CORE COURSE -XV:

Paper Title: Animal Biotechnology (Theory)

Course Code: ZOO 815C

Objective: Biotechnology is the advanced branch of biological sciences which mostly deals with technological application on biological systems. It is basically the management of biological processes for industrial and other human welfare purposes. The present paper on biotechnology attempts to give a wholesome idea of biotechnology at a basic level. It provides a tool kit in the form of a number of various techniques and processes developed over time to solve problems involving primarily human welfare with focus on health and medicine. It will equip the students with basic tools of biotechnology which are a must for everyone interested in pursuing a career in biotechnology. It makes one aware of the scope of this field which encompasses almost every field of science like engineering, research, commercialization and academics.

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

- Use or demonstrate the basic techniques of biotechnology like DNA isolation, PCR, transformation, restriction digestion etc.
- Make a strategy to manipulate genetic structure of an organism for the improvement in any trait or its well-being based on the techniques learned during this course.
- Understand better the ethical and social issues regarding GMOs.
- Use the knowledge for designing a project for research and execute it.

Course Content:

Theory [Credits: 4] 60 hrs/100 marks (Internal assessment=20, Attendance=5, End Semester Exam = 75)

Unit 1: Introduction to Biotechnology and Basic Tools 12 hrs/15 marks

Introduction to Biotechnology, Isolation and purification of DNA and RNA in Bacteria and Animal systems, Restriction Enzymes: Nomenclature, Types, Characteristics and uses; Detection of recombinant molecules, cDNA libraries; Cloning vectors: Plasmids, Cosmids, Phagemids, Lambda Bacteriophage, BAC, YAC,and Expression vectors (characteristics only).

Unit 2: Molecular Tools and Techniques 12 hrs/15 marks

DNA sequencing methods**:** Maxam- Gilbert, Sanger, Next generation sequencing (Illumina). Blotting techniques - Southern, Northern, Western, Dot blot. Polymerase Chain Reaction and DNA Finger Printing. Gene Editing Tools: Zinc finger nucleases (ZFNs), and Clustered regularly interspaced short palindromic repeats(CRISPR/Cas9) system.

Unit 3: Animal Cell culture 12 hrs/15 marks

History of Cell culture, Laboratory design and basic requirements for animal cell culture;

Instrumentation and equipments; Aseptic and Sterilization concepts; Culture media and reagents, types of Culture media, Types of culture: Suspension and continuous Cell lines, maintenance of Cell lines, Primary and secondary Culture; Organ Culture, Cryopreservation.

Unit 4: Genetically modified organisms: 12 hrs/15 marks

History of GMOs, Production of cloned and transgenic animals: Nuclear Transplantation; Transgenic animals with examples: Applications, ethical, welfare issues and regulations.

Unit 5: Applications of Genetic Engineering 12 hrs/15 mark

Medicine: Stem Cell & Gene therapy; Vaccines, Insulin. **A g r i c u l t u r e** : disease resistant breeds, Biopesticides, Bioreactors & Biofarming. **Industry**: Enzyme, Bioplastic and Biofuel production.

CORE COURSE –XV Practical:

Paper Title: Animal Biotechnology (Practical)

Course Code: ZOO 815CP

Practical [Credit: 2] **30 hrs/ 50 marks**

1. DNA isolation from blood/ Animal tissue.
2. Restriction digestion of isolated DNA by restriction endonuclease.
3. Separation of DNA by Agarose gel electrophoresis.
4. To demonstrate following techniques: Southern/ Northern/Western blotting/ PCR (Any one)
5. Learning Aseptic handling techniques and use of PPE for animal cell culture.
6. Preparation of embryo extract for animal cell culture i.e Natural Media
7. Project on animal cell culture OR on a visit to any biotechnology Institute

Examination evaluation Structure:

1. Experiment (two numbers): 5x2; procedure: 5x2; result: 2x2. Total = 24 Marks
2. Demonstration of techniques : 5 Marks
3. Project report Submission on animal cell culture OR on a visit to any biotechnology Institute (5 marks)
4. Note Book: 6 marks (Based on the neatness, regularity, overall presentation)
5. Viva-Voce : 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

The students can have hands-on experience of basic biotechnology tools and can acquire jobs and internships in pharmaceutical companies directly after graduation and can also execute research in biotechnology. A problem-solving methodology can be employed in biotechnology education, which consists of four phases: design, production, evaluation and presentation. Various methods will be employed to make learning effective like tutorials, workshops, seminar, online assignments, questionnaires, simulation exercises and presentations. Evaluation

elements in these methods will also serve to direct student learning.

Assessment Methods:

Measures to be adopted for assessment are as follows.

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students.
- **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.
- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
- ***Viva-voce****: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- **Semester-end Examination**: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

Recommended Books:

- Brown, T.A. (2010) Gene Cloning and DNA Analysis. VI Edition,Wiley-Blackwell publishing (Oxford, UK), ISBN: 978-1-4051-8173-0.
- Glick, B.R., Pasternak, J.J. and Patten, C.L. (2010). Molecular Biotechnology - Principles and Applications of Recombinant DNA. IV Edition, ASM press, Washington, USA. ISBN: 978-1-55581-498-4 (HC).
- Primrose, S.B., and Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics.VIIEdition, Blackwell publishing (Oxford, UK) ISBN: 13: 978-1-4051-3544-3.

Suggested Readings:.

- Watson, J.D., Myers, R.M., Caudy, A. and Witkowski, J.K. (2007) Recombinant DNA-Genes and Genomes- A Short Course. III Edition, Freeman and Co., N.Y., USA.
- Clark, D. P. and Pazdernik, N.J. (2012) Biotechnology,,Academic Press, ISBN: 978-0-12-385063-8

Online Tools and Web Resources:

- https://swayam.gov.in/courses/5178-molecular-biology-genetic-engineering-and-plant- tissue-culture Module no.:14to 21,23&24
- https://nptel.ac.in/courses/102103041/2Gene Therapy
- https://nptel.ac.in/courses/102103013/49Genetic Engineering& Applications(Web)
- https://nptel.ac.in/courses/102107058/6Biomedical nanotechnology (Video)
- https://nptel.ac.in/courses/102107028/40Analytical Technologies in Biotechnology(Video) Electrophoresis, PCR, DNA sequencing methods
- https://www.edx.org/course?search_query=biotechnology
  https://www.coursera.org/courses?query=biotechnology

CORE COURSE –XVI:

Paper Title: Ethology & Chronobiology (Theory)

Course Code: ZOO816C

Objective:

This course aims to provide the undergraduate students a thorough knowledge of Animal Behaviour is the scientific study of the wild and wonderful ways in which animals interact with each other, with other living beings, and with the environment in which they live in. One important aspect pertaining to the studies on Animal Behaviour is that it can be conducted anywhere and at any time, depending on the interest of the researcher. Moreover, it is not confined to the four walls of the classroom or the laboratory. The behavioural biology has high applied value and currently linked to conservation biology, molecular biology, behavioural ecology and integrated pest management. The chronobiology addresses some periodic and cyclic nature of various life phenomena occurring in living beings in nature. They often correlate with the external environmental factors. Chronopharmacology, chronomedicine and chronotherapy are some of the direct applications of chronobiology in human health. This course aims to provide an overview of animal behaviour and chronobiology starting from historical prospective to types of behaviours and their evolutionary significance. The course also highlights types, mechanisms and importance of the biological rhythms and biological clocks operating in the living organisms. This course will help the learners to understand and appreciate different types of animal behaviours, their adaptive, evolutionary and practical significance.

