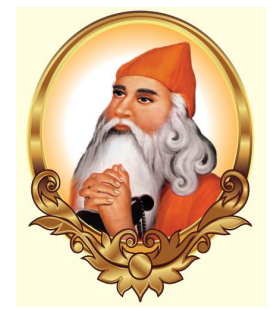
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**Department of Zoology**

**Scheme of Examination for**

**Post Graduate Program, M.Sc. Zoology in UTD and Affiliated Colleges for 1st and 2nd Year**

**Syllabus for 1st Year**

**Under Multiple Entry and Exit, Internship and**

**CBCS-LOCF as per NEP-2020**

**w.e.f. session 2025-2026**

**Subject: Zoology**

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**Department of Zoology**

**Guru Jambheshwar University of Science and Technology**

**Hisar-125001, Haryana**

**(A+ GRADE NAAC Accredited)**

|  |  |  |
| --- | --- | --- |
|  | **Guru Jambheshwar University of Science and Technology**  **Hisar-125001, Haryana**  **(‘A+’ Grade NAAC Accredited State Govt. University)** |  |

Scheme of Examination for Post Graduate Program w.e.f. session 2025-2026

For M.Sc. Zoology in UTD and Affiliated Colleges according to NEP-2020 for 1st and 2nd years (1st to 4th Semesters), Syllabus for 1st Year

**Subject: Zoology**

**SEMESTER-I**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Type of Course** | **Course Code** | **Nomenclature of Paper/Course** | **Credits** | **Contact Hours** | **Internal Marks** | **External Marks** | **Total Marks** | **Duration of Exam (Hours)** |
| **Discipline Specific Course** | U25ZOO101T | Cell Biology and Genetics | 4 | 4 | 30 | 70 | 100 | 3 |
| **Discipline Specific Course** | U25ZOO102T | Biochemistry and Biotechniques | 4 | 4 | 30 | 70 | 100 | 3 |
| **Discipline Specific Course** | U25ZOO103T | Biology of Invertebrates | 4 | 4 | 30 | 70 | 100 | 3 |
| **Discipline Elective Course** (Choose any one**)** | U25ZOO111T  OR  U25ZOO112T  OR  U25ZOO113T | Fish, Fisheries and Aquaculture  OR  Biosystematics and Computational Biology  OR  Animal Behaviour and Wildlife Conservation | 4 | 4 | 30 | 70 | 100 | 3 |
| **Practicum** | U25ZOO104P | Practical-I | 3 | 6 | 25 | 50 | 75 | 3 |
| **Practicum** | U25ZOO105P | Practical-II | 3 | 6 | 25 | 50 | 75 | 3 |
| **VAC** |  | To be taken from the Pool of VAC | 2 | 2 | 15 | 35 | 50 | 2 |
| **Total** | | | **24** | **30** |  |  | **600** |  |

**SEMESTER-II**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Type of Course** | **Course Code** | **Nomenclature of Paper/Course** | **Credits** | **Contact Hours** | **Internal Marks** | **External Marks** | **Total Marks** | **Duration of Exam (Hours)** |
| **Discipline Specific Course** | U25ZOO201T | Molecular Biology and Biostatistics | 4 | 4 | 30 | 70 | 100 | 3 |
| **Discipline Specific Course** | U25ZOO202T | Population Genetics and Evolution | 4 | 4 | 30 | 70 | 100 | 3 |
| **Discipline Specific Course** | U25ZOO203T | Advanced Animal Physiology | 4 | 4 | 30 | 70 | 100 | 3 |
| **Discipline Specific Course** | U25ZOO204T | Biology of Vertebrates | 4 | 4 | 30 | 70 | 100 | 3 |
| **Practicum** | U25ZOO205P | Practical-III | 3 | 6 | 25 | 50 | 75 | 3 |
| **Practicum** | U25ZOO206P | Practical-IV | 3 | 6 | 25 | 50 | 75 | 3 |
| **Seminar** | U25ZOO201S | Seminar\* | 2 | 2 |  |  | 50 | 2 |
| **Internship** | U25ZOO201I | Internship (4-6 weeks)\*\* | 4\*\* | 4\*\* |  |  | 100\*\* | - |
| **Total** | | | **24+4\*\*** | **30+4\*\*** |  |  | **600+**  **100\*\*** |  |

**SEMESTER-III**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Type of Course** | **Course Code** | **Nomenclature of Paper/Course** | **Credits** | **Contact Hours** | **Internal Marks** | **External Marks** | **Total Marks** | **Duration of Exam (Hours)** |
| **Discipline Specific Course** | U25ZOO301T | Population and Community Ecology | 4 | 4 | 30 | 70 | 100 | 3 |
| **Discipline Specific Course** | U25ZOO302T | Molecular Endocrinology | 4 | 4 | 30 | 70 | 100 | 3 |
| **Discipline Specific Course** | U25ZOO303T | Applied Zoology | 4 | 4 | 30 | 70 | 100 | 3 |
| **Discipline Elective Course** (Choose any one**)** | U25ZOO311T  OR  U25ZOO312T  OR  U25ZOO313T | Parasitology  OR  Protein Structure and Function  OR  Molecular Reproduction | 4 | 4 | 30 | 70 | 100 | 3 |
| **Practicum** | U25ZOO304P | Practical-V | 3 | 6 | 25 | 50 | 75 | 3 |
| **Practicum** | U25ZOO305P | Practical-VI | 3 | 6 | 25 | 50 | 75 | 3 |
| **OEC** |  | To be taken from the Pool of OEC | 2 | 2 | 15 | 35 | 50 | 2 |
| **Total** | | | **24** | **30** |  |  | **600** |  |

**SEMESTER-IV (Option A)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Type of Course** | **Course Code** | **Nomenclature of Paper/Course** | **Credits** | **Contact Hours** | **Internal Marks** | **External Marks** | **Total Marks** | **Duration of Exam (Hours)** |
| **Discipline Specific Course** | U25ZOO401T | Development Biology | 4 | 4 | 30 | 70 | 100 | 3 |
| **Discipline Specific Course** | U25ZOO402T | Vertebrate Immunology | 4 | 4 | 30 | 70 | 100 | 3 |
| **Discipline Elective Course**  (Choose any one**)** | U25ZOO411T | Environmental Toxicology  OR  A MOOC Course from SWAYAM portal of equal credits | 4 | 4 | 30 | 70 | 100 | 3 |
| **Discipline Elective Course** (Choose any one**)** | U25ZOO412T  OR  U25ZOO413T | Aquactic Resourses and their Conservation  OR  Insect Diversity, Society and Evolution | 4 | 4 | 30 | 70 | 100 | 3 |
| **Practicum** | U25ZOO403P | Practical-VII | 3 | 6 | 25 | 50 | 75 | 3 |
| **Practicum** | U25ZOO404P | Practical-VIII | 3 | 6 | 25 | 50 | 75 | 3 |
| **SEC/EEC/VOC** |  | To be taken from Pool of SEC/EEC/VOC | 2 | 2 | 15 | 35 | 50 | 2 |
| **Total** | | | **24** | **30** |  |  | **600** |  |

**OR**

**SEMESTER-IV (Option B)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Type of Course** | **Course Code** | **Nomenclature of Paper/Course** | **Credits** | **Contact Hours** | **Internal Marks** | **External Marks** | **Total Marks** | **Duration of Exam (Hours)** |
| **Discipline Specific Course** | U25ZOO401T | Development Biology | 4 | 4 | 30 | 70 | 100 | 3 |
| **Discipline Specific Course** | U25ZOO402T | Vertebrate Immunology | 4 | 4 | 30 | 70 | 100 | 3 |
| **Discipline Elective Course** (Choose any one**)** | U25ZOO414T | Environment, Epigenetics and Hormone Biology  OR  A MOOC Course from SWAYAM portal of equal credits | 2 | 2 | 15 | 35 | 50 | 2 |
| **SEC/EEC/VOC** |  | To be taken from the Pool of SEC/EEC/VOC | 2 | 2 | 15 | 35 | 50 | 2 |
| **Dissertation** | U25ZOO401D | PROJECT WORK/DISSERTATION\*\*\* | 12 |  |  |  | 300 |  |
| **Total** | | | **24** |  |  |  | **600** |  |

**\*Note: Evaluation for Credit Seminar will be done by a committee constituted by the Chairperson/Head of the Department in Affiliated colleges.**

\*\***Note: Students, whether exiting or continuing the PG Program after the Second Semester, are required to undertake an Internship/Summer Internship of four credits during the summer vacation following the Second Semester. The four credits of Internship/Summer Internship will be taken into account in 2nd Semester.**

