Darrang College (Autonomous), Tezpur-784001

Syllabus

Two year Post Graduate course

(As per National Education Policy, 2020)

Subject: Zoology

Approved by:

Board of Studies meeting held on 18/06/2026

&

Academic Council vide Resolution no. DC/AC/3/2026/06 dated 29th June 2026

Effective from the Academic Session 2026-27

POSTGRADUATE PROGRAMME IN ZOOLOGY
Darrang College (Autonomous)

Introduction:

The Postgraduate Programme in Zoology at Darrang College (Autonomous) has been thoughtfully designed in accordance with the vision and objectives of the National Education Policy (NEP) 2020, which encourages holistic, flexible and research-oriented higher education. The programme aims to create an academic environment where students not only gain advanced knowledge in Zoology but also develop scientific curiosity, critical thinking, ethical values and a deeper understanding of the living world.

This two-year Master's Degree Programme aims to provide students with a strong conceptual foundation along with practical exposure, research experience and interdisciplinary learning opportunities. The curriculum has been structured in a learner-friendly manner to encourage analytical thinking, innovation, environmental awareness and the application of scientific knowledge to real-life biological and ecological issues.

Keeping in view the academic flexibility promoted by NEP 2020, the programme also includes a lateral entry facility for students who have completed the Four-Year Undergraduate Programme (FYUGP) in Zoology from Darrang College (Autonomous). This ensures a smooth academic transition and enables students to continue their higher studies within an integrated educational framework.

The programme offers specialization in three important and emerging areas of Zoology — Animal Ecology and Wildlife Biology, Cell and Molecular Biology, and Fish Biology and Fishery Science. These specializations allow students to pursue their individual academic interests while gaining in-depth knowledge and practical expertise in their chosen field. The third semester is dedicated to specialization-specific advanced papers, helping students strengthen their subject expertise and technical understanding. The fourth semester is primarily focused on research work, where students undertake dissertation-based studies, field investigations and laboratory research to develop independent research skills and scientific aptitude.

The curriculum combines classroom learning with laboratory training, field-based activities, seminars, project work and continuous assessment methods to ensure all-round academic growth. Equal emphasis has been given to skill enhancement, communication abilities, scientific writing and ethical responsibility so that students are well prepared for careers in research, higher education, environmental management, fisheries, wildlife conservation and other allied sectors.

Through this programme, Darrang College (Autonomous) reaffirms its commitment to academic excellence, innovation and meaningful research, while nurturing responsible and competent learners capable of contributing positively to science, society and sustainable development.

Aims of the Postgraduate Programme in Zoology:

The Postgraduate Programme in Zoology is designed with the following core objectives:

1. To provide students with advanced and in-depth knowledge of Zoology, with special emphasis on Animal Ecology and Wildlife Biology, Cell and Molecular Biology, and Fish Biology and Fishery Science, while also strengthening their understanding of related areas such as Physiology, Genetics, Immunology and Environmental Biology.
2. To develop scientific thinking, critical analysis and problem-solving abilities so that students can understand and address biological and environmental challenges with confidence, creativity and responsibility.
3. To encourage learning through practical experiences including laboratory work, field studies, seminars and research activities, helping students build technical skills, curiosity and independent thinking.
4. To promote interdisciplinary learning in the spirit of NEP 2020 by creating meaningful connections between Zoology and allied subjects such as Environmental Science, Chemistry, Physics, Computational studies and other emerging areas of science.
5. To strengthen communication skills, scientific writing and ethical awareness, enabling students to express scientific ideas clearly and apply their knowledge responsibly for the benefit of society and the environment.
6. To prepare students for diverse career opportunities in higher education, research, teaching, fisheries, wildlife and environmental sectors, public service and other professional fields through specialized academic training and skill development.
7. To nurture a spirit of lifelong learning, intellectual curiosity and social responsibility, encouraging students to become thoughtful individuals who can contribute positively to science, society and sustainable development.
8. To provide opportunities for advanced specialization and research through specialization-specific courses in the third semester and dissertation-based research work in the fourth semester, thereby helping students gain deeper expertise and research experience in their chosen field.

Through these objectives, the Postgraduate Programme in Zoology at Darrang College (Autonomous) aims to shape knowledgeable, skilled and socially responsible graduates who are capable of contributing meaningfully to scientific advancement, environmental conservation and the welfare of society.

Programme Outcome (PO) of PG course in Zoology:

Programme Outcomes (POs)

After successful completion of the Postgraduate Programme in Zoology, students will be able to:

- **PO1:** Demonstrate advanced understanding of core and applied areas of Zoology such as Immunology, Molecular Cytogenetics, Cell Culture, Bioinformatics, Biostatistics, Biochemistry, Integrative Physiology and Developmental Biology.
- **PO2:** Apply laboratory techniques, biological instrumentation, computational tools and field-based methods for scientific investigation, data analysis and interpretation in diverse areas of biological sciences.
- **PO3:** Develop specialization-specific knowledge and practical competence in Cell and Molecular Biology, Ecology and Wildlife Biology, or Fish Biology and Fishery Science through advanced coursework, practical training and field exposure
- **PO4:** Conduct independent research through dissertation work, internships, project-based studies and scientific investigations while developing scientific temperament, analytical thinking and problem-solving abilities.
- **PO5:** Integrate interdisciplinary approaches in understanding biological systems, environmental challenges, wildlife conservation, fishery resources and molecular aspects of life sciences.
- **PO6:** Demonstrate awareness of scientific ethics, publication ethics, intellectual property rights (IPR) and responsible research practices necessary for academic and professional careers.
- **PO7:** Communicate scientific ideas effectively through scientific writing, seminars, presentations and collaborative academic activities.
- **PO8:** Become skilled, socially responsible and environmentally conscious professionals prepared for higher studies, research, teaching, fisheries, wildlife and environmental sectors, and other allied fields of biological sciences.

Teaching-Learning Process:

The Two-Year Postgraduate Programme in Zoology adopts a diverse range of pedagogical methods to enhance student engagement and understanding, both in classroom settings and laboratory environments. These include:

- Traditional lectures
- Tutorials for concept clarification
- PowerPoint presentations for visual learning
- Project work and dissertations to encourage independent research
- Participation in seminars, workshops, and conferences for academic exposure
- Industry visits and field trips to connect theoretical knowledge with real-world applications.

Teaching-Learning Tools:

To support effective delivery of the curriculum, a variety of instructional tools are utilized:

- Whiteboard/Green board/Blackboard
- LCD projectors and monitors
- Smart boards for interactive teaching
- Demonstration models
- Laboratory experiments to reinforce practical learning
- Industry and field visits for experiential learning.

Assessment Methods:

Student progress is continuously evaluated through a combination of formative and summative assessment techniques, including:

- Home assignments
- Reports based on projects, industry visits, or fieldwork
- Seminar presentations and group discussions to develop communication skills
- In-semester/Sessional examinations (both theory and practical)
- End-semester examinations (theory and practical)

CURRICULUM COMPONENTS:

Distribution of Credits in Two years

COURSE STRUCTURE OF Post Graduate Programme in ZOOLOGY

Semester	Course Name	Code	Credit
SEMESTER -1			
1	Paper 1 **Immunology**	**ZOO-1-DSC-4014 (Level-400)**	**3**
	Practical		**1**
	Paper 2 **Molecular Cytogenetics & Cell Culture**	**ZOO-1-DSC-4024 (Level-400)**	**3**
	Practical		**1**
	Paper 3 **Integrative Physiology**	**ZOO-1-DSC-4034 (Level-400)**	**3**
	Practical		**1**
	Paper 4/ DSE-1 **Applied Zoology**	**ZOO-1-DSE-4044 (Level-400)**	**3**
	Practical		
	Paper 4/ DSE-2 **Environmental Biology & Climate Change**		
	Practical		**1**
	Paper 5 ****Research Methodology**	**ZOO-1-FSC-4054 (Level-400)**	**3**
	Practical		**1**
SEMESTER -2			
2	Paper 1 **Advanced Biochemistry**	**ZOO-2-DSC-5014 (Level-500)**	**3**
	Practical		**1**
	Paper 2 **Bioinformatics and Biostatistics**	**ZOO-2-DSC-5024 (Level-500)**	**3**
	Practical		**1**
	Paper 3 **Advanced Developmental Biology**	**ZOO-2-DSC-5034 (Level-500)**	**3**
	Practical		**1**
	Paper 4/ DSE-1 **Aquaculture & Fish Biology** **ZOO-2-DSE-5044 (A)**	**ZOO-2-DSE-5044 (Level-500)**	**3**
	Practical		
	Paper 4/DSE-2 **Membrane Biology** **ZOO-2-DSE-5044 (B)**		

	Practical		
	Paper 4/DSE-3 **Wildlife Biology and Ornithology** **ZOO-2-DSE-5044 (C)**		
	Practical		**1**
	Paper 5 **Biological Techniques**	**ZOO-2-FSC-5054 (Level-500)**	**3**
	Practical		**1**
SEMESTER -3			
SPECIALIZATION: CELL & MOLECULAR BIOLOGY			
3	Paper 1 **Genomics and Proteomics**	**ZOO-CM-3-DSC-5064 (Level-500)**	**3**
	Practical		**1**
	Paper 2 **Advanced Immunology**	**ZOO-CM-3-DSC-5074 (Level-500)**	**3**
	Practical		**1**
	Paper 3 **Molecular Basis of Human Disease**	**ZOO-CM-3-DSC-5084 (Level-500)**	**3**
	Practical		**1**
	Paper 4 **Genetic Engineering and Recombinant DNA Technology**	**ZOO-3-DSC-5094 (Level-500)**	**3**
	Practical		**1**
	Paper 5/DSE-1 **Cell and Molecular Biology** (To be adopted from SWAYAM)	**ZOO-CM-3-DSE-5104A (Level-500)**	**3**
	Practical		**1**
	Paper 5/DSE-2 **Wildlife Management Practices**	**ZOO-EW-3-DSE-5104B (Level-500)**	
	Practical		
	Paper 5/DSE-3 **Advanced Aquaculture Technology** (To be adopted from SWAYAM)	**ZOO-FB-3-DSE-5104C (Level-500)**	
	Practical	**(Refer to annexure)**	
SPECIALIZATION: ECOLOGY & WILDLIFE BIOLOGY			
	Paper 1 **Ecosystem Functions and Stability**	**ZOO-EW-3-DSC-5064 (Level-500)**	**3**

	Practical		**1**
	Paper 2 **Wildlife & Wildlife Habitat Relations**	**ZOO-EW-3-DSC-5074** **(Level-500)**	**3**
	Practical		**1**
	Paper 3 **Wildlife Population Ecology & Methods**	**ZOO-EW-3-DSC-5084** **(Level-500)**	**3**
	Practical		**1**
	Paper 4 **Wildlife Conservation**	**ZOO-EW-3-DSC-5094** **(Level-500)**	**3**
	Practical		**1**
	Paper 5/DSE-1 **Cell and Molecular Biology** (To be adopted from SWAYAM)	**ZOO-CM-3-DSE-5104A** **(Level-500)**	**3**
	Practical	**ZOO-EW-3-DSE-5104B** **(Level-500)** **ZOO-FB-3-DSE-5104C** **(Level-500)** **(Refer to annexure**	**1**
	Paper 5/DSE-2 **Wildlife Management Practices**		
	Practical		
	Paper 5/DSE-3 **Advanced Aquaculture Technology** (To be adopted from SWAYAM)		
	Practical		
SPECIALIZATION: FISH BIOLOGY & FISHERY SCIENCE			
	Paper 1 **Systematics of Finfish**	**ZOO-FB-3-DSC-5064** **(Level-500)**	**3**
	Practical		**1**
	Paper 2 **Physiology of Finfish**	**ZOO-FB -3-DSC-5074** **(Level-500)**	**3**
	Practical		**1**
	Paper 3 **Fisheries Science**	**ZOO-FB -3-DSC-5084** **(Level-500)**	**3**
	Practical		**1**
	Paper 4 **Fish Disease and Health Management**	**ZOO-FB-3-DSC-5094** **(Level-500)**	**3**
	Practical		**1**
	Paper 5/DSE-1 **Cell and Molecular Biology** (To be adopted from SWAYAM)	**ZOO-CM-3-DSE-5104A** **(Level-500)**	**3**
	Practical		**1**

	Paper 5/DSE-2 **Wildlife Management Practices**	**ZOO-EW-3-DSE-5104B (Level-500)** **ZOO-FB-3-DSE-5104C (Level-500)** **(Refer to annexure)**	
	Practical		
	Paper 5/DSE-3 **Advanced Aquaculture Technology** (To be adopted from SWAYAM)		
	Practical		
SEMESTER -4			
4	**Paper 1: DISSERTATION (with 3 components)**	**ZOO-4-PRJ-511-16 (Level-500)**	**16**
	(i) Component 1: Dissertation/Thesis		
	(ii) Component 2: Viva Voce		
	(iii) **Component 3: Internship/ Field work**		
	Paper 2- Advanced Elective – SCIENTIFIC WRITING, PUBLICATION ETHICS & IPR	**ZOO-4-DSE-5124 (Level-500)**	**3**
	Practical		**1**

**** To be adopted from SWAYAM-based online credit course (Research Methodology and IPR by** Dr. G. Janardhanan, Professor, NITTTR Chennai)

Detailed Syllabus of 1st Semester

Semester	Course Name	Code	Credit
I	Paper 1 **Immunology**	**ZOO-1-DSC-4014**	3
	Practical		1
	Paper 2 **Molecular Cytogenetics & Cell Culture**	**ZOO-1-DSC-4024**	3
	Practical		1
	Paper 3 **Integrative Physiology**	**ZOO-1-DSC-4034**	3
	Practical		1
	Paper 4/ DSE-1 **Applied Zoology**	**ZOO-1-DSE-4044**	3
	Practical		
	Paper 4/ DSE-2 **Environmental Biology & Climate Change**		
	Practical		1
	Paper 5 **Research Methodology	**ZOO-1-FSC-4054**	3
	Practical		1

Title of the Course	**Paper -1/ IMMUNOLOGY**
Paper Code	**ZOO-1-DSC-4014**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]
Course Outcomes	By the end of this course/module, students will be able to: ▪ **CO1:** Describe the cells, organs and fundamental mechanisms of innate and adaptive immunity. ▪ **CO2:** Explain antigen recognition, MHC presentation, immunoglobulin structure and antigen–antibody interactions. ▪ **CO3:** Distinguish humoral and cell-mediated responses, T-cell subsets and cooperative immune mechanisms. ▪ **CO4:** Understand immunological disorders, types of vaccines, immunization strategies and traditional immune-boosting practices. • **CO5:** Perform basic immunological techniques including blood

	grouping, WBC counts, ELISA, immunoelectrophoresis and lymphoid organ studies.
Contact hours	**45 (Theory) + 30 (Practical)**

Paper –1/ IMMUNOLOGY
CODE- ZOO-1-DSC-4014
Credit: 3 (T) + 1 (P)

THEORY **Credit- 3/ Hours- 45**

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	▪ Introduction to immune System, Cells of the immune system: Types of cells and their subsets responsible for immune response- WBC, macrophages, dendritic cells, B, T and NK cells ▪ Innate and acquired immunity – components and characteristic features, primary and secondary responses ▪ Humoral immunity/Cell-mediated immunity, T cell subtypes ▪ Basic concept of B and T cell antigen receptors and CD markers, Cell cooperation in immune response ▪ Lymphoid organs – primary and secondary lymphoid organs and their functions, their micro and macro structures, vascular and lymphatic connections. ▪ Major histocompatibility complex, Antigen presentation, APCs	**20**	**04**		**24**
2	▪ **Immunoglobulins:** Structure domain of Immunoglobulin; Ig classes, subclasses and types. Types and functions of immunoglobulin. ▪ **Antigen-antibody reaction**: antibody affinity and avidity cross reactivity, agglutination reaction, precipitation reaction. Myelema protein, monoclonal antibody, Ig superfamily ▪ **Immunological disorder**: Basic concept of Hypersensitivity, Autoimmunity and Immunodeficiency ▪ **Immuno-boosters**: Various types of Vaccines. Active and Passive immunization. Vaccine production, Ancient Indian herbal remedies to enrich immunity	**18**	**03**	**--**	**21**

PRACTICALS				Credit- 1/ Hours- 30
1. Dissection and study of the Lymphoid organs 2. Histological study of spleen, thymus, Payer's patch and lymph nodes through slides/ microphotographs. 3. Differential WBC count in mammalian blood 4. Demonstration of ELISA and Immunoelectrophoresis 5. Submission of report on different infectious diseases and the immunoassays used to diagnose them.	--	--	30	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.

