Darrang College (Autonomous), Tezpur-784001

Syllabus for FYUGP B.Sc. Zoology (Major)

Approved by :

Board of Studies meeting held on 19-12-2025 &

&

Academic Council vide Resolution no. 2, dated 29-12-2025

FOUR-YEAR UNDERGRADUATE PROGRAMME (FYUGP) IN ZOOLOGY, Darrang College (Autonomous)

Introduction:

The Zoology syllabus at Darrang College (Autonomous) has been developed in accordance with the visionary framework of the National Education Policy (NEP) 2020, which advocates for a holistic, multidisciplinary and adaptable education system grounded in Indian values and aimed at cultivating globally competent individuals.

This curriculum is designed to equip students with a solid understanding of the principles and applications of Zoology, while encouraging scientific thinking, critical analysis, creativity and problem-solving skills. In line with NEP 2020, it incorporates flexible entry and exit points, skill-based learning, interdisciplinary connections and continuous formative assessments.

The programme follows a learner-centric structure that integrates core theoretical concepts, hands-on laboratory training, environmental and ethical awareness, and the enhancement of communication and research capabilities. It ensures students not only acquire zoological knowledge but also learn to apply it responsibly in real-life situations, thereby supporting sustainable development and societal well-being.

Darrang College (Autonomous) remains committed to academic excellence, innovation and contributing to nation-building by preparing students to tackle the scientific and technological demands of the modern world.

The Four-Year Undergraduate Programme (FYUGP) in Zoology is crafted to foster comprehensive and in-depth understanding of biological sciences, while encouraging interdisciplinary engagement, research orientation and employability. It aims to develop students' foundational knowledge, technical proficiency and ethical consciousness, preparing them for roles in academia, industry and society.

Aims of the Four-Year Undergraduate Programme (FYUGP) in Zoology:

The FYUGP in Zoology is designed with the following core objectives:

1. To build a solid foundation in the fundamental principles of Zoology and their applications across various branches, including Cell and Molecular Biology, Animal Physiology, Biochemistry, Fish Biology and Fishery Science, Animal Ecology, Wildlife Biology, Immunology, Entomology and Animal Biotechnology.
2. To cultivate critical thinking, scientific reasoning and analytical abilities, enabling students to address scientific challenges with both creativity and systematic approaches.
3. To promote hands-on learning through laboratory experiments, fieldwork and research activities, fostering innovation, curiosity and practical competence.
4. To encourage interdisciplinary learning and curricular flexibility, in line with NEP 2020, by facilitating connections between Zoology and other disciplines such as Botany, Biotechnology, Physics, Chemistry, Environmental Science, Materials science and computational fields.
5. To strengthen communication abilities and ethical awareness, empowering students to share scientific knowledge effectively and apply it responsibly for societal and environmental benefit.
6. To prepare students for a variety of career opportunities—including higher education, research, teaching, industry, entrepreneurship and public service—through skill-based training and value-added courses.
7. To nurture a mindset of lifelong learning and intellectual curiosity aligned with the broader goal of developing capable, compassionate and self-reliant individuals who can contribute meaningfully to national and global progress.

Through these aims, the FYUGP in Zoology at Darrang College seeks to develop graduates who are not only proficient in the Zoology, but also engaged citizens dedicated to sustainable and inclusive development.

Programme Outcome (PO) of (FYUGP) in Zoology:

- **PO1**- Students gain knowledge and skills in the fundamentals of animal sciences and are able to analyze the complex interactions among various animals across different phyla, their distribution and their relationships with the environment.

- **PO2**- Apply knowledge of the internal structure and functions of the cell in regulating various metabolic processes, along with its molecular aspects and understand key concepts of genetics and their significance in human health.

- **PO3**- Demonstrates an understanding of complex evolutionary processes and animal behaviour, along with the principles of environmental conservation, pollution control, biodiversity and the protection of endangered species, while fostering empathy and compassion toward animals.

- **PO4**-Correlates the physiological processes of animals and relationship of organ systems.

- **PO5**- Gain knowledge of small-scale industries such as sericulture, fish farming, beekeeping, aquaculture, animal husbandry and poultry farming, while promoting practical competencies through field visits and hands-on training in operational vermicomposting units; empower students with vocational skills in vermitechnology and organic agriculture to enhance employability and entrepreneurial potential.

- **PO6**- Apply ethical principles and establish a commitment to professional responsibilities and encourage awareness of laboratory ethics and safety standards to prepare students for advanced research environments.

- **PO7**- Apply zoological knowledge and understanding to personal and professional contexts, contributing to national initiatives such as Swachh Bharat, sustainable agriculture and Atmanirbhar Bharat through skill-based biological education.

Teaching-Learning Process:

The Four-Year Undergraduate Programme (FYUGP) 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 to develop communication skills
- In-semester/Sessional examinations (both theory and practical)
- End-semester examinations (theory and practical)

CURRICULUM COMPONENTS

Distribution of Credits in Four years

COURSE STRUCTURE OF Four Year Under Graduate Programme (FYUGP) in Zoology

Semester	Course Name	Code	Credit
1	**Major 1** **Diversity of Non-chordates**	**ZOO-MJ-01014 (Level-100)**	**3**
	Practical		**1**
	SEC Basics of Laboratory Practices in Zoology	**ZOO-SEC-01013 (Level-100)**	2
	Practical		1
	Minor 1 Diversity of Non-chordates	**ZOO-MN-01014 (Level-100)**	3
	Practical		1
2	**Major 2** **Diversity of Chordates**	**ZOO-MJ-02014 (Level-100)**	**3**
	Practical		**1**
	SEC Vermicomposting and Organic Farming	**ZOO-SEC-02013 (Level-100)**	2
	Practical		1
	Minor 2 Diversity of Chordates	**ZOO-MN-02014 (Level-100)**	3
	Practical		1
3	**Major 3** **Cell Biology**	**ZOO-MJ-03014 (Level-200)**	**3**
	Practical		**1**
	Major 4 **Animal Taxonomy, Systematics & Biostatistics**	**ZOO-MJ-03024 (Level-200)**	**3**
	Practical		**1**
	SEC Ornamental Fish and Aquarium Fish keeping	**ZOO-SEC-03013 (Level-200)**	2
	Practical		1
	Minor 3 **Biodiversity** and Conservation Biology	**ZOO-MN-03014 (Level-200)**	3
	Practical		1
4	**Major 5** **Entomology and Fishery**	**ZOO-MJ-04014 (Level-200)**	**3**
	Practical		**1**
	Major 6 **Fundamentals of Biochemistry**	**ZOO-MJ-04024 (Level-200)**	**3**
	Practical		**1**

	Major 7 **Biodiversity and Conservation Biology**	**ZOO-MJ-04034 (Level-200)**	**3**
	Practical		**1**
	Major 8 **Developmental Biology**	**ZOO-MJ-04044 (Level-200)**	**3**
	Practical		**1**
	Minor 4 Cell Biology and Genetics	**ZOO-MN-04014 (Level-200)**	3
	Practical		1
5	**Major 9** **Principles of Genetics**	**ZOO-MJ-05014 (Level-300)**	**3**
	Practical		**1**
	Major 10 **Fundamentals of Ecology**	**ZOO-MJ-05024 (Level-300)**	**3**
	Practical		**1**
	Major 11 **Animal Physiology**	**ZOO-MJ-05034 (Level-300)**	**3**
	Practical		**1**
	Internship	**ZOO-MJ-05044 (Level-300)**	4
	Minor 5 Fundamentals of Ecology	**ZOO-MN-05014 (Level-300)**	3
	Practical		1
6	**Major 12** **Molecular Biology**	**ZOO-MJ-06014 (Level-300)**	**3**
	Practical		**1**
	Major 13 **Evolution, Animal Behaviour and Chronobiology**	**ZOO-MJ-06024 (Level-300)**	**3**
	Practical		**1**
	Major 14 **Endocrinology and Reproductive Biology**	**ZOO-MJ-06034 (Level-300)**	**3**
	Practical		**1**
	Major 15 **Bioinformatics and Biotechniques and Instrumentation**	**ZOO-MJ-06044 (Level-300)**	**3**
	Practical		**1**
	Minor 6 Taxonomy, Evolution and Animal Behaviour	**ZOO-MN-06014 (Level-300)**	3
	Practical		1
	Major 16 **Advanced Biochemistry**	**ZOO-MJ-07014 (Level-400)**	**3**

7	**Practical**		**1**
	Major 17 **Immunology**	**ZOO-MJ-07024 (Level-400)**	**3**
	Practical		**1**
	Major 18 **Research Methodology (to be adopted from Swayam)**	**ZOO-MJ-07034 (Level-400)**	**3**
	Practical		**1**
	Major 19 **Applied Zoology**	**ZOO-MJ-07044 (Level-400)**	**3**
	Practical		**1**
	Minor 7 Applied Zoology	**ZOO-MN-07014 (Level-400)**	3
	Practical		1
Degree with Honours			
8	**Major 20** **Genetic Engineering and Cytogenetics**	**ZOO-MJ-08014 (Level-400)**	**3**
	Practical		**1**
	Major 21 **Advanced Developmental Biology**	**ZOO-MJ-08024 (Level-400)**	**3**
	Practical		**1**
	Major 22 **Parasitology and Microbiology**	**ZOO-MJ-08034 (Level-400)**	**3**
	Practical		**1**
	Research Project/ Dissertation	**ZOO-MJ-08044 (Level-400)**	4
	Minor 8 Animal Physiology and Biochemistry	**ZOO-MN-08014 (Level-400)**	3
	Practical		1
or **Degree with Honours with Research**			
8	**Major 20** **Genetic Engineering and Cytogenetics**	**ZOO-MJ-08014 (Level-400)**	**3**
	Practical		**1**
	Research Project/ Dissertation	**ZOO-MJ-080212 (Level-400)**	12
	Minor 8 Animal Physiology and Biochemistry	**ZOO-MN-08014 (Level-400)**	3
	Practical		1

Major and Minor disciplines:

Major discipline:

Major subject is the main focus and the degree will be awarded in that discipline. Students should secure the prescribed number of credits (about 50% of total credits) through the core courses in major discipline.

Minor discipline:

Minor discipline helps a student to gain a wider understanding beyond the major discipline. For example, if a student pursuing an Botany major obtains a minimum of 12 credits from a bunch of courses in Statistics, then the student will be awarded B.Sc. degree in Botany with a Minor in Statistics.

Awarding UG Certificate, UG Diploma and Degree:

UG Certificate: Students who opt to exit after completion of the first year and have secured 40 credits will be awarded a UG Certificate . In addition, they have to complete one vocational course of 4 credits during summer vacation of the first year. These students are allowed to re-enter the degree programme within three years and complete the degree programme within the stipulated maximum period of seven years.

UG Diploma: Students who opt to exit after completion of the second year and have secured 80 credits will be awarded a UG Diploma, if , in addition , they complete one vocational course of 4 credits during the summer vacation of the second year. These students are allowed to re-enter within a period of three years and complete the degree programme within a period of seven years.

3-year UG Degree: Students who want to undergo a 3-year UG programme will be awarded UG Degree in the Major discipline after successful completion of three years, securing 120 credits and satisfying the minimum credit requirement.

4-year UG Degree (Honours): A four-year UG Honours degree in the major discipline will be awarded to those students who complete a four-year degree programme with 160 credits and have satisfied the prescribed credit requirements.

