

Week 6: Gene Mapping in Prokaryotes
1. Bacterial Growth and Conjugation
2. Conjugation And Sexduction: Gene Mapping in Bacteria
3. Transformation: Gene Mapping in Bacteria
4. Transduction and Gene Mapping in Bacteria
5. Gene mapping in Phages: Mapping the rII Locus – History, Concepts & Applications

Week 7: Gene Mapping on Eukaryotic Chromosomes
1. Linkage and crossing over: Concepts in Classical & Molecular Genetics
2. Recombination and Cytological Determination of Crossing over
3. Gene Mapping Using Two point and three Point Test Cross
4. Interference and Coincidence
5. Gene Mapping in yeast and Neurospora Using Tetrad Analysis Methods

Week 8: Chromosomal alterations
1. Anomalies in chromosome number: Aneuploidy
2. Anomalies in chromosome number: Polyploidy
3. Anomalies in chromosome structure: Deletions and duplications
4. Meiotic consequences in inversion heterozygotes
5. Meiotic consequences in inversion heterozygotes

Week 9: Human Genetics: Pedigree Analysis
1. Making A Pedigree Chart and showing dominant and recessive traits
2. Study Of Autosomal Traits in A Pedigree
3. Study Of Sex-Linked Traits in A Pedigree
4. Study Inheritance of Mitochondrial Traits in A Pedigree
5. Genetic Counselling

Week 10: Human Genetics: Chromosome Analysis
1. Human karyotyping
2. G-banding
3. Chromosome bandings other than G-banding
4. Fluorescence in situ hybridization
5. Nomenclature of G-ban

Week 11: Human Genetics: Genetic Disorders
1. Human genetic disorders: Gene mutations
2. Human genetic disorders: Chromosomal aneuploidy
3. Human genetic disorders: Chromosome translocations
4. An introduction to cancer
5. An introduction to cancer with special reference to Human papilloma virus papilloma virus

Week 12: Regulation Of Gene Activity in Eukaryotes
1. Regulation of gene activity in eukaryotes: Transcription unit
2. Regulation of gene activity in eukaryotes: Initiation, elongation and termination of transcription
3. Regulation of gene activity in eukaryotes: Activators, enhancers and boundary elements
4. Regulation of gene activity in eukaryotes: RNA processing

5. Regulation of gene activity in eukaryotes: RNA editing, epigenetic modifications

BASIC GENETICS Code: ZLG0300104 Credit: 01	
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:

- Snustad and Simmons: Principles of Genetics (2019, 7th ed. John Wiley)
- Hartl and Jones: Essential Genetics- A Genomic Perspective (2009, Jones and Bartlet)
- Pierce: Genetics - A Conceptual Approach (2012, Freeman) Suggested Readings
- Griffith et al.: An Introduction to Genetic Analysis (Freeman 11th ed, 2015)
- Brooker: Genetics - Analysis and Principles (2012, 4th ed McGraw Hill)
- Russell: Genetics (2010, Benjamin Cummings)
- Gersen & Keagle: The Principles of Clinical Cytogenetics (2005, Humana)
- Hawley & Walker: Advanced Genetic Analysis (2003, Blackwell)
- Resonance Journal for Science education (https://www.ias.ac.in/listing/issues/reso)
- What is a Gene? A Question with Variable Answers
https://www.ias.ac.in/describe/article/reso/002/04/0038-0047
https://www.ias.ac.in/describe/article/reso/002/05/0044-0053
- Tracing the Roots of Molecular Biology: Part 1/2/3: Genesis of Cell Theory
https://www.ias.ac.in/describe/article/reso/030/03/0379-0409,
https://www.ias.ac.in/describe/article/reso/030/01/0077-0095,
https://www.ias.ac.in/describe/article/reso/029/12/1669-1687
- Pedigree Analysis in Medical Genetics: History and Diagnostic Efficacy
https://www.ias.ac.in/describe/article/reso/030/05/0601-0620
- Chromatin is a Dynamic Structure: https://www.ias.ac.in/describe/article/reso/027/06/0983-1002
- Dosage Compensation: https://www.ias.ac.in/article/fulltext/reso/026/05/0649-0669