Outcome:

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

- Understand types of animal behaviour and their importance to the organisms.
- Enhance their observation, analysis, interpretation and documentation skills by taking short projects pertaining to Animal behaviour and chronobiology.
- Relate animal behaviour with other subjects such as Animal biodiversity, Evolutionary biology, Ecology, Conservation biology and Genetic basis of the behaviour.
- Understand various process of chronobiology in their daily life such as jet lag.
- Learn about the biological rhythm and their application in pharmacology and modernmedicine.
- Realize, appreciate and develop passion to biodiversity; and will respect the nature and environment.

Course Content:
Theory [Credits: 4] 60 hrs/100 marks (Internal assessment=20, Attendance=5, End Semester Exam = 75)

Unit 1: Introduction to Animal Behaviour 12hrs/15 marks

History of Ethology; Pioneers of Modern Ethology: Karl *von* Frisch, Ivan Pavlov, Konrad Lorenz, Niko Tinbergen; Proximate and ultimate causes of behaviour; tools,techniques and methods used in studying animal behaviour (In Lab and Field).

Unit 2: Patterns of Behaviour 12hrs/15 marks

Stereotyped behaviours (Orientation, Reflexes); Kinesis, Tropotaxis, Klinotaxis, Menotaxis, Individual behavioural patterns; Instinct *versus* Learned behaviour; Associative learning, Classical and Operant conditioning, Habituation, Imprinting. Animal bonds (Parent-Parent, Parent-Child etc.).

Unit 3:Social and Sexual Behaviour 12hrs/15 marks

Social Behaviour: Concept of Society, Communication and the senses (Chemical, Tactile, Auditory, Visual); Altruism, Inclusive fitness, Hamilton's rule; Insects' society (Example: Honey bee/Termites); Foraging in honey bee and advantages of the waggle dance. Sexual Behaviour: Asymmetry of sex, Sexual dimorphism, Mate choice, Intra-sexual selection (male rivalry), Inter-sexual selection (female choice), Courtship behavior (Specially in Birds). Parental care.

Unit 4: Introduction to Chronobiology & Biological Clocks 12hrs/15 marks

Historical developments in chronobiology, Biological oscillation: the concept of Average, amplitude, phase and period. Adaptive significance of biological clocks. Relevance of biological clocks; Chronopharmacology, Chronomedicine, Chronotherapy

Unit 5: **Biological Rhythm** 12hrs/15 marks

Characteristics of biological rhythms; Short-and Long-term rhythms; Circadian rhythms; Tidal rhythms and Lunar rhythms; Concept of synchronization and masking; Photic and non- photic zeitgebers; Circannual rhythms; Photoperiod and regulation of seasonal reproductionof vertebrates; Role of melatonin and serotonin.

Core Course XVI Practical

Ethology & Chronobiology (Practical)

Course Code: ZOO816CP

Practical [Credit: 2] **30 hrs/50 marks**

1. To study nests and nesting behaviour of the birds and social insects.
2. To study the behavioural responses of wood lice to dry and humid conditions.
3. To study geotaxis behaviour in earthworm/ phototaxis behaviour in insect larvae.
4. Study of courtship behaviour in birds from short videos/films.
5. Parental Care in Fishes from short Videos/ Models/ observation.
6. Visit to Forest/Wild life Sanctuary/Biodiversity Park/Zoological Park to study and record behavioral activities of animals and prepare a short report.
7. Study and actogram construction of locomotor activity of suitable animal models.
8. To study circadian functions in humans (daily eating, sleep and temperature patterns).