4-year UG Degree (Honours with Research): Students who secure 75% marks and above in the first six semesters and wish to undertake research at the undergraduate level can choose a research stream in the fourth year. They should carry out a research project or dissertation under the guidance of a faculty member of the University/College. The research project/dissertation will be in the major discipline. The students who secure 160 credits, including 12 credits from a research project/dissertation, are awarded UG Degree (Honours with Research).

FYUGP in Zoology
Detailed Syllabus of 1st Semester Major

Title of the Course	Zoology –1/ DIVERSITY OF NON-CHORDATES -MAJOR
Paper Code	**ZOO-MJ-01014**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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. Learn about the importance of systematics, taxonomy and structural organization of animals. • CO2. Describe general taxonomic rules on animal classification. • CO3. Classify Phylum Protozoa to Echinodermata with taxonomic keys. • CO4. Critically analyze the organization, complexity and characteristic features of non-chordates making them familiarize with the morphology and anatomy of representatives of various animal phyla. • CO5. Imparts conceptual knowledge of non-chordates, their adaptations and associations in relation to their environment.
Contact hours	**45 (Theory) + 30 (Practical)**

DIVERSITY OF NON-CHORDATES Code: ZOO-MJ-01014 Credit: 3 (T) + 1 (P) THEORY					Credit- 3/ Hours- 45
Unit	**Content**	**Lecture**	**Tutorial**	**Practical**	**Total hours**
1	• Basis of Classification- Levels of organization (cellular, tissue, organ and organ system), symmetry, body wall, coelom types and its definition, segmentation and notochord. • Phylum Protista- General Characteristics, classification upto class; locomotion, nutrition and reproduction in Protozoa.	**06**	**01**	**--**	**07**
2	• Phylum Porifera- General Characteristics, classification upto class; Canal system in Porifera; Spicules in Sponges. • Phylum Cnidaria- General Characteristics, classification upto class; Corals and coral reef formation. • Phylum Ctenophora- General Characteristics, classification upto class	**06**	**02**	**--**	**08**
3	• Phylum Platyhelminthes- General Characteristics, classification upto class; Life cycle of *Fasciola hepatica* and *Wuchereria bancrofti*, Parasitic adaptation. • Phylum Nemathelminthes- General Characteristics, classification upto class; Life cycle of *Ascaris lumbricoides.* • Phylum Annelida- General Characteristics, classification upto class; Metamerism and excretion in Annelida	**13**	**03**	**--**	**15**
4	• Phylum Arthropoda- General Characteristics, classification upto class; Vision and respiration in Arthropoda; Evolutionary significance of Onychophora. • Phylum Mollusca- General Characteristics, classification upto class; Torsion and Detorsion in Gastropoda. • Phylum Echinodermata- General Characteristics, classification upto class; Water Vascular System in Echinodermata.	**13**	**2**	**--**	**15**

PRACTICALS				Credit- 1/ Hours- 30	
7	1. Study of minimum of four representative (specimen/slide/model) of each phylum of non-chordates. 2. Study of larval forms of Arthropoda. 3. T.S through crop and gizzard of Leech; Pharynx, gizzard and typhlosolar intestine of earthworm. 4. Dissection and display of digestive and nervous system of nervous system of cockroach. 5. To prepare an album of GPS photographs of at least ten locally available invertebrate species.	--	--	30	30

Suggested Readings:

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

Detailed Syllabus of 2nd Semester Major

Title of the Course	Zoology –2/ DIVERSITY OF CHORDATES -MAJOR
Paper Code	**ZOO-MJ-02014**
Teaching Method	**L-T-P**
Total Credits	**4 (Theory: 03, Practical: 01)**
Distribution of Marks	**45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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. Learn about the importance of systematics, taxonomy and structural organization of chordates. • CO2. Describe general taxonomic rules on chordate classification.

	• CO3. Classify Protochordates to Mammalia with taxonomic keys. • CO4. Critically analyze the organization, complexity and characteristic features of chordates making them familiarize with the morphology and anatomy of representatives of various chordates. • CO5. Imparts conceptual knowledge of chordates, their adaptations and associations in relation to their environment.
Contact hours	**45 (Theory) + 30 (Practical)**

DIVERSITY OF CHORDATES -MAJOR
Code: ZOO-MJ-02014
Credit: 3 (T) + 1 (P)

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

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	• Origin of Chordates- Dipleurula concept and Echinoderm theory. General characteristics and outline classification of Chordates. • General characteristics of Hemichordata, Urochordata and Cephalochordata. Study of larval forms of protochordates- Tornaria, Ascidian tadpole larva and Amphioxus. Retrogressive Metamorphosis in Ascidia.	**10**	**02**	**--**	**12**
2	• Advanced features of vertebrate over protochordate. Overview of axial and appendicular skeleton, Jaw suspensorium and visceral arches. • General characteristics and classification of cyclostomes upto class. Distinguishing features of Petromyzon and Myxine.	**08**	**02**	**--**	**10**
3	• General characteristics of Chondrichthyes and Osteichthyes and classification upto order. Swim Bladder in Fishes. Migration in Fishes	**04**	**01**	**--**	**05**
4	• Origin of Tetrapoda • General characteristics and classification of Amphibia upto order; Parental care in Amphibia. • General characteristics and classification of Reptiles upto order. Biting mechanism in snakes.	**06**	**02**	**--**	**08**

5	• General characteristics and classification of Aves upto order. Archaeopteryx as a connecting link; Aerodynamics of flight in Birds. • General characteristics and classification of Mammalia upto order. Affinities in Prototheria; Dentition in Mammals.	**08**	**2**	**--**	**10**
PRACTICALS					**Credit- 1/ Hours- 30**
7	1. Study of museum specimens/ Models - Protochordata (*Balanoglossus, Herdmania, Amphioxus*), Agnatha (*Petromyzon, Myxine*), Fishes (*Scoliodon, Torpedo, Mystus, Heteropneustes, Labeo, Hippocampus, Tetraodon*), Amphibia (*Ichthyophis, Necturus, Bufo, Hyla*), Reptilia (*Chelone, Hemidactylus, Varanus, Chamaeleon, Bungarus, Naja*), Aves (Kingfisher , White breasted water hen, Red vented bulbul, Openbilled stork, Common maina, Pied maina, House Sparrow, Water heron, Common tit and Spotted dove), Mammalia (common primates- Lories, Rhesus Macaque), common ungulates- (Sambar Deer, Spotted Deer, Swamp Deer). 2. Identification key of venomous and non-venomous snakes. 3. To study the larval forms (Ascidian Tadpole, Tornaria, *Amphioxus*, Ammocoete, *Axolotol* and Frog Tadpole larva through slides/ microphotographs. 4. To submit a project report on any five native Amphibia/ Reptilia/Aves/Mammal with GPS photographs.	**--**	**--**	**30**	**30**

Suggested Readings:

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

Detailed Syllabus of 3rd Semester Major

Title of the Course	Zoology –3/ CELL BIOLOGY -MAJOR
Paper Code	**ZOO-MJ-03014**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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:** Understand the structural and functional differences between prokaryotic cells, eukaryotic cells, and acellular entities such as viruses, viroids, mycoplasma and prions. ▪ **CO2:** Explain plasma membrane organization, membrane transport mechanisms, cell junctions and the roles of major endomembrane organelles. ▪ **CO3:** Describe the structure and functions of mitochondria, peroxisomes, cytoskeletal elements, cilia–flagella systems and nuclear components. ▪ **CO4:** Interpret chromosome organization, nucleosome packaging, cell cycle regulation and the processes of mitosis and meiosis. ▪ **CO5:** Analyse cell signalling pathways, mechanisms of apoptosis and perform laboratory techniques related to cell division, tissue histology and organelle identification.
Contact hours	**45 (Theory) + 30 (Practical)**

Zoology –3/ CELL BIOLOGY -Major
CODE- ZOO-MJ-03014
CREDIT- 3(T) + 1(P)

THEORY — **Credit- 3/ Hours- 45**

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	▪ **Over view of Cells**: Prokaryotic and Eukaryotic cells, Virus, Viroids, Mycoplasma, Prions. ▪ **Plasma Membrane:** Various models of plasma membrane structure, Transport across membranes: Active and Passive transport, Facilitated transport, Types of transporters ▪ **Cell junctions:** Structure and functions of Tight junctions, Desmosomes, Gap junctions	**12**	**03**	**--**	**15**

	▪ **Endomembrane System**: Structure and Functions of Endoplasmic Reticulum, Golgi Apparatus and Lysosomes				
2	▪ **Mitochondria:** Structure, Semi-autonomous nature, Endosymbiotic hypothesis, Mitochondrial Respiratory Chain, Chemi-osmotic hypothesis ▪ **Peroxisomes:** Structure and functions ▪ **Cytoskeleton**: Structure and Functions of Microtubules, Microfilaments and Intermediate filaments, Cillia and flagella ▪ **Nucleus**: Structure of Nucleus (Nuclear envelope, Nuclear pore complex, Nucleolus)	**12**	**3**	**--**	**15**
3	▪ **Chromosomes:** Giant chromosome (Polytene and lampbrush), Types of eukaryotic chromosomes based on centromeres, Euchromatin and Hetrochromatin, DNA packaging within the nucleus (nucleosome model) ▪ **Cell Division**: Mitosis, Meiosis, Cell cycle and its regulation ▪ **Cell Signalling:** Types of signaling molecules, Mechanism of signal transductions, GPCR and Role of second messenger (cAMP) ▪ **Cell Deaths:** Necrosis and apoptosis, significance of apoptosis in cellular homeostasis, Mechanism of apoptosis	**12**	**3**	**--**	**15**
PRACTICALS			**Credit- 1/ Hours- 30**		
7	**1.** Study of different types of cells (Representatives of prokaryotic and eukaryotic cell) **2.** Preparation of temporary stained squash of onion root tip to study various stages of mitosis **3.** Study of various stages of meiosis in testis (Grasshopper /Cockroaches/ Mice/Rat). **4.** Preparation of permanent slide to show the presence of Barr body in human female blood cells/cheek cells. **5.** Study of permanent slides/ microphotograph showing subcellular organelles viz. nucleus, mitochondria, golgi apparatus, endoplasmic reticulum, lysosome, ribosome and giant chromosomes.	**--**	**--**	**30**	**30**

Suggested Readings:

1. Cooper, G. M. (2018). 8th Edition. The cell: A molecular approach. Massachusetts, USA: Sinauer Associates. ISBN-13:978-1605357072

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

Title of the Course	**Zoology –4/ANIMAL TAXONOMY, SYSTEMATICS & BIOSTATISTICS-Major**
Paper Code	**ZOO-MJ-03024**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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:** Understand the foundations of biosystematics and animal taxonomy, including taxonomic categories, species concepts and the role of systematics in biological research. ▪ **CO2:** Apply taxonomic tools such as dichotomous keys and evaluate taxonomic characters including morphological, behavioural, ecological and geographical traits. ▪ **CO3:** Explain modern trends in taxonomy such as chemotaxonomy, cytotaxonomy, molecular taxonomy and the key principles of zoological nomenclature under ICZN. ▪ **CO4:** Interpret phylogenetic concepts such as homology, analogy, monophyly, and convergence and construct basic phylogenetic representations like cladograms and phenograms. • **CO5:** Use biostatistical methods to analyze biological data, including measures of central tendency and variation, correlation, regression and hypothesis testing through t-tests, chi-square, ANOVA and related tools.
Contact hours	**45 (Theory) + 30 (Practical)**

ZOOLOGY–4/ ANIMAL TAXONOMY, SYSTEMATICS & BIOSTATISTICS -Major
CODE- ZOO-MJ-03024
CREDIT- 3(T) + 1(P)