Title of the Course	**Paper-2/MOLECULAR CYTOGENETICS & CELL CULTURE**
Paper Code	**ZOO-1-DSC-4024**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]
Course Outcomes	By the end of this course/module, students will be able to: • **CO1:** Define chromatin and its role in DNA packaging. • **CO2:** Understand the variations in the chromosomal number with the particular genetic disorder. • **CO3:** Learn to locate the probable position of genes with the banding techniques and also appreciate the role of linkages and crossing over in genetic variation in successive generations and hence evolution. • **CO4:** Interpret karyotypes, chromosomal abnormalities and molecular markers used in cytogenetic analysis. • **CO5:** Define basic cell culture techniques and key concepts used in culture of animal cells.

Contact hours	**45 (Theory) + 30 (Practical)**

Paper-2/ MOLECULAR CYTOGENETICS & CELL CULTURE
CODE- ZOO-1-DSC-4024
Credit: 3 (T) + 1 (P)

THEORY **Credit- 3/ Hours- 45**

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	**Principles of Cytogenetics** ▪ Historical development of cytogenetics, Relationship between genetics, cytogenetics and cytogenomics. ▪ Chromatin structure and chromosome organization, packaging of DNA in chromatin, histones and non-histone proteins, nucleosome and higher-level organization. ▪ Metaphase chromosome, centromere and kinetochore, structure and functions of telomere ▪ Holocentric and supernumerary chromosomes, chromosomal domains (matrix, loop domains) and their functional significance, heterochromatin and euchromatin. ▪ Functional states of chromatin and alterations in chromatin organization, structural and functional organization of interphase nucleus.	**10**	**02**	**--**	**12**
2	**Molecular Cytogenetics Techniques** ▪ Karyotyping: Classic karyotype, Spectral karyotype (SKY technique), digital karyotyping ▪ Karyotype Analysis of autosomal and sex chromosomal abnormalities ▪ Types of chromosome banding, Principles and applications of Fluorescence in-situ hybridization (FISH) and Comparative genomic hybridization (CGH). ▪ Manual identification of GTG bands, Identification using computerized image analyzer	**08**	**02**	**--**	**10**
	Clinical Cytogenetics ▪ Cytogenetic effects of ionizing and nonionizing radiations ▪ Environmental and genetic factors affecting the frequency of crossing over, Recombination and its effect during reproduction ▪ Genome instability and its role in cancer, Chromosomal anomalies in malignancy (Chronic myeloid leukaemia, Burkitt's lymphoma, Retinoblastoma and Wilm's tumor).	**10**	**02**	**--**	**12**

▪ Cytogenetic and linkage maps, Two- and three-point cross in Drosophila;RFLP mapping ▪ Genetic counselling and Prenatal diagnosis.				
Cell Culture ▪ Basic requirement of animal cell culture, Cell culture media: types and applications ▪ Basic techniques of cell culture, Types of cell culture, Development of primary cell cultures: cell separation, harvesting and maintenance of cell lines; ▪ Transformation and differentiation of cell cultures ▪ Measurement of viability and parameters of growth, Cell cycle synchronization of cultures, Safety parameters ▪ Cell culture Bioassays: Cell proliferation assays	**10**	**01**	**--**	**11**
PRACTICALS			**Credit- 1/ Hours- 30**	
1. Preparation and study of metaphase chromosomes from mouse bone marrow/fish. 2. C- and G-banding from metaphase chromosomal spread. 3. Identification of abnormality from given karyotype/ slide. 4. Preparation of human karyotype and study of chromosomal aberrations with respect to number, translocation, deletion etc., from the pictures provided. 5. Sister Chromatid Exchange (SCE) assay - for genotoxicity 6. Construction of Linkage maps 7. Demonstration of telomere and centromere using FISH technology. 8. MTT cell proliferation assay, cell viability assay. 9. Visit to advanced cytogenetic/Animal cell culture laboratory.	**--**	**--**	**30**	**30**

Suggested Readings:

1. Principle of Genome Analysis and Genomics, Primrose, S. B. and Twyman R. M., (7th Ed., 2006), Blackwell Publishing Company, Malden, USA
2. Genomes 3, Brown, T. A., Garland Science Publishing, London, UK
3. Genes VIII by Benjamin Lewis
4. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). Molecular Biology of the Cell (6th ed.). Garland Science.
5. Rooney, D. E., & Czepulkowski, B. H. (2013). Human Cytogenetics: Constitutional Analysis (4th ed.). Oxford University Press.
6. Lewin, B., Krebs, J. E., & Goldstein, E. S. (2000). Genes IX. Jones and Bartlett Publishers.
7. Vogel, F., & Motulsky, A. G. (2010). Human Genetics: Problems and Approaches (4th ed.). Springer Science & Business Media.
8. Cultures of animal cell. R. Freshny
9. Basic cell culture protocol. Cheryl D. Helgason
10. Animal cell culture essential methods. John M. Davis

Title of the Course	Paper-3 / INTEGRATIVE PHYSIOLOGY
Paper Code	**ZOO-1-DSC-4034**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]
Course Outcomes	By the end of this course/module, students will be able to: ▪ **CO1:** Explain how diverse organ systems communicate with each other through molecular and cellular pathways to maintain **homeostasis**. ▪ **CO2:** Understand the dynamic integration of physiological systems in both health and disease states. ▪ **CO3**: Analyze the strategies of body adaption to internal and external stressors, such as **exercise**, biological rhythms, and extreme environmental conditions. ▪ **CO4**: Evaluate impact of lifestyle, stress, and aging on different physiological system. ▪ **CO5:** Create a deep molecular – to – systemic understanding of human physiological systems and their functions.
Contact hours	**45 (Theory) + 30 (Practical)**

Paper-2/ INTEGRATIVE PHYSIOLOGY
CODE- ZOO-2-DSC-4034
Credit: 3 (T) + 1 (P)

THEORY **Credit- 3/ Hours- 45**

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	• **System as a basic unit in physiology:** Different systems in physiological process, interaction of different systems in normal and stress conditions • **Body Fluid:** Blood, Lymph, and Hemolymph; Blood homeostasis and its abnormality; Lymphatic flow and pump; Interstitial fluid: its pressure regulation, fluid dynamics, Edema. • **Cardiovascular system**: Generation and conduction of cardiac impulse, neuro-hormonal regulation of cardiac amplitude and frequency, Cardiac failure, Microcirculation and peripheral circulation, Regulation of circulation in special situation: hemorrhage, exercise	**09**	**02**	**--**	**11**

2	• **Respiratory system:** Pulmonary ventilation, alveolar ventilation. Respiratory centres: organization and function. Respiratory adjustments- Hypoxia and oxygen therapy, Dyspnea, Hypercapnia. High altitude: decreased pressure of gas, hypoxic effects, mountain sickness and acclimatization. • **Excretory system:** RAAS and hormonal regulation of urine formation. Role of Kidney in the regulation of ionic, osmotic, acid and base balance of the body fluid, control of extracellular fluid volume, blood pressure, Homeostasis. • **Gastrointestinal System:** Chemical nature and functions of Gastro intestinal hormones and digestive enzymes. Regulation of digestion and absorption (neural/hormonal), Physiology of gastrointestinal disorders	**10**	**02**	**--**	**12**
3	• **Nervous system:** Types of synapses and synaptic knobs, Axonal transmission. Membrane potential and generation of action potential. Neuromuscular junction; Excitatory and inhibitory post-synaptic potential, Chemical transmission, neurotransmitters (acetylcholine, or catecholamines, serotonin and GABA), Autonomic nervous system (Sympathetic and parasympathetic) Neuropathology: Strokes, Epilepsy, Alzheimer disease, Huntington disease and Parkinson disease. • **Special sensory system**: Eye: Anatomical Organisation of retina, Photoreceptors: Processing of visual impulses Ear: Cochlea, basilar membrane, and organ of Corti. Generation of endochochlear potential. Processing of auditory impulses.	**09**	**02**	**--**	**11**
4	• **Muscle**: Ultrastructure of skeletal muscles, Properties of muscle: muscle twitch, summation, tetanus and fatigue, Sliding filament theory of muscle contraction and regulation. Smooth & Cardiac muscle physiology, Muscular dystrophy. • **Environmental Physiology**: Physiology of hot environment, Physiology of cold environment, Aviation physiology, Deep-sea diving & hyperbaric conditions. Space physiology, Physiological requirement of space travel. • **Environment and health** Nutrition and diet, Physical activity, metabolic benefits and behavioural strategies; Sleep hygiene, circadian rhythm and metabolic health; Stress, cortisol, and metabolic implications; Environmental risk factors: pollution, endocrine-disrupting chemicals (EDCs)	**09**	**02**	**--**	**11**

PRACTICALS				Credit- 1/ Hours- 30
1. Detection of uric acid in malpighian tubules. 2. Hemocyte count and estimation of protein in hemolymph. 3. Determination of bleeding time and clotting time 4. Total RBC and WBC count in human blood. 5. Determination of Erythrocyte sedimentation rate (ESR) in blood sample 6. Determination of pulse rate and heart rate 7. Measuring of blood pressure using sphygmomanometer 8. Study of lung volumes and capacities by Spirometry; Comparison of normal physiological and one pathological condition. 9. Recording of blood glucose level by using glucometer 10. Recording of simple muscle twitch with electrical stimulation (or Virtual lab)	--	--	30	30

Suggested Readings:

1. Cox, M.M and Nelson, D.L. (2008). Lehninger Principles of Biochemistry, V Edition, W.H. Freeman and Co., NewYork.
2. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. /W.B. Saunders Company.
3. Christopher D. Moyes, Patricia M. Schulte. Principles of Animal Physiology. 3rd Edition, Pearson Education (2016). Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons
4. Kesar, Saroj and Vashishta N. (2007). Experimental Physiology: Comprehensive Manual. Heritage Publishers, New Delhi
5. Hill, Richard W., et al. Animal physiology. Vol. 2. Sunderland, MA: Sinauer Associates, (2004).
6. Chatterjee C C Human Physiology Volume 1 & 2. 11th edition. CBS Publishers (2016).

Title of the Course	**Paper–4/ APPLIED ZOOLOGY**
Paper Code	**ZOO-1-DSE-4044**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]

Course Outcomes	By the end of this course/module, students will be able to: • **CO1:** Understand the concepts of ethnozoology and IKS and recognize traditional animal-based practices of India and Assam. • **CO2:** Describe the biology, rearing and economic importance of Muga and Eri silkworms in Assam's sericulture sector. • **CO3:** Explain the biology and management of honey bees and apply basic techniques of sustainable apiculture. • **CO4:** Understand the cultivation, processing and economic value of lac and pearls, with emphasis on Assam's potential. • **CO5:** Apply basic principles of poultry and dairy management and perform essential field/practical skills related to applied zoology.
Contact hours	**45 (Theory) + 30 (Practical)**

Paper-4/ APPLIED ZOOLOGY
CODE- ZOO-1-DSE-4044
Credit: 3 (T) + 1 (P)

THEORY **Credit- 3/ Hours- 45**

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	**Ethnozoology & Indian Knowledge Systems (IKS)** Concept, scope and relevance of ethnobiology and ethnozoology. Traditional animal-based practices in India and Assam: Indigenous knowledge of Muga/Eri rearing, Traditional beekeeping. Folk medicinal uses of animal products. Aquatic resource use in local communities. Documentation methods: field interviews, participatory observation, ethical considerations, benefit-sharing. Role of ethnozoology in biodiversity conservation, livelihood sustenance and cultural preservation.	**06**	**01**	**--**	**07**
2	**Sericulture (with special focus on Muga & Eri)** History, scope and economic importance of sericulture in India and Assam. Classification and biology of silkworms: *Antheraea assamensis* (Muga) and *Samia ricini* (Eri). Host plants of silkworms. Rearing methods: outdoor rearing for Muga, indoor/outdoor for Eri; grainage techniques; disease management. Post-cocoon technology: cocoon processing, reeling, spinning, weaving; special focus on Muga/Eri enterprises and GI tag. Sericulture-based rural livelihoods in Assam	**07**	**01**	**--**	**08**
	Apiculture (Beekeeping) Introduction, significance and commercial potential of apiculture in India. Types of honey bees: *Apis cerana indica*, *Apis mellifera*, *Apis dorsata*. Bee biology: caste system, communication, foraging behaviour, pollination.	**07**	**01**	**--**	**08**

3	Beekeeping equipment: indigenous vs modern hives; colony management; seasonal management. Bee diseases, pests and their control. Honey extraction, wax processing, value-added hive products; Assam-specific floral resources and beekeeping potential.				
4	**Lac Culture** Biology and taxonomy of lac insect (*Kerria lacca*). Host plants and lac strains; life cycle and lac secretion process. Cultivation practices: inoculation, pruning, crop management and harvesting. Lac processing: seedlac, shellac and value-added products. Economic importance and prospects of lac culture as a cottage industry in NE India.	**06**	**01**	**--**	**07**
5	**Pearl Culture (Freshwater & Marine)** Introduction to pearls: natural and cultured pearls; economic significance. Biology of pearl-producing molluscs: marine oysters and freshwater mussels (including species found in NE India). Site selection and environmental requirements. Techniques of pearl culture: grafting, nucleation, implantation methods; husbandry practices. Pearl quality, harvesting, grading and marketing; potential for freshwater pearl culture in Assam's ponds/beels.	**07**	**01**	**--**	**08**
6	**Livestock Rearing (Poultry & Dairy)** Role of livestock in Indian and Assamese rural economy. Poultry: breeds, housing, feeding, breeding, incubation, vaccination schedule, disease management; backyard poultry systems used in Assam. Dairy: cattle breeds (Indian, crossbred); feeding and nutrition; housing; health management; artificial insemination basics. Farm management: record keeping, small-scale enterprise planning, government schemes for Assam.	**06**	**01**	**--**	**07**
PRACTICALS				**Credit- 1/ Hours- 30**	
	1. Identification of silkworm species and host plants; cocoon sorting. 2. Demonstration of honey extraction/ hive inspection. 3. Identification of freshwater mussels/oysters; water-quality assessment. 4. Visit to poultry/dairy unit and preparation of farm report. 5. Ethnozoological documentation of one Assamese traditional practice.	**--**	**--**	**30**	**30**

Recommended Readings:

1. Economic Zoology. Shukla and Upadhyay. Rastogi Publications.

2. Textbook of Fish Biology and Fisheries 3rd edn (PB). Khanna S. S. and H. R. Singh. Narendra Publishing House.
3. Sericulture with Special Reference to Assam. Tarali Kalita. Eastern Book House.
4. Ethnozoological Knowledge in Northeast India: Opportunities and Prospects. Kuldip Sarma, Amal Bawri, Imlikumba and Robindra Teron. Northeastern Institute of Ayurvedic and Folk Medicine Research.