**\*\*\*Evaluation will be done by External Examiner.**

**The Department of Zoology, Guru Jambheshwar University of Science & Technology, Hisar, Haryana will offer the following three courses, namely, VAC, OEC and SEC (2 Credits each) for students of other Departments as given below in respective 1st, 3rd and 4th semesters. Likewise, the students of M.Sc. Zoology will take three courses, namely, VAC, OEC and SEC (2 Credits each) in respective 1st, 3rd and 4th semesters from the pool of courses offered by other Departments of the University.**

**SEMESTER-I**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Type of Course** | **Course Code** | **Nomenclature of Paper/Course** | **Credits** | **Contact Hours** | **Internal Marks** | **External Marks** | **Total Marks** | **Duration of Exam (Hours)** |
| **Value Added Course** | U25VAC129T | Wildlife and Conservation | 2 | 2 | 15 | 35 | 50 | 2 |

**SEMESTER-III**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Type of Course** | **Course Code** | **Nomenclature of Paper/Course** | **Credits** | **Contact Hours** | **Internal Marks** | **External Marks** | **Total Marks** | **Duration of Exam (Hours)** |
| **Open Elective Course** | U25OEC329T | Economic Zoology | 2 | 2 | 15 | 35 | 50 | 2 |

**SEMESTER-IV**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Type of Course** | **Course Code** | **Nomenclature of Paper/Course** | **Credits** | **Contact Hours** | **Internal Marks** | **External Marks** | **Total Marks** | **Duration of Exam (Hours)** |
| **Skill Enhancement Course** | U25SEC429T | Apiculture | 2 | 2 | 15 | 35 | 50 | 2 |

**Wildlife and Conservation**

**(Value Added Course)**

**Course Code: U25VAC129T**

**(2Hrs /week) External Marks: 35**

**Credits: 2 Internal Marks: 15 Exam Time: 2 Hrs Maximum Marks: 50**

Note: The examiner is required to set five questions in all. The first question will be compulsory consisting of five short questions covering the entire syllabus consisting of 3 marks each. In addition to this, four more questions (each question may be of 2 parts) will be set consisting of two questions from each unit.

The student/candidate is required to attempt three questions in all selecting one question from each unit consisting of 10 marks each including compulsory Question No.1.

**Unit-I**

Wildlife: Definition, significance, Techniques of animal counts (Examples of Tiger count), Wildlife zones of the India, Wildlife Tourism

**UNIT- II**

Biodiversity: Concept, threats to biodiversity, its Conservation (objectives and strategies), biodiversity indices, Concept and objectives of Protected areas. Important Protected Areas of India (Biosphere reserve, National Park & Wildlife sanctuaries), Red Data Book, IUCN Categories of wildlife species.

**Suggested Readings:**

1. Hosetti, B. B and Venkateshwarlu, M. Trends in wildlife biodiversity conservation and management.

2. Mathur R. Wildlife conservation and management.

3. Hosetti B. B. Concepts of Wildlife management.

4. Techniques for wildlife Census in India by W.A. Rogers (A field manual); Wildlife Institute of India, Dehradun.

5. Majupuria T. C. Wildlife Wealth of India, Tecpress Services, L.P., 487/42-SOL-Wattenslip, Pratunam Bangkok, 10400, Thailand.

6. Ali, S. and Ripley, S. D. Handbook of Birds of India, Pakistan 10-Vols. Oxford University Press, Bombay.

7. Prater S. H. The Book of Indian Animals, BNHS-Publication, Bombay.

8. Saharia, V. B. Wildlife in India, Natraj Publishers, Dehradun.

9. Gee E. P. The Wildlife of India.

**Course Outcome:**

At the end of the course, the students would be able to:

**CO1.** To **define** wildlife and biodiversity, and recall important protected areas in India such as biosphere reserves, national parks, and wildlife sanctuaries.

**CO2.** To **explain** the techniques of animal counting (e.g., tiger census) and the classification of wildlife zones in India.

**CO3.** To **analyze** threats to biodiversity and assess the effectiveness of conservation strategies including biodiversity indices and IUCN categories.

**CO4**. To **evaluate** the role of wildlife tourism in conservation and design educational programs or awareness strategies to promote biodiversity protection.

**CO5.** To **construct** a conservation action plan or eco-tourism model integrating wildlife protection, public awareness, and sustainable biodiversity use.

**Economic Zoology (Open Elective Course)**

**Course Code: U25OEC329T**

**(2Hrs /week) External Marks: 35**

**Credits: 2 Internal Marks: 15**

**Exam Time: 2 Hrs Maximum Marks: 50**

Note: The examiner is required to set five questions in all. The first question will be compulsory consisting of five short questions covering the entire syllabus consisting of 3 marks each. In addition to this, four more questions (each question may be of 2 parts) will be set consisting of two questions from each unit.

The student/candidate is required to attempt three questions in all selecting one question from each unit consisting of 10 marks each including compulsory Question No.1.

**UNIT -I**

Integrated pest management: cultural-control, chemical control, biological control, herbal control, legal control.

Sericulture: Types of silk, species of silk moth (scientific names), Silkworms and their host plants, mulberry silk worm culture, natural enemies and diseases of silkworm and their control

Apiculture: Species of honey bees in India, life history of *Apis cerana indica*, agriculture techniques, bee products and their uses, natural enemies and diseases of honey bee and their control.

Lac culture: lac insect (Scientific name), composition of lac, strains of lac insect, cultivation of lac host plants (in brief) processing of lac and uses of lac.

**UNIT-II**

Vermiculture: species of vermiculture, culture methods, significance of vermicomposting Economic status of Vermiculture.

Economic status and products of Poultry keeping and Dairy industry in Haryana.

Aquaculture (Fresh water fishes and Prawn culture). leather industry: processing and enemies of skin. Economic importance of mammals.

**Suggested Reading:**

1. Dent, D. and Binks, R.H., 2020. *Insect pest management*. Cabi.
2. Hill, D.S., 1994. *Agricultural entomology*. Timber Press.
3. Nayar, K.K., Ananthakrishnan, T.N. and David, B.V., 1976. General and applied entomology. Tata McGrew Hill Publications. New Delhi*.*
4. Pedigo, L.P., 1996. *Entomology and pest management*. Prentice Hall.
5. Nazir, T., Khan, S. and Qiu, D., 2019. Biological control of insect pest. *Pests Control and Acarology*.
6. Shukla, G.S. and Upadhyay, V.B., 2010. *Economic Zoology*. Rastogi Publications

**Course Outcome:**

At the end of the course, the students would be able to:

**CO1.** To **recall** important pest control methods, identify species involved in sericulture, apiculture, lac culture, vermiculture, and recognize the scientific names of economically important insects.

**CO2.** To **describe** the life cycle and culture techniques of silkworms, honey bees, lac insects, and earthworms, along with their agricultural applications and control of natural enemies.

**CO3.** To **analyze** the integrated pest management strategies by comparing cultural, chemical, biological, herbal, and legal control methods and their effectiveness in sustainable agriculture.

**CO4.** To **evaluate** the economic potential of vermiculture, poultry, dairy, aquaculture, and leather industries in Haryana and propose viable models for rural employment and income generation.

**CO5.** To **design** an integrated bio-resource management plan using multiple components (vermicompost, aquaculture, poultry, dairy, etc.) to improve rural livelihood and sustainable income.

**Apiculture (Skill Enhancement Course)**

**Course Code: U25SEC429T**

**(2Hrs /week) External Marks: 35**

**Credits: 2 Internal Marks: 15**

**Exam Time: 2 Hrs Maximum Marks: 50**

Note: The examiner is required to set five questions in all. The first question will be compulsory consisting of five short questions covering the entire syllabus consisting of 3 marks each. In addition to this, four more questions (each question may be of 2 parts) will be set consisting of two questions from each unit.

The student/candidate is required to attempt three questions in all selecting one question from each unit consisting of 10 marks each including compulsory Question No.1

**UNIT-I**

Apiculture meaning, definition scope and history. Status of Apiculture Industry in India. Classification and Life Cycle of Honey Bee. Identification of Indigenous and exotic Honey bee species. Role of Bees in cross pollination in horticulture and agriculture. Methods of Artificial Bee keeping.

**UNIT-II**

Equipments used in Bee keeping Industry. Methods of extraction of Honey and other products. Products of Apiculture Industry and their Uses (Honey, Bee Wax, Royal Jelly, Bee Venom, Propolis and Pollen). Bee Keeping Industry: Present and future. Prospects of apiculture as self-employment venture. Economics of Apiculture: Expenditure, Net Income, and Additional benefits.