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

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	**BIO-SYSTEMATICS & ANIMAL TAXONOMY** ▪ Introduction to Systematics -Taxonomy vs Systematics; Taxon and Phenon; Contribution of Systematics to biology; Systematics as a profession ▪ Taxonomic categories; concepts of species – typological, nominalistic, biological and evolutionary ▪ Taxonomic keys – various types; dichotomous nature of keys ▪ Taxonomic characters – morphological, behavioural, ecological, and geographical ▪ Trends in taxonomy – chemotaxonomy, cytotaxonomy and molecular taxonomy ▪ Zoological Nomenclature – ICZN, Principles, functions, and importance of The Code of nomenclature; principle of priority, homonymy and synonymy, principle of typification and use of types for specimens ▪ Basics of phylogeny – Characters (ancestral vs. derived), homology and analogy, parallelism and convergence, monophyly, polyphyly, paraphyly; representing phylogenies – Rooted and unrooted phylogenetic trees; clades; Cladograms and Phenograms	**20**	**05**	**--**	**25**
2	**BIOSTATISTICS** ▪ Concept of Statistics and its Applications in Biological Sciences; Sampling methods; Primary and Secondary Data; Qualitative and Quantitative data; Discrete and Continuous Data. ▪ Concept of Statistical Population and Samples ▪ Measures of Central Tendency- Mean. Median and Mode Partition Values ▪ Measures of Variations- Range, Quartile deviation, Mean deviation, Standard Deviation; Co-efficient of Variation and Standard Error ▪ Concept of Correlation and Regression ▪ Testing of Hypothesis- Null and Alternative hypothesis, Critical region, Level of significance, Type-I and Type-II Error,	**16**	**4**	**--**	**20**

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

Suggested Readings:

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

Detailed Syllabus of 4th Semester Major

Title of the Course	**Zoology –5/ ENTOMOLOGY AND FISHERY -Major**
Paper Code	**ZOO-MJ-04014**
Teaching method	**L-T-P**

Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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:** Understand the general features, classification, morphology and ecological roles of insects, including their significance as pollinators, pests and disease vectors. ▪ **CO2:** Apply insect collection, preservation and identification techniques and relate insect structures such as antennae, legs and mouthparts to their functions and habitats. ▪ **CO3:** Explain vector biology, metamorphosis, pest management approaches including IPM and botanicals and emerging areas such as forensic entomology and entomotherapy. ▪ **CO4:** Describe the taxonomy, morphology and physiology of freshwater fishes, including locomotion, respiration, osmoregulation, scales, fins and special organs like swim bladders and electric organs. • **CO5:** Analyse fishery practices including capture and culture techniques, broodstock and hatchery management, water quality assessment and modern tools such as remote sensing, GIS and fish models in research.
Contact hours	**45 (Theory) + 30 (Practical)**

Zoology –5/ ENTOMOLOGY AND FISHERIES
CODE- ZOO-MJ-04014
CREDIT- 3(T) + 1(P)

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

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	**ENTOMOLOGY** ▪ **General Features of Insects**, Classification of insects up to orders, causes of success of insects on earth, role of insects in pollination ▪ **Insect Collection and Preservation Techniques:** Collection method and required equipments, Dry and Wet preservation. ▪ **General Morphology of insects** -compound Eyes, Types of antennae, Mouth parts with respect to feeding habits and Types of legs adapted to diverse habitat. Molting and Metamorphosis in Insects. ▪ **Insects as Vectors**: Insects as mechanical and	**20**	**03**	**--**	**23**

	biological vectors of pathogens and parasites, Common insect vectors (Aedes, Culex, Anopheles, Phlebotomus, Musca domestica). ▪ **Insects as Pests**- Insects as plant pests, IPM concept, Role of Botanicals in Pest management. ▪ **Introduction to medical entomology**- Insects in Forensic science, Entomophagy and Entomotherapy.nomenclature; principle of priority, homonymy and synonymy, principle of typification and use of types for specimens				
2	**FISHERY** ▪ **Introduction to fish** - General description of a fish; Account of systematic classification of freshwater teleosts of NE India (up to Order) ▪ **Morphology and Physiology** - Types of fins and their modifications; Locomotion in fishes; Types of Scales; Structure and functions of Gills, basic mechanism of gas exchange; Swim Bladder - types, role in Respiration and buoyancy; Osmoregulation in Elasmobranchs; Electric organs ▪ **Capture Fisheries** - Inland Capture Fisheries resources of India; marine fisheries; Fishing crafts and Gears; Application of remote sensing and GIS in fisheries; Fisheries rules and regulations; Climate change and its impact on fisheries; Fishery by-products ▪ **Culture fisheries** - Extensive, semi-intensive and intensive culture of fish; Pen and cage culture; Polyculture; Composite fish culture; Brood stock management; Induced breeding of Indian Major Carps; Management of hatcheries; Role of soil and water quality in aquaculture ▪ **Fish in research** - Transgenic fish, Zebrafish as a model organism in research	**18**	**4**	**--**	**22**
PRACTICALS				**Credit- 1/ Hours- 30**	
7	**1.** Study of different types of mouth parts/ antenna of insects through slides/specimens. **2.** Study of insect vectors through permanent slides or photographs or model: *Aedes, Culex, Anopheles*, *Pediculus*, *Cimex*, *Phlebotomus* (sand fly), and *Musca domestica* (house fly). **3.** Preparation of project report on any one vector and diseases transmitted by the vector (*Aedes/Culex/Anopheles*/ lice/ bed bug, sand fly/ house fly). **4.** Identification of insects belonging to different orders, common insect pest of paddy, tea, stored	**--**	**--**	**30**	**30**

grain, citrus and sugarcane.

5. Classification and characterization of commercially important food and ornamental fishes of NE India.
6. Study of different types of indigenous/locally available fishing gears.
7. Estimation and interpretation of pH of pond soil; dissolved oxygen (D.O.) and free carbon dioxide (fCO2) in pond water.
8. Dissection and display of Pituitary Gland of Indian Major Carp.
9. Demonstration of induced breeding of IMCs (video)

Suggested Readings:

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

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Title of the Course	**Zoology –6/ FUNDAMENTALS OF BIOCHEMISTRY -Major**
Paper Code	**ZOO-MJ-04024**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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:** Understand the structures and biological roles of carbohydrates and lipids, including major classes such as monosaccharides, polysaccharides, fatty acids, phospholipids and steroids. ▪ **CO2:** Describe amino acid properties, protein structure levels and mechanisms of protein folding, denaturation and amino acid catabolism. ▪ **CO3:** Explain the structural organization of nucleic acids, base pairing, DNA–RNA types, supercoiling and principles of DNA melting and renaturation. ▪ **CO4:** Interpret enzyme classification, catalytic mechanisms, enzyme kinetics including Km and Vmax and the effects of inhibitors, cofactors and allosteric regulation. • **CO5:** Perform biochemical experiments involving biomolecule detection, chromatography, enzyme activity assays and analysis of factors influencing enzyme function.
Contact hours	**45 (Theory) + 30 (Practical)**

Zoology –6/ FUNDAMENTALS OF BIOCHEMISTRY
CODE- ZOO-MJ-04024
CREDIT- 3(T) + 1(P)

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

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	**Carbohydrates and Lipids** ▪ **Carbohydrates:** Structure and Biological importance, Monosaccharides, Disaccharides, Polysaccharides and Glycoconjugates ▪ **Lipids**: Structure and Significance: Physiologically important saturated and unsaturated fatty acids, Tri-acylglycerols, Phospholipids, Glycolipids, Steroids.	**13**	**02**	**--**	**15**
2	**Amino Acids, Proteins and Nucleic Acids** ▪ **Amino acids:** Structure, Classification and General properties of α- amino acids; Physiological importance of essential and non-essential α- amino acids. Amino acid catabolism: Transamination, Transdeamination and oxidative deamination. ▪ **Proteins:** Bonds stabilizing protein structure; Levels of organization in proteins; Denaturation; Introduction to simple and conjugate proteins. ▪ **Nucleic Acids**: Structure: Purines and	**13**	**02**	**--**	**15**

	pyrimidines, Nucleosides, Nucleotides, folding motifs, conformational flexibility, and supercoiling. Nucleic acids Cot Curves: Base pairing, Denaturation and Renaturation of DNA. Types of DNA and RNA, Complementarity of DNA.				
3	**Enzymes** ▪ Nomenclature and classification; Cofactors; Specificity of enzyme action; Isozymes; Mechanism of enzyme action; Factors affecting rate of enzyme-catalyzed reactions; ▪ Derivation of Michaelis-Menten equation, Concept of Km and Vmax, ▪ Regulation of enzyme action and Different types of Enzyme Inhibition (Competitive, Non-competitive and Uncompetitive Inhibition). Multi-substrate reactions; Allosteric enzymes and their kinetics	**13**	**02**	**--**	**15**
PRACTICALS				**Credit- 1/ Hours- 30**	
7	**1.** Qualitative tests of functional groups in carbohydrates, proteins and lipids. **2.** To determine the iodine number of given oil/fat. **3.** Estimation of a reducing sugar in a given sample. **4.** Paper chromatography of amino acids. **5.** Denaturation and coagulation of proteins. **6.** Effect of pH, temperature on the action of salivary amylase **7.** To find the pKa value of acetic acid. **8.** To study the activity of Salivary Amylase and Determination of Amylase Number.	**--**	**--**	**30**	**30**

Suggested Readings:

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

Title of the Course	Zoology –7/ BIODIVERSITY AND CONSERVATION BIOLOGY /Major
Paper Code	**ZOO-MJ-04034**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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:** Understand the concepts, components, evolution and global patterns of biodiversity, including the influence of climate, land use and human population pressures. ▪ **CO2:** Explain the values, uses, and conservation approaches for biodiversity, including in situ and ex situ methods, restoration techniques and sustainable resource management. ▪ **CO3:** Analyse conservation priorities, sustainable development goals, gender perspectives and legal frameworks governing biodiversity and wildlife protection. ▪ **CO4:** Describe wildlife habitat management, ecological restoration and the use of GIS, remote sensing and field techniques in studying and monitoring wildlife populations. • **CO5:** Identify major wildlife groups, apply field survey tools and methods, interpret indirect animal signs and conduct basic wildlife activity and habitat assessments.
Contact hours	**45 (Theory) + 30 (Practical)**

Zoology –7/ BIODIVERSITY AND CONSERVATION BIOLOGY
CODE- ZOO-MJ-04034
CREDIT- 3(T) + 1(P)

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

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	▪ Concept and history of biodiversity , Major elements of global diversity, Evolution and distribution, Components of Biodiversity (Genetic, Organismal and Ecological) ▪ Biodiversity in different levels (Country, Global, Regional) ▪ Magnitude and pattern of Biodiversity, Carrying capacity, land use and population pressure on	**10**	**02**	**--**	**12**