MAJOR-4
ENTOMOLOGY AND FISHERIES
Code: ZLG0300204
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-4
ENTOMOLOGY AND FISHERIES
Code: ZLG0300204
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 hatcheries; Role of soil and water quality in aquaculture	13

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. 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)	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. 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

SEMESTER IV

MAJOR-5
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-5
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-6
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-6
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-7
FUNDAMENTALS OF ECOLOGY
Code: ZLG0400304
Credit: 3 (T) + 1 (P)

TO BE ADOPTED FROM SWAYAM

By Prof. Vishwesha Guttal, Prof. Kavita Isvaran, Prof. Kartik Shanker, Prof. Umesh Srinivasan, Prof. Maria Thaker, Prof. Saskya van Nouhuys; IISc Bangalore

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.

THEORY
Credit: 03

Course layout

Week 1: Introduction, Sensory Ecology, and Resource Acquisition

Week 2: Movement, Anti-predator and Social Behaviours

Week 3: Population Growth and Dynamics

Week 4: Population Dynamics and Spatial Structure

Week 5: Study Design and Quantitative Thinking

Week 6: Community Ecology: Introduction, Niche and Community Assembly

Week 7: Community Ecology: Species Interactions

Week 8: Community Ecology: Food webs and Species Invasion

Week 9: Community Ecology: Species Diversity and its Estimation

Week 10: Community Ecology: Macroecology and Biogeography

Week 11: Ecosystems and Bio-geochemical Cycles

Week 12: Anthropogenic Environmental Changes & Synthesis of the course

FUNDAMENTALS OF ECOLOGY	
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 CO2 4. 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

MAJOR-8
COMPARATIVE ANATOMY OF VERTEBRATES
Code: ZLG0400404 (DSE-I)
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-8
COMPARATIVE ANATOMY OF VERTEBRATES
Code: ZLG0400404 (DSE-I)
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-8
ANIMAL BEHAVIOUR AND CHRONOBIOLOGY
Code: ZLG0400404 (DSE-II)
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-8
ANIMAL BEHAVIOUR AND CHRONOBIOLOGY
Code: ZLG0400404 (DSE-II)
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-8
PARASITOLOGY
Code: ZLG0400404 (DSE-III)
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-8
PARASITOLOGY
Code: ZLG0400404 (DSE-III)
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

SEMESTER V

MAJOR-9
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-9
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)	15

Cell Division: Mitosis, Meiosis, Cell cycle and its regulation
Cell to Cell communications: Types of signalling molecules, Cell surface 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-10
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-10
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
Unit 3: Nomenclature and classification; Cofactors; Specificity of enzyme action; Isozymes; Mechanism of enzyme action; Enzyme kinetics; Factors affecting rate of enzyme-catalyzed reactions; Derivation of Michaelis-Menten equation, Concept of Km and Vmax, Regulation of enzyme action and Different types of Enzyme Inhibition (Competitive, Non-competitive and Uncompetitive Inhibition). Multi-substrate reactions; Allosteric enzymes and their kinetics; Regulation of enzyme action	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. 7. Demonstration of proteins separation by SDS-PAGE.	30

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-11

IMMUNOLOGY

Code: ZLG0500304 (DSE-I)

Credit: 3 (T) + 1 (P)

TO BE ADOPTED FROM SWAYAM

By Prof. Sudip Kumar Ghosh, Prof. Agneyo Ganguly; IIT Kharagpur

Course Outcomes:

The course will provide basic knowledge of Immunology for UG students in the field of Life Science and Biotechnology. The course introduces students to a wide range of topics in immunology starting from cells of immune system, innate and adaptive immune systems, humoral immunity, antibody structure and function, basic immunological techniques, autoimmunity, hypersensitivity and vaccine production. The course is well balanced with the basics of immunology as well as advanced topics delivered easily for UG students in particular.