Examination evaluation structure:

1. Procedure and result of any two Studies made (to be given during exam) out of sl. No. 1 to 7 (Procedure = 5, Result=5)x2 = 20 marks

2. Report submitted on the Visit to Forest/Wild life Sanctuary/Biodiversity Park/Zoological Park to study and record the behavioural activities of animals 10 marks

3. Submission of a Geotagged Photo and description of the Bird nest/ Insect colony in his/ her locality. 5 marks

4. Note Book: (Based on the neatness, regularity, overall presentation) 5 marks

5. Viva-Voce: (Testing of Knowledge in the said Course) 10 marks

Recommended Books:

- Alcock J. (2013). Animal Behaviour. Sinauer Associate Inc., USA.
- Dunlap J. C, Loros J. J, DeCoursey P. J. (2004) Chronobiology Biological Timekeeping. Sinauer Associates, Inc. Publishers, Sunderland, MA, USA
- Manning, A. and Dawkins, M. S. (2012). An Introduction to Animal Behaviour. Cambridge, University Press, UK.
- McFarland D. Animal Behaviour. (1982). Pitman Publishing Limited, London, UK.
- Vinod Kumar (2002) Biological Rhythms. Narosa Publishing House, Delhi/ Springer-Verlag, Germany

Suggested Readings:

- Paul W. Sherman and Alcock J. (2013). Exploring Animal Behaviour. Sinauer AssociateInc., Massachusetts, USA.
- Saunders D. S. (2002). Insect Clocks. III Edition, Barens and Noble Inc. New York,USA

Teaching and Learning Process:

In order to ensure best understanding of concepts and learning of skills by students, various strategies will be adopted to explore Animal behaviour and chronobiology. The animal behaviour in the wild can be shown to the student with the help of videos and short films. The classroom teaching should be inclusive, have opportunities for the students to participate in the class discussion and the students should be encouraged to observe various live animal behaviours in their immediate surrounding environment and interpret them. There should be ample scope for field visits and visit to the research laboratories. Seminar should be arranged at the departmental level for the student, where student can have paper presentation on various themes of animal behaviour and chronobiology. Quizzes and debates can be arranged to make the teaching learning more innovative. Students should be advised to use e resources along with standard text books and reference books. They should take short project work and case study on the animal behaviour. They should relate various concepts in chronobiology taught in the classroom with their daily life.

Assessment Methods:

Measures to be adopted for assessment are as follows.

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students.
- **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.
- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
- ***Viva-voce****: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- **Semester-end Examination**: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

Core Course XVII:

Paper Title: **Research Methodology in Zoology (Theory)**

Course Code: ZOO817C

Objective:

The course is designed with an aim to provide the students the knowledge to learn and get acquainted with the different techniques and methodologies adopted in Research in the field of Zoology. It aims to equip students with skills to formulate research questions, conduct literature reviews, design experiments, and communicate findings through scientific writing and presentations. Emphasis is placed on developing proficiency in preparing theses, research papers, and scientific posters or PowerPoint presentations. The course also fosters an understanding of the philosophy and ethics of science, highlighting responsible conduct in research and addressing misconduct such as plagiarism, falsification, and authorship disputes. Additionally, students will be introduced to modern research tools and publishing practices, including open access platforms, journal selection tools, and software for identifying predatory journals. Training includes the use of citation databases (e.g., Scopus, Web of Science), understanding metrics like impact factor and h-index, and using plagiarism detection and AI tools responsibly. The course also covers essential biosafety practices in laboratory settings, focusing on safe handling of chemicals and equipment, first-aid measures, and adherence to safety protocols to ensure a secure and ethical research environment.

Outcome:

- Upon completion of the course, students shall be able to get a thorough knowledge on the philosophies and ethics of research and publication. They will be able to understand the different criteria of calculating Impact factors, metrices and indices, Prepare scientific reporting and make a presentation, Have knowledge about the Principles and application of Biological techniques, Operate Sophisticated instruments and take precautions in the Laboratory including Biosafety labs.
- Formulate research questions and hypotheses based on literature review.
- Design experiments and choose appropriate research methodologies.
- Prepare scientific documents such as theses, research papers, and posters.
- Deliver effective scientific presentations using tools like MS PowerPoint.
- Understand key concepts in the philosophy and ethics of science.
- Identify and avoid research misconduct, including plagiarism and data fabrication.
- Recognize and steer clear of predatory journals and unethical publishing practices.
- Use journal selection tools (e.g., JANE, Elsevier Journal Finder) for ethical publishing.
- Evaluate research impact using metrics like impact factor, h-index, and altmetrics.
- Navigate citation databases such as Scopus and Web of Science.