**Suggested Reading:**

1. Prost P. J. (1962). Apiculture. Oxford and IBH, New Delhi.

2. Bisht D.S. (2004). Agricultural Development in India, Anmol Pub. Pvt. Ltd.

3. SinghS. (1964). Beekeeping in India, Indian council of Agricultural Research, New Delhi

4. Mehrotra, K.N. and Bisht, D.S. (1981). Twenty-five years of apiculture research at IARI. I. Apiculture in relation to agriculture.

5. The Social Behavior of the Bees, 1974: By Missioner C.D

**Course Outcome:**

At the end of the course, the students would be able to:

**CO1.**To **define** apiculture and recall the history, scope, and classification of honey bees.

**CO2.** To **explain** the life cycle of honey bees and identify indigenous and exotic species commonly found in India.

**CO3.** To **analyze** the ecological and agricultural significance of bees in cross-pollination and assess their role in horticulture and crop yield enhancement.

**CO4.** To **evaluate** the economic potential of apiculture as a self-employment venture and propose suitable artificial bee-keeping techniques and product extraction methods based on local conditions.

**CO5.** To **design** a small-scale apiculture business model, including equipment, expenditures, expected yield, and marketing of bee products.

**SEMESTER-I**

**Cell Biology and Genetics (Discipline Specific Course)**

**Course Code: U25ZOO101T**

**(4 Hrs /week) External Marks: 70**

**Credits: 4 Internal Marks: 30**

**Exam Time: 3 Hrs Maximum Marks: 100**

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit.

The student/candidate is required to attempt five questions in all selecting one question from each unit in addition to compulsory Question No.1. All questions will carry equal marks.

**Unit-I**

Biomembranes: molecular composition and arrangement, functional consequences, cellular Transport – Recapitulation of the plasma membrane; diffusion, active transport and pumps, uniports, symports and antiports. Donnan equilibrium; ion movements and cell function: acidification of cell organelles. Maintenance of cellular pH; cell excitation; bulk transport; Receptor mediated endocytosis, transepithelial transport, Cytoskeleton and cell movement; introduction to cytoskeleton and its role, molecular structure of actin, myosin and their organization, structure and dynamic organizations of microtubules, microfilaments and intermediate filament, structure and functions of Cilia and flagella

**Unit-II**

Cell interactions and cell-matrix adhesions: cell walls, the ECM and cell-matrix interactions, Cell matrix adhesion: integrins, collagen, non-collagen components, Auxin and cell expansion, Cellulose fibril synthesis and orientation, Protein sorting and transport: protein uptake into the ER, Membrane proteins and Golgi sorting, Mechanism of vesicular transport, Lysosomes, Cell cycle; eukaryotic cell cycle, Regulators of cell cycle progression, Role of Meiosis in Genetic Variation, Cell-Cell signaling, Signaling molecules and their receptors, Pathways of intracellular signal transduction. Basic biology of Cancer, the development and causes of cancer, oncogenes, tumor suppressor genes

**Unit-III**

Gene mutation, DNA repair: types of gene mutations, methods for detection of induced mutations; P- element insertional mutagenesis in Drosophila; DNA damage, repair. Regulation of Gene Expression: Regulation of gene activity in lac and trp operons of E. coli. General introduction to gene regulation in eukaryotes at transcriptional and post-transcriptional levels; Organization of a typically eukaryotic gene, transcription factors, enhancers and silencers, non-coding genes

**Unit IV**

Sex determination and dosage compensation: sex determination-in humans, *Drosophila* and other animals; dosage compensation of X-linked genes– hyperactivation of X-linked gene in male *Drosophila*, inactivation of X-linked genes in female mammals; human genetics-karyotype and nomenclature of metaphase chromosome bands; chromosome anomalies and diseases- chromosomal anomalies in malignancy (chronic myeloid leukemia, Burkitt's lymphoma, retinoblastoma and Wilms'tumor); genetic analysis of complex traits - complex pattern of inheritance, quantitative traits, threshold traits; human genome and mapping

**Suggested Reading:**

1. Molecular Cell, Biology, J. Darnell, H. Lodish and D. Baltimore Scientific American Book, Inc., USA.
2. Molecular Biology of the Cell, B. Alberts, D. Bray, J. Lewis, M. Raff, K. Roberts and

J.D. Watson. Garland Publishing Inc., New York.

1. Cell Biology by A.K. Berry, EMKAY Publlications
2. Molecular Cell Biology, Lodishet al., W.H. Freeman and Company (8th Ed. 2016)
3. Molecular Biology, Weaver R. F., McGraw-Hill Education (5th Ed. 2011)

Principles of Genetics, Snustad and Simmons, John Wiley & Sons, USA [Latest edition]

1. Genetics, J. Russell, Benjamin-Cummings Publishing Company, San Francisco, California, USA [Latest edition]

**Course Outcome:**

At the end of the course, the students would be able to:

**CO1**. To **describe** the structural and functional organization of cells, membranes, and organelles.

**CO2**. To **apply** fundamental principles of molecular transport, cell cycle, and cell signaling to explain cellular processes.

**CO3.** To **analyze** mechanisms of gene mutation, DNA repair, and gene expression in prokaryotes and eukaryotes.

**CO4.** To **evaluate** the genetic basis of sex determination, chromosomal abnormalities, and their clinical significance.

**CO5**. To **design** basic experimental approaches to investigate genetic traits, cancer biology, and molecular cell functions

**Biochemistry and Bio-techniques (Discipline Specific Course)**

**Course Code: U25ZOO102T**

**(4 Hrs /week) External Marks: 70 Credits: 4 Internal Marks: 30**

**Exam Time: 3 Hrs Maximum Marks: 100**

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit.

The student/candidate is required to attempt five questions in all selecting one question from each unit in addition to compulsory Question No.1. All questions will carry equal marks.

**Unit-I**

General Principles of Biochemistry and chemical composition of Life: General Introduction to Biomolecules, Protein Biology: Primary, Secondary, tertiary and quaternary structure of proteins: i) Domain, ii)Reverse turn of Ramachandran plot and its significance, Enzyme: Classification and nomenclature, Co-enzymes and Cofactors, Induced fit and Molecular Mechanism of Enzyme action, Enzyme feedback mechanism, Isozymes, Nucleic acids: Structure and functions, DNA structure and functions RNA structure and functions, DNA choreography, Qualitative and quantitative estimation of DNA

**Unit-II**

Metabolism: Glycolysis, citric acid cycles its regulation and role as metabolic hub, Hexose monophosphate- pathway its regulation and significance, Cholesterol biosynthesis, its metabolism avid steroidogenesis, Bile acids and their metabolism, Saturated and unsaturated fatty acid and their metabolism

**Unit-III**

Chemical and Biological assays (in-vitro and in-vivo assays), Principles and uses of analytical instruments: Microscopes and imaging, Spectrophotometer, NMR spectrophotometer. Microbiological and cell culture Techniques: Setting of microbiological laboratory, Sterilization and Media preparation techniques, Inoculation and growth monitoring (Standard plate count technique), Isolation of a microbial colony and slant preparation, Design and functioning of tissue culture laboratory, Basics of cell/tissue culture, Culture media preparation, Cell proliferation measurements, Cell viability testing and Cell harvesting methods, Biosafety and levels Cryotechniques: Cryopreservation for cells, tissue, organisms, Cryotechniques for microscopy

**Unit-IV**

Separation techniques in biology: Molecular separations by chromatography, electrophoresis, precipitation etc. Organelle separation by centrifugation. Density gradient centrifugation, Ultra Centrifugation, unit gravity centrifugation, affinity adsorption, anchorage-based techniques etc., Cell separation by flowcytometry and FACS, Radioisotope and mass isotope techniques in biology: Sample preparation for radioactive counting, Autoradiography, Biosensors, DNA fingerprinting

**Suggested Reading:**

1. Animal Cell Culture – A practical approach, Ed. John R.W. Masters, IRL Press.
2. Introduction to Instrumental analysis, Robert Braun, McGraw Hill International editions
3. A Biologists guide to Principles and Techniques of Practical Biochemistry, K. Wilson and K.H. Goulding, ELBS Edn.
4. Lehninger AL, Nelson DL & Cox MM (1993) Principles of Biochemistry, 2nd edn. New York: Worth.
5. Stryer L (1995) Biochemistry, 4th edn. New York: WH Freeman.
6. Voet D, Voet JG & Pratt CW (1999) Fundamentals of Biochemistry. New York: Wiley.