THEORY
Credit: 03

Course layout

Week 1: Introduction to immune System, Immune cell types, Hematopoiesis, B and T lymphocytes, NK cells, Lymphoid organs (primary and secondary)

Week 2: Features of/introduction to inflammation, Adaptive immune system, Innate Immune system

Week 3: Antibody structure, Generation of antibody diversity

Week 4: Generation of antibody diversity and TCR rearrangement

Week 5: Major histocompatibility complex, Antigen presentation, APCs

Week 6: Immuno-diffusion assay, ELISA (Sandwich), Immuno-blotting, flowcytometry.

Week 7: T-cell development, negative/positive selection,co-stimulatory molecules.

Week 8: Humoral immunity/Cell-mediated immunity, T cell subtypes: Th1, Th2, Th17, Tregs etc.

Week 9: B-cell maturation/activation BCR signaling, memory B and T cell

Week 10: Pro-inflammatory and anti-inflammatory cytokines,cell polarization/Complement activation (classical/alternate), hypersensitivity

Week 11: Autoimmunity, host vs graft reaction

Week 12: Active immunization Vaccines, , Vaccine production, passive immunization. , polyclonal and monoclonal antibodies

IMMUNOLOGY
Credit: 01

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. 3. ABO blood group and Rh factor determination. 4. Demonstration of - a) ELISA; b) Immunoelectrophoresis 5. Isolation of lymphocytes from blood.	30

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.
4. Janeway's Immunobiology by K. Murphy, P. Travers and M. Walport, Publisher: Garland Science.

MAJOR-11
REPRODUCTIVE BIOLOGY
Code: ZLG0500304 (DSE-II)
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-11
REPRODUCTIVE BIOLOGY
Code: ZLG0500304 (DSE-II)
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. 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	30

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-11
DEVELOPMENTAL BIOLOGY
Code: ZLG0500304 (DSE-III)
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-11
DEVELOPMENTAL BIOLOGY
Code: ZLG0500304 (DSE-III)
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.

SEMESTER VI

MAJOR-12
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-12
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) 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).	30

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-13
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-13
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-14
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-14
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. 2. Extraction of lipids from insect.	30

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-15
FUNDAMENTALS OF BIOINFORMATICS
Code: ZLG0600404 (DSE-I)
Credit: 4

TO BE ADOPTED FROM SWAYAM

By Dr. VIVEK P J; Sree Neelakanta Govt. Sanskrit College, Pattambi

Course Outcomes:
The proposed course is framed for UG students in the life science or biological sciences domain. Through this course, the students will be able to address some questions like, How do we find potentially harmful mutations in your genome? How can we reconstruct the evolutionary Tree of Life? How do we compare related genes from different species? These are just three of the major questions in modern biology that can only be answered using bioinformatics approaches. The course will delve into computational ideas used in biology as well as let students apply existing resources that are used in practice every day by bioinformatics professionals. The course offers an opportunity for students who possess a biological background to become more familiar with the biological process occurring within an organism at genetic level.

THEORY
Credit: 03

Course layout

Week 1
Day 1 Module 1: Origin, History, and Scope of Bioinformatics
Day 2 Module 2: Importance and Use of Bioinformatics
Day 3 Module 3: Applications of Bioinformatics
Day 4 Interaction based on the three modules covered

Week 2
Day 1 Module 4: IT in teaching, Learning and Research
Day 2 Module 5: Open Access Bibliographic Resources
Day 3 Module 6: Basic Concepts of Copyrights and Patents
Day 4 Interaction based on the three modules covered

Week 3
Day 1 Module 7: Central Dogma and Emergence of Omics Technologies
Day 2 Module 8: Genomics and Transcriptomics
Day 3 Module 9: Proteomics and Metabolomics
Day 4 Interaction based on the three modules covered
Day 5 Deadline for submitting assignments