- Utilize plagiarism detection tools like Turnitin and Urkund.
- Apply AI tools ethically in various stages of research, from writing to data analysis.
- Follow standard biosafety and laboratory safety protocols.
- Handle laboratory instruments and hazardous materials responsibly.

Course Content:
Theory [Credits: 4] 60 hrs/ 100 marks (Internal assessment=20, Attendance=5; End Semester exam: 75)

Unit 1: Scientific research, reporting & Presentation: 12hrs/15 marks

Concept of Scientific research, Choice of research topic, review of literature, hypothesis, Materials and methods, discussion and writing of references. Scientific reporting: Writing of thesis /research paper. Scientific presentation: Poster /MS-Powerpoint.

Unit 2: Ethics in Research & Publication : 12hrs/15 marks

Definition of Ethics, Ethics with respect to Science & research, research integrity; Scientific misconduct- Falsification, Fabrication and Plagiarism. Examples of Fraud in Research & publication from India & abroad. Redundant publications - duplicate & overlapping publications, salami slicing, selective reporting and misrepresentation of data; Definition and importance of Publication ethics; Publication misconduct Conflict of interest during research and publication; authorship, Predatory Journals; Phantom publications; violation of publication ethics, authorship and contributorship; complaints and appeals.

Unit3: Open Access Publishing; Research metrics : 12hrs/15 marks

Open access publishing and initiatives; SHERPA/ RoMEO online resource to check publisher copyright & self archiving policies. Journal finder/ Journal suggestion tools viz. JANE, Elsevier, Springer etc. Indexing data bases, citation databases; Web of Science, Scopus etc; Impact factor of Journal as per Journal citation report, SNIP, SJR, IPP, Cite score, Metrics: h-index, g-index, i10 index, altmetrics.

Unit 4: Software tools and Applications 12hrs/15 marks

Use of Plagiarism software like Drillbit, Turnitin, Urkund and other open source software tools. Ethical use of AI as research tools: Literature Review & Information Retrieval, Data Analysis and Interpretation, Experimental Design & Hypothesis Generation, Automated Writing and Reporting, Data Visualization, Plagiarism and Reference Management, Simulation & Modelling, Translation & Accessibility.

Unit 5: **Bio-safety issues in the Laboratory:** 12hrs/15 marks

Guidelines for precaution and Biosafety issue in the handling of sophisticated

instruments, Lab items, Toxic chemicals, Glasswares. First aids. Personal protective equipments, safe handling of infectious agents. Safe disposal of biological laboratory wastes: Autoclaving, incineration, chemical disinfection and dry heat sterilization, encapsulation, microwave/ UV treatment.

Core Course XVII Practical

Paper Title: **Research Methodology in Zoology (Practical)**

Course Code: ZOO817CP

Practical [Credit : 2] **30 hrs/50 marks**

1. Preparation of Scientific data using MS- Excel/Powerpoint/ Poster.
2. Demonstration of Journal finder tools (JANE, Elsevier, Springer).
3. Demonstration and practical use of Plagiarism softwares (Drillbit, Turnitin, Urkund).
4. Use of AI in Research. (Scientific reporting, data mining, modelling).
5. Demonstration of human biosafety cabinet

Examination evaluation Structure:

1.	Preparation of Scientific data using MS- Excel/Powerpoint/Poster.	10 marks
2.	Major practical (Serial no. 2 and 3)	15 marks
3.	Minor practical (Serial no. 4 and 5)	10 marks
4.	Note Book: (Based on the neatness, inclusiveness, overall presentation)	5 marks
5.	Viva-Voce: (Testing of Knowledge in the said Course)	10 marks