**Course Outcome:**

At the end of the course, the students would be able to:

**CO1**. To **describe** the structure and function of biomolecules, enzymes, and nucleic acids involved in cellular processes.

**CO2.** To **explain** key metabolic pathways and their regulation in carbohydrate, lipid, and steroid metabolism.

**CO3**. To **demonstrate** the principles and applications of basic biochemical and microbiological laboratory techniques.

**CO4**. To **analyze** the working and utility of analytical, imaging, and separation techniques used in biological research*)*

**CO5**. To **evaluate** and design experimental strategies using modern biotechnological tools like flow cytometry, biosensors, and DNA fingerprinting.

**Biology of Invertebrates (Discipline Specific Course)**

**Course Code: U25ZOO103T**

**(4 Hrs /week) External Marks: 70**

**Credits: 4 Internal Marks: 30**

**Exam Time: 3 Hrs Maximum Marks: 100**

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit.

The student/candidate is required to attempt five questions in all selecting one question from each unit in addition to compulsory Question No.1. All questions will carry equal marks.

**Unit-I**

Introduction to invertebrates with their general characters, Basic body plan, Concept of Invertebrate v/s Vertebrata and Non-Chordata v/s Chordata, Organization of coelom; Concept and structure of Acoelomate, Pseudocoelomates and coelomates, Protostomia and Deuterostomia, Metamerism in Annelida, Pseudo metamerism. Minor Phyla: Concept and significance, organization and general characters of Acoelomate, Pseudocoelomates and Coelomates. Minor phyla (with special emphasis on Ctenophora, Rotifera, Endoprocta, Ectoprocta, Phoronida, Sipunculida and Echiuroidea)

**Unit-II**

Locomotion: Flagella and ciliary movement in Protozoa, Hydrostatic movement in Coelenterata, Annelida and Echinodermata. Nutrition and Digestion: Patterns of feeding and digestion in lower metazoan, Filter-feeding in Polychaeta, Molluscs and Echinodermata. Respiration: Organs of respiration: Gills, lungs, trachea, skin etc. Respiratory pigments, Mechanism of respiration

**Unit-III**

Excretion: Organs of excretion: Coelom, coelomoducts, Nephridia and Malpighian tubules. Mechanism of separation and osmoregulation. Nervous system: Primitive nervous system: Coelenterata and Echinodermata, Advanced nervous system: Annelida, Arthropoda (Crustacea and Insecta) Mollusca (Cephalopoda), Trends in neural evolution, social life in insects, social life in Isoptera and Hymenoptera

**Unit-IV**

Invertebrate larvae: Larval forms of free-living invertebrates, Strategies and Evolutionary significance of larval forms, Conservation of invertebrates. Introduction to insects: Mouthparts of Insects, Mechanism of insect flight and hovering, Metamorphosis in insects, Hormonal control of moulting. Economic importance of invertebrates; Various Adaptations in Invertebrates

# Suggested Reading:

1. Hyman, L.H. The invertebrates, Vol. I. Protozoa through Ctenophora, McGraw Hill Co., New York.
2. Barrington, E.J.W. Invertebrate structure and function. Thomas Nelson and Sons Ltr J. London.
3. Jagerstein, G. Evolution of Metazoan life cycle, Academic Press, New York & London.
4. Hyman, L.H. The Invertebrates. Vol.2. McGraw Hill Co., New York. 18
5. Hyman, L.H. The Invertebrates. Vol.8. McGraw Hill. Co., New York.
6. Barnes, R.D. Invertebrate Zoology, IIIrd edition. W.B. Saundrs Co., Philadelphia.
7. Russel-Hunter, W.D. A Biology of higher invertebrates, the Macmillin Co. Ltd. London.
8. Hyman, L.H. the Invertebrates smaller coelomate groups, Vol. V. McGraw Hill Co., New York
9. Read, C.P. Animal Parasitism. Prentice Hall Inc., New Jersey.
10. Sedgwick, A.A. Student text book of Zoology. Vol. I, II and III Central Book Depot, Allahabad
11. Parker, T.J., Haswell, W.A. Text book of Zoology, McMillan Co., London.

**Course Outcome:**

At the end of the course, the students would be able to:

**CO1.** To **describe** the structural organization, classification, and general features of invertebrates including minor phyla.

**CO2.**To **explain** fundamental physiological processes such as locomotion, respiration, digestion, and excretion in major invertebrate groups.

**CO3.** To **analyze** the organization and evolution of nervous systems and behavioral patterns in selected invertebrate taxa.

**CO4**. To **evaluate** the developmental strategies, metamorphosis, and adaptive significance of invertebrate larval forms and morphologies.

**CO5**. To **assess** the ecological and economic importance of invertebrates, emphasizing their roles in biodiversity and conservation.

**Fish Fisheries and Aquaculture (Discipline Elective Course)**

**Course Code: U25ZOO111T**

**(4 Hrs /week) External Marks: 70**

**Credits: 4 Internal Marks: 30**

**Exam Time: 3 Hrs Maximum Marks: 100**

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit.

The student/candidate is required to attempt five questions in all selecting one question from each unit in addition to compulsory Question No.1. All questions will carry equal marks.

**Unit-I**

Definition of Fish, Fisheries and aquaculture: Types of Aquacultures, Classification of fishes with distinguishing characters and examples of each group, Estuarine, Marine, Riverine and wetland fisheries: characteristic species and their exploitation, Culture fisheries: Cultivable organisms for aquaculture, Criteria of selection of cultivable fishes, Design, construction and maintenance of fish culture ponds, Ecology of fish pond ecosystem, Physico-chemical conditions of ponds water and soil, Biological conditions of water and productivity of fish ponds

**Unit-II**

Fish integument: Exoskeleton and colouration, Fins: origin, types and functions, Food and feeding habits of fishes, Digestion in fishes, Respiratory system Gill structure and functions, Accessory respiratory organs swim bladder and webberian ossicles, Osmoregulation in fishes, Receptors in fishes: Chemoreceptors, Lateral line organs, Eye, Ear, Pineal organ, Hormones and reproduction: Induced breeding in carps and catfishes

**Unit-III**

Introduction to fish biotechnology, selection and hybridization, androgenesis and gynogenesis-natural and induced, polyploidy techniques, sex reversal and sterility, transgenesis, transgenes and application, cryopreservation and gametes and embryo, Fish by products

**Unit-IV**

Different systems for aquaculture: pond culture, cage culture, raceway culture, culture of important fish species (major carps, common carps, Chinese carps, cat fish, culture and tilapia culture), integrated aquaculture and wastewater aquaculture, pearls culture, prawn culture-fresh and brackish water, methods of fishing: crafts and gear technology, fish diseases and their control

# Suggested Reading:

1. Encyclopedia of Fish Physiology. 2011. Anthony P. Farrell, E.D. Stevens, J.J. Cech& J.G. Richards (Eds). Academic Press, UK.
2. APHA (1995) Standard Methods of Examination of Water and Wastewater. American Public Health Association, AWWA, WCPF, Washington DC.
3. Bardach, JE, Ryther & McLarney, Wo (1972) Aquaculture, New York: Wiley-Interscience. 896pp. 58
4. Boulenger, GA & Bridge, TW (1910) Fishes (Vol. VII of the Cambridge Natural History) Cambridge Univ. Press, London.
5. Das, P, Verma, SR, Dhaje, RJ & Malik DS (2002) Coldwater Fish Genetic Resources and their Conservation. National Conservators publication, 7, 325pp.
6. Datta Munshi, JS & Srivastava, MP (1998) Natural History of Fishes and Systematics of Freshwater Fishes of India. Narendra Publishing house, Delhi, 403pp.
7. Jayram, KC (2013) The Freshwater Fishes of the Indian Region (Corrected 2nd Edition) Narendra Publishing house, Delhi, 616pp, XXXIX plates.
8. Lagler, KF, Bardach, JE, Miller, RR & Passino, DRM (1977) Ichthyology, 21nd Edition, New York.

**Course Outcome:**

At the end of the course, the students would be able to:

**CO1.** To **identify** the types, classification, and anatomical features of fishes and aquatic organisms.

**CO2**. To **describe** aquaculture systems, fish culture techniques, and criteria for selection of cultivable species.

**CO3.** To **analyze** the ecological, physico-chemical, and biological conditions influencing fish pond productivity.

**CO4**. To **apply** knowledge of fish physiology, reproduction, and biotechnology in aquaculture practices.

**CO5**. To **evaluate** fish diseases, fishing methods, and advanced breeding technologies for sustainable aquaculture.

**Biosystematics and Computational Biology (Discipline Elective Course)**

**Course Code: U25ZOO112T**

**(4 Hrs /week) External Marks: 70**

**Credits: 4 Internal Marks: 30**

**Exam Time: 3 Hrs Maximum Marks: 100**

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit.