Week 4
Day 1 Module 10: Introduction to Biological Databases
Day 2 Module 11: Sequence and Structural Databases

Day 3 Module 12: Functional and Other Databases
Day 4 Interaction based on the three modules covered
Day 5 Deadline for submitting assignments

Week 5
Day 1 Module 13: Basic Concepts of Sequence Similarity and Identity
Day 2 Module 14: File Formats for Sequences
Day 3 Module 15: Sequence – Patterns and Profiles
Day 4 Interaction based on the three modules covered
Day 5 Deadline for submitting assignments

Week 6
Day 1 Module 16: Scoring Matrices
Day 2 Module 17: Sequence – Pairwise alignments
Day 3 Module 18: Multiple Sequence Alignments
Day 4 Interaction based on the three modules covered
Day 5 Deadline for submitting assignments

Week 7
Day 1 Module 19: GenBank
Day 2 Module 20: BLAST
Day 3 Module 21: Protein Data Bank (PDB)
Day 4 Interaction based on the three modules covered
Day 5 Deadline for submitting assignments

Week 8
Day 1 Module 22: Taxonomy and Phylogeny
Day 2 Module 23: Phylogenetics – Methods
Day 3 Module 24: Phylogenetics – Tools
Day 4 Interaction based on the three modules covered
Day 5 Deadline for submitting assignments

Week 9
Day 1 Module 25: Molecular Modelling
Day 2 Module 26: Molecular visualization – Rasmol and Pymol
Day 3 Module 27: Molecular docking
Day 4 Interaction based on the three modules covered
Day 5 Deadline for submitting assignments

Week 10
Day 1 Module 28: Definition of Drugs and its Advances
Day 2 Module 29: Pharmacophore Identification and Novel Drug Design
Day 3 Module 30: Structure based drug design
Day 4 Interaction based on the three modules covered
Day 5 Deadline for submitting assignments

Week 11
Day 1 Module 31: DNA sequencing – Basic methods
Day 2 Module 32: Next Generation Sequencing (NGS)
Day 3 Module 33: Human Genome Project

Day 4 Interaction based on the three modules covered
Day 5 Deadline for submitting assignments

Week 12
Day 1 Module 34: Protein structure – Primary
Day 2 Module 35: Protein structure - Secondary
Day 3 Module 36: Protein structure - Tertiary and Quaternary
Day 4 Interaction based on the three modules covered
Day 5 Deadline for submitting assignments

Week 13
Day 1 Module 37: Protein Structure Prediction
Day 2 Module 38: Protein Interaction analysis
Day 3 Module 39: Gene Predication
Day 4 Interaction based on the three modules covered
Day 5 Deadline for submitting assignments

Week 14
Day 1 Module 40: Mapping Populations
Day 2 Interaction based on the module covered
Day 3 Revision
Day 4 End term assessment

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.
5. An Introduction to Computational Systems Biology, By Karthik Raman.
6. An Introduction to Systems Biology, By Uri Alon.

MAJOR-15
ADVANCED ENTOMOLOGY
Code: ZLG0600404 (DSE-II)
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-15
ADVANCED ENTOMOLOGY
Code: ZLG0600404 (DSE-II)
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

ADVANCED 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-15
ANIMAL CELL CULTURE AND GENETIC ENGINEERING
Code: ZLG0600404 (DSE-III)
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-15
ANIMAL CELL CULTURE AND GENETIC ENGINEERING
Code: ZLG0600404 (DSE-III)
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
A. Degree with Honours
B. Degree with Honours & Research

MAJOR-16
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-17
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-18
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-19
EVOLUTION & 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 origin of life on earth

2. Understand the means of natural selection in relation to fitness of individuals and the overall population.

3. Comprehend the sources and factors of evolutionary synthesis

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.

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

THEORY	**Hours**
Unit 1: Evolution (2 credits)	30
1. Origin of life - From chemogeny to biogeny, Experimental evidences, RNA world 2. Evolutionary perspectives – Pre-Darwinian concepts, Darwinism vs Neo-Darwinism 3. Paleontological evidences of evolution, Geological timescale 4. Natural selection – concept of fitness, selection coefficient, kin selection, sexual selection 5. 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 6. Evolution of Horse	
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.	