Title of the Course	**Paper-4 / ENVIRONMENTAL BIOLOGY & CLIMATE CHANGE**
Paper Code	**ZOO-1-DSE-4044**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]
Course Outcomes	By the end of this course/module, students will be able to: • CO1. Understand environmental pollution and its impact on living organisms. • CO2. Explain climate change processes and atmospheric dynamics. • CO3. Analyze biological responses to climate change. • CO4. Apply basic environmental monitoring and assessment methods. • CO5. Evaluate environmental policies and regional environmental issues.
Contact hours	**45 (Theory) + 30 (Practical)**

Paper-4 / ENVIRONMENTAL BIOLOGY & CLIMATE CHANGE
CODE- ZOO-1-DSE-4044
Credit: 3 (T) + 1 (P)

THEORY **Credit- 3/ Hours- 45**

Unit	**Content**	**Lecture**	**Tutorial**	**Practical**	**Total hours**
1	▪ Environmental pollution: types (air, water, soil, noise) ▪ Sources and effects of pollution on organisms and human health ▪ Bioaccumulation and biomagnification ▪ Pesticides and heavy metals ▪ Emerging pollutants: microplastics, pharmaceuticals ▪ Tea garden pesticide impact in Assam ▪ Water pollution in Brahmaputra river system	**06**	**01**	**--**	**07**
2	▪ Weather and climate: basic concepts ▪ Greenhouse effect and global warming ▪ Carbon cycle	**06**	**02**	**--**	**08**

	▪ Climate variability: monsoon, floods, droughts ▪ Evidence and impacts of climate change ▪ Floods in Brahmaputra basin ▪ Changing rainfall patterns in Northeast India				
3	▪ Effects of climate change on animals ▪ Thermal stress and adaptation ▪ Changes in migration and breeding ▪ Species distribution and extinction risk ▪ Climate-related diseases (vector-borne diseases) ▪ Climate-induced wildlife stress in Kaziranga ▪ Disease spread (malaria/dengue) in Assam	**06**	**02**	**--**	**08**
4	▪ Environmental monitoring: basic concepts ▪ Sampling of air, water, and soil ▪ Bioindicators and biomonitoring ▪ Introduction to GIS and remote sensing ▪ Environmental Impact Assessment (EIA) ▪ Wetland monitoring (Deepor Beel) ▪ Flood mapping in Assam	**05**	**02**	**--**	**07**
5	▪ Sustainable development concept ▪ Climate mitigation and adaptation ▪ Renewable energy (basic idea) ▪ Environmental laws in India ▪ Global agreements (Paris Agreement, SDGs) ▪ Assam State Action Plan on Climate Change ▪ Human–wildlife conflict issues	**06**	**02**	**--**	**08**
6	▪ Climate change and human health ▪ Urban environmental issues ▪ Biodiversity loss and conservation challenges ▪ Nature-based solutions ▪ Role of community and citizen science ▪ Wetland degradation in Assam	**06**	**01**	**--**	**07**
PRACTICALS			**Credit- 1/ Hours- 30**		
	1. Determination of pH of water and soil samples (Using pH paper or simple pH meter) 2. Estimation of Dissolved Oxygen (DO) in water (Winkler's method) 3. Estimation of Biological Oxygen Demand (BOD) (Demonstration or simplified procedure) 4. Determination of turbidity/Total Dissolved Solids (TDS) (Simple field/lab method) 5. Study of aquatic organisms as bioindicators (Plankton/invertebrates indicating pollution levels) 6. Identification of pollution-tolerant and sensitive species (Based on charts/specimens) 7. Field study of a local ecosystem (river/wetland/forest) • Site observation • Environmental issues • Human impact	**--**	**--**	**30**	**30**

8. Analysis of climate data (temperature/rainfall) • Collection of secondary data • Graph preparation and interpretation

Suggested Readings:

1. Cunningham, W., & Cunningham, M. (2014). Environmental science: A global concern (13th ed.). McGraw Hill.
2. Hassenzahl, D. M., Hager, M. C., Gift, N. Y., Berg, L. R., & Raven, P. H. (2018). Environment (10th ed.). Wiley.
3. Odum, E. P., & Barrett, G. W. (2005). Fundamentals of ecology (5th ed.). Thomson Brooks/Cole.
4. Hannah, L. (2021). Climate change biology (3rd ed.). Academic Press.
5. Landis, W., Sofield, R., & Yu, M.-H. (2017). Introduction to environmental toxicology: Molecular substructures to ecological landscapes (5th ed.). CRC Press.
6. De, A. K. (2006). Environmental chemistry (5th ed.). New Age International.
7. Joseph, B. (2005). Environmental studies. McGraw-Hill Education (India) Pvt Limited.

Title of the Course	**Paper –5/ RESEARCH METHODOLOGY IN NATURAL SCIENCES**
Paper Code	**ZOO-1-FSC-4054**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]
Course Outcomes	By the end of this course/module, students will be able to: • **CO1**: Understand the basics of performing research in science • **CO2**: Create and develop the concepts of designing a research plan • **CO3:** Comprehend the important data collection, analyses and report writing • **CO4**: Identify the importance of ethics in research • **CO5**: Develop a formal research proposal (synopsis) including a timeline (Gantt chart) and budget. • **CO6:** Develop skills to write a research report
Contact hours	**45 (Theory) + 30 (Practical)**

OR

TO BE ADOPTED FROM SWAYAM

1. .

OPTION-A

Research Methodology and IPR

(SWAYAM-based online credit course)

Course Coordinator: Dr. G. Janardhanan, Professor, NITTTR Chennai
Course Link: https://onlinecourses.swayam2.ac.in/e-learning/preview/ntr26_ed154

Course outline:

Credits: 3 (Theory)

Module 1: RESEARCH DESIGN

Overview of research process and design, Use of Secondary and exploratory data to answer the research question, Qualitative research, Observation studies, Experiments and Surveys. – Case Studies

Module 2: DATA COLLECTION AND SOURCES

Measurements, Measurement Scales, Questionnaires and Instruments, Sampling and methods. Data - Preparing, Exploring, examining and displaying.

Module 3: DATA ANALYSIS AND REPORTING

Overview of Multivariate analysis, Hypotheses testing and Measures of Association. Presenting Insights and findings using written reports and oral presentation.

Module 4: INTELLECTUAL PROPERTY RIGHTS

Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, utility Models, IPR & Biodiversity, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance.

Module 5: PATENTS

Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filling, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licenses, Licensing of related patents, patent agents, Registration of patent agents.

PRACTICALS (CREDIT- 1)	Hours
1. Research problem identification logform 2. To develop a research plan 3. Project proposal writing, Presentation and submission 4. Statistical tools for Hypothesis testing	**30**

Suggested Readings:

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

OPTION-B:

RESEARCH METHODOLOGY IN NATURAL SCIENCES
Credit: 3 (Theory)

(SWAYAM-based online credit course)
By Prof. Soumitro Banerjee; IISER Kolkata Course

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

PRACTICALS (CREDIT- 1)	Hours
1. Research problem identification logform 2. To develop a research plan 3. Project proposal writing, Presentation and submission 4. 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

Detailed Syllabus of 2nd Semester

Semester	Course Name	Code	Credit
II	Paper 1 **Advanced Biochemistry**	**ZOO-2-DSC-5014**	3
	Practical		1
	Paper 2 **Bioinformatics and Biostatistics**	**ZOO-2-DSC-5024**	3
	Practical		1
	Paper 3 **Advanced Developmental Biology**	**ZOO-2-DSC-5034**	3
	Practical		1
	Paper 4/ DSE-1 **Aquaculture & Fish Biology** **ZOO-2-DSE-5044(A)**	**ZOO-2-DSE-5044**	3
	Practical		
	Paper 4/DSE-2 **Membrane Biology** **ZOO-2-DSE-5044(B)**		
	Practical		
	Paper 4/DSE-3 **Wildlife Biology and Ornithology** **ZOO-2-DSE-5044(C)**		
	Practical		1
	Paper 5 **Biological Techniques**	**ZOO-2-FSC-5054**	3
	Practical		1

Title of the Course	**Paper–1/ ADVANCED BIOCHEMISTRY**
Paper Code	**ZOO-2-DSC-5014**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**

Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]
Course Outcomes	By the end of this course/module, students will be able to: ▪ **CO1:** Explain ATP as an energy currency and describe protein structures, enzyme kinetics and regulatory mechanisms. ▪ **CO2:** Analyze major metabolic pathways, their regulation, energy yield and inter-conversion of biomolecules. ▪ **CO3:** Interpret oxidative phosphorylation, ETS inhibitors, fatty acid metabolism and urea cycle mechanisms. ▪ **CO4:** Apply quantitative biochemical methods for analyzing biomolecules, enzyme parameters and metabolic intermediates. • **CO5:** Perform practical techniques such as biomolecule extraction, biochemical estimations and protein separation using SDS-PAGE.
Contact hours	**45 (Theory) + 30 (Practical)**

Paper –1/ ADVANCED BIOCHEMISTRY
CODE- ZOO-2-DSC-5014
Credit: 3 (T) + 1 (P)

THEORY **Credit- 3/ Hours- 45**

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	▪ **Energy rich compound:** Role of ATP/ADP cycle in transfer of high energy phosphate ▪ Biological oxidation reduction reactions, redox potential, Important respiratory complex of ATP synthesis and oxidative phosphorylation and chemiosmotic hypothesis, Inhibitors and un-couplers of Electron Transport System ▪ **Secondary structure of Protein**: α-helix, β-pleated sheet & bends, Prediction of secondary structure, Ramachandran plot ▪ **Tertiary structure of Protein**: Forces stabilizing tertiary structure, Domains and motifs, Quaternary Structure of proteins. ▪ **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, Random sequential, Ordered, Ping-pong (double reciprocal) mechanism ▪ **Regulation of Enzyme activity**: Allosterism, covalent modifications and regulation by proteolytic cleavage	**21**	**02**	**--**	**23**
2	**Metabolic Pathways, their regulation and Significance**: ▪ Reactions and regulation of: Glycolysis, Citric acid cycle, Phosphate pentose pathway,				

Gluconeogenesis, Glycogenolysis and Glycogenesis, Hexose monophosphate shunt pathway; Metabolism of disaccharides, Hormonal regulation of carbohydrate metabolism. ▪ Synthesis of fatty acids, β-oxidation and omega-oxidation of saturated fatty acids with even and odd number of carbon atoms; Ketogenesis ▪ Metabolism of Nucleic acids - Nucleotide biosynthesis - Pathways for purine and pyrimidine biosynthesis, Biosynthesis of coenzymes ▪ General reactions of amino acid metabolism, Catabolism of amino acid carbon skeleton-glucogenic and ketogenic amino acids ▪ Intermediary metabolism: inter-conversion between lipids, carbohydrate and proteins. ▪ Urea cycle: Reactions and regulation	**20**	**02**	**--**	**22**
PRACTICALS			**Credit- 1/ Hours- 30**	
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.** Determination of Urea in Urine sample. **8.** Separation of protein by SDS PAGE	**--**	**--**	**30**	**30**

Suggested Readings:

1. Cox, M.M and Nelson, D.L. (2008). Lehninger Principles of Biochemistry, V Edition, W.H. Freeman and Co., NewYork.
2. V.W.and Well, P.A. (2009). Harper's Illustrated Biochemistry, XXVIII Edition, International Edition, The McGraw- Hill CompaniesInc.
3. Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd.,U.K.
4. 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
5. Text book of Biochemistry by Lippincott
6. Clinical Biochemistry by Varley
7. Text Book of Biochemistry by Vasudevan
8. Text Book of Biochemistry by Styrer
9. Text Book of Biochemistry by Voet and Voet
10. Text Book of Biochemistry by Garret and Gisham

Title of the Course	Paper-2 / Bioinformatics and Biostatistics
Paper Code	**ZOO-2-DSC-5024**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]
Course Outcomes	By the end of this course/module, students will be able to: • **CO1:** Explain phylogenetic tree concepts, sequence alignment algorithms and computational approaches for protein structure prediction and drug discovery. • **CO2:** Apply bioinformatics tools for homology modelling, molecular docking, protein–ligand interaction analysis and sequence-based data mining. • **CO3:** Perform computational and laboratory-based exercises including sequence search, ORF finding, phylogenetic tree construction, structure visualization and molecular docking. • **CO4:** Apply statistical methods to analyze various data collected during their study period. • **CO5:** Apply biostatistical techniques to analyze real-life datasets using industry-standard software like SPSS and **R**.
Contact hours	**45 (Theory) + 30 (Practical)**

Paper-3/ BIOINFORMATICS AND BIOSTATISTICS
CODE- ZOO-1-DSC-5024
Credit: 3 (T) + 1 (P)

THEORY **Credit- 3/ Hours- 45**

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	**BIOINFORMATICS** ▪ Origin, History, Scope and applications of Bioinformatics ▪ 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. ▪ Theoretical aspects of sequence analysis. Needleman-Wunsch and Smith-Waterman methods of global and local alignments for a pair of sequences.	**20**	**02**		**22**

	▪ Computational tools and methods for prediction of protein secondary and tertiary structures. Description of machine learning methods for secondary structures. ▪ Homology modelling, fold recognition and ab initio methods for tertiary structure prediction. ▪ Introduction to Bioinformatics approaches in drug discovery. Application of Molecular docking and Pharmacokinetics studies. ▪ Overview of protein-protein and protein-ligand interactions (use of Cluspro and Autodock)				
2	**BIOSTATISTICS** ▪ Statistical investigation: Data collection methods (Census survey and sample survey), Types of sampling. ▪ Measures of Central Tendency and Dispersion: Quartile, Deciles and percentiles; Absolute measures (standard deviation and variance) and Relative measure (coefficient of variation) of Dispersion; Standard error ▪ Probability and Theoretical Distribution: Probability Theory; Theoretical Distribution: Binomial, poison and normal distributions, Skewness, Kurtosis and Moments. ▪ 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. ▪ Statistical hypothesis: Kruskal-Wallis or H test; Man-Whitney U test. ▪ Estimation theory: point and interval estimation (concept); Confidence intervals (detailed applications); Errors in estimation and reliability ▪ One-way and two-way ANOVA (concept and applications), Generalizations of ANOVA ▪ Residual analysis (basic idea), Applications in biological data ▪ Data analysis with statistical packages, Basics of R and SPSS, Data visualization.	**21**	**02**	**--**	**23**
PRACTICALS				**Credit- 1/ Hours- 30**	
	1. Data mining for sequence analysis **2.** Web based tools for sequence searches and homology screening **3.** Finding possible genes in a given nucleotide sequence (ORF finder) **4.** Prediction and validation of protein structure using homology modeling approach (use of	**--**	**--**	**30**	**30**

	Swiss model) **5.** Calculating the distance between the ligand and a particular amino acid (using PYMOL). Visualizing the secondary structure of a protein (using PYMOL) **6.** Construction for phylogenetic trees for proteins using UPGMA or Neighbor joining method (no software to be used) **7.** Reproduction of the same phylogeny using MEGA software for the given set of sequences **8.** Determination of binding modes of a given ligand in the active site of a protein (use of Autodock) **9.** Calculation of Standard deviation, Variance, Standard error, Coefficient of variation from data provided. **10.** Analysis of Spearman Correlation coefficient, ANOVA, chi square test, Kruskal Wallis test, Man-Whitney U test manually or by using computer operated statistical software (SPSS/ R Programming) from dataset provided.

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. Chainy, G. B. N., Mishra, G. and Mohanty, P. K. 2008. Biostatistics Theory and Applications, Kalyani Publishers, Ludhiana-New Deli, 353pp.
4. Satguru Prasad, 2020. Elements of Biostatistics, Rastogi Publications.314pp.
5. Gupta, S. P. 2022. Statistical Methods, Published by Sultan Chand & Sons. 46th Edition
6. P. N. Arora, & Malhan, P. K. 1998. Biostatistics. Himalaya Publishing House. 447 pp.

Title of the Course	**Paper-3/ ADVANCED DEVELOPMENTAL BIOLOGY**
Paper Code	**ZOO-2-DSC-5034**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]

Course Outcomes	By the end of this course/module, students will be able to: • **PO1**: Interpret how fertilization happens and the factors that affect various stages of pre and post fertilization events. • **PO2:** Correlate the basic embryonic development with nucleo- cytoplasmic interaction, morphogenesis andorganogenesis. • **PO3**: Define the role of maternal contribution in development of Drosophila which includes several genes. • **PO4:** Compare the role cell adhesion molecules and other factors in cell-cell communication and cellular signalling during development . • **PO5**: Analyze the applications of stem cells and regeneration therapy in developmental biology perspective.
Contact hours	**45 (Theory) + 30 (Practical)**

ADVANCED DEVELOPMENTAL BIOLOGY
CODE- ZOO-2-DSC-5034
Credit: 3 (T) + 1 (P)

THEORY **Credit- 3/ Hours- 45**

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	▪ **Principles of experimental embryology:** the developmental dynamics of cell specification; Stem cells and developmental commitment, totipotency and pluripotency. ▪ **Morphogenesis and cell adhesion**: Concept of morphogen gradients and morphogenetic fields, the thermodynamic model of cell interactions, cell adhesion molecules ▪ **Fertilization-** Pre and post fertilization events, activation of eggs, Gamete fusion and prevention of polyspermy ▪ **Nucleo-cytoplasmic interaction** in development of unicellular and multi cellular organisms (in early development and differentiations), Importance and role of cytoplasm, hybridization experiments, nature of changes in nuclei, cell hybridization and nuclear transplantation experiments. ▪ **Cell to cell communications** in development: Induction and competence, Reciprocal and sequential inductive events, Instructive and permissive interactions, Epithelial and mesenchymal interactions, Genetic specificity of induction, Paracrine Factors; the inducer molecules.	**21**	**02**		**23**
2	• **Differential gene expression during development:** Genomic Constancy during Cell Differentiation, Differential Gene Activity, Regulation of Gene Expression in Early Development Transition from maternal to zygotic				

control. Models of Cell Differentiation, Introduction to developmental genetics (techniques and concepts) • **Role of maternal contribution in early embryogenic development in Drosophila:** Maternal effect genes, gap genes, pair rule genes, segment polarity genes, homeotic genes and hox genes in development. • **Organogenesis**: vulva formation in *Caenorhapditis elegans*. Cell aggregation and differentiation in *Dictyostelium* • **Regeneration:** Epimorphic regeneration of Salamander limbs, Morphallactic regeneration in hydra, Compensatory regeneration in Mammalian liver. • Different types of **stem cells** and their applications, Regeneration therapy • **Role of environment in animal Development**: environmental regulation of normal development, Gravity and pressure, Developmental symbiosis, Larval settlement. Diapause: suspended development	**20**	**02**		**22**
PRACTICALS			**Credit- 1/ Hours- 30**	
1. Study and report preparation on various developmental stages in the life cycle of *Drosophila* using stock culture. 2. Dissection and study of larval pre pupal wing, leg, eye, and antennal imaginal disc in *D. melanogaster.* 3. Study of developmental stages of fish from egg to hatchling. 4. Demonstration of culture of chick embryo from fertilized eggs to study various developmental stages. 5. Study of chick embryo using vital staining. 6. Study of whole mounts of developmental stages 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	**--**	**--**	**30**	**30**

Suggested Books:

1. Developmental Biology, Gilbert, (8th Ed., 2006) Sinauer Associates Inc., Massachusetts, USA.
2. Principles of Development, Wolpert, Beddington, Brockes, Jessell, Lawrence, Meyerowitz, (3rd Ed., 2006), Oxford University Press, New Delhi, INDIA.
3. Analysis of Biological Development, Kalthoff, (2nd Ed., 2000), McGraw-Hill Science, New Delhi, INDIA.