	Biodiversity ▪ Impact of climate Change, Global health and diseases on Biodiversity				
2	▪ Value of Biodiversity (Species and Ecosystems), Utilization of Biodiversity ▪ Methods and tools for biodiversity conservation (*ex situ*, *in situ*, Restoration and Rehabilitation, Sustainable land use practices) ▪ Priority setting: Criteria for conservation, Concept of sustainable development, Sustainable development goals, Harnessing and benefit sharing ▪ Integrating gender perspectives in biodiversity conservation ▪ Challenges in Biodiversity Conservation: Impacts of population pressure, land use changes and urbanization on biodiversity; Impact of climate Change on biodiversity loss, public health and disease dynamics. ▪ Legal instruments for biological diversity conservation	**15**	**03**	**--**	**18**
3	▪ Habitat management of wildlife in different ecosystems, Restoration of degraded habitats, Concepts of GIS and Remote sensing and their utility in wildlife habitat management ▪ Wildlife protected areas in India, National Parks, Sanctuaries, Man and Biosphere Reserve, Community reserves, Sacred Groves. ▪ Concepts of elephant and tiger reserves, Ramsar sites, Concepts and management of renewable natural resources and wildlife's welfare factors.	**12**	**03**	**--**	**15**
PRACTICALS			**Credit- 1/ Hours- 30**		
7	1. Identification of wild fauna (Mammals, Birds, Herpetofauna and Butterflies) 2. Demonstration and applicability of basic equipment needed for wildlife studies (Compass, Range finder, GPS, Camera Traps). 3. Demonstrations of field study techniques: line transect and quadrate sampling. 4. Importance of indirect evidences in wildlife survey and its identification [Animal Footprints (Pug mark & hoof mark), Animal Droppings (Scat, Dung, Pellet), Other animal signs, Antlers, Nests of birds]. Animal trail survey or trail monitoring, use of plaster of Paris for wildlife survey (for the indirect survey). 5. Activity budgeting of bird/mammal.	**--**	**--**	**30**	**30**

Suggested Readings:

1. M.Kato (Ed) ; The Biology of Biodiversity: Springer-Verlag, 2000
2. Anne E. Magurran; Measuring Biological Diversity; Blackwell Publishing, 2004
3. K. C. Agrawal: Global Biodiversity, Nidhi Publishers (India), 2002
4. Kelvin J. Gaston & John I Spicer: Biodiversity An Introduction; 2nd Edn. Blackwell Publishing; 2004
5. Caughly, G. and Sinclair, A. R. E. (1994). Wildlife Ecology and Management. Blackwell Scientific Publications, 1-334pp.
6. Shekhar, S. Kolipaka, (2014). A Field Guide to Tracks & Signs of Indian Wildlife. 1-385pp.
7. Sinclair, A.R. E., John M. Frysell, and Graeme Caughley (2006). Wildlife Ecology, Conservation, and Management, Blackwell Publishing, 1-463, pp.
8. Raj, M. (2012). Wildlife Ecology and Management (With special reference to Northeast India). Assam Book Depot, Panbazar, Guwahati-1, 1-294pp.
9. Berwick S. H. and Saharia, V. B. (1995). Development of International principles of Wildlife Research and Management (Asian and American approaches). Oxford University Press, Delhi, Bombay, Madras. 1-481. pp.
10. Vivek Menon, (2014). Indian mammals, A Field Guide.Hachetta Book Publishing India Pvt. Ltd.4th and 5th Floor Corporate centre, Plot No. 94, Sector 44, Gurgoan, 122001, India.
11. Hunter M. L., Gibbs, J. B. and Sterling, E. J. (2008). Problem-Solving Conservation Biology and Wildlife Management: Exercise for class, Field and laboratory, Blackwell Publishing.
12. Southerland, W. J. (2000). The conservation handbook: Research management and Policy. Blackwell Sciences.
13. Bookhout, T. A. (1996). Research and management techniques for wildlife and habitats, 5th edition. The Wildlife Society, Allen Press.
14. Woodroffe, R., Thirgood, S. and Rabinowitz, A. (2005). People and Wildlife, Conflict or Co-existence? Cambridge University.

Title of the Course	**Zoology –8/ DEVELOPMENTAL BIOLOGY -Major**
Paper Code	**ZOO-MJ-04044**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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:** Understand the processes of gametogenesis, fertilization and parthenogenesis, including cellular interactions, biochemical events and developmental significance. ▪ **CO2:** Describe egg types, vitellogenesis, cleavage patterns, blastula formation and early embryonic organization in vertebrates. ▪ **CO3:** Explain key developmental events such as embryonic induction, organizer function, fate map construction and the organogenesis of major

	systems like the heart and eye. ▪ **CO4:** Analyse vertebrate developmental adaptations including placental structure, metamorphosis and the role of hormones and teratogenic agents in regulating or disrupting development. • **CO5:** Apply practical skills to identify gametes, study embryonic stages in frog and chick, examine placental structures and understand assisted reproductive and stem-cell-based technologies.
Contact hours	**45 (Theory) + 30 (Practical)**

Zoology –8/ DEVELOPMENTAL BIOLOGY
CODE- ZOO-MJ-04044
CREDIT- 3(T) + 1(P)

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

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	▪ **Gametogenesis:** Spermatogenesis and Oogenesis ▪ **Fertilization:** External and internal fertilization**,** sperm-egg interactions, biochemical events, post-fertilizations events. ▪ **Parthenogenesis**: Natural haploid, diploid and cyclic parthenogenesis. Artificial stimulus for parthenogenesis and its significance.	**12**	**03**	**--**	**15**
2	▪ **Types of Egg**; Different egg types, egg membrane and vitellogenesis, Planes and patterns of cleavage; Types of Blastula ▪ Embryonic induction and Organizer, Fate map construction in frog and chick. ▪ **Organogenesis:** Development of heart and eye in vertebrates Development of chick embryo up to three germ layer formation. Extra embryonic	**12**	**03**	**--**	**15**
3	▪ **Placenta:** Types, function and physiology ▪ **Metamorphosis: types of metamorphosis, metamorphic changes**, hormonal regulations of metamorphosis in insects and amphibians. ▪ **Teratogenesis:** Teratogenic agents and their effects on embryonic development ▪ In vitro fertilization, Embryonic Stem cell (ESC), Amniocentesis.	**12**	**03**	**--**	**15**

PRACTICALS **Credit- 1/ Hours- 30**

1. Collection and study of different type of eggs
2. Examination of gametes of frog/rat/mice: Sperm and ova through permanent slides or photomicrographs.
3. Study of developmental stages of Frog: Whole

7	mounts and sections through permanent slides of cleavage stages, blastula, gastrula, neurula, tail bud stage, tadpole external and internal gill stages. 4. Study of developmental stages of Chick embryo: Whole mounts of chick through permanent slides (Hamburger and Hamilton Stages): Stage 3 (Intermediate Streak, 13 hours), Stage 4 (Definitive Streak, 18hours), Stage 5 (Head Process, 21 hours), Stage 7 (24 hours), Stage 8 (28 hours), Stage10 (33 hours), Stage 11 (40 hours), Stage 13 (48hours), Stage 19 (72 hours) and Stage 24 (96 hours) of incubation 5. Study of different types of placenta: Histological sections through permanent slides or photomicrographs	--	--	30	30

Suggested Readings:

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

Detailed Syllabus of 5th Semester Major

Title of the Course	**Zoology –9/ PRINCIPLES OF GENETICS -Major**
Paper Code	**ZOO-MJ-05014**
Teaching method	**L-T-P**

Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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:** Understand Mendelian and post-Mendelian inheritance patterns, including gene interactions, penetrance, expressivity and the inheritance of sex-linked, sex-influenced and sex-limited traits. ▪ **CO2:** Explain linkage, crossing over, recombination frequencies and construct gene maps using two-point and three-point test crosses, including concepts like interference and coefficient of coincidence. ▪ **CO3:** Describe chromosomal and gene-level mutations, their molecular basis, detection methods in Drosophila and cellular DNA repair mechanisms. ▪ **CO4:** Analyse genetic, environmental, and hormonal mechanisms of sex determination, dosage compensation, extranuclear inheritance and maternal effect phenomena. • **CO5:** Apply basic genetic tools such as chi-square tests, linkage analysis, karyotype interpretation, polytene chromosome preparation and pedigree construction for understanding human genetic traits.
Contact hours	**45 (Theory) + 30 (Practical)**

Zoology –9/ PRINCIPLES OF GENETICS
CODE- ZOO-MJ-05014
CREDIT- 3(T) + 1(P)

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

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	**Elements Of Heredity and Variations:** ▪ Principles of inheritance, Chromosomal Basis of Inheritance, **Extension of Mendelism** ▪ Incomplete dominance and co-dominance; Multiple alleles; Lethal alleles, ▪ Penetrance and expressivity; Gene Interaction, Epistasis; Pleiotropy; ▪ Sex-linked, Sex-Influenced and Sex-limited characters inheritance **Linkage, Crossing over and Gene Mapping** : ▪ Linkage and Crossing over, Cytological Basis of crossing over, Recombination frequency as a measure of linkage intensity; ▪ Gene Mapping Using Two point and three Point Test crosses; Linkage map; coefficient of coincidence and Interference;	**16**	**02**	**--**	**18**

	▪ Gene mapping by Somatic cell hybridization.				
2	**Chromosomal alterations** ▪ Anomalies in chromosome number; ▪ Anomalies in chromosome structure **Gene Mutations** : ▪ Induced versus spontaneous mutations; Backward and forward mutations; Suppressor mutations; ▪ Molecular basis of mutation; Detection of mutations in Drosophila: CLB method, attached X method. DNA repair mechanisms	**07**	**02**	**--**	**09**
3	**Sex determination and Inheritance of Sexual Traits**: ▪ Genetic, Environmental and Hormonal basis of Sex determination; ▪ Sex Influenced, Sex-Limited and Sex-Linked Traits, ▪ Dosage compensation in Drosophila and human **Extranuclear inheritance**: ▪ Comparison of nuclear and extranuclear inheritance; ▪ Organelle inheritance: Antibiotic resistance in *Chlamydomonas*, Mitochondrial mutations in *Saccharomyces* and human disorders, Infective heredity in *Paramecium*. ▪ Maternal effects: Shell coiling in *Limnaea*, pigmentation in *Ephestia*. **Human Genetics** ▪ Making A Pedigree Chart and showing dominant, recessive, Autosomal and sex-linked traits, Genetic counselling	**16**	**02**	**--**	**18**
PRACTICALS				**Credit- 1/ Hours- 30**	
7	1. To study Mendelian laws and gene interactions and their verification by Chi-square analyses using seeds/beads/*Drosophila* 2. Study of linkage maps based on data from *Drosophila* crosses. 3. Identification of various mutant types of *Drosophila* (through culture/photomicrographs) 4. Study of human karyotype (normal and abnormal) using photomicrograph. 5. Preparation of Polytene chromosomes from *Chironomous*/ *Drosophila* larvae. 6. Pedigree analysis of some human inherited traits.	**--**	**--**	**30**	**30**

Suggested Readings:

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). Principles of Genetics. 8th edition. Wiley India.

2. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. 5th edition. John Wiley ans Sons Inc

3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2020). Concepts of Genetics. 10th edition. Benjamin

Cummings.
4. Russell, P.J. (2009). Genetics- A molecular approach. 3rd edition. Benjamin Cummings.
5. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. Introduction to genetic Analysis. 9th edition. W.H. Freeman and Co.
6. Tamarin R.H. (2017). Principles of Genetics. Tata McGraw Hill Edition
7. Brown, T.A. (2023). Genomes 5. 5th edition, CRC Press.