EVOLUTION & MICROBIOLOGY

PRACTICALS	**Hours**
1. Study of fossils from models/pictures 2. Study of homology and analogy from suitable specimens/models	30

3. Study and verification of Hardy-Weinberg Law by Chi-square analysis
4. Preparation and study of whole mount of ciliates.
5. Demonstration on techniques of isolation of bacteria and preparation of pure culture.
6. Bacterial colony count.
7. Gram staining and identification of bacteria.

Suggested Readings:

1. Hall B.K. & Hallgrimsson B. (2013). Strickberger's Evolution. 5th Edition, Jones and Bartlett Publishers, Inc.
2. Futuyama, D. J. (2017). Evolution. 4th Edition, Sinauer Associates
3. Ridley, M. (2020). Evolution. 2nd edition (South Asia Edition), Oxford University Press.
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-20
RESEARCH METHODOLOGY IN NATURAL SCIENCES
Code: ZLG0700504
Credit: 03 (Theory) + 01 (Practical)

TO BE ADOPTED FROM SWAYAM

By Prof. Soumitro Banerjee; IISER Kolkata

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

Course layout

Week 1: Philosophy of Science (subjective versus objective, materialism versus idealism, causality, etc.)
Week 2: Logical Reasoning (inductive logic, deductive logic, syllogistic logic)
Week 3: History of development of science and the influence of philosophy
Week 4: What Scientists Actually Do
Week 5: Forming a Hypothesis
Week 6: Techniques of Scientific Measurement
Week 7: Testing of hypothesis
Week 8: Methods of Theoretical Research
Week 9: The Art of Scientific Communication
Week 10: Presentation in Seminars and Conferences
Week 11: Sponsored Research
Week 12: Ethical Conduct in Science

RESEARCH METHODOLOGY IN NATURAL SCIENCES Code: ZLG0700504 Practical: 01 credit	
PRACTICALS	**Hours**
1. Research problem identification logform 2. Project proposal writing, presentation and submission 3. Statistical tools for Hypothesis testing	30

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.

FOURTH YEAR: SEMESTER VIII

Only for
A. Degree with Honours

MAJOR-21
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. 1. Theoretical aspects of sequence analysis. Needleman-Wunsch and Smith-Waterman methods of global and local alignments for a pair of sequences. 2. Computational tools and methods for prediction of protein secondary and tertiary structures. Description of machine learning methods for secondary structures. 3. Homology modelling, fold recognition and ab initio methods for tertiary structure prediction. 4. Introduction to Bioinformatics approaches in drug discovery. Application of Molecular docking and Pharmacokinetics studies. 5. 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 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.	30

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-22
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-23
DATA ANALYSIS FOR BIOLOGISTS
Code: ZLG0800304
Credit: 4

TO BE ADOPTED FROM SWAYAM

By Prof. Biplab Bose; IIT Guwahati

Analysis of data is an integral part of biology, both in academic research and the industry. With the advent of high-throughput techniques, biological data analysis has crossed the realm of classical statistical techniques and now involves techniques used by the wider data analytic and machine learning community. It is now expected that every biology student is acquainted with the key concepts and tools of data analysis. This course is designed specifically for biology students to learn the key concepts, applications, and limitations of commonly used data analysis techniques. This course emphasizes visualization and analysis of higher-dimensional data, like clustering, classification, and dimensionality reduction.