Title of the Course	Paper –4 (DSE-1) / AQUACULTURE AND FISH BIOLOGY
Paper Code	**ZOO-2-DSE-5044**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]
Course Outcomes	By the end of this course/module, students will be able to: • **PO1:** Acquire comprehensive knowledge of aquaculture, fish biology, physiology, anatomy and fish health management. • **PO2:** understand the management and economic importance of pisciculture. • **PO3**: know about cultivable species of fish, anatomy, reproductive physiology and foods of the fish. • **PO4**: Analyze various aspects of pisciculture including comparative anatomy, stages of major carps, morphometry and fish breeding. • **PO5:** Apply sustainable and eco-friendly aquaculture practices for long term productivity and conservation.
Contact hours	**45 (Theory) + 30 (Practical)**

AQUACULTURE AND FISH BIOLOGY
CODE- ZOO-2-DSC-5044
Credit: 3 (T) + 1 (P)

THEORY **Credit- 3/ Hours- 45**

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	▪ Aquaculture: concept, history, status and scope in Northeast India; ▪ Aquaculture systems – freshwater, brackish water and marine; ▪ Biology of aquaculturally important finfishes, shellfishes, algae and crustaceans; ▪ Principles and methods in taxonomy for aquatic zoology.	08	**04**	**--**	**12**
2	• Identification of eggs and juveniles of cultivable major carps; • Food habits and feeding mechanisms in fishes; • Digestive systems of cultivable fishes; digestion and absorption;	**08**	**04**	--	**12**

	• Concept of fish nutrition and bioenergetics.				
3	• Determination of age and growth of fishes; length-weight relationship and condition factor; • Respiration– aquatic mechanism and aerial adaptation; • Swim bladder in fish: structure and functions.	**06**	**03**	**--**	**09**
4	• Comparative anatomy of reproductive systems in fishes and crustacea; modes of reproduction; role of hormones in reproduction; • Fecundity, breeding and parental care in fishes; • Developmental stages of carps and prawn – embryo, hatching and metamorphosis; • Comparative anatomy of heart in fish; fish blood; excretion – kidney; osmoregulation; • Fish migration.	**08**	04	**--**	**12**
PRACTICALS				**Credit- 1/ Hours- 30**	
	1. Taxonomy of edible and ornamental fishes (with special reference to Assam): carps, catfishes, glassfishes, mahseers, minnows & barbs, loaches, perches, eels and prawns; taxonomy and identification of disease-causing organisms in fishes. 2. Morphometrics, meristic and sexual dimorphism in catfishes, carps, tilapia, crabs and prawns. 3. Dissection and morpho-anatomy of digestive and reproductive systems of carp, catfishes and prawns; accessory respiratory system of fish; 4. Morpho-anatomical localization of endocrine glands – pituitary and thyroid.	**--**	**--**	**30**	**30**

Recommended readings:

1. Ayyappan, S., J.K. Jena., A Gopalakrishan., A.K.Pandey (eds.,)Hand Book of Fisheries and Aquaculture, ICAR, New Delhi , 2006:
2. Desilva, Sena. S., T.A. Anderson (eds.) Feed nutrition in aquaculture, Chapman & Hall, 2-6 Boundary Row, London,
3. Jyoti, M.K & A. Sharma (2006) Fishes (Aid to collection preservation and identification), Daya Publishing House, Delhi-35,
4. Turner, W.B. Algae Aquae Dulcis Indiae Oriantalis (The Freshwater algae (Principally Desmidieae), Bishen Singh Mahendra Pal Singh, 23-A, New connout place, Dehra Dun-01,
5. Pentecost, A. Introduction to Freshwater algae, Richmond Publishing Co. Ltd, Surrey, London
6. Ponniah, A.G & U.K. Sarkar (eds., 2000) Fish Biodiversity of North East India, Director, NBFGR, Canal Ring Road, Lucknow-02, U.P,
7. Raghuramulu N, K.M Nair, S. Kalyanasundaram (eds., 1983) A manual of Laboratory Techniques, National Institute of Nutrition, Indian council of medical research, jamai Osmania, Hyderabad

8. Mahanta P.C. & D. Sarma (eds., 2010) Coldwater Fisheries Management. ICAR-Directorate of Coldwaer Fisheries Research, Bhimtal-36, Nainital, Uttarakhand,
9. McMillan D.B. Fish Histology: Female Reproductive Systems, Springer-Verlag New York Inc.

Title of the Course	**Paper –4 (DSE-2) / MEMBRANE BIOLOGY**
Paper Code	**ZOO-2-DSE-5044**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]
Course Outcomes	By the end of this course/module, students will be able to: • **CO1:** Identify and describe the molecular composition of plasma membrane along with the role of fluid mosaic model and membrane fluidity. • **CO2:** Have knowledge of membrane transport mechanisms • **CO3**: Know cell compartmentalization and trafficking • **CO4**: Have basic concepts on membrane physiology and bioenergetics • **CO5:** Understand cell interaction and extracellular matrix.
Contact hours	**45 (Theory) + 30 (Practical)**

MEMBRANE BIOLOGY
CODE- ZOO-2-DSC-5044
Credit: 3 (T) + 1 (P)

THEORY — **Credit- 3/ Hours- 45**

Unit	**Content**	**Lecture**	**Tutorial**	**Practical**	**Total hours**
1	**Membrane Structure and Organization** ▪ Chemical composition of biological membranes ▪ Membrane lipids: phospholipids, glycolipids, cholesterol ▪ Membrane proteins: integral, peripheral, lipid anchored ▪ Fluid mosaic model and modified models ▪ Membrane fluidity and phase transition ▪ Membrane curvature and bending	06	**02**	**--**	**08**
	Membrane Dynamics ▪ Lateral diffusion of lipids and proteins ▪ Flip-flop movement				

2	▪ Role of flippase, floppase and scramblase ▪ Membrane fusion and fission ▪ Vesicle formation ▪ Endomembrane system organization	**06**	**01**	--	**07**
3	**Transport Across Membranes** ▪ Passive diffusion, Facilitated diffusion, Active transport, Primary active transport (ATPases), Secondary active transport ▪ Symport and antiport, Uniport transporters ▪ Ion channels and carriers ▪ Aquaporins ▪ ABC transporters	**05**	**01**	**--**	**06**
4	**Membrane Potential and Bioelectricity** ▪ Electrochemical gradient and Membrane potential ▪ Donnan equilibrium, Nernst equation, Goldman equation ▪ Ion distribution across membranes ▪ Generation of action potential	**04**	02	**--**	**06**
5	**Vesicular Transport** ▪ Endocytosis, Exocytosis, Receptor-mediated endocytosis, Phagocytosis and pinocytosis ▪ Clathrin-coated vesicles, COP I and COP II vesicles ▪ SNARE proteins, Rab proteins, and membrane trafficking	**04**	**01**	**--**	**05**
6	**Membrane Specialization** ▪ Plasma membrane domains, Epithelial polarity, Tight junctions, Adherens junctions, Desmosomes, Gap junctions, Cell adhesion molecules	**04**	**02**	**--**	**06**
7	**Membrane Signalling** ▪ Receptor-mediated signalling, GPCRs, Receptor tyrosine kinases, Ion channel receptors and Second messengers (cAMP, Ca^{2+}, IP3) ▪ Signal transduction across membranes	**05**	**02**	**--**	**07**
PRACTICALS				**Credit- 1/ Hours- 30**	
	1. Osmotic hemolysis of erythrocytes 2. Membrane permeability using RBC hemolysis. 3. Effect of organic solvents on membranes 4. Effect of temperature on membrane permeability 5. Lipid extraction from membranes 6. Isolation of plasma membrane fraction 7. Diffusion across a semipermeable membrane 8. Study of electron micrographs of membranes 9. Identification of membrane proteins 10. Patch clamp setup (demonstration)	**--**	**--**	**30**	**30**

Title of the Course	**Paper -4 (DSE-3) /WILDLIFE BIOLOGY AND ORNITHOLOGY**

Paper Code	**ZOO-2-DSE-5044**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]
Course Outcomes	By the end of this course/module, students will be able to: • **PO1**: Ability to classify, identify, and document wildlife and bird species by sight, sound, and morphometric data using field guides and observational tools. • **PO2**: Grasping the core principles of avian and wildlife ecology, including evolutionary adaptations, migration patterns, and habitat selection. • **PO3:** Compare different habitat patters of birds. • **PO4:** Apply standard wildlife and ornithological research methods such as bird ringing, line/point transect counts, and mist-netting. • **PO4**: Recognize the animal communication.
Contact hours	**45 (Theory) + 30 (Practical)**

Paper-4 / WILDLIFE BIOLOGY AND ORNITHOLOGY
CODE- ZOO-2-DSE-5044
Credit: 3 (T) + 1 (P)

THEORY **Credit- 3/ Hours- 45**

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	**CONCEPTS OF WILLIFE** - Wildlife Concept and Definition, Wildlife resources of Assam, NE India & other parts of India - Consumptive and non – consumptive values of wildlife, IUCN Red list categories of wildlife, threats to wildlife - Concept of keystone, umbrella, flagship, cryptic , rare ,endemic, endangered and exotic species - Wildlife diseases- viral, bacterial, protozoan, Helminth, Mycotic and their control. Tick born and mite born disease.	**13**	**02**	**--**	**15**
2	**BEHAVIOUR AND WILDLIFE** - Biome concept and types (India & World) - Biogeography- concept and types (India & World). - Animal communication and signaling, Mode &significance - Home range and territory, Strategies of territory defend & advertisement, influence of water, soil,	**13**	**02**	**--**	**15**

	salt & Gap formation on wildlife, - Adaptation- camouflage & mimicry.				
3	**ORNITHOLOGY** - Ornithology – concepts & scope, speciation of birds, diversity & classification - Natural selection & adaptive radiation in birds, - Morphology of birds-body topography, feathers & plumages, leg types & beak types, toe arrangements & webbing in birds - Extinct birds, Endemic birds of north- east India, Raptors in India, Bird conservation issues, endangered birds of north east India	**13**	**02**	**--**	**15**
PRACTICALS				**Credit- 1/ Hours- 30**	
	1. Taxonomic study of the mammals of Assam. 2. Taxonomic study of vulture of Assam. 3. Study of the various types of feathers of the birds. 4. Study of the various parts of wings of any bird. 5. Study of the body topography of any bird. 6. Sexual dimorphism in birds. 7. Study of the various nesting patterns of birds.	**--**	**--**	**30**	**30**

Suggested Readings:

1. Goutam Kumar Saha & Subhendu Mazumdar (2022): Wildlife Biology: An Indian Perspective (1st edition), PHI Learning Pvt Ltd, Delhi India.
2. Noble, S. Pand Patrick, J.L. (1993). Mannual of ornithology: Avian structure and function. Yale University
3. Binita Das (2021). IUCN Listed Bird Watching in Sonitpur District, Endangered Birds of N.E. Region and Eagles of India. Kiran Prakashan

Title of the Course	**Paper-5 / BIOLOGICAL TECHNIQUES**
Paper Code	**ZOO-2-FSC-5054**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]

Course Outcomes	By the end of this course/module, students will be able to: ▪ **CO1:** Master the principles, mechanisms, and safe operation of core laboratory equipment such as spectrophotometers, pH meters, centrifuges, and autoclaves. ▪ **CO2:** Gain knowledge of basic concepts, applications, merits and limitations of various bio separation techniques like chromatography, electrophoresis and centrifugation. ▪ **CO3:** Describe principles, working mechanisms and applications of advanced microscopes, tracer techniques, immunological assays and chromatography methods. ▪ **CO4:** Analyze electrophoresis systems, blotting techniques, hybridization methods, cryopreservation and chromosome-based techniques such as banding and FISH. • **CO5:** Gain hands-on experience of separation of mixtures using gel electrophoresis techniques (PAGE) and laboratory centrifuges, density gradient centrifugation with the help of virtual lab / videos.
Contact hours	**45 (Theory) + 30 (Practical)**

Paper-5/ BIOLOGICAL TECHNIQUES
CODE- ZOO-2-FSC-5054
Credit: 3 (T) + 1 (P)

THEORY **Credit- 3/ Hours- 45**

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	**Principles and applications of microscopy** ▪ Microscopic techniques: Concept of resolving power and magnification, Visualization of cells and subcellular components by light microscopy, microscopy of living cells ▪ Principles, working and applications of : Bright-field and darkfield microscopy, phase contrast microscopy, fluorescence microscopy, confocal microscopy, scanning (SEM), transmission(TEM) & Cryo- electron microscopy ▪ Different fixation and staining techniques for Light and Electron Microscopy, freeze-etch and freeze fracture methods for EM	**10**	**02**	**--**	**12**
2	**Principles and applications of separation techniques:** ▪ Principles and types of Centrifugation- Density gradient and unit gravity centrifugation, ultracentrifugation. ▪ Principle and applications of electrophoresis- Agarose gel, SDS, SDS-PAGE, Pulsed gel and Disc gel electrophoresis, determination of molecular weight by SDS-gel electrophoresis	**12**	**02**	**--**	**14**

	▪ Principles and applications of molecular separation Techniques: Partition chromatography: thin layer chromatography, Column chromatography: gel filtration, ion-exchange, affinity and HPLC.				
3	**Radiolabelling techniques:** • Detection and measurement of different types of radioisotopes used in biology • Incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, safety guidelines. • Principle and applications of autoradiography and radio immunoassay. **Histochemical and Immunotechniques:** • Antibody generation, Detection of molecules using ELISA, RIA, immunoprecipitation, Immunoelectrophoresis • Flow cytometry and immunofluorescence microscopy • Detection of molecules in living cells, in situ localization by techniques such as FISH and GISH	**08**	**02**	**--**	**10**
	Molecular biology techniques: • Polymerase Chain Reaction, DNA sequencing methods, Blotting techniques : Southern, Northern and Western **Principles and applications of other analytical techniques**: • Molecular analysis using UV/visible, fluorescence, IR spectroscopy, Spectrophotometry (Beer and Lambert Law), nuclear magnetic resonance (NMR) spectroscopy,	**07**	**02**	**--**	**09**
PRACTICALS			**Credit- 1/ Hours- 30**		
	1. Determination of the sizes of different microbial cells by micrometry. 2. Separation of complex mixtures of biomolecules by paper chromatography. 3. Determination of molecular mass of proteins by SDS-PAGE. 4. Separation of components of a given mixture using a laboratory scale centrifuge using various rotors. 5. Demonstration of ELISA and Western blotting technique 6. Understanding density gradient centrifugation with the help of virtual lab. 7. Demonstration of autoradiography using virtual lab / video.	**--**	**--**	**30**	**30**

***Suggested Readings**:*

1. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGraw Hill Higher Education, USA. 2019
2. Biotechniques by P. Ponmurugan; B. Ganagadhara Prabhu
3. Wilson And Walker's Principles and Techniques of Biochemistry And Molecular Biology Johnson, M.H. (2018).
4. Biophysical Chemistry by D. Klostermeier and M.G. Rudolph. 1st edition. CRC press, UK. 2017.
5. Techniques and Methodsin Biology. K. L. Ghatak. PHI Learning Private Limited, India. 2011.
6. Lab Manual in Biochemistry, Immunology and Biotechnology by A. Nigam and A. Ayyagari. Tata McGraw Hill, India. 2007.