Title of the Course	**Zoology –10/ FUNDAMENTALS OF ECOLOGY -Major**
Paper Code	**ZOO-MJ-05024**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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:** Understand the basic concepts of ecology and ecosystem organization, including autecology, synecology, limiting factors and the structural and functional components of ecosystems. ▪ **CO2:** Explain trophic interactions, food chains, food webs, ecological pyramids, energy flow, nutrient cycling and the impacts of human-modified ecosystems. ▪ **CO3:** Analyse population attributes such as density, natality, mortality, growth patterns, life tables, survivorship curves and regulatory mechanisms including r–K strategies. ▪ **CO4:** Describe community structure, species diversity, stratification, ecotones, edge effects and ecological succession leading to climax communities. • **CO5:** Apply ecological field methods to assess population density, diversity indices, water quality parameters and ecosystem characteristics, and interpret ecological data through practical investigations and field visits.
Contact hours	**45 (Theory) + 30 (Practical)**

Zoology –10/ FUNDAMENTALS OF ECOLOGY
CODE- ZOO-MJ-05024
CREDIT- 3(T) + 1(P)

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

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	**Introduction to Ecology and Ecosystem** ▪ Basic concept of ecology and ecosystem, Autecology and synecology, Levels of organization, Laws of limiting factors ▪ Structural components of Ecosystem ▪ Functional attributes of Ecosystem-Trophic structure, Food chain: Detritus and grazing food chains, Linear and Y-shaped food chains, Food web, Energy flow through the ecosystem ▪ Ecological pyramids and Ecological efficiencies Nutrient and biogeochemical cycle with one example of Nitrogen cycle Human modified ecosystem.	**15**	**03**	**--**	**18**
2	**Population** ▪ Unitary and Modular populations ▪ Unique and group attributes of population: Density, Natality, Mortality, Life table, Fecundity tables and Survivorship curve, Age ratio, Sex ratio, Dispersion and Dispersal, Exponential and logistic growth, equation and patterns, r and K strategies ▪ Biotic potential and Environmental resistance ▪ Population regulation - density-dependent and independent factors Population interactions, Gause's Principle, Lotka-Volterra equation	**15**	**02**	**--**	**17**
3	**Community** ▪ Community characteristics: species richness, dominance, diversity, abundance, vertical stratification, ▪ Ecotone and edge effect ▪ Ecological succession with one example, Theories pertaining to climax community	**09**	**01**	**--**	**10**
PRACTICALS			**Credit- 1/ Hours- 30**		
7	**1.** Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided **2.** Determination of population density by quadrate method and calculation of Shannon Weiner diversity index in a natural/ hypothetical community **3.** Study of an aquatic ecosystem: Phytoplankton and zooplankton,	**--**	**--**	**30**	**30**

	Measurement of area, temperature, turbidity/penetration of light, **4.** Determination of pH, and Dissolved Oxygen content (Winkler's method) and free CO_2 in an ecosystem **5.** Report on a visit to National Park/Biodiversity Park/Wild life sanctuary

Suggested Readings:

1. Colinvaux, P.A. (1973). Ecology. 2nd Edition. John Wiley and Sons Inc.
2. Krebs, C. J. (2001). Ecology. 6th Edition. Benjamin Cummings.
3. Odum, E.P. (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole
4. Smith, R. L., Smith, T.M. (2000). Ecology and field biology Harper and Row publisher
5. Ricklefs, R.E. (2000). Ecology. V Edition. Chiron Pres

Title of the Course	**Zoology –11/ ANIMAL PHYSIOLOGY -Major**
Paper Code	**ZOO-MJ-05034**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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:** Understand the structure and functions of major tissue types, including epithelial, connective, muscular, nervous tissues as well as bones and cartilage. ▪ **CO2:** Describe the physiology of digestion, respiration and circulation, including nutrient absorption, gas exchange mechanisms, oxygen transport dynamics and the cardiac cycle with ECG interpretation. ▪ **CO3:** Explain muscle organization, neuromuscular transmission, nerve impulse conduction, synaptic communication and neurotransmitter functions. ▪ **CO4:** Analyse excretory physiology, nephron structure, urine formation, nitrogenous waste patterns and regulatory mechanisms such as the counter-current system and urea cycle. • **CO5:** Perform laboratory techniques involving blood cell

	identification, haemoglobin estimation, blood grouping, cell counts and histological examination of major mammalian organs.
Contact hours	**45 (Theory) + 30 (Practical)**

Zoology – 11/ ANIMAL PHYSIOLOGY
CODE- ZOO-MJ-05034
CREDIT- 3(T) + 1(P)

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

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	▪ **Tissues:** Types of Tissues; Structure and Function of Epithelial, Connective, Muscular and Nervous Tissues, Bones and Cartilage	03	--		03
2	▪ **Digestive System** Digestion and absorption of carbohydrates, proteins and lipids. Absorption and Assimilation of Various Food Stuffs. ▪ **Respiratory System** Breathing and Ventilation, Mechanism of Breathing, Transport of oxygen and Carbon dioxide, Oxygen-Haemoglobin curve and Bohr's effect, Chloride Shift and Haldane Effect, Respiratory Volume and Capacities. ▪ **Cardiovascular System** Structure of Heart, Origin and Conduction of heart impulse, Concept of Neurogenic and myogenic heart, Cardiac Cycle and ECG patterns in Human. Homeostasis and Mechanism of Blood Clotting	20	02	--	22
3	▪ **Muscles** Structure, kinds and characteristics of Muscle, Mechanism of muscle stimulation and contraction, Neuro - Muscular Junction ▪ **Nervous System** Structure of Neuron, Generation of Action potential and transmission of nerve impulse, Synaptic Transmission and Neurotransmitters ▪ **Excretory System** Structure of Nephron and Kidney, Functions of Kidney, Types of nitrogenous wastes in different animal groups, Urea cycle and Urine formation, Counter-current mechanism.	18	02	--	20

PRACTICALS				**Credit- 1/ Hours- 30**	
7	1. Preparation of temporary mount of blood cells (blood film preparation), squamous epithelium and striated muscle fibres. 2. Preparation of haemin and haemochromogen crystals. 3. Haemoglobin estimation using Sahli's haemoglobinometer. 4. Determination of ABO Blood group and Rh factor. 5. Study of total count of RBC and WBC in mammalian blood. 6. Study of sickle cell anaemia in human using photomicrograph. 7. Preparation of histological slides from tissues as liver, Lung, Stomach, Duodenum, Intestine, Kidney, Pancreas, Testes and Ovary.	--	--	**30**	**30**

Suggested Readings:

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

INTERNSHIP

Detailed Syllabus of 6th Semester Major

Title of the Course	**Zoology –12/ MOLECULAR BIOLOGY -Major**
Paper Code	**ZOO-MJ-06014**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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:** Explain the structure and types of nucleic acids and describe the mechanism of DNA replication in prokaryotes and eukaryotes, including telomere replication. • **CO2:** Describe the mechanism of transcription in prokaryotes and eukaryotes, including RNA polymerase, transcription units and transcription factors. • **CO3:** Discuss post-transcriptional modifications such as splicing, alternative splicing, RNA editing and the concept of split genes. • **CO4:** Explain the genetic code, wobble hypothesis, tRNA charging and the complete mechanism of translation along with inhibitors of protein synthesis. • **CO5:** Analyze gene regulation in prokaryotes and eukaryotes and evaluate mechanisms of DNA damage and repair, gene silencing, and RNA interference. • **CO6:** Perform quantitative estimation and isolation of nucleic acids and interpret electrophoretic and electron micrograph-based observations.
Contact hours	**45 (Theory) + 30 (Practical)**

Zoology –12/ MOLECULAR BIOLOGY
CODE- ZOO-MJ-06014
CREDIT- 3(T) + 1(P)

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

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	▪ **Nucleic Acids**: Structure and types of DNA and RNA, Watson and Crick model of DNA. ▪ **DNA Replication**: Enzymes used in DNA Replication, DNA Replication in prokaryotes and eukaryotes, mechanism of DNA replication, Semi-conservative, bidirectional and semi-discontinuous replication, Telomere and replication of telomeres	**10**	**--**		**12**
2	▪ **Transcription**: RNA polymerase structure and transcriptional Unit, mechanism of transcription in prokaryotes and eukaryotes, synthesis of rRNA and mRNA, transcription factors ▪ **Post Transcriptional Modifications and Processing of Eukaryotic RNA:** Split genes: concept of introns and exons, splicing mechanism and alternative splicing, RNA editing ▪ **Translation**: Genetic code, Degeneracy of the genetic	**16**	**02**	**--**	**18**

	code and Wobble Hypothesis; aminoacyl tRNA synthetases and charging of tRNA; Proteins involved in initiation, elongation and termination of polypeptide chain; Mechanism of translation, Inhibitors of protein synthesis				
3	▪ **Regulation of gene expression**: Operon concept, Transcription regulation in prokaryotes (lac operon and tryptophan operon) ▪ **Transcription regulation in eukaryotes**: Activators, repressors, enhancers, silencer elements; Gene silencing and Genetic imprinting. ▪ DNA Damage and Repair Mechanisms, RNA interference	**13**	**02**	**--**	**15**
PRACTICALS				**Credit- 1/ Hours- 30**	
	▪ Quantitative estimation of DNA using colorimeter (Diphenylamine reagent) ▪ Quantitative estimation of RNA using Orcinol reaction ▪ Study and interpretation of electron micrographs/ photograph showing: DNA double helix, DNA replication, Transcription and Split genes ▪ Studying absorption spectra of DNA and Protein using spectrophotometer	**--**	**--**	**30**	**30**

Suggested Readings:

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

Title of the Course	**Zoology –13/ EVOLUTION, ANIMAL BEHAVIOUR AND CHRONOBIOLOGY -Major**

Paper Code	**ZOO-MJ-06024**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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:** Explain major evolutionary concepts including origin of life, Darwinism vs. Neo-Darwinism, fossil evidences, geological timescale and key evolutionary transitions such as horse and human evolution. ▪ **CO2:** Apply population genetics principles such as Hardy–Weinberg equilibrium, gene flow, genetic drift, mutation, migration and natural selection to understand changes in allele frequencies. ▪ **CO3:** Describe fundamental concepts of ethology, behavioural patterns, communication systems, navigation and social organization in animals. ▪ **CO4:** Analyse biological rhythms, biological clocks, circadian and seasonal cycles, environmental zeitgebers and the molecular basis involving clock genes. • **CO5:** Perform practical studies including fossil interpretation, Hardy–Weinberg analysis, behavioural observations, circadian measurements and preparation of behaviour reports.
Contact hours	**45 (Theory) + 30 (Practical)**

Zoology –13/ EVOLUTION, ANIMAL BEHAVIOUR AND CHRONOBIOLOGY
CODE- ZOO-MJ-06024
Credit: 3 (T) + 1 (P)