The student/candidate is required to attempt five questions in all selecting one question from each unit in addition to compulsory Question No.1. All questions will carry equal marks.

**Unit-I**

Biosystematics and taxonomy: definition and perspectives, historical resume, importance and applications of systematics in biology, concepts of newer aspects of biosystematics in biology: chemotaxonomy, cytotaxonomy, molecular taxonomy, dimension of speciation and taxonomic characters, subspecies and other intra specific categories, theory of biological classification hierarchy of categories, taxonomic characters different kinds weighing of characters

**Unit-II**

Methodology: taxonomic collections preservation, curetting processes and identification, taxonomic keys different kinds of taxonomic keys their merits and demerits, systematic publications: different kinds of publications, international code of zoological nomenclature: principles, objectives and rules: stability, priority, concept of availability, formation of names synonymy, homonymy the type methods kinds of type specimen type designation. Principles of bioethics in biodiversity.

**Unit-III**

Basic components of computers– hardware (CPU, input, output, storage devices), Software (operating systems), Application software; Introduction to MS-EXCEL- use of worksheet to enter data, edit data, copy data, move data; Use of in- built statistical functions for computations of mean, S. D., correlation, regression coefficients etc., Use of bar diagram, histogram, scatter plots, etc., Graphical tools in EXCEL for presentation of data; Introduction to MS-WORD; word processor- editing, copying, moving, formatting, table insertion, drawing flow charts etc; Introduction to Power Point, image and data handling.

**Unit-IV**

The era of computerized biology information: review of relevant definitions in molecular biology, overview of challenges of molecular biology computing, proteins, secondary structure and folding, RNA secondary structures, Introduction to phylogenetic analysis; introduction to bioinformatics; introduction to genomics and proteomics databases- nucleic acid sequence database: Genbank, UCSC, ENSEMBL, EMBL, DDBJ, protein sequence databases: Swiss- prot, PDB, BLAST, PSI- BLAST (steps involved in use and interpretation of results) and HMMER, BLAST vs FASTA, file formats- FASTA, GCG and ClustalW. Databank search- data mining, data management and interpretation, multiple sequence alignment, genes, primer designing; Protein modeling, protein structure analysis, docking, LigPlot interactions, phylogenetic analysis with the program PHYLIP, DISTANCES, GROWTREE etc

**Suggested Reading:**

1. M. Kato. The Biology of Biodiversity, Springer.
2. E.O. Wilson, Biodiversity, Academic Press, Washington.
3. G.G. Simpson, Principle of animal taxonomy, Oxford ISH Publishing Company.
4. E. Mayer, Elements of Taxonomy. E.O. Wilson, The Diversity of Life (The College Edition), W.W. Northerm & Co.
5. Bioinformatics: Sequence and Genome Analysis, Mount, D. W. (2nd Ed., 2001), Cold Spring Harbor Laboratory Press, New York, USA.

**Course Outcome:**

At the end of the course, the students would be able to:

**CO1.** To **define** key concepts in biosystematics, taxonomy, and computerized biological data.

**CO2**. To **explain** methodologies for taxonomic identification, classification, and nomenclature following ICZN rules.

**CO3.** To **demonstrate** proficiency in using MS Excel, Word, and PowerPoint for biological data analysis and presentation.

**CO4**. To **analyze** biological databases and sequence data using tools like BLAST, HMMER, and ClustalW.

**CO5**. To **evaluate** phylogenetic relationships and molecular interactions using bioinformatics software and modeling techniques.

**Animal Behaviour & Wildlife Conservation (Discipline Elective Course)**

**Course Code: U25ZOO113T**

**(4 Hrs /week) External Marks: 70**

**Credits: 4 Internal Marks: 30**

**Exam Time: 3 Hrs Maximum Marks: 100**

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit.

The student/candidate is required to attempt five questions in all selecting one question from each unit in addition to compulsory Question No.1. All questions will carry equal marks.

**Unit-I**

Concept of animal behaviour; Mile-Stones in the history of animal behaviours and scope Stereotyped and acquired behaviour patterns: Tropisms, Taxes, Reflexes, Instincts, leasing & reasoning; Change in major modes of adaptive behaviour in phylogeny, Perception of the environment: Mechanical, Electrical, chemical, olfactory, auditory, visual, biological rhythms and concept of biological clock. Brief study of social behaviours in animals

**Unit-II**

Motivation Introduction, goal-oriented behaviour, biological drives-Primary and Secondary drives, Concept of learning: law of learning, types of learning-Habitation, trial & error learning, latent learning, Insight, Imprinting, Classical conditioning & Instrumental learning, Concept of Migratory behaviour, Hormones and animal behaviour

**Unit-III**

Wildlife: Definition, significance and Biogeographic/wildlife zones of India, Biodiversity of the Indian Subcontinent and World, Protected Area Systems: Concept, Historical background, categories and management objectives of protected areas, world growth of protected areas, and Present status of National PA-Systems, Theory and practice of Biosphere Reserves of the world: biosphere Reserves of India, Wildlife conservation techniques

**Unit-IV**

Natural Heritage Sites of the world, Natural Heritage sites in India. Important National Park and Wildlife Sanctuaries of India, Wildlife and livelihood; Wildlife and illegal trade & control; Role of WWF, IUCN, UNEP, Red Data Book; Categories of Endangered Wildlife Species, Wildlife census and programs for conservation

**Suggested Reading:**

1. Techniques for wildlife Census in India by W.A. Rogers (A field manual); Wildlife Institute of India, Dehradun.
2. T.C. Majupuria, *Wildlife wealth of India*. Bangkok, Thailand: Tecpress Services, L.P.
3. Ali, S. Ripley S.D. Handbook of Birds of India, Pakistan 10-Vols. Oxford University Press, Bombay.
4. The Book of Indian Animals by S.H. Prater, BNHS-Publication, Bombay.
5. Wildlife in India by V.B. Saharia Natraj Publishers, Dehradun.

6. E.P. Gee, The Wildlife of India.

**Course Outcome:**

At the end of the course, the students would be able to:

**CO1.** To **identify** key patterns and types of animal behaviors in relation to their evolutionary significance.

**CO2.** To **classify** animal behavioral responses such as reflexes, instincts, and learned behaviors based on stimulus-response mechanisms.

**CO3.** To **apply** the principles of biological rhythms and environmental perception to assess behavioral adaptations in animals.

**CO4.** To **analyze** the role of hormones, motivation, and learning processes in shaping complex animal behaviors.

**CO5.** To **evaluate** wildlife conservation strategies and biodiversity management practices in Indian and global contexts.

**Practical-I**

**Course Code: U25ZOO104P**

**(6 Hrs /week) External Marks: 50**

**Credits: 3 Internal Marks: 25**

**Exam Time: 3 Hrs Maximum Marks: 75**

1. Preparation of mitotic chromosomes from onion root tips.
2. Preparation of meiotic chromosomes from grasshopper testis.
3. Preparation of karyotypes from micrographs
4. Calculation of morphometric data and preparations of idiogram.
5. Determination of chiasma frequency and terminalization coefficient.
6. Study of permanent slides of different stages of meiosis and mitosis
7. Preparation of polytene chromosomes (*Chironomus*/ mosquito) and mapping.
8. Preparation of solutions/standard solution, molar, molal and normal solution.
9. Proteins: isolectric point in protein (casein): quantitative estimation of proteins by Biuret method and Lowry’s method.
10. Carbohydrates: quantitative estimation of total carbohydrates and glucose.
11. Analysis of Fats/oils: iodine number, saponification value, acid value, quantitative estimation of total lipids.
12. Preparation of standard curve for the estimation and extraction of nucleic acids (DNA and RNA)
13. Paper chromatography: amino acids and carbohydrates.
14. Thin layer chromatography: neutral and phospholipids.
15. Tools: demonstration of parts and working of the following tools: PCR, GLC, Spectrophotometers, various kinds of microscopes, pH meter, Electrophoresis, Centrifuges, Tissue culture unit, Incubators.
16. Microbiological media preparation, sterilization, dilution, inoculation and standard plate count.