SYLLABUS FOR THE SECOND YEAR OF MASTERs PROGRAM IN ZOOLOGY
ONE-YEAR MASTER PROGRAMME IN ZOOLOGY
[UNDER NEP 2020]

SPECIALIZATION: CELL & MOLECULAR BIOLOGY			
3	Paper 1 **Genomics and Proteomics**	**ZOO-CM-3-DSC-5064 (Level-500)**	**3**
	Practical		**1**
	Paper 2 **Advanced Immunology**	**ZOO-CM-3-DSC-5074 (Level-500)**	**3**
	Practical		**1**
	Paper 3 **Molecular Basis of Human Disease**	**ZOO-CM-3-DSC-5084 (Level-500)**	**3**
	Practical		**1**
	Paper 4 **Genetic Engineering and Recombinant DNA Technology**	**ZOO-3-DSC-5094 (Level-500)**	**3**
	Practical		**1**
	Paper 5/DSE-1 **Cell and Molecular Biology** (To be adopted from SWAYAM)	**ZOO-CM-3-DSE-5104A (Level-500)**	**3**
	Practical		**1**
	Paper 5/DSE-2 **Wildlife Management Practices**	**ZOO-EW-3-DSE-5104B (Level-500)**	
	Practical		
	Paper 5/DSE-3 **Advanced Aquaculture Technology** (To be adopted from SWAYAM)	**ZOO-FB-3-DSE-5104C (Level-500)**	
	Practical	**(Refer to annexure)**	

Title of the Course	PAPER 1/ GENOMICS AND PROTEOMICS (Specialization: Cell and Molecular Biology)
Paper Code	**ZOO-CM-3-DSC-5064**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]
Course Outcomes	By the end of this course/module, students will be able to: • **CO1**: Understand the Genome organization and structure • **CO2:** Explain the principles of Genome analysis and DNA sequencing technologies. • **CO3:** Apply the knowledge of **gene** identification and functional genomics • **CO4**: Predict protein structures, determine gene functions, and mine biological databases using modern computational tools. • **CO5:** Comprehend the working methods of genomics and proteomics to explain complex biological systems, post-translational modifications, and gene-disease relationships.
Contact hours	**45 hrs (Theory) + 30 hrs (Practical)**

Genomics and Proteomics
Code: ZOO-CM-3-DSC-5064
Credit: 3 (T) + 1 (P)

THEORY **Credit- 3/ Hours- 45**

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	• Proteins and Proteome: Protein Chemistry: primary, secondary, tertiary and quaternary levels of protein structure; Concept of subunit, motifs and domains; DNA binding Motif • Protein-Protein interaction; Important examples of Protein structure and their functions; convergent and divergent evolution of protein structure and functions • Isoelectric focusing, 2D gel electrophoresis, enzymatic digestion of protein and peptide fingerprinting.	**13**	**02**	**--**	**15**

2	▪ Genome organization: Prokaryotic and Eukaryotic genome organization: Mitochondrial DNA, Protein-DNA interactions in the genome ▪ Genome complexity: C-value paradox; Genome mapping: methods of gene mapping, restriction mapping, linkage mapping. ▪ Sequencing of genomes: methodology of DNA sequencing: Sanger Sequencing, Next generation sequencing, Pyro-sequencing, potential challenges; Contiguous DNA sequence: Reads, contig and scaffold, Contig assembly ▪ Chromosome walking and characterization of Chromosome; Site-specific recombinase technique: Cre-loxP system	**13**	**02**	**--**	**15**
3	▪ DNA libraries: Construction of DNA libraries-Genomic DNA LIBRARY, c DNA Library, clonal selection techniques; Transfection techniques, Application of DNA libraries in biomedical sciences; Human genome project. ▪ Comparative Genomics: Meta-genomics: techniques and application ▪ Identification and classification of organisms using molecular markers - 16s rRNA typing, Dominant and co-dominant molecular markers; Orthologous and Paralogous genes; utilization of genome to understand evolution.	**13**	**02**	**--**	**15**
PRACTICALS				**Credit- 1/ Hours- 30**	
	1. To retrieve a gene sequence from a biological database and perform BLAST to observe percentage homology. 2. Study of protein and drug interaction using bioinformatics. 3. To design a primer for a given gene sequence using BLAST software. 4. To isolate genomic DNA from tissue and amplify the DNA sample using PCR. 5. To separate DNA using agarose gel electrophoresis. 6. To isolate and quantify total proteins from a biological sample. 7. To separate proteins using SDS gel electrophoresis.	**--**	**--**	**30**	**30**

Suggested Readings:

1. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2015). Molecular biology of the cell (6th ed.). Garland Science.
2. Brown, T. A. (2018). Genomes 4. Garland Science.
3. Cooper, G. M., & Hausman, R. E. (2018). The cell: A molecular approach (8th ed.). Oxford University Press.
4. De Robertis, E. D. P., & De Robertis, E. M. F. (2017). Cell and molecular biology (8th ed.). Wolters Kluwer.
5. Hartl, D. L., & Jones, E. W. (2009). Genetics: Analysis of genes and genomes (7th ed.). Jones & Bartlett Learning.
6. Karp, G. (2010). Cell and molecular biology: Concepts and experiments (6th ed.). John Wiley & Sons.
7. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., & Martin, K. C. (2021). Molecular cell biology (9th ed.). W. H. Freeman.
8. Mount, D. W. (2004). Bioinformatics: Sequence and genome analysis (2nd ed.). Cold Spring Harbor Laboratory Press.
9. Nelson, D. L., & Cox, M. M. (2021). Lehninger principles of biochemistry (8th ed.). W. H. Freeman.
10. Pennington, S. R., & Dunn, M. J. (2002). Proteomics: From protein sequence to function. Viva Books.
11. Primrose, S. B., & Twyman, R. M. (2013). Principles of gene manipulation and genomics (7th ed.). Wiley-Blackwell.
12. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. (2013). Molecular biology of the gene (7th ed.). Pearson.

Title of the Course	**PAPER-2/ ADVANCED IMMUNOLOGY** **(Specialization: Cell and Molecular Biology)**
Paper Code	**ZOO-CM-3-DSC-5074**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]

Course Outcomes	By the end of this course/module, students will be able to: • **CO1:** Understand molecular mechanisms of immunology • CO2: Recall the structure and classes of immunoglobulins. • **CO3**: Describe the complement system and its pathways. • **CO4**: Explain the processes of B and T cell maturation and activation. • **CO5**: Use knowledge of immunodeficiency disorders to explain their impact on immune function. • **CO6**: Assess the impact of hypersensitivity reactions on health and disease management.
Contact hours	**45 hrs (Theory) + 30 hrs (Practical)**

Advanced Immunology
CODE- ZOO-CM-3-DSC-5074
Credit: 3 (T) + 1 (P)

THEORY **Credit- 3/ Hours- 45**

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	**Molecular Basis of the Immune System** ▪ Molecular organization of the immune system ▪ Innate immune recognition (PRRs, TLRs, NLRs) ▪ Antigen processing and presentation at molecular level ▪ Molecular structure of T-cell receptor (TCR) and B-cell receptor (BCR)	**06**	**01**	**--**	**07**
2	**Antibody Molecular Biology** ▪ Gene organization of immunoglobulins ▪ V(D)J recombination mechanism ▪ Somatic recombination and junctional diversity ▪ Class switching (CSR) and affinity maturation ▪ Monoclonal antibody production (hybridoma technology at the molecular level)	**06**	**01**	**--**	**07**
3	**T-cell and B-cell Signalling Pathways** • TCR signalling cascade (CD3 complex, ZAP-70, LAT pathway) • BCR signalling and activation mechanisms • Cytokine signalling (JAK-STAT pathway) • Co-stimulatory molecules (CD28–B7 interaction) • Molecular checkpoints in immune activation	**06**	**01**	**--**	**07**
4	**Cytokines and Molecular Immunoregulation** • Cytokine gene expression and regulation • Interleukins, interferons, TNF family • Chemokines and receptor interactions	**06**	**01**	**--**	**07**

	• Molecular basis of immune tolerance				
5	**Molecular Basis of Antigen Processing** • Endogenous antigen pathway (MHC I) • Exogenous antigen pathway (MHC II) • Role of proteasome and TAP transporters • Peptide loading complex (PLC) • Cross-presentation mechanisms	**04**	**01**	**--**	**05**
6	**Immunology of Diseases** • HIV infection: molecular immune evasion mechanisms • Tumor immunology at the molecular level • Immune escape strategies of pathogens • Molecular basis of hypersensitivity reactions	**05**	**01**	**--**	**06**
7	**Techniques in Immunology** • ELISA (enzyme-linked immunosorbent assay) • Flow cytometry (FACS analysis of immune cells) • Immunoprecipitation and co-immunoprecipitation • PCR-based immune gene analysis	**05**	**01**	**--**	**06**
PRACTICALS				**Credit- 1/ Hours- 30**	
	1. Viability test of lymphocytes (Trypan blue) 2. Demonstration of lymphoid organs (spleen, thymus, lymph node) 3. Ouchterlony double diffusion test 4. Preparation of blood smear and percentage quantification of different types of WBC. 5. Total RBC count in blood sample using a haemocytometer 6. Identification of blood groups to demonstrate antigen-antibody reactions by haemagglutination reaction. 7. Preparation of a single cell suspension from mouse spleen, staining and counting of viable splenocytes. 8. Histological observation of T-cell and B-cell specific zones in spleen and thymus. 9. Isolation of peritoneal macrophages and study of phagocytosis	**--**	**--**	**30**	**30**

Suggested Readings:

1. Abbas, A. K., Lichtman, A. H., & Pillai, S. (2012). *Cellular and molecular immunology* (7th ed.). Elsevier/Saunders.
2. Murphy, K., & Weaver, C. (2017). *Janeway's immunobiology* (9th ed.). Garland Science/Taylor & Francis.
3. Punt, J., Owen, J. A., Stranford, S. A., & Jones, P. P. (2013). *Kuby immunology* (7th ed.). W.H. Freeman.

4. Parham, P. (2014). *The immune system* (4th ed.). Garland Science.
5. Roitt, I. M., Delves, P. J., Martin, S. J., & Burton, D. R. (2017). *Roitt's essential immunology* (13th ed.). Wiley-Blackwell.
6. Paul, W. E. (Ed.). (2013). *Fundamental immunology* (7th ed.). Lippincott Williams & Wilkins.
7. Sompayrac, L. (2019). *How the immune system works* (6th ed.). Wiley-Blackwell.

Title of the Course	**PAPER-3/ MOLECULAR BASIS OF HUMAN DISEASES** **(Specialization: Cell and Molecular Biology)**
Paper Code	**ZOO-CM-3-DSC-5084**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]
Course Outcomes	By the end of this course/module, students will be able to: • **CO1:** Describe the pathophysiology of human diseases such as Alzheimer's, Parkinson's, and dementia along with their molecular diagnosis and therapeutics • **CO2:** Apply knowledge of normal and cancer stem cells to research and therapeutic contexts. • **CO3** Explain the genetic basis and clinical manifestations of Cancer, Thalassemia and cystic fibrosis. • **CO4**: Describe the cellular and molecular basis of aging and the factors that contribute to it. • **CO5:** Recall the histological characteristics of normal and pathological tissues.
Contact hours	**45 hrs (Theory) + 30 hrs (Practical)**

Molecular Basis of Human Diseases
CODE- ZOO-CM-3-DSC-5084
Credit: 3 (T) + 1 (P)

THEORY **Credit- 3/ Hours- 45**

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	▪ Concept of health and disease at the molecular level ▪ Relationship between genes, proteins, and disease phenotype ▪ Types of diseases: a) Genetic b) Metabolic c) Infectious (molecular interactions) d) Multifactorial diseases e) Lipid peroxidation in health and diseases	**05**	**02**	**--**	**07**
2	▪ Blood pressure and its regulation, hypertension and mechanism of drug action, Atherosclerosis and coronary heart disease ▪ Diabetes mellitus: types, causes, and therapeutic approaches. Thalassemia and cystic fibrosis ▪ Pathophysiology of neurological Diseases (Alzheimer's disease, Parkinson's disease and Dementia)	**10**	**02**	**--**	**12**
3	▪ Cancer: monoclonal origin; differences between normal and cancer cells; cell transformation and factors for cell proliferation; concepts of oncogenes and their role in cancer, tumour suppressor and apoptotic genes; chromosomal basis of cancer. ▪ Ageing: Cellular basis of ageing; causes of ageing; oxidative damage; genetic instability; mitochondrial genome damage; genetic ageing programme; anti-aging using TKS	**10**	**02**	**--**	**12**
4	▪ Introduction to stem cells, basic principles and methodologies, and classification of stem cells. Normal stem cells: hematopoietic stem cells, mesenchymal stem cells, cardiac stem cells. Embryonic stem cells (ESC),	**12**	**02**	**--**	**14**

Identification and characterization of pluripotent stem cells in animals and humans; sources of pluripotent cells– blastocysts, parthenogenesis, nuclear transfer, iPSCs. ▪ Cancer stem cells: Historical perspective, isolation and characterization of cancer stem cells. Stem cell-based regenerative therapy for various diseases (neurodegenerative, retinal, leukaemia, heart)				
PRACTICALS			**Credit- 1/ Hours- 30**	
1. Induction of diabetes and Glucose tolerance test in an animal model 2. Study of histological slides of normal and diabetic pancreas 3. Induction of Alzheimer's disease in an animal model 4. Study of histological slides of the brain for the presence of amyloid plaques 5. Histological Study of atherosclerotic plaques and identification of foam cells in pathological conditions. 6. Study of different types of cancer using histopathological slides	**--**	**--**	**30**	**30**

Suggested Readings:

1. Coleman, W. B., & Tsongalis, G. J. (Eds.). (2010). Molecular pathology: The molecular basis of human disease (2nd ed.). Academic Press.
2. Coleman, W. B., & Tsongalis, G. J. (Eds.). (2017). Molecular pathology: The molecular basis of human disease (3rd ed.). Elsevier.
3. Cooper, G. M., & Hausman, R. E. (2019). The cell: A molecular approach (8th ed.). Oxford University Press.
4. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., & Martin, K. C. (2021). Molecular cell biology (9th ed.). W. H. Freeman.
5. Strachan, T., & Read, A. P. (2018). Human molecular genetics (5th ed.). Garland Science.
6. Nussbaum, R. L., McInnes, R. R., & Willard, H. F. (2016). Thompson & Thompson genetics in medicine (8th ed.). Elsevier.
7. Brown, T. A. (2018). Genomes 4. Garland Science.
8. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. (2013). Molecular biology of the gene (7th ed.). Pearson.
9. Nelson, D. L., & Cox, M. M. (2021). Lehninger principles of biochemistry (8th ed.). W. H. Freeman.

10. Mount, D. W. (2004). Bioinformatics: Sequence and genome analysis (2nd ed.). Cold Spring Harbor Laboratory Press.

Title of the Course	PAPER-4/ GENETIC ENGINEERING & RECOMBINANT DNA TECHNOLOGY
Paper Code	**ZOO-CM-3-DSC-5094**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]
Course Outcomes	By the end of this course/module, students will be able to: • **CO1**: Understand the fundamentals of genetic engineering and recombinant technology • **CO2:** Recall the methods of transformation, transfection, Cloning vectors and gene transfer systems • **CO3:** Describe the molecular mechanisms of antisense RNA, microRNA, siRNA, and ribozymes. • **CO4**: Explain the principles behind each molecular techniques and its applications in genetic engineering • **CO5:** Assess the role of marker and reporter genes in the identification of successful cloning events.
Contact hours	**45 hrs (Theory) + 30 hrs (Practical)**

GENETIC ENGINEERING & RECOMBINANT DNA TECHNOLOGY
Code: ZOO-CM-3-DSC-5094
Credit: 3 (T) + 1 (P)

THEORY **Credit- 3/ Hours- 45**

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	▪ Basic of Genetic Engineering: Gene manipulation tools for molecular cloning, Steps involved in Genetic Engineering. ▪ Restriction enzymes, their types, cohesive and blunt end ligation, linkers, adaptors,	**14**	**03**	**--**	**17**

	and homopolymeric tailing. ▪ Gene Cloning Vectors: Plasmids, bacteriophages, cloning in M13 Vectors, phagemids, Lambda vectors; insertion and replacement vectors, Cosmid vectors, Artificial chromosome vectors (YACs, BACs), Animal virus-derived vectors-SV40, retroviral vectors, Expression vectors ▪ Introduction of DNA into Host: Genetic manipulation of cells; Transformation, types of transfection: chemical and physical methods, Infection ▪ Marker gene and reporter gene in selection of recombinant DNA				
2	▪ Restriction modification system; Reporter genes; Microarrays; Gene therapy ▪ In situ hybridization, RNase protection assay, RTPCR ▪ Genetic Libraries: Construction of genomic and cDNA libraries and screening by colony and plaque hybridization ▪ RNA interference: History, molecular mechanisms and applications of antisense RNA, microRNA, siRNA, and ribozymes. ▪ Somatic cell hybridization ▪ Genome editing, CRISPR-based genome editing and application of genome editing ▪ Basic instrumentation in Genetic Engineering;	**14**	**02**	**--**	**16**
3	▪ Basis of DNA footprinting and fingerprinting ▪ RFLP and RAPD techniques ▪ Genetically modified organism (GMO) and transgenic mice, future trends ▪ Gene knockout mice: Procedure of creation and application	**10**	**02**	**--**	**12**
PRACTICALS			**Credit- 1/ Hours- 30**		
	1. Extraction of Genomic DNA from *Drosophila*/ Fish/ Mouse. 2. Isolation of mitochondrial DNA from animal tissues 3. Restrictiondigestion of mitochondrial DNA/Plasmid DNA sample and separation of fragments by performing agarose gel electrophoresis. Interpretation of the results by	**--**	**--**	**30**	**30**

comparing with the standard digests.