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

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	**Evolution** ▪ Origin of life - From chemogeny to biogeny, Experimental evidences, RNA world ▪ Evolutionary perspectives – Pre-Darwinian concepts, Darwinism vs Neo-Darwinism ▪ Paleontological evidences of evolution, Geological timescale ▪ Natural selection – concept of fitness, selection coefficient, kin selection, sexual selection ▪ Population genetics - Hardy-Weinberg Law (statement and derivation), concept of gene flow, arrival of the	**12**	**02**		**14**

	fittest – sources of variations and role in evolution, Genetic Drift (Founder's and Bottleneck effect), Role of migration and mutation in changing allelic frequencies Evolution of Horse, Human Evolution				
2	**Animal Behaviour** ▪ Concept of Ethology, Proximate and ultimate causes of behaviour; Animal behaviour and Human society ▪ Development of behaviour: Genetic basis of behaviour, Hormone brain relationship; Neural basis of behaviour: Key stimuli, Stimulus filtering, Supernormal stimuli, Open and closed IRM ▪ Patterns of behaviour - instinct vs. learned behaviour; Animal orientation - Taxis vs. Kinesis; Navigation; Methods of studying behaviour ▪ Learning Definition, Types of learning, Neural mechanism of learning; Concept of Motivation, Physiological basis of motivation, control of hunger drive and thirst drive in animals Fixed Action Pattern, ▪ Animal Communication - Dance Language in honey bees; Eusocial organization - honey bee, termite, and ant; Schooling behaviour in fishes; Social behaviour in monkeys. ▪ Sociobiology: Units of Sociobiology; major social behaviours; Alturism: Reciprocal altruism, group selection, kin selection, Inclusive fitness, cooperation /reciprocation; Selfishness; Eusociality	**14**	**02**	**--**	**16**
3	**Chronobiology** ▪ Historical developments; biological oscillations - concept of average, amplitude, phase and period. ▪ Biological timekeeping - adaptive significance and importance, Concept of biological clock ▪ Biological rhythms - Circadian, circalunar/infradian and circannual, Centres of biological rhythms- Suprachiasmatic nuclei, Pineal gland, Optic lobes ▪ Factors influencing biological rhythms- Environmental zeitgebers; photoperiod and regulation of seasonal reproduction of vertebrates; role of melatonin in daily sleep-wake cycle.Environmental, Photoperiod, Temperature, Other Zeitgebers. ▪ Molecular basis of circadian rhythms: Clock genes.	**13**	**02**	**--**	**15**
PRACTICALS					**Credit- 1/ Hours- 30**

1. Study of fossils from models/pictures 2. Study of homology and analogy from suitable specimens (insects, birds and mammals) 3. Study and verification of Hardy-Weinberg Law by Chi-square analysis 4. To study nest and nesting habits of birds/social insects 5. To study geotaxis behaviour in earthworm. 6. To study scan and focal animal sampling in wetland birds/mammals. 7. To study circadian function in human with special reference to body temperature. 8. To study behavioural activities of animals in home/backyard garden and prepare a short report by student.	--	--	30	30

Suggested Readings:

1. Hall B.K. & Hallgrimsson B. (2013). Strickberger's Evolution. 5th Edition, Jones and Bartlett Publishers, Inc.
2. Futuyama, D. J. (2017). Evolution. 4th Edition, Sinauer Associates
3. Ridley, M. (2020). Evolution. 2nd edition (South Asia Edition), Oxford University Press
4. Manning, A. & Dawkins, M. S. (2012). An Introduction to Animal Behaviour. Cambridge University Press, 6th edition.
5. Barnard, C. (2003). Animal Behaviour: Mechanism, Development, Function and Evolution. Pearson, 1st edition.
6. Mechanism of Animal Behaviour, Peter Marler and J. Hamilton; John Wiley & Sons, USA
7. Animal Behaviour, David McFarland, Pitman Publishing Limited, London, UK
8. Animal Behaviour, John Alcock, Sinauer Associate Inc., USA
9. Lehner, P. N. (1996). Handbook of Ethological Methods. Cambridge University Press, 2nd edition
10. Kumar, V. (2017). Biological Timekeeping: Clocks, Rhythms and Behaviour. Springer, 1st edition
11. Nelson, R.J. (2000). An introduction to behavioural Endocrinology, 2nd edition.
12. Binkley, S. (1990). The clockwork sparrow: time, clocks and calendars in biological organisms.
13. Chadrashekaran, M.K. (1985). Biological rhythms. Madras science foundation, Chennai

Title of the Course	**Zoology –14/ ENDOCRINOLOGY and REPRODUCTIVE BIOLOGY -Major**
Paper Code	**ZOO-MJ-06034**
Teaching method	**L-T-P**

Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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:** Describe hormone types, receptors, signalling pathways, and the functions and regulation of major endocrine glands including pituitary, pineal, thyroid, parathyroid, pancreas and adrenal. ▪ **CO2:** Explain the structural and functional anatomy of male and female reproductive systems, including gametogenesis, hormonal regulation, fertilization, implantation and pregnancy. ▪ **CO3:** Analyse reproductive cycles, hypothalamo–hypophyseal–gonadal regulation, placental hormones, lactation physiology and mechanisms of parturition. ▪ **CO4:** Evaluate environmental endocrine issues such as endocrine disruptors and environmental estrogens and their effects on reproductive and hormonal functions. • **CO5:** Perform laboratory skills including gland identification, histological preparation, estrous cycle study, gonadal slide analysis, sperm count and motility assessment.
Contact hours	**45 (Theory) + 30 (Practical)**

Zoology –14/ ENDOCRINOLOGY and REPRODUCTIVE BIOLOGY
CODE- ZOO-MJ-06024
Credit: 3 (T) + 1 (P)

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

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	**Endocrinology** ▪ Hormone and target organs: hormone receptors and their characteristics. Neurocrine, endocrine and paracrine secretion of hormones, Hormonal signal transduction ▪ Structural organization, Hormone secretion and functions of Pituitary gland and its hypothalamic control. ▪ Pineal Gland- Structure and Function. ▪ Thyroid and Parathyroid Gland-Structure, function and mechanism of action ▪ Structure of pancreas, Pancreatic hormones, their functions and mechanism of action, Dysfunction and disease of pancreatic hormones Structural Organizations of Adrenals, Functions of	**13**	**02**		**15**

	Cortical and Medullary Hormones and mechanism of action.				
2	**Functional anatomy of male and female reproduction** ▪ Development of gonads and Disorder of gonadal development ▪ Puberty and adolescence, role of hormones ▪ Sexual differentiation within the gonads. Anatomical organization of male and female reproductive system ▪ Testis: Spermatogenesis- kinetics and hormonal regulation; Androgen synthesis and metabolism; Epididymal function and sperm maturation; Accessory glands functions; Sperm transportation in male tract ▪ Ovary: Folliculogenesis, ovulation, corpus luteum formation and regression; Steroidogenesis and secretion of ovarian hormones; ▪ Fertilization, implantation and pregnancy in mammals ▪ Reproductive cycles in animals and human: Estrous and menstrual cycle	**13**	**02**	**--**	**15**
3	**Reproductive Endocrinology** ▪ Gonadal hormones and mechanism of hormone action: steroids, glycoprotein hormones and prostaglandins ▪ Hypothalamo–hypophyseal–gonadal axis, Regulation of gonadotrophin secretion in male and female; ▪ Implantation and role of hormones ▪ Pregnancy and hormones of pregnancy, Placenta and Placental hormones, ▪ Development of breast, Lactation and hormonal regulation ▪ Parturition in mammals ▪ Environmental endocrine issue: environmental estrogens, endocrine disruptors	**13**	**02**	**--**	**15**
PRACTICALS				**Credit- 1/ Hours- 30**	
	1. Study of mammalian Pituitary, Thyroid, Parathyroid, Pancreas and Adrenal, through permanent slides. **2.** Pituitary gland of mouse /fish – Dissection, display and permanent slide preparation using metachromatic stains. **3.** Preparation of histological slides from testis and ovary from fish/mice. **4.** Study of estrous cycle in rat/mice. **5.** Study of histological sections from	**--**	**--**	**30**	**30**

photomicrographs/ permanent slides of rat/human: testis, epididymis and accessory glands of male reproductive systems.

6. Study of histological sections from photomicrographs/ permanent slides of sections of ovary, fallopian tube, uterus (proliferative and secretory stages), cervix and vagina.
7. Total sperm count and determination of sperm motility in mammal

***Suggested Readings**:*

1. Zarrow, M. (1964). Experimental Endocrinology-A source book of basic techniques, Elsevier, 1st Edition
2. Vertebrate Endocrinology, Norris D. O., Elsevier Academic Press,
3. Molecular Endocrinology Methods and Protocol by Thomas E. Curie.
4. Larson: Williams Text Book of Endocrinology, 10th edition. W. B. Saunders Company, Philadelphia. 2002.
5. Austin, C.R. and Short, R.V. Reproduction in Mammals. Cambridge University Press.
6. Degroot, L.J. and Jameson, J.L. (eds). Endocrinology. W.B. Saunders and Company.
7. Knobil, E. et al.(eds). The Physiology of Reproduction. Raven Press Ltd.
8. Johnson, M.H. (2018). Essential Reproduction, Wiley-Blackwell, 8th Edition

Title of the Course	**Zoology –15/ BIOINFORMATICS, BIOTECHNIQUES AND INSTRUMENTATIINSTRUMENTATION -Major**
Paper Code	**ZOO-MJ-06044**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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:** 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:** Describe principles, working mechanisms and applications of advanced microscopes, tracer techniques, immunological assays and chromatography methods. ▪ **CO4:** Analyse electrophoresis systems, blotting techniques, hybridization methods, cryopreservation and chromosome-based techniques such as banding and FISH. • **CO5:** Perform computational and laboratory-based exercises including sequence search, ORF finding, phylogenetic tree construction, structure visualization and molecular docking.
Contact hours	**45 (Theory) + 30 (Practical)**

Zoology –15/ BIOINFORMATICS, BIOTECHNIQUES AND INSTRUMENTATION
CODE- ZOO-MJ-06044
Credit: 3 (T) + 1 (P)

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

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	**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. ▪ 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)	**20**	**02**		**22**
2	**BIOTECHNIQUES** AND **INSTRUMENTATION** ▪ Microscopic techniques: Visualization of cells and subcellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells, scanning and transmission microscopes, different fixation and staining techniques for EM, freeze-etch and freezefracture methods for EM, Fluorescent and confocal microscopy ▪ Histochemical and Immunotechniques: Antibody generation, Detection of molecules using ELISA, RIA, western blot, immunoprecipitation, Immunoelectrophoresis, Flow cytometry and immunofluorescence microscopy, detection of molecules in living cells, in situ localization by techniques. ▪ Radiolabelling techniques: Detection and measurement of different types of radioisotopes used in biology, incorporation of radioisotopes in biological tissues and cells, molecular imaging of	**21**	**02**	**--**	**23**

radioactive material, safety guidelines.

- Separation techniques: Principles and types of Centrifugation- Density gradient and unit gravity centrifugation, Principle and applications of electrophoresis- Agarose gel, SDS, SDS-PAGE, Pulsed gel and Disc gel electrophoresis, determination of molecular weight by SDS-gel electrophoresis
- Molecular separation Techniques: Ion-Exchange, Absorption, partition, gel filtration, affinity chromatography and HPLC.
- Biophysical Method: Molecular analysis using UV/visible, fluorescence, IR spectroscopy.
- Molecular biology techniques: Polymerase Chain Reaction, DNA sequencing methods, Blotting techniques : Southern, Northern and Western

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 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)	**--**	**--**	**30**	**30**

***Suggested Readings**:*

1. Bioinformatics, Sequence and Genome analysis. Second Ed. By David W. Mount
2. Bioinformatics and Functional genomics. Third Ed. By Jonathan Pevsner
3. Biotechniques by P. Ponmurugan; B. Ganagadhara Prabhu
4. Wilson And Walker's Principles And Techniques Of Biochemistry And Molecular Biology Johnson, M.H. (2018).