**Suggested Reading:**

1. Sharma R K, Sangha S P S (2009). Basic Techniques in Biochemistry and Molecular Biology, I.K. International Publishing House Pvt. Ltd. New Delhi

2. Podder T, Mukhopadhyay S, Das S K (2003). An Advanced Laboratory Manual of Zoology Published by Rajiv Beri for Macmillan India Limited, Rajkamal Electric Press, Delhi

3. Sadasivam S, Manickam A (1997). Biochemical Methods, Ed. 2nd, New Age International Publishers, New Delhi

4. David T. Plummer (1987). An Introduction to Practical Biochemistry. Ed., 3rd, McGraw-Hill Publisher, Rajkamal Electric Press, Delhi

5. Rajgopal G, Toora B D (2022). Practical Biochemistry. Ed. 5th, Ahuja Publishing House, New Delhi

**Course Outcome:**

At the end of the course, the students would be able to:

**CO1.** To **recall and identify** key cytological and biochemical procedures including mitotic and meiotic chromosome preparations, protein/carbohydrate estimations, and chromatographic techniques.

**CO2.** To **explain** the principles and working of common laboratory tools and techniques such as spectrophotometry, electrophoresis, chromatography, and centrifugation used in molecular and biochemical analysis.

**CO3.** Toperform laboratory experiments to **estimate**, biomolecules (proteins, carbohydrates, lipids, nucleic acids) and prepare karyotypes and idiograms using real data.

**CO4.** To **analyze** morphometric and chromosomal data including calculation of chiasma frequency, terminalization coefficient, and interpretation of chromatographic results.

**CO5.** To **design and interpret** a complete experimental workflow involving biochemical estimations, chromosome analysis, and microbiological techniques to solve a biological research question.

**Practical-II**

**Course Code: U25ZOO105P**

**(6 Hrs /week) External Marks: 50**

**Credits: 3 Internal Marks: 25**

**Exam Time: 3 Hrs Maximum Marks: 75**

1. Slides and Museum specimens of following Phyla:
   1. PROTOZOA
   2. PORIFERA
   3. CNIDARIA
   4. ANNELIDA
   5. ARTHROPODA
   6. MOLLUSCA
   7. ECHINODERMATA
2. Study of mouth parts of different insects: Cockroach, Honeybee, Redcotton bug and House fly
3. Mounting: *Obelia*, Turbellaria, Trachea of Cockroach, Crustacean Larva, *Cyclops*, Nauplius, *Daphnia*
4. Demonstration of Digestive system, Reproductive system and nervous system of earthworm, Cockroch, Prawn, *Loligo* and starfish

**And**

**Fish Fisheries &Aquaculture**

1. Study of anatomy and morphology of important group of fishes
2. Taxonomic studies of common families, genera and species of fishes
3. Survey and collection of fishes of Haryana
4. Examination of skeleton of cartilaginous and bony fishes
5. Study of histological and microscopic structure in fishes
6. Analysis of physical and chemical properties of water: temperature, pH, turbidity, salinity, total solids, dissolved oxygen, free carbon-di-oxide, hardness, chlorides, orthophosphates, nitrates, ammonia
7. Qualitative and quantitative examination of phyto and zooplanktons in a water body
8. Determination of percent composition of different groups of phyto and zooplanktons
9. Determination of species diversity of phyto and zooplanktons
10. Study of aquatic weeds and aquatic insects

OR

**Biosystematics and Computational Biology**

1. Use of computers Microsoft word and Microsoft office excel, graphs statistics.
2. Preparation and use of different types of taxonomic keys.
3. Use of search engines like Pub-Med, Scopus, Science direct for reference material collection and management.
4. Nucleic acid and protein sequence databases
5. Web– based tools for sequence searches and homology screening.
6. Primer designing for gene amplification and gene cloning
7. Construction of phylogenetic trees for DNA and proteins.

OR

**Animal Behaviour and Wildlife Conservation**

1. Designing of experiments, observations, techniques of data analysis, presentation of
2. results and writing of laboratory report.
3. To demonstrate locomotive, explorative withdrawal and habituation behaviours in
4. animals.
5. To demonstrate response of animals to light.
6. To demonstrate antennal grooming behaviour in cockroach.
7. Demonstration of food preferences in insects/pests
8. Investigation of habituation of diving response of mosquito larvae.
9. To study the effect of temperature on heartbeat of cockroach/ Gill movements in Fishes.
10. Field study of nesting behaviour of common available avian fauna of the region.
11. Study of Migratory Birds
12. To study mobbing response of birds.
13. Study of animal behavior patterns using repertoire sheets.
14. To prepare charts of wildlife zones of India and the world.
15. Field visits to local areas/Project Report

**Suggested Reading:**

1. P S Verma (2010). A Manual of Practical Zoology: INVERTEBRATES, S Chand and Company Limited, New Delhi

2. S.S. Lal (1980). A Textbook of Practical Zoology: Invertebrate. Edition, 4. Publisher, Rastogi Publications

3. S.C. Agarwal (2019). Practical Invertebrate Zoology, Publisher: Pragati Prakashan

4. V Benerjee (2021). A Textbook of Invertebrate Practical Zoology, Bharti Bhawan Publishers, Noida, UP

5. Robert L. Wallace, Walter K. Taylor (2002). Invertebrate Zoology Lab Manual, 6th edition, Publisher: Pearson

**Course Outcome:**

At the end of the course, the students would be able to:

**CO1.** To **identify and recall** the diagnostic features of representative specimens from Protozoa to Hemichordata and insect mouthparts using preserved slides, museum specimens, and mounts.

**CO2.** To **explain** the anatomy and function of major organ systems (digestive, reproductive, nervous) through dissection and demonstration of non-chordate animals like Earthworm, Cockroach, Prawn, Starfish, and *Loligo*.

**CO3.** To **apply** field and lab techniques such as fish sampling, water quality analysis, or behavioural assays (e.g., response to stimuli, grooming, locomotion) to investigate real-life biological systems.

**CO4.** To **analyze and interpret** biological data using software (e.g., Excel, PubMed, BLAST tools), statistical methods, or diversity indices to draw inferences about aquatic ecosystems or behavioural responses.

**CO5.** To **design** project reports, charts, or phylogenetic trees, or construct behaviour repertoires and wildlife conservation charts, integrating observational, ecological, or molecular data.

**SEMESTER-II**

**Molecular Biology and Biostatistics (Discipline Specific Course)**

**Course Code: U25ZOO201T**

**(4 Hrs /week) External Marks: 70**

**Credits: 4 Internal Marks: 30**

**Exam Time: 3 Hrs Maximum Marks: 100**

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit.

The student/candidate is required to attempt five questions in all selecting one question from each unit in addition to compulsory Question No.1. All questions will carry equal marks.

**Unit-I**

DNA Replication: Prokaryotic and Eukaryotic DNA replication, Mechanism of DNA replication, Enzymes and accessory proteins involved in DNA replication, Transcription: Prokaryotic and Eukaryotic transcription, General and specific transcription factors, Regulatory elements and mechanisms of transcription regulation, Transcriptional and post- transcriptional gene silencing.

Translation: Genetic code and deciphering of genetic code, Prokaryotic and Eukaryotic translation, The translational machinery, Adaptor hypothesis, Kozak rule, Mechanism of initiation, elongation and termination, Regulation of translation.

**Unit-II**

Recombination and Repair: Holiday junction, gene targeting, gene disruption, Cre/lox recombination, RecA and other recombinases, DNA repair mechanisms, Antisense and Ribozyme technology: Molecular mechanisms of antisense molecules. Molecular mapping of genome: genetic and physical maps, Physical mapping and map-based cloning, Southern end fluorescence in situ hybridization for genome analysis, Chromosome micro-dissection and micro-cloning, Molecular markers in genome analysis RFLP, RAPD and AFLP analysis and their applications.

**Unit-III**

Measures of central value: arithmetic mean, mode and median, definition, calculation and properties, measures of dispersion: range, interquartile range, quartile deviation, mean deviation and standard deviation, standard error, correlation types and method studying correlation, scatter diagram method, graphic method, Karl pearson coefficient of correlation, rank correlation, regression analysis (regression lines and regression equation), chi-square analysis.

**Unit-IV**

Concept of sampling and sampling methods: definition and law of sampling, judgment sampling, random sampling, stratified sampling, systematic sampling, multi stage sampling and quota sampling, test of significance for large samples and small samples (student t test, F-test, ANOVA), probability and law of probability, theoretical probability distribution: Binomial distribution, poison distribution, normal distribution. Components of computers, basic functioning of computers use of statistical software in biology.