4. Determination of DNA & RNA purity
5. Determination of G+C percentage rate & Melting temperature
6. Measurement of DNA GC% ratio by melting curve analysis
7. Preparation of a standard curve and estimation of DNA using DPA method
8. Isolation and quantification of total RNA from animal tissues

Suggested Readings:

1. Glick, B. R., Pasternak, J. J., & Patten, C. L. (2010). *Molecular biotechnology: Principles and applications of recombinant DNA* (4th ed.). ASM Press.
2. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., & Martin, K. C. (2021). *Molecular cell biology* (9th ed.). W. H. Freeman.
3. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. (2013). *Molecular biology of the gene* (7th ed.). Pearson
4. Brown, T. A. (2018). *Genomes 4*. Garland Science.
5. Primrose, S. B., & Twyman, R. M. (2013). *Principles of gene manipulation and genomics* (7th ed.). Wiley-Blackwell.
6. Clark, D. P., & Pazdernik, N. J. (2016). *Molecular biology*. Academic Press.
7. Rajagopal, K. (2012). *Recombinant DNA technology and genetic engineering*. Tata McGraw-Hill Education.
8. Miglani, G. (2016). *Genetic engineering: Principles, procedures and consequences*. Alpha Science International / Narosa Publishing House.
9. Nelson, D. L., & Cox, M. M. (2021). *Lehninger principles of biochemistry* (8th ed.). W. H. Freeman.
10. Cooper, G. M., & Hausman, R. E. (2019). *The cell: A molecular approach* (8th ed.). Oxford University Press.

SPECIALIZATION: ECOLOGY & WILDLIFE BIOLOGY		
Paper 1 **Ecosystem Functions and Stability**	**ZOO-EW-3-DSC-5064 (Level-500)**	**3**
Practical		**1**
Paper 2 **Wildlife & Wildlife Habitat Relations**	**ZOO-EW-3-DSC-5074 (Level-500)**	**3**
Practical		**1**

Paper 3 **Wildlife Population Ecology & Methods**	**ZOO-EW-3-DSC-5084** **(Level-500)**	**3**
Practical		**1**
Paper 4 **Wildlife Conservation**	**ZOO-EW-3-DSC-5094** **(Level-500)**	**3**
Practical		**1**
Paper 5/DSE-1 **Cell and Molecular Biology** (To be adopted from SWAYAM)	**ZOO-CM-3-DSE-5104A** **(Level-500)**	**3**
Practical	**ZOO-EW-3-DSE-5104B** **(Level-500)** **ZOO-FB-3-DSE-5104C** **(Level-500)** **(Refer to annexure)**	**1**
Paper 5/DSE-2 **Wildlife Management Practices**		
Practical		
Paper 5/DSE-3 **Advanced Aquaculture Technology** (To be adopted from SWAYAM)		
Practical		

Title of the Course	**Paper-1 / ECOSYSTEM FUNCTIONS AND STABILITY**
Paper Code	**ZOO-EW-3-FSC-5064**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]
Course Outcomes	By the end of this course/module, students will be able to: • **CO1:** Demonstrate an understanding of fundamental ecological concepts, including ecosystem productivity, nutrient cycling and trophic dynamics. • **CO2:** Synthesize information from diverse sources to evaluate the effectiveness of ecosystem management strategies in promoting sustainability and resilience.

	• **CO3:** Develop critical thinking skills by analyzing complex ecological issues and proposing evidence-based solutions. • **CO4:** Apply ecological principles to analyze and assess the functioning of ecosystems in real- world scenarios. • **CO5:** Communicate ecological concepts and findings through written reports, oral presentations and collaborative projects.
Contact hours	**45 (Theory) + 30 (Practical)**

ECOSYSTEM FUNCTIONS AND STABILITY
CODE- ZOO-EW-3-DSC-5064
Credit: 3 (T) + 1 (P)

THEORY **Credit- 3/ Hours- 45**

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	**Ecosystem Function** ▪ Natural and Artificial ecosystems, Concept of Ecological footprint; Productivity, Productivity and biodiversity ▪ Energy flow Models, Energy partitioning in food chain and food web, trophic structure and ecological pyramid; Ecosystem energetic ▪ Nutrient cycling (N cycle), Nutrient Pools and exchange; Restoration ecology and its relevance to present context. ▪ Fundamental and realized Niche, Quantification of Niche breadth and niche overlap, Niche partitioning, Niche segregation, Niche Relationship and community structures, Guild concept, Ecological equivalents, Parallel niche, Competitive Displacement (Gaus's Principle), Principles of co-existence.	**20**	**02**	**--**	**22**
2	**Ecosystem Stability** ▪ Stability concept, Types of Stability; Resistance and resilience stability, Relationship of Species Diversity and Stability, Stability of their steady state and Influence of random perturbations on population	**20**	**03**	**--**	**23**

▪ Two views of community organization: Equilibrium Hypothesis, Non-equilibrium Hypothesis and Intermediate disturbance hypothesis. ▪ Keystone species, Strategy of Ecosystem development, Models of succession, Climax concept, Ecosystem maturity and role of Natural selection, Relevance of Ecosystem development theory to human ecology ▪ Ecological Principles of Management, Role of Ecologist in the management of Natural Ecosystem, Management Techniques, Significance of Planning of Ecosystem Management ▪ Ecological Risk Assessment in terrestrial and Aquatic ecosystem and planning and strategies.				
PRACTICALS			**Credit- 1/ Hours- 30**	
1. Identification and study of pioneer plant species in the process of primary/secondary succession. 2. Pattern of seed dispersals in pioneer stages of ecosystem succession taking animals as dispersal agents. 3. Conduct surveys to measure biodiversity, measures of species richness and evenness (Shannon Wiener Index (H′), Margalefs' D Index, Simpsons' D Index, Evenness or Equitability index) 4. Quantification of Niche overlap and Niche breadth using appropriate methods.	--	--	**30**	**30**

Suggested Readings:

1. Fundamentals of Ecology by Eugene P. Odum
2. Principles of Terrestrial Ecosystem Ecology by F.Stuart Chapin, Pamela A. Matson, and Harold A. Mooney
3. Growth and Development: Ecosystems Phenomenology by Robert E. Ulanowicz
4. Resilience and Stability of Ecological Systems by C.S. Holling (1973)
5. The Diversity-Stability Debate by Kevin S. McCann (2000)
6. BiogeochemistryAnAnalysisofGlobalChangebyWilliamH.Schlesingerand Emily S. Bernhardt
7. RestorationEcology:RepairingtheEarth'sEcosystemsintheNewMillenniumby Richard J. Hobbs and James A. Harris
8. DiversityinTropicalRainForestsandCoralReefsbyJosephH.Connell(1978)
9. What is Ecosystem Management? By R.Edward Grumbine (1994)

Title of the Course	Paper-2 / WILD LIFE AND WILD LIFE HABITAT RELATIONS
Paper Code	**ZOO-EW-3-FSC-5074**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]
Course Outcomes	By the end of this course/module, students will be able to: ▪ **CO1:** Understand the characteristics, compositions and distribution of different types of wild life habitats, including grasslands, wetlands and forests in India and Northeast India. ▪ **CO2:** Apply various habitat assessment techniques to evaluate wild life habitats and assess their suitability for different species. • **CO3:** Analyze the relationships between wild life and their habitats and the impact of habitat fragmentation and climate change on wildlife species. • **CO4:** Evaluate the effectiveness of conservation strategies in mitigating habitat loss and preserving wild life species, including the role of wet lands in biodiversity conservation and the ecological role of different wildlife habitats. • **CO5:** Effectively communicate habitat conservation principles and strategies through written reports, oral presentations, and discussions.
Contact hours	**45 (Theory) + 30 (Practical)**

WILD LIFE AND WILD LIFE HABITAT RELATIONS
CODE- ZOO-EW-3-DSC-5074
Credit: 3 (T) + 1 (P)

THEORY **Credit- 3/ Hours- 45**

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	▪ Grassland Ecosystem: Characteristics, Compositions and distribution in India and NE India; ▪ Wetlands: Definition, Ramsar Convention and criteria for inclusion and types ▪ Forest types in NE Region, Dominance species composition in different Forest types(Tropical, Temperate and Alpine forest); Canopy openness, closed Canopy and Open canopy forests ▪ High altitudes habitat of wildlife and wildlife species compositions; ▪ Wildlife Habitat Assessment methods: Community Dominance Index (CDI), Canopy Area Coverage, Foliage Height Diversity (FHD), Similarity and Dissimilarity index and Association index; ▪ Changing patterns of environmental gradients of light, temperature and humidity in degraded forest and its impact on wildlife.	**18**	**04**	**--**	**22**
2	▪ Succession of Wildlife Habitat within the Wildlife Sanctuaries and National parks of Assam (KNP, ONP, NNP, MNP & PWLS), Implication of habitat Succession in wildlife habitat ▪ Forest fragmentation & wildlife habitat loss, Gap formation and their impact on wildlife, Gap dynamics ▪ Impact of climate changes on wildlife species; Island Factor and its relationship with present day wildlife conservation networks ▪ Habitat utilization pattern of Rhino, Elephant, Greater Adjutant Stork, Hoolock Gibbon, Golden Langur and Tiger ▪ Habitat selections, theory of habitat selections, Loss of wetland habitat and its relation to wildlife	**19**	**04**	**--**	**23**

species. ▪ Ecological Role of Wetlands in Biodiversity conservation.				
PRACTICALS			**Credit- 1/ Hours- 30**	
1. Collect and analyze vegetation/animal data to calculate Community Dominance Index (CDI), Association Index, Similarity & Dissimilarity Index 2. Plant community analysis: Vegetation sampling using quadrate method. 3. Basics of wild life habitat map preparation using GIS and Remote Sensing techniques. 4. Studies on biodiversity of aquatic and terrestrial ecosystem: Data collection, compilation and analysis. 5. Studies on physical characteristics of soil, measurement of soil temperature and pH. 6. Types of pollinating animal biota in grassland, scrubland and forest habitat, and Comparative study of species involved in pollination among these habitats.morphometry and meristics.	**--**	**--**	**30**	**30**

Suggested readings:

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

Title of the Course	**Paper-3 / WILDLIFE POPULATION ECOLOGY AND METHODS**
Paper Code	**ZOO-EW-3-FSC-5084**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional

	Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]
Course Outcomes	By the end of this course/module, students will be able to: ▪ **CO1:** Demonstrate an understanding of the characteristics of wildlife populations and vital statistics such as life tables and reproductive values. ▪ **CO2:** Evaluate different sampling design methods used in wildlife studies and understand their importance in obtaining representative data. ▪ **CO3:** Apply concepts of carrying capacity, dispersal, and migration to analyze wildlife population dynamics and health. ▪ **CO4:** Demonstrate proficiency in various wildlife study methods, including mist netting, radio telemetry, census techniques and modern census techniques for different wildlife species. ▪ **CO5:** Apply statistical analysis techniques to analyze wildlife data and test hypotheses related to population ecology.
Contact hours	**45 (Theory) + 30 (Practical)**

WILDLIFE POPULATION ECOLOGY AND METHODS
CODE- ZOO-EW-3-DSC-5084
Credit: 3 (T) + 1 (P)

THEORY **Credit- 3/ Hours- 45**

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	**Wildlife Population Ecology** ▪ Wildlife Population Characteristics; Characteristics and types of Carrying Capacity, Carrying capacity of wildlife habitat and wildlife population sizes, Sign of wildlife habitat and carrying capacity and population health ▪ Wildlife population dispersal and three modes of population dispersal; Ecological density vs crude density ▪ Causes of Migration, Migratory routes of birds associated with NE India, study of bird migration and local movement pattern using mist nets and plastic colour banding and metallic rings; ▪ Home range: Importance of Home range in species conservation, Territoriality among Mammals and Birds.	**20**	**03**	**--**	**23**
2	**Wildlife Study Methods** ▪ Methods of Samplings & Sampling Design,				

Why Sampling design has been done prior to any study and its importance, differences between simple, Random and stratified random samplings and systematic random samplings ▪ Terrestrial vegetation studies for Wildlife habitat; Statistical analysis of wildlife data using computer software and circular statistics ▪ Occupational survey methods and its necessity for the study of large vertebrates; research designed and statistical approach for hypothesis testing ▪ Wildlife Population Survey methods: Importance and Direct and Indirect wildlife census or survey methods, Mist netting, Radio telemetry techniques, Modern Census Techniques of Rhino, Tiger, Elephant**,** Migratory and residential birds, terrestrial birds; Survey of Herpetofauna, butterflies, spiders & other invertebrates.	**20**	**02**	**--**	**22**
PRACTICALS			**Credit- 1/ Hours- 30**	
1. Direct methods of wildlife census: (i)Line transact (ii)Point transact. 2. Estimating the home range of mammals/ birds using radio telemetry/ grid methods and minimum convex polygon (MCP) methods in Laboratory from data sheets. 3. Census of Residential, Migratory and Terrestrial birds using appropriate methods and Data analysis. 4. Measure habitat parameters: species composition, canopy area coverage and foliage height diversity using standard protocols. 5. Identification of food plant species of both birds and mammals. 6. Bio statistical Applications: Null Hypothesis Significance Test (t-test, ANOVA etc.), Circular statistics, biological interpretation of statistical results. 7. Survey and document the diversity of herpetofauna, butterflies, spiders and other invertebrates in a local area using established methods.	**--**	**--**	**30**	**30**

Suggested readings:

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

Title of the Course	**Paper-4 / WILDLIFE CONSERVATION**
Paper Code	**ZOO-EW-3-FSC-509-4**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]
Course Outcomes	By the end of this course/module, students will be able to: ▪ **CO1:** Demonstrate an understanding of umbrella, flagship and edge species and their importance in species conservation. ▪ **CO2:** Apply concepts such as wildlife corridors, meta population dynamics and island biogeography to develop conservation strategies for protecting wildlife habitats and populations. ▪ **CO3:** Evaluate wildlife conservation practices based on attributes, criteria and values. ▪ **CO4:** Demonstrate proficiency in modern conservation techniques such as camera trapping, microchips and radio collars and understand their applications in wildlife conservation. ▪ **CO5:** Synthesize knowledge of biodiversity conservation, conservation practices in the Northeast region and global biodiversity hotspots to develop comprehensive conservation plans.