Degree with Honours

Detailed Syllabus of 7th Semester Major

Degree with Honours

Title of the Course	**Zoology –16/ ADVANCED BIOCHEMISTRY -Major**
Paper Code	**ZOO-MJ-07014**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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:** 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)**

Zoology –16/ ADVANCED BIOCHEMISTRY
CODE- ZOO-MJ-07014
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, Important respiratory complex of ATP synthesis ▪ **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	**20**	**02**	**----**	**22**
2	**Metabolic Pathways, their regulation and Significance**: ▪ Glycolysis, Citric acid cycle, Phosphate pentose pathway, Gluconeogenesis, Glycogenolysis and Glycogenesis, Hexose monophosphate shunt pathway ▪ Redox systems; Oxidative phosphorylation and chemiosmotic hypothesis, Inhibitors and un-couplers of Electron Transport System ▪ Synthesis of fatty acids, β-oxidation and omega-oxidation of saturated fatty acids with even and odd number of carbon atoms; Ketogenesis ▪ Intermediary metabolism: inter-conversion between lipids, carbohydrate and proteins. ▪ Urea cycle	**21**	**02**	**--**	**23**
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	**Zoology –17/ IMMUNOLOGY -Major**
Paper Code	**ZOO-MJ-07024**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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:** 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)**

Zoology –17/ IMMUNOLOGY CODE- ZOO-MJ-07024 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	**22**	**02**		**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	**19**	**02**	**--**	**21**
PRACTICALS				**Credit- 1/ Hours- 30**	
	1. Dissection and study of the Lymphoid organs 2. Histological study of spleen, thymus, Payers 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	**Zoology –18/ RESEARCH METHODOLOGY IN NATURAL SCIENCES -Major**
Paper Code	**ZOO-MJ-07034**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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: • Understand the basics of performing research in science • Create and develop the concepts of designing a research plan • Comprehend the important data collection, analyses and report writing • Identify the importance of ethics in research • Develop skills to write a research report
Contact hours	**45 (Theory) + 30 (Practical)**

TO BE ADOPTED FROM SWAYAM

By Prof. Soumitro Banerjee; IISER Kolkata Course

Outcomes:

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

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

Course layout:

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

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.

Title of the Course	Zoology –19/ APPLIED ZOOLOGY -Major
Paper Code	**ZOO-MJ-07044**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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:** 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)**

Zoology –19/ APPLIED ZOOLOGY
CODE- ZOO-MJ-07044
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**
	Sericulture (with special focus on Muga & Eri)				

2	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**
3	**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. 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.	**07**	**01**	**--**	**08**
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.

Detailed Syllabus of 8th Semester Major

DEGREE WITH HONOURS

Title of the Course	Zoology –20/ GENETIC ENGINEERING AND CYTOGENETICS -Major
Paper Code	**ZOO-MJ-08014**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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:** Understand the fundamental principles, tools and techniques of genetic engineering and Cytogenetics. • **CO2:** Explain cloning methods, vector systems, gene expression control and genome editing technologies. • **CO3:** Apply DNA manipulation, transfection techniques and basic procedures for developing transgenic organisms. • **CO4:** Interpret karyotypes, chromosomal abnormalities and molecular markers used in cytogenetic analysis. • **CO5:** Evaluate the major applications of genetic engineering in medicine, agriculture, biotechnology and disease diagnosis.
Contact hours	**45 (Theory) + 30 (Practical)**

Zoology –20/ GENETIC ENGINEERING AND CYTOGENETICS
CODE- ZOO-MJ-08014
Credit: 3 (T) + 1 (P)

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

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	• **Fundamentals of Genetic Engineering:** Introduction to Genetic Engineering; Tools of Genetic Engineering; Steps involved in Genetic Engineering. • **Cloning and Cloning vectors:** Principles of cloning; Restriction enzymes and DNA modifying enzymes. Applications of cloning, Plasmids, Lambda Bacteriophage, M13, YAC and Expression vectors (characteristics); BAC, YAC, MAC. • **Introduction of DNA into Host:** Genetic manipulation of cells; Types of transfection; Transgenic animals • **Cell Transformation techniques:** Calcium chloride method, electroporation and biolistic method. • **Genetic Libraries:** Construction of genomic and cDNA libraries and screening by colony and plaque hybridization	**16**	**02**	**--**	**18**
	• **Gene Silencing:** Gene silencing; mRNA, siRNA,				

	RNAi; Knockout technology				
2	• **Restriction Modification System and Applications of Genetic Engineering:** Restriction modification system; Reporter genes; Microarrays; DNA footprinting; Gene therapy; Future trends in transgenic animals; Pharm animals. • **Genome Editing:** Genome editing; CRISPR-Cas technology; Mechanism of CRISPR-Cas; Case studies; Basic instrumentation in Genetic Engineering; Sequence analysis.	**10**	**02**	**--**	**12**
	Cytogenetics ▪ Functional states of chromatin and alterations in chromatin organization, structural and functional organization of interphase nucleus. ▪ History of organization, goals and values of human genome project, organization and distribution of human genes ▪ Karyotyping: Karyotype analysis and Nomenclature, spectral karyotyping (SKY), digital karyotyping; Chromosome Banding techniques, banding patterns and significance, FISH technique and applications; Principles and applications of Comparative Genomic Hybridization (CGH) ▪ Cytogenetics and cancer; Molecular basis of chromosomal abnormalities and diseases; Chromosomal anomalies in malignancies : Chronic Myeloid Leukaemia, Burkitt's Lymphoma, Retinoblastoma, Wilm's Tumor; ▪ Cytogenetic and linkage maps, RFLP mapping	**12**	**02**	**--**	**15**
	PRACTICALS			**Credit- 1/ Hours- 30**	
	1. Extraction of Genomic DNA from Drossophila/ Fish/ Mouse. 2. Restriction-digestion of DNA sample and separation of fragments by performing agarose gel electrophoresis. Interpretation of the results by comparing with the standard digests. 3. Preparation and study of metaphase chromosomes from mouse bone marrow/fish. 4. C- and G-banding from metaphase chromosomal spread. 5. Identification of abnormality from given karyotype/ slide. 6. Preparation of human karyotype and study of chromosomal aberrations with respect to number, translocation, deletion etc., from the pictures	**--**	**--**	**30**	**30**

provided.

7. Demonstration of telomere and centromere using FISH technology.

8. Visit to advanced cytogenetic laboratory .

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. Principles of Gene Manipulation by Sandy B Primrose, Richard M Twyman and Robert W Old
4. Genes VIII by Benjamin Lewis
5. An Introduction to Genetic Engineering, 3rd Edition (South Asian Edition) by Desmond S. T. Nicholl
6. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). Molecular Biology of the Cell (6th ed.). Garland Science.
7. Rooney, D. E., & Czepulkowski, B. H. (2013). Human Cytogenetics: Constitutional Analysis (4th ed.). Oxford University Press.
8. Lewin, B., Krebs, J. E., & Goldstein, E. S. (2000). Genes IX. Jones and Bartlett Publishers.
9. Vogel, F., & Motulsky, A. G. (2010). Human Genetics: Problems and Approaches (4th ed.). Springer Science & Business Media.

Title of the Course	**Zoology –21/ADVANCED DEVELOPMENTAL BIOLOGY -Major**
Paper Code	**ZOO-MJ-08024**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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: • **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)**

Zoology –21/ ADVANCED DEVELOPMENTAL BIOLOGY -Major **CODE- ZOO-MJ-07044** **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-the thermodynamic model of cell interactions, concept of morphogen gradients and morphogenetic fields, 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	▪ 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*. ▪ Regeneration: Epimorphic regeneration of Salamander limbs, Morphallactic regeneration in hydra, Compensatory regeneration in Mammalian liver. ▪ Different types of stem cells and their applications,	**20**	**02**		**22**

Regeneration therapy ▪ Role of environment in animal Development: Gravity and pressure, Developmental symbiosis, Larval settlement. Diapause: suspended development				
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. In vitro culture of chick embryo. 5. Study of chick embryo using vital staining.	**--**	**--**	**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	**Zoology –22/ PARASITOLOGY AND MICROBIOLOGY -Major**
Paper Code	**ZOO-MJ-08034**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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: • **PO1**: Identify the variation among parasites, parasitic invasion with special reference to medical and agricultural aspects. • **PO2:** Compare and contrast the stages of the life cycle of parasites and their respective infective stages. • **PO3**: Develop skills and realize significance of diagnosis of parasitic attack and treatment of host. • **PO4**: Define and differentiate between Bacteria, Archea, Viruses, Algae, Fungi and Protists. • **PO5:** Evaluate the impact of different microbial species on human health and

	the environment.
Contact hours	**45 (Theory) + 30 (Practical)**

Zoology –22/ PARASITOLOGY AND MICROBIOLOGY -Major **CODE- ZOO-MJ-08034** **Credit: 3 (T) + 1 (P)** **THEORY**					**Credit- 3/ Hours- 45**
Unit	**Content**	**Lecture**	**Tutorial**	**Practical**	**Total hours**
1	**PARASITOLOGY (2 credit)** **Introduction to Parasitology** Brief introduction of Parasites and parasitic diseases, Parasitism; Parasitoid and Vectors; Portal of entry and implications of parasitism, Host-parasite relationship; types of parasites and hosts; evolution of parasitism	**05**	**01**	**----**	**06**
2	**Non-chordates Parasites** **Parasitic Protists** Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Trypanosoma gambiense, Leishmania donovani , Plasmodium vivax* **Parasitic Platyhelminthes** Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of: *Schistosoma haematobium, Taenia solium* and *Hymenolepis nana.*	**10**	**02**	**--**	**12**
3	**Parasitic Nematodes** Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity of *Ascaris lumbricoides*, *Ancylostoma duodenale*, *Trichinella spiralis* **Parasitic Arthropods** Importance and control of : ticks, mites (Sarcoptes), Lice (Pediculus), Flea (Xenopsylla); Study of mosquito-borne diseases – Dengue, Chikungunya, Viral	**10**	**02**	**---**	**12**

encephalitis **Parasite Vertebrates** A brief account of parasitic vertebrates – Candiru and Vampire bat				
Microbiology (1 credit) • Microbial diversity: Prokaryotic microbes-Bacterial and archea; Eukaryotic microbesAnaerobic and aerobic Protozoa • Microbial modes of Pathogenicity: Portals of entry of microbes; • Host pathogen interaction: invasion, antigenic heterogeneity, toxins and enzymes secretions. Invasiveness and Toxigenicity. • Bacterial growth characteristic: basic requirements of growth; types of culture media; concept of generation time; phases of growth; measurement of growth; pure culture techniques. • Microbes and human welfare: Microbial products; Microbial biocontrol; microbial sewage water treatment • Applied microbiology: Microbial products; Food microbiology; Biocontrol; Biological weapons; Wastewater treatment.	**13**	**02**	**---**	**15**
PRACTICALS			**Credit- 1/ Hours- 30**	
1. Study of life stages of Entamoeba histolytica, *Trypanosoma gambiense, Leishmania donovani* and *Plasmodium vivax* through permanent slides/photographs. 2. Study of adult and life stages of *Schistosoma haematobium, Taenia solium* and *Hymenolepis nana* through permanent slides/photographs. 3. Study of adult and life stages of *Ascaris lumbricoides, Ancylostoma duodenale* and *Trichinella spiralis* through permanent slides/microphotographs.	**--**	**--**	**30**	**30**

4. Study and preparation of report of any two common protozoan/ helminth/ arthropod parasites
5. Study of Pediculus humanus (Head louse and Body louse), Xenopsylla cheopis and Cimex lectularius through permanent slides/ photographs.
6. Gram staining and identification of bacteria
7. Demonstration on techniques of isolation of bacteria and preparation of pure culture.
8. Preparation of liquid media (broth) and solid media for routine cultivation of bacteria.
9. Bacterial colony count.