**Suggested Reading:**

1. Molecular Biology of the Gene, J.D. Watson, N.H. Hopkins, J.W. Roberts, J.A Steitz and A.M. Weiner. The Benjamin/Cummings Pub. Co., Inc., California.
2. Molecular Cell Biology, J. Darnell, H. Lodish and D. Baltimore Scientific American Books, Inc., USA.
3. Molecular Biology of the Cell, B. Alberts, D. Bray, J. Lewis, M. Raff, K. Roberts and J,D. Watson. Garland Publishing Inc., New York.
4. Gene VI, Benjamin Lewin, Oxford University Press, U.K.
5. Molecular Biology and Biotechnology. A comprehensive desk reference, R.A Meyers (Ed.), VCH Publishers, Inc., New York.
6. Molecular Cloning: a Laboratory Manual, J. Sambrook, E.F. Fritsch and T. Maniatis, Cold Spring Harbor Laboratory Press, New York.
7. Introduction to Practical Molecular Biology, P.D. Dabre, John Wiley & Sons Ltd., New York.

**Course Outcome:**

At the end of the course, the students would be able to:

**CO1.** To **recall** key enzymes and steps involved in DNA replication, transcription, and translation processes.

**CO2.** To **differentiate** between prokaryotic and eukaryotic mechanisms of gene expression and protein synthesis.

**CO3.** To **apply** molecular biology techniques such as gene cloning, recombination, and molecular mapping in genome analysis.

**CO4.** To **analyze** statistical data using correlation, regression, and chi-square tests to interpret biological research findings.

**CO5**. To **evaluate** sampling methods and statistical tests to select appropriate tools for biological data analysis.

**Population Genetics and Evolution (Discipline Specific Course)**

**Course Code: U25ZOO202T**

**(4 Hrs /week) External Marks: 70**

**Credits: 4 Internal Marks: 30**

**Exam Time: 3 Hrs Maximum Marks: 100**

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit.

The student/candidate is required to attempt five questions in all selecting one question from each unit in addition to compulsory Question No.1. All questions will carry equal marks.

**Unit-I**

Concepts of evolution and theories of organic evolution with an emphasis on Darwinism, Emergence of Neo-Darwinism. Neo Darwinism; Hardy-Weinberg law of genetic equilibrium. A detailed account of destabilizing forces: (i) Natural selection (ii) Mutation (iii) Genetic drift (iv) Migration (v) Meiotic drive

**Unit-II**

Quantifying genetic variability, Genetic structure of natural populations, Phenotypic variations, Models explaining changes in genetic structure of populations, factors affecting human disease frequencies, Molecular population genetics, Patterns of change in nucleotide and amino acid sequences, Ecological significance of molecular variations, Genetics of quantitative traits in populations; Analysis of quantitative traits, Estimation of heritability, Genotype-environment interactions, Inbreeding depression and heterosis. Molecular analysis of quantitative traits. Phenotypic plasticity

**Unit-III**

Genetics of speciation: Concept of species, Patterns and mechanisms of reproductive isolation, Modes of speciation (Allopatric, Sympatric, Parapatric, Peripatric), Molecular Evolution: Gene Evolution; Evolution of gene families, Molecular drive, Assessment of molecular variations, Origin of higher categories, Phylogenetic gradualism and punctuated equilibrium, Major trends in the origin of higher categories, Micro-and Macro-evolution

**Unit-IV**

Molecular phylogenetics: Concept of phylogenetic trees, Methods of construction of Phylogenetic trees, Population genetics and ecology; Metapopulations, Monitoring natural population, Populations size and extinction, Loss of genetic variations, Conservation of genetic resources in diverse taxa

**Suggested Reading:**

1. Dobzhansky, T. (1951). Genetics and the origin of Species: Columbia University. New York.
2. Futuyma, D. J. (1998). Evolutionary Biology (3rd ed.). Sunderland, MA: Sinauer Associates.
3. Hartl, D. L. (1988). A primer of population genetics. Sinauer Associates, Inc. Massachusetts.
4. Smith, J.M. (1998) Evolutinary Genetics (2nd ed.). Oxford University Press, New York.
5. Strickberger, M. W. (2005). Evolution. Jones & Bartlett Learning.

**Course Outcome:**

At the end of the course, the students would be able to:

**CO1.** To **recall** fundamental concepts and theories of organic evolution including Darwinism and Neo-Darwinism.

**CO2.** To **explain** genetic mechanisms influencing population structure and factors causing genetic variability.

**CO3.** To **apply** principles of population genetics to analyze phenotypic variation and quantitative traits in populations.

**CO4.** To **analyze** patterns of speciation and molecular evolution to interpret evolutionary relationships.

**CO5.** To **evaluate** molecular phylogenetic methods and conservation strategies for preserving genetic diversity.

**Advanced Animal Physiology (Discipline Specific Course)**

**Course Code: U25ZOO203T**

**(4 Hrs /week) External Marks: 70**

**Credits: 4 Internal Marks: 30**

**Exam Time: 3 Hrs Maximum Marks: 100**

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit.

The student/candidate is required to attempt five questions in all selecting one question from each unit in addition to compulsory Question No.1. All questions will carry equal marks.

**Unit-I**

Digestion: Feeding mechanisms and regulation, digestion and absorption. Respiration: Respiratory organs, Types of respiration, mechanism of breathing, Transport of respiratory gases, Respiratory pigments. Physiological response to oxygen deficient stress. Excretion: Patterns of nitrogen excretion, Functional anatomy of renal unit; mechanisms of ultrafiltration, Counter Current mechanism, Dialysis, Osmoregulation and basic classification of organisms on the basis of osmoregulation, osmotic challenges of different environments, mechanisms of osmoregulation in fresh water, estuarine and marine animals, osmoregulation in migratory organisms control and regulation of osmoregulation.

**Unit-II**

Thermoregulation: homeothermic animals, poikilotherms, hibernation and aestivation, physical, chemical, neural regulation. Circulation of body fluids: systems of circulation, heart beat and blood pressure, cardiac cycle, cardiac output and its regulation. Receptor physiology: study of mechanoreception, photoreception, chemoreception and equilibrium reception, muscle and contractile physiology: contractile elements cells and tissues, muscle structure and function-correlation, electric organs and tissues.

**Unit -III**

Testicular physiology in animals: morphology, differentiation, function and its regulation, ovarian physiology and differentiation in vertebrates, neuronal physiology: structure and classification of neurons and glial cells, synaptic action, dendritic properties and functional operation of spinal cord, brain stem, autonomic nervous system.

**Unit-IV**

Principles of synaptic transmission: Ca2+ and transmitter release; post synaptic transmission mechanism, diversity of neurotransmitters: acetylcholine, catecholamine, serotonin, GABA, glycine, histamine, peptides, NO and opioids. Physiological adaptations to different environments: physiological adaptations acclimatization and acclimation in response to high low ambient temperature, physiological adaption at high altitude and in deep sea environment, stress physiology concept of stress and strain, stress hormones and stress regulatory mechanisms.

**Suggested Reading:**

1. Prosser, C. L., & Brown, F. A. (1961). Comparative animal physiology. W.B. Saunders & Company.
2. Randall, D. J., Burggren, W., French, K., & Eckert, R. (2002). *Eckert animal physiology*. W.H. Freeman & Company.
3. Moss, M. L. (1966). General and comparative physiology. (815 pp.) WS Hoar Prentice‐ Hall, Inc., Englewood Cliffs, NJ 1966.
4. Guyton, A.X., (1986) Text Book of Medical Physiology, 7th edition, Saunders Company.

**Course Outcome:**

At the end of the course, the students would be able to:

**CO1.** To **identify** comparative digestive and respiratory mechanisms across different animal groups.

**CO2.** To **classify** various osmoregulatory strategies and thermoregulatory adaptations in diverse animal habitats.

**CO3.** To **apply** knowledge of circulatory and receptor physiology to explain animal physiological responses.

**CO4.** To a**nalyze** neuronal and reproductive physiology in vertebrates to interpret functional regulation.

**CO5.** To **evaluate** physiological adaptations and stress responses in animals under extreme environmental conditions.

**Biology of Vertebrates (Discipline Specific Course)**

**Course Code: U25ZOO204T**

**(4 Hrs /week) External Marks: 70**

**Credits: 4 Internal Marks: 30**

**Exam Time: 3 Hrs Maximum Marks: 100**

Note: The examiner is required to set nine questions in all. The first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to this, eight more questions (each question may be of 2-3 parts) will be set consisting of two questions from each unit.

The student/candidate is required to attempt five questions in all selecting one question from each unit in addition to compulsory Question No.1. All questions will carry equal marks.