Contact hours	**45 (Theory) + 30 (Practical)**

WILDLIFE CONSERVATION
CODE- ZOO-EW-3-DSC-5094
Credit: 3 (T) + 1 (P)

THEORY **Credit- 3/ Hours- 45**

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	**Wildlife Conservation** ▪ Key species in Conservation: Keystone and Umbrella species, Flagship species and edge species, Importance of Umbrella and flagship species in conservation; Contribution of Wildlife in GNP ▪ Distribution of Large Cats, Elephant, Rhino, Swamp Deer, Asiatic Wild Buffalos, Hoolock Gibbon and Globally endangered birds of NE Region ▪ Conservation needs; Identifying land for Nature Reserve, SLOSS debate, Wildlife Corridors, conservation prospects of urban wildlife and strategies ▪ Meta population and meta population dynamics, concept of Island biogeography, Mammalian biogeography of Assam and India, Endemic and restricted species and species conservation.	**20**	**03**	**--**	**23**

2	**Conservation Practices** ▪ Principles of wildlife management; Conservationist Preservationist and Conservationist Utilizationisti on ▪ Wildlife Conservation Evaluation: Attributes, Criteria and Values; IUCN Criteria of Threatened Wildlife; Conservation and Preservation ▪ Biodiversity and types of diversity, importance of biodiversity Conservation, Prospects of biodiversity in economic development, biodiversity & human livelihood, Global biodiversity hot spots ▪ DNA Finger Printing, Genetic Depression; Protected area network and Wildlife Conservation practices in NE region, Reintroduction and Translocation, In-situ and Ex-situ conservation ▪ Modern conservation tools: Camera trapping, Radio Collar Microchips, Scat and Dung analysis.	**20**	**02**	**--**	**22**
PRACTICALS			**Credit- 1/ Hours- 30**		
	1. Preparation of list of endemic species of Assam and NE India based on available published literature. 2. Use of Compass and GPS in transact laying, monitoring and tracking wildlife and mapping wildlife corridor. 3. Setting up and monitoring camera traps to study wildlife existence and behavior of wildlife. 4. Scat and Dung Analysis to know the food habits of wild animals. 5. Mist Netting study of birds, followed by data recording. 6. Introduction to various statistical packages: Statistical analysis of ecological data using Excel, SPSS and R. 7. Advanced ecological methods: Occupancy modeling, Species Distribution Modelling.	**--**	**--**	**30**	**30**

Suggested Readings:

1. Conservation Biology: Foundations, Concepts, Applications by Fred Van Dyke
2. Wildlife Conservation in a Changing Climate by Jedediah F.Brodie, Eric Post and Daniel F. Doak
3. Mammals of South Asia: Volume Two by John R. Mallon and Prachi Thatte
4. The SLOSS Debate: Assessing the Role of Single Large or Several Small Reserves by Graham, J., & Sherman, P.
5. Wildlife Management and Conservation: Contemporary Principles and Practices by Paul R. Krausman and James W. Cain III
6. Principles of Conservation Biology by Martha J. Groom, Gary K. Meffe and C. Ronald Carroll

SPECIALIZATION: FISH BIOLOGY & FISHERY SCIENCE		
Paper 1 **Systematics of Finfish**	**ZOO-FB-3-DSC-5064 (Level-500)**	**3**
Practical		**1**
Paper 2 **Physiology of Finfish**	**ZOO-FB-3-DSC-5074 (Level-500)**	**3**
Practical		**1**
Paper 3 **Fisheries Science**	**ZOO-FB-3-DSC-5084 (Level-500)**	**3**
Practical		**1**
Paper 4 **Fish Disease and Health Management**	**ZOO-FB -3-DSC-5094 (Level-500)**	**3**
Practical		**1**
Paper 5/DSE-1 **Cell and Molecular Biology** (To be adopted from SWAYAM)	**ZOO-CM-3-DSE-5104A (Level-500)**	**3**
Practical		**1**
Paper 5/DSE-2 **Wildlife Management Practices**	**ZOO-EW-3-DSE-5104B (Level-500)**	
Practical		
Paper 5/DSE-3 **Advanced Aquaculture Technology** (To be adopted from SWAYAM)	**ZOO-FB-3-DSE-5104C (Level-500)**	
Practical	**(Refer to annexure)**	

Title of the Course	**Paper-1 / SYSTEMATICS OF FINFISH**
Paper Code	**ZOO-FB-3-FSC-5064**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional

	Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]
Course Outcomes	By the end of this course/module, students will be able to: • **CO1:** Classify and interpret the methods of identification and classification of fishes. • **CO2:** Compare and contrast the transition from classical approaches to modern trends of fish taxonomy. • **CO3:** Infer and assess the conservation status and distribution of freshwater fish diversity of NE India • **CO4:** Estimate and apply the various methods of fish phylogenetics. • **CO5:** Apply the concept of fish systematics in conservation.
Contact hours	**45 (Theory) + 30 (Practical)**

SYSTEMATICS OF FINFISH
CODE- ZOO-FB-3-DSC-5064
Credit: 3 (T) + 1 (P)

THEORY **Credit- 3/ Hours- 45**

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	Northeast India as a global hotspot of freshwater biodiversity; origin and evolution of freshwater finfishes of the Eastern Himalayas; status and distribution of fishes in major river basins of Northeast India.	**08**	**04**	**--**	**12**
2	Classification of Indian freshwater teleosts up to families; major diagnostic characters and diversity of important freshwater fish families.	**08**	**04**	**--**	**12**
3	Classical taxonomy of fishes: morphological characters, colour patterns, body form, morphometry, meristics and taxonomic keys for identification of common freshwater fishes.	**08**	**04**	**--**	**12**
4	Fish skeleton as a tool in taxonomy; modern trends in taxonomy including DNA barcoding and karyology; concepts and methods applied in fish phylogeny.	**06**	**03**	**--**	**09**
PRACTICALS				**Credit- 1/ Hours- 30**	
	1. Identification and characterization up to family of representative freshwater finfish species of Northeast India. 2. Comparative biometric assessment using	--	--	**30**	**30**

morphometry and meristics.
3. Osteological preparation and comparative report.
4. Internal anatomy for identification of fishes.
5. Microscopic analysis of lips and associated structures.
6. Preparation of taxonomic key.
7. Construction and interpretation of phylogeny using software.

Suggested Readings:

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

Title of the Course	**Paper-2 / PHYSIOLOGY OF FINFISH**
Paper Code	**ZOO-FB-3-FSC-5074**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]

Course Outcomes	By the end of this course/module, students will be able to: • **CO1:** Identify and explain the detailed physiology and anatomy of a fish. • **CO2:** Interpret the role and mechanism of various organs and organ systems of a fish. • **CO3:** Infer the concepts of genetics applicable to aquaculture and fisheries. • **CO4:** Utilize the basic knowledge of fish endocrinology. • **CO5:** Interpret and associate the scope of physiology in higher studies/research
Contact hours	**45 (Theory) + 30 (Practical)**

PHYSIOLOGY OF FINFISH
CODE- ZOO-FB-3-DSC-5074
Credit: 3 (T) + 1 (P)

THEORY **Credit- 3/ Hours- 45**

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	Physiology of digestion in teleosts; digestive system: anatomical differentiation and modifications; feeding adaptations in fishes.	**06**	**03**	**--**	**09**
2	Respiratory system: gill structure, mechanism of respiration, counter-current principle, exchange of gases; physiological adaptation in air-breathing fishes; accessory respiratory organs – types, structure and functions.	**08**	**04**	**--**	**12**
3	Excretion: excretion of nitrogenous wastes, urea cycle; principles of osmoregulation in freshwater and marine teleosts– processes and functional aspects.	**08**	**04**	**--**	**12**
4	Nervous system – brain and cranial nerves; sensory system– lateral line sensory organ; endocrine system– hypothalamo-hypophysial system, pituitary gland, thyroid, pancreas, caudal neurosecretory system and hormones; reproductive system– spermatogenesis, oogenesis, vitellogenesis and reproductive hormones.	**09**	**03**	**--**	**12**
PRACTICALS				**Credit- 1/ Hours- 30**	
	1. Dissection and display of digestive system of herbivorous, carnivorous and omnivorous fishes. 2. Dissection and visualization of types of gill-rakers in different groups of finfish. 3. Calculation of Relative Length of Gut (RLG) and interpretation of feeding habit. 4. Identification of different cell types in digestion using supplied slides of T.S. of stomach and intestine of fishes. 5. Dissection and display of Weberian apparatus, urinogenital system (male/female), brain and cranial nerves V, VII, IX and X.	**--**	**--**	**30**	**30**

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

Suggested Readings:

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

Title of the Course	**Paper-3 / FISHERIES SCIENCE**
Paper Code	**ZOO-FB-3-DSC-5084**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]
Course Outcomes	By the end of this course/module, students will be able to: • **CO1:** Interpret and analyse the importance and scope of fisheries in the country. • **CO2:** Compare and contrast the prospects and problems of fisheries in the Indian context. • **CO3:** Outline the basic principles and processes of post-harvest technology of Indian fisheries. • **CO4:** Estimate and apply the various indices of fish growth and diversity analyses. • **CO5:** Explain and relate the basic concepts of fish stock assessments.
Contact hours	**45 (Theory) + 30 (Practical)**

FISHERIES SCIENCE CODE- ZOO-FB-3-DSC-5084 Credit: 3 (T) + 1 (P)					
THEORY					**Credit- 3/ Hours- 45**
Unit	**Content**	**Lecture**	**Tutorial**	**Practical**	**Total hours**
1	Inland capture fisheries resources of India; fisheries statistics in Indian context; fish and fisheries of River Brahmaputra.	**07**	**03**	**--**	**10**
2	Floodplain wetland (beel) fisheries resources, problems and management; marine pelagic fisheries– sardine and mackerel; estuarine fisheries resources and associated issues.	**08**	**04**	**--**	**12**
3	Concept of absolute and relative growth; growth rate and ageing; stock assessment and management; stock composition analysis; morphological and genetic markers; marking and tagging.	**08**	**04**	**--**	**12**
4	Fisheries indices– length-weight relationship, condition factor, fecundity, index of preponderance; fish preservation methods; fishery by-products and utilization.	**08**	**03**	**--**	**11**
PRACTICALS					**Credit- 1/ Hours- 30**
	1. Estimation of length-weight relationship and condition factor. 2. Estimation of fecundity. 3. Hepatosomatic and gonadosomatic indices. 4. Gut content analysis. 5. Age estimation through hard parts. 6. Case study on climate change in fisheries. 7. Fish landing centre visit and report	**--**	**--**	**30**	**30**

Suggested Readings:

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

Title of the Course	Paper-4/ FISH DISEASE AND HEALTH MANAGEMENT
Paper Code	**ZOO-FB-3-DSC-5094**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]
Course Outcomes	By the end of this course/module, students will be able to: • **CO1:** Identify and locate the various kinds of diseases of fish. • **CO2:** Classify the important fish pathogens in finfish aquaculture systems. • **CO3:** Associate and apply the basic knowledge of prophylaxes in aquaculture. • **CO4:** Infer and analyze the harmful effects of algal blooms and toxins in aquaculture. • **CO5:** Classify and apply the utilities of nutraceuticals in aquaculture.
Contact hours	**45 (Theory) + 30 (Practical)**

FISH DISEASE AND HEALTH MANAGEMENT
CODE- ZOO-FB-3-DSC-5094
Credit: 3 (T) + 1 (P)

THEORY **Credit- 3/ Hours- 45**

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	Diseases of fishes: bacterial, fungal, viral diseases of finfish in farm ponds and natural waters; nutritional disorders and environmental diseases.	**08**	**04**	**--**	**12**
2	Disease diagnostic tools: histopathology, immunoassay, biochemical assay, serological techniques and basics of virological techniques.	**08**	**04**	**--**	**12**
3	Isolation and culture of pathogenic bacteria of finfish; fish parasites – types and symptoms caused.	**06**	**03**	**--**	**09**
4	Harmful algal bloom and microbial toxins in aquaculture; sanitation; disease control measures; herbal therapeutants; antibiotics guidelines; nutraceuticals as immunobiotics.	**08**	**04**	**--**	**12**

PRACTICALS				Credit- 1/ Hours- 30
1. Identification of disease conditions in cultivable finfish. 2. Colony count of bacteria. 3. Identification of finfish parasites. 4. Histopathological examination of liver, kidney and gills. 5. Isolation and culture of pathogenic bacteria. 6. Preparation of blood smear for DLC.	--	--	30	30

Suggested Readings:

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

Detailed Syllabus of 4th Semester

Semester	Course Name	Code	Credit
IV	**Paper 1: DISSERTATION**	**ZOO-4-PRJ-511-16**	**16**
	(i) Component A: Dissertation		
	(ii) Component B: Viva-Voce		
	(iii) Component C: Internship/Fieldwork		
	Paper 2 **SCIENTIFIC WRITING,** **PUBLICATION ETHICS & IPR**	**ZOO-4-DSE-5124**	**3**
	Practical		**1**

Title of the Course	Paper-1/ DISSERTATION
Paper Code	**ZOO-4-PRJ-511-16**

Component-1	Paper-1/ Dissertation
Code	**ZOO-4-PRJ-511A**
Teaching method	**L-T-P**
Total Credits	**Practical: 12**
Distribution of Marks	
Course Outcomes	By the end of this course/module, students will be able to: • **CO1:** Identify a research gap, formulate specific research questions or hypotheses and select appropriate research methodologies. • **CO2:** Develop the skill to critically evaluate existing scholarly work, identify contradictions, and position one's own research within the broader academic context. • **CO3:** Understand the skill of collection, organisation and rigorous analysis of data using relevant qualitative or quantitative tools. • **CO4:** Effectively synthesising findings into a structured, formal document (the thesis) that adheres to professional standards of clarity, logic, and ethical referencing. • **CO5:** Demonstrate the ability to present and defend research findings orally.
Contact hours	**45 (Theory) + 30 (Practical)**

Component-2	VIVA-VOCE
Code	**ZOO-4-PRJ-511B**
Teaching method	**L-T-P**
Total Credits	**2**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 20 (Internal) [Sessional Exam: 15 marks, Home Assignment: 6 marks, Class Test/ Group discussion/

	Seminar presentation: 5 marks, Attendance: 4 marks]
Course Outcomes	By the end of this course/module, students will be able to: • **CO1: Synthesize** and explain core concepts from the entire curriculum without the aid of notes. • **CO2: Articulate** complex scientific ideas clearly, concisely and accurately in a verbal format. • **CO3: Justify** the conclusions and reasoning, when challenged on a particular scientific concept.
Contact hours	**45 (Theory) + 30 (Practical)**

Component-3	**Field study/Internship**
Code	**ZOO-4-PRJ-511C**
Total Credits	**02 (1 credit= 30 hours)**
Contact hours	**30*2 (60)**
Course outcomes	• Apply theoretical concepts and disciplinary knowledge to real-world field situations and professional environments. • Conduct field investigations using appropriate research methodologies, data collection techniques, and analytical tools. • Evaluate socio-economic, environmental, or organizational issues and propose suitable solutions based on field observations. • Demonstrate effective communication, teamwork, leadership, and ethical conduct in professional and community settings. • Prepare and present comprehensive field study/internship reports incorporating evidence-based findings and recommendations.

Title of the Course	Paper-3/ SCIENTIFIC WRITING, PUBLICATION ETHICS & IPR
Paper Code	**ZOO-4-DSE-51304**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]
Course Outcomes	By the end of this course/module, students will be able to: • **CO1:** Understand the structure and style of scientific writing • **CO2:** Prepare research papers, reports, and theses in standard formats • **CO3:** Apply principles of publication ethics and avoid misconduct (plagiarism, fabrication, etc.) • **CO4:** Analyze journal quality, indexing, and impact metrics • **CO5:** Understand basics of IPR, patents, copyrights, and their application in biological sciences • **CO6:** Use reference management tools and plagiarism detection software
Contact hours	**45 (Theory) + 30 (Practical)**

Scientific Writing, Publication Ethics & IPR
CODE- ZOO-4-DSE-51304
Credit: 3 (T) + 1 (P)

THEORY
3/ Hours- 45 **Credit-**

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	**Fundamentals of Scientific Writing** ▪ Types of scientific writing: research paper, review, thesis, report ▪ Structure of a scientific paper: IMRAD format ▪ Title, abstract, keywords ▪ Writing clarity, conciseness, and scientific tone ▪ Use of tables, figures, and illustrations	**06**	**01**	**--**	**07**
2	**Research Documentation & Referencing** ▪ Literature review techniques				

	▪ Citation styles: APA, MLA, Vancouver, Harvard ▪ Reference management tools: Mendeley, Zotero, EndNote ▪ Avoiding plagiarism and paraphrasing techniques ▪ Use of plagiarism detection software	**06**	**02**	**--**	**08**
3	**Publication Ethics & Research Integrity** ▪ Definition and importance of ethics in research ▪ Misconduct: fabrication, falsification, plagiarism (FFP) ▪ Duplicate publication, salami slicing ▪ Authorship criteria and conflicts of interest ▪ Peer review process (single blind, double blind, open review) ▪ Predatory journals and publishers ▪ Guidelines by organizations like: o Committee on Publication Ethics (COPE) o UGC-CARE list ▪ Retraction and correction policies	**13**	**03**	**--**	**15**
4	**Intellectual Property Rights (IPR)** ▪ Concept and types of IPR: ➢ Patents ➢ Copyrights ➢ Trademarks ➢ Geographical Indications ▪ Patent filing process in India ▪ Patentability criteria (novelty, inventiveness, industrial applicability) ▪ IPR in biological sciences and biotechnology ▪ Traditional knowledge and biodiversity laws (e.g., Biological Diversity Act) ▪ Technology transfer and commercialization	**13**	**02**	**--**	**15**
PRACTICALS	**Hours- 30**				**Credit- 1/**
	1. Writing a scientific article (mini research/review paper) 2. Literature search using databases (Google Scholar, PubMed, Scopus) 3. Reference management using software (Mendeley/Zotero) 4. Plagiarism checking using standard tools 5. Identification of predatory journals vs	**--**	**--**	**30**	**30**

indexed journals

6. Preparation of a manuscript for journal submission
7. Drafting a simple patent document (basic exposure)
8. Seminar presentation on ethics/IPR case studies

Suggested Readings:

1. Day, R.A. & Gastel, B. – How to Write and Publish a Scientific Paper
2. CSE Manual – Scientific Style and Format
3. COPE Guidelines (online resources)
4. WIPO materials on IPR
5. UGC-CARE and plagiarism regulations documents

ANNEXURE FOR 3RD SEMESTER DSE

CELL & MOLECULAR BIOLOGY

CODE- ZOO-CM-3-DSE-5104A

Option-1: TO BE ADOPTED FROM SWAYAM

By Prof. Vishal Trivedi; IIT Guwahati

Course Outcomes*:*

An individual cell plays a crucial role in the organ's biological activity. The coordinated action of different cells within an organ or across different organs determines the organism's final outcome. Biological processes are controlled by various types of molecules, including cell signalling, replication, transcription, protein expression, and development. Understanding cellular structure, functions and coordination mechanisms is important for understanding disease mechanisms and designing therapeutic molecules. Apart from these aspects, molecular cell biology theory leads to the development of several diagnostic methods and recombinant DNA technology. The aim of this core course is to provide a detailed insight into the concepts of molecular biology and its mechanisms that control cell functions, along with a sense of its complex regulatory mechanisms.