DATA ANALYSIS FOR BIOLOGISTS
Code: ZLG0800304
Credit: 2 (T)

THEORY	**Hours**
Course layout	60

Week 1: Basic concepts of probability and statistics
Week 2: Basic concepts of linear algebra
Week 3: Basics of R
Week 4: Data visualization
Week 5: Correlation and regression
Week 6: Clustering and classification, Correlation and regression
Week 7: Clustering and classification
Week 8: Analysis of higher-dimensional data

DATA ANALYSIS FOR BIOLOGISTS
Code: ZLG0800304
Credit: 02

PRACTICAL	**Hours**
1. Data visualisation in R	30
2. Hypothesis testing using R	
3. Correlation and regression using R functions	
4. PCA, NMDS analyses on biological data	
5. Preparation of a R script and submission of a statistical analysis	

MAJOR-24
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: 3(T) + (P)

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.

MAJOR-25

MINI PROJECT AND SEMINAR PRESENTATION

Code: ZLG0800504

Credit: 4

MINI PROJECT WITH SEMINAR PRESENTATION

FOURTH YEAR: SEMESTER VIII

Only for
B. Degree with Honours & Research

Major-21 **RESEARCH/DISSERTATION** **Code: ZLG0800104** **Credit: 16**
Major-22 **Seminar presentation based on dissertation** **Code: ZLG0800204** **Credit: 4**

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GENERAL CURRICULAR STRUCTURE OF THE MINOR PAPERS TO BE OPTED BY A STUDENT DURING THE FIRST 3 YEARS OF FYUGP UNDER GAUHATI UNIVERSITY

"MINOR" courses to be opted by a student in the period of 03 years = 06

Semester-1			Semester-2		
Type	**Course**	**Credit**	**Type**	**Course**	**Credit**
Major	Major-1	4	Major	Major-2	4
Minor	Minor-1	4	Minor	Minor-2	4
SEC	SEC-1 (Major oriented)*	3	SEC	SEC-2 (Major oriented)*	3
AEC	AEC-1	4	AEC	AEC-2	4
MDC	MDC-1	3	MDC	MDC-2	3
VAC	VAC-1	2	VAC	VAC-2	2
TOTAL		**20**	**TOTAL**		**20**

Semester-3			Semester-4		
Type	**Course**	**Credit**	**Type**	**Course**	**Credit**
Major	Major-3	4	Major	Major-5	4
	Major-4	4		Major-6	4
Minor	Minor-3	4		Major-7	4
SEC	SEC-3 #	3		Major-8	4
MDC	MDC-3	3	Minor	Minor-4	4
VAC	VAC-3	2			
TOTAL		**20**	**TOTAL**		**20**

Semester-5			Semester-6		
Type	**Course**	**Credit**	**Type**	**Course**	**Credit**
Major	Major-9	4	Major	Major-12	4
	Major-10	4		Major-13	4
	Major-11	4		Major-14	4
Minor	Minor-5	4		Major-15	4
Internship		4	Minor	Minor-6	4
TOTAL		**20**	**TOTAL**		**20**

NOTE
Boxes indicate the number of MINOR courses for <u>ONE SUBJECT as MINOR</u> per Semester

E.g.
Here, Minor-1, Minor-2, etc… indicates Zoology taken as a MINOR SUBJECT

COURSE STRUCTURE OF THE FIRST THREE YEARS OF FYUGP WITH ZOOLOGY AS ONE OF THE MINOR SUBJECTS

Semester	Course Name	Code	Credit
1	**Minor-1 (Same as Major-1***)** Diversity of Non-chordates	ZLG0100104	3
	Practical		1
2	**Minor-2 (Same as Major-2***)** Diversity of Chordates	ZLG0200104	3
	Practical		1
3	**Minor-3 (Same as Major-3***)** Principles of Genetics	ZLG0300104	3
	Practical		1
4	**Minor-4 (Same as Major-5***)** Animal Taxonomy, Systematics & Biostatistics	ZLG0400104	3
	Practical		1
5	**Minor-5 (Same as Major-9***)** Cell Biology	ZLG0500104	3
	Practical		1
6	**Minor-6 (Same as Major-12***)** Wildlife Conservation & Management	ZLG0600104	3
	Practical		1

*****Note:**

The content of Syllabus of the above-mentioned Minor papers is same with the Major courses mentioned in parentheses

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