Suggested Readings:

1. Chernin, J. (2000). Parasitology. Taylor & Francis Group.
2. Arora, D. R and Arora, B. B. (2018) Medical Parasitology. 5th Edition, CBS Publications and Distributors Pvt Ltd.
3. Noble, E.R. and Noble, G.A. (1982) Parasitology: The Biology of Animal Parasites. 5th Edition, Lea & Febiger.
4. Ahmed, N., Dawson, M., Smith, C. and Wood, Ed. (2007) Biology of Disease. Taylor and Francis Group
5. Taylor, M. A., Coop, R. L., & Wall, R. L. (2016). Veterinary Parasitology. 4th edition, Wiley Blackwell 6. Loker, E. S. & Hofkin, B. V. (2015). Parasitology – A conceptual approach. Taylor & Francis Group
6. Michael T. Madigan, John M. Martinko, David A. Stahl, David P. Clark (2012). Brock Biology of Microorganisms. 13th ed, Pearson [ISBN 10: 0-321-64963-X (Student edition)].
7. Prescott, Harley, Klein (2002). Microbiology. 5th ed, The McGraw−Hill Companies [ISBN: 0-07- 282905-2].
8. Gerard J. Tortora, Berdell R. Funke, Christine L. Case (2013). Microbiology - An Introduction. 11th ed., Pearson [ISBN 10: 0-321-73360-6; ISBN 13: 978-0-321-73360-3 (Student edition)]

Title of the Course	**Zoology –23/ RESEARCH PROJECT/ DISSERTATION-Major**
Paper Code	**ZOO-MJ-08044**
Teaching method	**L-T-P**
Total Credits	**4**

Degree with Honours with Research

Detailed Syllabus of 7th Semester Major

Degree with Honours

Title of the Course	**Zoology –16/ ADVANCED BIOCHEMISTRY -Major**
Paper Code	**ZOO-MJ-07014**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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:** 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)**

Zoology –16/ ADVANCED BIOCHEMISTRY
CODE- ZOO-MJ-07014
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, Important respiratory complex of ATP synthesis ▪ **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	**20**	**02**		**22**
2	**Metabolic Pathways, their regulation and Significance**: ▪ Glycolysis, Citric acid cycle, Phosphate pentose pathway, Gluconeogenesis, Glycogenolysis and Glycogenesis, Hexose monophosphate shunt pathway ▪ Redox systems; Oxidative phosphorylation and chemiosmotic hypothesis, Inhibitors and un-couplers of Electron Transport System ▪ Synthesis of fatty acids, β-oxidation and omega-oxidation of saturated fatty acids with even and odd number of carbon atoms; Ketogenesis ▪ Intermediary metabolism: inter-conversion between lipids, carbohydrate and proteins. ▪ Urea cycle	**21**	**02**	**--**	**23**
PRACTICALS				**Credit- 1/ Hours- 30**	
	9. Extraction of biomolecules (carbohydrates, proteins, lipids) from fish liver. **10.** Estimation of protein extracted from fish liver by Biuret/Lowry/Bradford method. **11.** Estimation of glycogen extracted from fish liver by Anthrone reagent method. **12.** Estimation of blood glucose by Folin-Wu method. **13.** Effect of substrate concentration on enzyme activity and determination of Km and Vmax by plotting Michaelis-Menten and LB plot. **14.** Determination of Pka & PI value of glycine using Titration method. **15.** Determination of Urea in Urine sample. **16.** Separation of protein by SDS PAGE	**--**	**--**	**30**	**30**

***Suggested Readings**:*

11. Cox, M.M and Nelson, D.L. (2008). Lehninger Principles of Biochemistry, V Edition, W.H. Freeman and Co., NewYork.
12. V.W.and Well, P.A. (2009). Harper's Illustrated Biochemistry, XXVIII Edition, International Edition, The McGraw- Hill CompaniesInc.
13. Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd.,U.K.
14. 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
15. Text book of Biochemistry by Lippincott
16. Clinical Biochemistry by Varley
17. Text Book of Biochemistry by Vasudevan
18. Text Book of Biochemistry by Styrer
19. Text Book of Biochemistry by Voet and Voet
20. Text Book of Biochemistry by Garret and Gisham

Title of the Course	**Zoology –17/ IMMUNOLOGY -Major**
Paper Code	**ZOO-MJ-07024**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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:** 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)**

Zoology –17/ IMMUNOLOGY CODE- ZOO-MJ-07024 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	**22**	**02**		**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	**19**	**02**	**--**	**21**
PRACTICALS					**Credit- 1/ Hours- 30**
	1. Dissection and study of the Lymphoid organs 2. Histological study of spleen, thymus, Payers 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	**--**	**--**	**30**	**30**

	diseases and the immunoassays used to diagnose them.

Suggested Readings:

5. Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J (2006). Immunology, VI Edition. W.H. Freeman and Company.
6. David, M., Jonathan, B., David, R. B. and Ivan R. (2006). Immunology, VII Edition, Mosby, Elsevier Publication.
7. Abbas, K. Abul and Lechtman H. Andrew (2003.) Cellular and Molecular Immunology. V Edition. Saunders Publication.
8. Janeway's Immunobiology by K. Murphy, P. Travers and M. Walport, Publisher: Garland Science.

Title of the Course	**Zoology –18/ RESEARCH METHODOLOGY IN NATURAL SCIENCES -Major**
Paper Code	**ZOO-MJ-07034**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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: • Understand the basics of performing research in science • Create and develop the concepts of designing a research plan • Comprehend the important data collection, analyses and report writing • Identify the importance of ethics in research • Develop skills to write a research report
Contact hours	**45 (Theory) + 30 (Practical)**

TO BE ADOPTED FROM SWAYAM

By Prof. Soumitro Banerjee; IISER Kolkata

Course Outcomes:

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

6. Understand the basics of performing research in science
7. Create and develop the concepts of designing a research plan
8. Comprehend the important data collection, analyses and report writing
9. Identify the importance of ethics in research
10. Develop skills to write a research report

Course layout:

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

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.

Title of the Course	Zoology –19/ APPLIED ZOOLOGY -Major
Paper Code	**ZOO-MJ-07044**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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:** 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)**

Zoology –19/ APPLIED ZOOLOGY
CODE- ZOO-MJ-07044
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	**06**	**01**	**--**	**07**

	ethnozoology in biodiversity conservation, livelihood sustenance and cultural preservation.				
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**
3	**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. 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.	**07**	**01**	**--**	**08**
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**	
6. Identification of silkworm species and host plants; cocoon sorting. 7. Demonstration of honey extraction/ hive inspection. 8. Identification of freshwater mussels/oysters; water-quality assessment. 9. Visit to poultry/dairy unit and preparation of farm report. 10. Ethnozoological documentation of one Assamese traditional practice.	**--**	**--**	**30**	**30**

Recommended Readings:

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

Detailed Syllabus of 8th Semester Major

DEGREE WITH HONOURS WITH RESEARCH

Title of the Course	**Zoology –20/ GENETIC ENGINEERING AND CYTOGENETICS -Major**
Paper Code	**ZOO-MJ-08014**
Teaching method	**L-T-P**
Total Credits	**04 (Theory: 03, Practical: 01)**
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (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:** Understand the fundamental principles, tools and techniques of genetic engineering and Cytogenetics. • **CO2:** Explain cloning methods, vector systems, gene expression control and genome editing technologies. • **CO3:** Apply DNA manipulation, transfection techniques and basic procedures for developing transgenic organisms. • **CO4:** Interpret karyotypes, chromosomal abnormalities and molecular markers used in cytogenetic analysis. • **CO5:** Evaluate the major applications of genetic engineering in medicine, agriculture, biotechnology and disease diagnosis.
Contact hours	**45 (Theory) + 30 (Practical)**

Zoology –20/ GENETIC ENGINEERING AND CYTOGENETICS
CODE- ZOO-MJ-08014
Credit: 3 (T) + 1 (P)

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

Unit	Content	Lecture	Tutorial	Practical	Total hours
1	• **Fundamentals of Genetic Engineering:** Introduction to Genetic Engineering; Tools of Genetic Engineering; Steps involved in Genetic Engineering. • **Cloning and Cloning vectors:** Principles of cloning; Restriction enzymes and DNA modifying enzymes. Applications of cloning, Plasmids, Lambda Bacteriophage, M13, YAC and Expression vectors (characteristics); BAC, YAC, MAC. • **Introduction of DNA into Host:** Genetic manipulation of cells; Types of transfection; Transgenic animals • **Cell Transformation techniques:** Calcium chloride method, electroporation and biolistic method. • **Genetic Libraries:** Construction of genomic and cDNA libraries and screening by colony and plaque	**16**	**02**	**--**	**18**

	hybridization				
2	• **Gene Silencing:** Gene silencing; mRNA, siRNA, RNAi; Knockout technology • **Restriction Modification System and Applications of Genetic Engineering:** Restriction modification system; Reporter genes; Microarrays; DNA footprinting; Gene therapy; Future trends in transgenic animals; Pharm animals. • **Genome Editing:** Genome editing; CRISPR-Cas technology; Mechanism of CRISPR-Cas; Case studies; Basic instrumentation in Genetic Engineering; Sequence analysis.	**10**	**02**	**--**	**12**
	Cytogenetics ▪ Functional states of chromatin and alterations in chromatin organization, structural and functional organization of interphase nucleus. ▪ History of organization, goals and values of human genome project, organization and distribution of human genes ▪ Karyotyping: Karyotype analysis and Nomenclature, spectral karyotyping (SKY), digital karyotyping; Chromosome Banding techniques, banding patterns and significance, FISH technique and applications; Principles and applications of Comparative Genomic Hybridization (CGH) ▪ Cytogenetics and cancer; Molecular basis of chromosomal abnormalities and diseases; Chromosomal anomalies in malignancies : Chronic Myeloid Leukaemia, Burkitt's Lymphoma, Retinoblastoma, Wilm's Tumor; ▪ Cytogenetic and linkage maps, RFLP mapping	**12**	**02**	**--**	**15**
PRACTICALS				**Credit- 1/ Hours- 30**	
	1. Extraction of Genomic DNA from Drossophila/ Fish/ Mouse. 2. Restriction-digestion of DNA sample and separation of fragments by performing agarose gel electrophoresis. Interpretation of the results by comparing with the standard digests. 3. Preparation and study of metaphase chromosomes from mouse bone marrow/fish.	**--**	**--**	**30**	**30**

4. C- and G-banding from metaphase chromosomal spread.
5. Identification of abnormality from given karyotype/ slide.
6. Preparation of human karyotype and study of chromosomal aberrations with respect to number, translocation, deletion etc., from the pictures provided.
7. Demonstration of telomere and centromere using FISH technology.
8. Visit to advanced cytogenetic laboratory .

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. Principles of Gene Manipulation by Sandy B Primrose, Richard M Twyman and Robert W Old
4. Genes VIII by Benjamin Lewis
5. An Introduction to Genetic Engineering, 3rd Edition (South Asian Edition) by Desmond S. T. Nicholl
6. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). Molecular Biology of the Cell (6th ed.). Garland Science.
7. Rooney, D. E., & Czepulkowski, B. H. (2013). Human Cytogenetics: Constitutional Analysis (4th ed.). Oxford University Press.
8. Lewin, B., Krebs, J. E., & Goldstein, E. S. (2000). Genes IX. Jones and Bartlett Publishers.
9. Vogel, F., & Motulsky, A. G. (2010). Human Genetics: Problems and Approaches (4th ed.). Springer Science & Business Media.

Title of the Course	**Zoology –21/ RESEARCH PROJECT/ DISSERTATION-Major**
Paper Code	**ZOO-MJ-080212**
Teaching method	**L-T-P**
Total Credits	**12**