THEORY **Hours**

Week 1*: *Origin of Life and Evolution

Origin of Life

Evolution (Part 1)

Evolution (Part 2)

***Week 2: Cellular* Structure** Structure of Prokaryotic Cell Structure of Eukaryotic Cell Cellular Fractionation

Week 3: Cellular Homeostasis

Cell Growth and Regulation Mitosis and Meiosis
Apoptosis and Autophagy

Week 4: Cellular Transport

Transport in Prokaryotic Cells
Transport in Eukaryotic Cells (Part 1)
Transport in Eukaryotic Cells (Part 2)

***Week 5: Cellular* Communications**

Cellular Communication (Part 1)

Cellular Communication (Part 2)

Cellular Communication (Part 3)

Week 6: Genetic Materials in Cells

Organization of Prokaryotic Genome

Organization of the Eukaryotic Genome

Genome Damage and Repair Mechanism

Week 7: Concepts of Genetics (Part 1)

Law of Inheritance (Part 1)

Law of Inheritance (Part 2) Epigenetics

Week 8: Concepts of Genetics (Part 2)

Genetic Recombination

Transgenic Organisms

Gene regulation in an organism

Week 9: Central Dogma of Molecular Biology (Part 1)

Central Dogma of Molecular
Biology: Structure of DNA
Structure of RNA

Week 10: Central Dogma of Molecular Biology (Part 1)

Replication

Transcription

Translation

Week 11: Molecular Immunology

Components of Immunology
Antibody: Structure, Genetic Diversity and
Function Vaccines

Week 12: Summary and Conclusions

Cell Factory: Concept and applications; Gene Therapy

Summary and Conclusions

Practical:

Full Marks 25	**1 Credit**	**30 Hours**
List of Practical		
1. Study of different stages of mitosis and meiosis 2. Study of chromosomal aberration and micronucleus (MN) as an indicator of genotoxicity 3. Study of heat shock puffing activity in polytene chromosomes 4. Staining of certain organelles in situ using specific stains (Mitochondria, Golgi, etc.) 5. Quantification of DNA by the diphenylamine (DPA) method. 6. Meiotic chromosome preparation of rat or mice. 7. Bone marrow cell study in rat or mice 8. Study of morphological features of apoptotic and necrotic cells. 9. Agarose Gel Electrophoresis. 10. Instruments and accessories used in PCR, SDS PAGE, Western Blot, Southern Blot: to be shown by photographs		

Option-2: Offline Mode

Title of the Course	PAPER-5/ CELL & MOLECULAR BIOLOGY
Paper Code	**ZOO-CM-3-DSE-5104A**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]
Course Outcomes	By the end of this course/module, students will be able to: • **CO1**: Understand cellular macromolecules and protein sorting • **CO2:** Explain the mechanisms of cellular dynamics, communication andstem cell biology. • **CO3**: Understand DNA repair mechanisms and the genetic code that ensures hereditary information is accurately propagated. • **CO4**: **Describe** the stages of the **cell cycle** and the regulatory roles of checkpoints, Cyclins, and Cdks. • **CO5: Relate** molecular biology concepts to medical diagnostics, drug development, and recombinant DNA technology.
Contact hours	**45 hrs (Theory) + 30 hrs (Practical)**

CELL & MOLECULAR BIOLOGY
CODE- ZOO-CM-3-DSE-5104A
Credit: 3 (T) + 1 (P)

THEORY **Credit- 3/ Hours- 45**

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	**Integration of cellular macromolecules & protein sorting** ▪ Transport of macromolecules between nucleus and cytosol, Transport between cytosol and mitochondria, ER → Golgi transport ▪ Protein folding & degradation mechanisms, Post-translational modifications	**05**	**02**	**--**	**07**
2	**Cell-to-cell communication** ▪ Gap junctions, tight junctions, adhesion				

	junctions ▪ Signal transduction pathways, Role of Ca^{2+} and NO signalling, Crosstalk mechanisms ▪ Morphogen gradients and cell fate	**05**	**01**	**--**	**06**
3	**Stem cell biology** ▪ Concept and types of stem cells, Self-renewal and pluripotency, Stem cell differentiation ▪ Isolation & characterization, Applications in tissue repair.	**04**	**01**	**--**	**05**
4	**Cell cycle, cell death & renewal** ▪ Cell cycle regulation mechanisms, Checkpoints and cyclins ▪ Programmed cell death (apoptosis), Autophagy, Cellular senescence	**04**	**02**	**--**	**06**
5	**Gene Regulation** ▪ Regulation of Transcription in prokaryotes: lac operon and trp operon (Attenuation control) ▪ Regulation of Transcription in eukaryotes: Activators, enhancers, silencers, repressors ▪ miRNA-mediated gene silencing.	**07**	**01**	**--**	**08**
6	**DNA Repair Mechanisms** ▪ Types of DNA repair mechanisms, the Rec BCD model in prokaryotes, nucleotide and base excision repair and SOS repair	**04**	**02**	**--**	**06**
7	**Methods in molecular cell biology** ▪ Protein purification and detection ▪ RNA interference and miRNA ▪ Immunocytochemistry/Immunohistochemistry ▪ Nanoparticle-based cell targeting	**06**	**01**	**--**	**07**
PRACTICALS			**Credit- 1/ Hours- 30**		
	1. Study of different stages of mitosis and meiosis 2. Study of chromosomal aberration and micronucleus (MN) as an indicator of genotoxicity 3. Study of heat shock puffing activity in polytene chromosomes 4. Staining of certain organelles in situ using specific stains (Mitochondria, Golgi, etc.) 5. Quantification of DNA by the diphenylamine (DPA) method. 6. Meiotic chromosome preparation of rat or mice. 7. Bone marrow cell study in rat or mice 8. Study of morphological features of apoptotic and necrotic cells. 9. Agarose Gel Electrophoresis. 10. Instruments and accessories used in PCR, SDS PAGE, Western Blot, Southern Blot: to be shown by photographs	--	--	**30**	**30**

Suggested Readings:

1. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2015). *Molecular biology of the cell* (6th ed.). Garland Science.
2. Alberts, B., Hopkin, K., Johnson, A. D., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2019). *Essential cell biology* (5th ed.). W. W. Norton & Company.
3. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., & Martin, K. C. (2021). *Molecular cell Biology* (9th ed.). W. H. Freeman.
4. Cooper, G. M., & Hausman, R. E. (2019). *The cell: A molecular approach* (8th ed.). Oxford University Press.
5. Karp, G. (2019). *Cell and molecular biology: Concepts and experiments* (9th ed.). Wiley.
6. De Robertis, E. D. P., & De Robertis, E. M. F. (2017). *Cell and molecular biology* (8th ed.). Wolters Kluwer.
7. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. (2013). *Molecular biology of the gene* (7th ed.). Pearson.
8. Lewin, B., Krebs, J. E., Goldstein, E. S., & Kilpatrick, S. T. (2017). *Lewin's genes XII*. Jones & Bartlett Learning.
9. Nelson, D. L., & Cox, M. M. (2021). *Lehninger principles of Biochemistry* (8th ed.). W. H. Freeman.
10. Berg, J. M., Tymoczko, J. L., Gatto, G. J., & Stryer, L. (2019). *Biochemistry* (9th ed.). W. H. Freeman.

Title of the Course	**Paper-5/ WILDLIFE MANAGEMENT PRACTICES**
Paper Code	**ZOO-EW-3-DSE-5104B**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]
Course Outcomes	By the end of this course/module, students will be able to: ▪ **CO1:** Understand and interpret key wildlife protection laws and international treaties. ▪ **CO2:** Analyze the principles and objectives of wildlife management in different habitats. ▪ **CO3:** Critically assess the effectiveness of conservation breeding programs and evaluate the impacts of human activities on wildlife and devise mitigation strategies. ▪ **CO4:** Develop sustainable ecotourism models that benefit both wildlife and local communities. ▪ **CO5:** Design and implement management practices based on species ecological requirement.

Contact hours	45 (Theory) + 30 (Practical)

WILDLIFE MANAGEMENT PRACTICES
CODE- ZOO-EW-3-DSE-5104B
Credit: 3 (T) + 1 (P)

THEORY **Credit- 3/ Hours- 45**

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	**Wildlife Management** ▪ Wildlife legislation and policy: Wildlife Protection (Act)1972, Wetland (Act) 2016, Biodiversity (Act) 2002, **CITES** ▪ Wildlife Crime: Issues and preventive measures; ▪ Conservation Breeding: Economics, Breeding species in Captivity, Effective Population size, Genetic Management in Captivity ▪ Cryopreservation and DNA bar coding: Importance and techniques; Molecular aspects: wildlife management and forensic application; ▪ Role of Zoo in species Conservation; Definition of wildlife, Wildlife conservation model and management objectives, management of wildlife based on habitat and species carrying capacity ▪ Human- Wildlife conflict: Impact on human life and livelihoods ▪ Ecotourism: community-based tourism in Northeast India (NER); ▪ Biological basis of wildlife management; Effects of flood in wildlife habitat and its control, Effects of competition with introduced species in the protected area and its impact.	**20**	**03**	**--**	**23**

2	**Ecological Association &Wildlife Management** ▪ Reasons of wildlife Taxonomic Diversity in NE Region; Utilitarian Values of Wildlife and species management; Pivotal linkages in ecosystems, Wild mammal groups, Linkage of Primates in Tropical ecosystem functioning ▪ Importance of Wetland and Forests of NE region as complementary Habitat for Birds and Mammals ▪ Key Wildlife areas: Wildlife species composition in Kaziranga and Manas, Dehang-Debang and Namdapha NP ▪ Side effect of Pest Control, Effects of Invasive predators on wildlife and habitat; Species Extinction: Estimating the risk of extinction, Quantifying risk of extinction, catastrophic digesters, species colonization vs species extinction.	**20**	**02**	**--**	**22**
PRACTICALS				**Credit- 1/ Hours- 30**	
	1. Identification of mammals, birds, lizards, snakes and butter flies, in the natural habitats. 2. Identification of vertebrate wildlife species using indirect evidence (Scat, Dung, Pugmarks, etc.) in the field and laboratory. 3. Study on interactions of wildlife with invasive species present in nearby areas, including data collection and analysis. 4. Make a report based on field survey to identify nearby human-wildlife conflict and propose potential mitigation measures. 5. Field trip to a local wildlife area to conduct habitat assessment and species documentation.	**--**	**--**	**30**	**30**

Suggested readings:

1. Wildlife ProtectionAct,1972, Biodiversity Act, 2002 and Wetland (Conservation and Management) Rules, 2010
2. International Wildlife Trade: ACITES Source book by Rosalind Reeve
3. Wildlife Forensics: Methods and Applications by Jane E. Huffman and John R. Wallace
4. Genetics for Captive Breeding Programs by Richard Frankham, Jonathan D. Ballou and David A. Briscoe
5. Zoo Conservation Biology by John E. Fa and Stephan M. Funk
6. Human-Wildlife Conflict: Complexity in the Marine Environment by Robert

M. Entman and Susan Joy Hassol
7. Biodiversity of North east India: Status and Conservation by N.Choudhury and P.K. Singh
8. Wildlife Ecology and Management by Eric G.Bolen and William L. Robinson

ADVANCED AQUACULTURE TECHNOLOGY
Code: ZOO-FB-3-DSE-5104C
Credit: 3 (T) + 1 (P)

Option-1: TO BE ADOPTED FROM SWAYAM

By Prof. Gourav Dhar Bhowmick; IIT Kharagpur

Course Outcomes:

The course deals with technological advancement in the field of aquacultural engineering all over the globe. The science behind conventional and advanced technologies in the aquacultural sector is discussed, along with the basic engineering details. The necessity of strict environmental considerations is also discussed, along with the economic return. The audience of the course is expected to be acquainted with the career opportunities in this field that align with the Neel Kranti Mission of the Government of India.

ADVANCED AQUACULTURE TECHNOLOGY

Credit: 3 (T)

Course layout

Week 1: Introduction to Aquaculture:

Characteristics of important cultivable fish and shellfish; Selection criteria, Water budget, and Conservation strategies.

Week 2: Technology of Closed Aquaculture:

Transformation of open culture to closed high tech technology; Intensive farming in high-tech tanks, Re-circulatory system; Flow-through system, Raceway culture.

Week 3: Farming systems:

Polyculture, Integrated multitrophic aquaculture; Coastal and Mariculture, Algal culture, Macroalgae or Seaweed culture, Pearl culture.

Week 4: Technology of Crustacea farming:

Culture of freshwater prawn, shrimps, and crabs.

Week 5: Technology of larval rearing:

Design and construction of hatcheries for carp, prawn, and shrimps; Maintenance of optimum conditions.

Week 6: Aquafeed Technology:

Balanced diet, Feed formulation, Linear programming, Feed additives, Feed conversion ratio (FCR), Protein retention, Calorie retention.

Week 7: Water Quality Management:

Important water quality parameters, Criteria for aquaculture, Aeration, and Chemical treatment.

Week 8: Technology of wastewater treatment:

Conventional systems, Bio-electrochemical systems, Zero water exchange, and Reuse.

Week 9: Technology of organic farming:

Wastewater- fed aquaculture, Integrated farming, Biofloc technology.

Week 10: Technology of Cleaner Production:

Green aquaculture, Smart Aquaponic system, Bioremediation, Biofiltration, Eco-labelling.

Week 11: Aquaculture Industries:

Technology of Fish products and Byproducts, zero waste recycling.

Week 12: Environmental considerations:

Impact of Climate Change on aquaculture, Mitigation and adaptive strategies.

ADVANCED AQUACULTURE TECHNOLOGY

Credit: 01

PRACTICAL Hours

1. Identification of commercially important indigenous and exotic carps 30
2. Identification of indigenous and exotic ornamental fishes
3. Identification of common aquarium plants
4. Induced breeding of carp/catfish using synthetic hormones
5. Identification and classification of developmental stages from egg to larva of IMCs
6. Estimation of water and soil quality parameters – soil organic

carbon; water hardness; alkalinity; Calcium and magnesium content.

7. Visit to a local food/ornamental fish farm and report preparation.

Option-2: offline

Title of the Course	Paper-5/ Advanced Aquaculture Technology
Paper Code	**ZOO-FB-3-DSC-5104C**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	60 (End Semester Theory) + 20 (End Semester Practical) + 20 (Internal) [Sessional Exam+ Home Assignment+ Class Test/ Group discussion/ Seminar presentation + Attendance]
Course Outcomes	By the end of this course/module, students will be able to: • **CO1:** Know the science behind conventional and advanced technologies in the aquacultural sector along with the basic engineering details. • **CO2:** Describe advanced types of aquaculture such as polyculture, integrated multitrophic aquaculture and coastal aquaculture as well as various larval rearing technologies. • **CO3:** Learn to integrate finfish, shellfish, and aquatic plant cultivation for zero-waste recycling and pollution mitigation. • **CO4:** Acquire skills in aquafeed technology, algal culture, seaweed and crustacean culture with the use of sustainable alternative proteins. • **CO5:** Analyze the strict environmental considerations along with the economic return.
Contact hours	**45 (Theory) + 30 (Practical)**

ADVANCED AQUACULTURE TECHNOLOGY
CODE- ZOO-FB-3-DSC-5104C
Credit: 3 (T) + 1 (P)

THEORY **Credit- 3/ Hours- 45**

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	Introduction to aquaculture; cultivable fish and shellfish; selection criteria; water budget; conservation strategies; closed aquaculture systems, recirculatory and raceway systems.	**08**	**04**	**--**	**12**

2	Farming systems: polyculture, integrated multitrophic aquaculture, coastal aquaculture, mariculture, algal culture, seaweed culture, pearl culture; crustacean farming.	**08**	**04**	**--**	**12**
3	Larval rearing technology; hatchery design for carp, prawn and shrimp; aquafeed technology – balanced diet, feed formulation, additives, FCR, protein retention, calorie retention; water quality management.	**08**	**03**	**--**	**11**
4	Wastewater treatment; zero water exchange; organic farming, biofloc technology; cleaner production, smart aquaponics, bioremediation, eco-labelling; aquaculture industries; climate change impacts and mitigation.	**07**	**03**	**--**	**10**
PRACTICALS			**Credit- 1/ Hours- 30**		
	1. Identification of indigenous and exotic carps. 2. Identification of ornamental fishes. 3. Identification of aquarium plants. 4. Induced breeding of carp/catfish. 5. Developmental stages from egg to larva of IMCs. 6. Water and soil quality parameters. 7. Farm visit and report preparation.	**--**	**--**	**30**	**30**

Suggested Readings:

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