**Unit-I**

Introduction to Chordates with their general characters: Origin of Chordates, Concept of Protochordata or pre-vertebrates. Classification of Vertebrates upto orders, Integument and its derivatives; Development, general structure and functions of skin and its derivatives, Glands, scales, horns, claws, nails, hoofs, feathers and hair

**Unit-II**

Skeletal system: Forms, function, body size and skeletal elements of the body, Comparative account of jaw suspensorium, Vertebral column, Limbs and girdles, Digestive system: Dentition, Stomach, Digestive Glands, Anatomy of gut in relation to feeding habits-herbivores, carnivores and omnivores. Respiratory system, Comparative account of respiratory organs

**Unit-III**

General plan of circulation in various groups: Components of Blood, General plan of circulation in reptiles, birds and mammals, Evolution of heart, aortic arches and Portal systems. Evolution of Urino-genital system in vertebrates’ series: Structure and functions of different types of kidneys, Urino-genital ducts, Flight adaptation in birds, Migration in fishes and Birds

**Unit-IV**

Nervous system: Comparative anatomy of the brain in relation to its functions, Comparative anatomy of spinal cord, Nerves-Cranial, Peripheral and Autonomous nervous systems, Sense organs; Simple receptors: Organs of Olfaction and taste, Lateral line system, Electroreception

**Suggested Reading:**

1. Barrington, E.J.W. (1965) The Biology of Hemichordata and Protochordata. Oliver and Boyd, Edinbourgh.
2. Bourne, G.H. (1972) The structure and functions of nervous tissue. Academic Press, New York.
3. Carter, G.S. (1967) Structure and habit in vertebrate evolution. Sedgwick and Jackson, London.
4. Kingsley, J.S. Outlines of Comparative Autonomy of Vertebrates. Central Book Depot, Allahabad.
5. Kent, G. C. & Carr, Robert K. (2009) Comparative Anatomy of the Vertebrates.

**Course Outcome:**

At the end of the course, the students would be able to:

**CO1.** To **identify** key structural and functional features of chordates and their evolutionary significance.

**CO2.** To **compare** major vertebrate systems such as skeletal, digestive, and respiratory across different classes.

**CO3.** To **apply** anatomical and physiological concepts to relate vertebrate adaptations with their environments.

**CO4.** To **analyze** circulatory, nervous, and urino-genital systems to trace functional evolution among vertebrates.

**CO5**. To **evaluate** adaptive features such as flight in birds and migration in fishes to infer ecological and evolutionary roles.

**Practical-III**

**Course Code: U25ZOO205P**

**(6 Hrs /week) External Marks: 50**

**Credits: 3 Internal Marks: 25**

**Exam Time: 3 Hrs Maximum Marks: 75**

1. Extraction of genomic DNA from Animal tissue
2. Preparation of Agarose gel
3. Separation of DNA using Agarose gel electrophoresis
4. Demonstration of SDS-PAGE
5. Statistical analysis of data using manual and computer software method:
6. Mean, mode and median
7. Range, Inter-quartile range and Mean Deviation
8. Standard deviation, standard error and Variance
9. Coefficient of Correlation
10. Regression Analysis
11. Diversity indices

6. Calculation of Allelic and Genotypic frequencies

7. Construction of Phylogenetic tree

8. Homologous Organs and Analogous Organs

**Suggested Reading:**

1. Ausubel, F. M., Brent, R., Kingston, R. E., Moore, D. D., Seidman, J. G., Smith, J. A., & Struhl, K. (1995). Short protocols in molecular biology (3rd ed.). John Wiley & Sons.

2. Sambrook, J., & Russell, D. W. (2001). Molecular cloning: A laboratory manual (3rd ed.). Cold Spring Harbor Laboratory Press.

3. Walker, J. M. (Ed.). (1984–present). Methods in molecular biology (Vols. 1–current). Humana Press.

4. Singh, B. R., & Kumar, R. (2013). Practical techniques in molecular biotechnology. Cambridge University Press.

5. Sundar Rao, P. S. S., & Richard, J. (2006). *Introduction to biostatistics and research methods* (4th ed.). Prentice-Hall of India.

6. Bickel, D. R. (2003). Statistical applications in genetics and molecular biology. *Statistical Applications in Genetics and Molecular Biology*, 2(1)

**Course Outcome:**

At the end of the course, the students would be able to:

**CO1.** To **recall fundamental principles and protocols** related to DNA extraction, gel electrophoresis, and statistical concepts in biological research.

**CO2.** To **explain the working principles** of techniques like Agarose Gel Electrophoresis, SDS-PAGE, and statistical tools (mean, SD, correlation, etc.) and their relevance to biological analysis.

**CO3.** To **apply** techniques for DNA extraction, electrophoresis, and statistical calculations (both manual and software-based) to solve biological problems.

**CO4.** To **analyze biological data sets** to compute allelic/genotypic frequencies, diversity indices, and conduct regression and correlation to interpret evolutionary and genetic patterns.

**CO5.** To **construct phylogenetic trees** and **design comparative models** using homologous and analogous traits to deduce evolutionary relationships among species.

**Practical-IV**

**Course Code: U25ZOO206P**

**(6 Hrs /week) External Marks: 50**

**Credits: 3 Internal Marks: 25**

**Exam Time: 3 Hrs Maximum Marks: 75**

1. Histochemistry: Methods of fixation of different tissues.

2. Preparation of tissues for microtomy and cryostat.

3. Histochemical test:

(a) Haemotoxylin-eosin

(b) Toluidine Blue

(c) Sudan Block-B

(d) Mercury bromophenol blue

(e) Methyl green-pyronin-Y

4. Demonstration of live gametes and their staining procedure.

5. Effect of insulin and epinephrine on blood and urine sugar levels of rat.

6. Determination of optimum pH, temperature and concentration of amylase, trypsin and Lipase enzyme.

7. DLC, TLC, total RBC count

8. Determination of Blood Groups.

9. Identification of blood with non-blood like substances.

10. Museum specimens/models and slides:

Protochordates – *Herdmania*, *Amphioxus* (Branchiostoma)

Fishes – *Scoliodon, Torpedo*, *Anguilla, Clarias batrachus, Mystus spp., Rita spp, Notopterus notopterus, Labeo spp, Channa spp. (snakeheads), Anabas, Polypterus spp Hippocampus, Exocoetus, Pleuronectes, Pterois, Echeneis, Diodon*

Amphibians –*Bufo, Hyla*

Reptiles *– Python, Viper, Bungarus*, *Chameleon, Chelone mydas*.

Birds – Indian Koel (male), India koel (female), *Milvus*, Penguine.

Mammals –*Loris,* *Echidna*, *Manis*, *Ornithorhynchus*, *Erinaceus*, Porcupine, Mongoose.

11. Types of vertebrae of Procoelous, Opisthocoelous, Amphicoelous, Amphiplatian, Heterocoelous, Axis and atlas vertebrae.

12. Comparative Osteology of Vertebrates : Vertebrate, Girdles, Limb-bones.

**Suggested Reading:**

1. Podder T, Mukhopadhyay S, Das S K (2003). An Advanced Laboratory Manual of Zoology Published by Rajiv Beri for Macmillan India Limited, Rajkamal Electric Press, Delhi

2. Garg S K, Bhatnagar A, Kalla A, Johal M S(2002). Experimental Ichthyology. Ed. 1 st , CBS Publishers and Distributors, New Delhi

3. Verma P S (2021). A Manual Of Practical Zoology Chordates, Ed. 11 th , S Chand Publisher, New Delhi

4. Balakrishna Shetty, Sweekritha H Poonja (2018). Histology Practical Manual, Jaypee Brothers Medical Publishers Pvt. Limited, New Delhi

5. APHA (2017). Standard methods for the examination of water and wastewater. American Public Health association, American water Works association and Water environment Federation. Ed. 23 rd 1 Street, NW, Washington DC

6. Baker H and Frank O (1968). Clinical Vitaminology: Methods and Interpretation

**Course Outcome:**

At the end of the course, the students would be able to:

**CO1.** To **recall** the principles and protocols of tissue fixation, staining methods, and histological preparation techniques used in histochemistry and microtomy.

**CO2.** To **explain** the physiological effects of insulin and epinephrine on blood and urine sugar levels, and the role of enzymes under varying pH, temperature, and concentration.

**CO3.** To **perform and interpret** hematological tests including RBC count, DLC, TLC, blood grouping, and identification of blood vs non-blood substances using standard lab protocols.

**CO4.** To **analyze and compare** vertebrate skeletal structures and types of vertebrae across different classes (amphibians, reptiles, birds, mammals), highlighting adaptive significance.

**CO5.** To **develop** a visual classification chart or reference guide of preserved museum specimens and vertebrate anatomical features, integrating morphological and evolutionary data.