Recommended Books:

1. Ajibade, V & Ajenifuja,O. (2019). Instrumentation in biology. Lambert Aca. Publishing
2. Arumugam, N. (1994) Bioinstrumentation. Saras publication
3. Baruah,T.C. & Barthakur, H.P. (1997). A textbook of Soil analysis. Vikas Pub. House Pvt. Ltd, Delhi
4. Bajwa, D.R. & Ahuja, Sh. (2023) Research Methodology Theory and Practice, Nation Press, 1st Edition
5. Kothari,C.R. & Garg, G. (2024). Research Methodology-methods and techniques. New Age International Publishers
6. Rao,K.H. & Pasumarti , S.S. (2012) Research Methodology: Techniques and Applications
7. Salerno, R.M. & Gaudiosa,J. (2015). Laboratory Biorisk management. CRC Press
8. Salerno, R.M. & Gaudiosa,J. (2007). Laboratory biosecurity handbook. CRC Press
9. Sarma, M. (2012). Research Methodology – assignment, Seminar paper & Project. EBH publishers, Ghy
10. Thomas, C. G. (2021) Research Methodology and Scientific Writing, Ane Books Pvt. Ltd. 2nd Edition
11. Zou, P. and Xu, X. (2023) Research Methodology and Strategy- Theory and Practice, John Wiley & Sons Ltd.

https://www.UGC.gov.in; https://gemini.google.com ; ChatGPT, Scite.ai, Jenni.ai, Elicit, Research Rabbit, Google Scholar, Scinapse, Semantic Scholar, Scorpus, Connected papers, Dimensions, Litmaps

Teaching and Learning Process:

- The teaching strategy will emphasize on problem-based learning to develop the requisite knowledge, skills and learning attitude of the student.
- A variety of approaches to teaching-learning process, including lectures, seminars, power point presentations, workshops, peer teaching/learning, assignments, project-

based learning, simulation videos, group or co-operative learning, book reviews, research colloquium willbe adopted to achieve this.

- Laboratory sessions will constitute an important part of the course along with its theoretical background. The laboratory sessions will include pre-lab questions and post-lab questions on start and completion of experiment. The experiments will be presented in the form of laboratory reports, which will train the students to write and formulate scientific text.

Assessment Methods:

Measures to be adopted for assessment are as follows.

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students.
- **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.
- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
- ***Viva-voce****: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- **Semester-end Examination**: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

DISCIPLINE SPECIFIC ELECTIVE - III
(Zoology in Sustainable Development)
Subject Code: ZOO803D

Objective:

The course aims to provide an in-depth understanding of the role of zoology in promoting sustainable development through the conservation and responsible management of biodiversity, natural resources, and ecosystems. It seeks to equip students with knowledge of sustainable practices in wildlife conservation, aquaculture, livestock management, and biocontrol, while addressing challenges posed by climate change, pollution, and habitat degradation. The course also emphasizes the interconnections between zoology, public health, ethics, traditional knowledge, and policy, aligning with relevant Sustainable Development Goals (SDGs) to foster ecological balance, human well-being, and long-term environmental resilience.

Outcome:

- Explain the principles of sustainable development and their linkages with zoology, biodiversity, ecosystem health, and human well-being.
- Apply in-situ and ex-situ conservation methods, resource management strategies, and traditional ecological knowledge for wildlife protection.
- Design and evaluate sustainable aquaculture, livestock, and biocontrol practices with emphasis on indigenous species and waste-to-wealth concepts.
- Assess the impacts of climate change, habitat degradation, and pollution on species distribution, vulnerability, and ecosystem resilience.
- Integrate the One Health approach, ethical research practices, and policy engagement to support SDGs and promote environmental awareness.

Course Content:

Theory [Credits: 4] **60 hrs /100 marks**

(Internal assessment=20, Attendance=5, End Semester Exam = 75 marks)

Unit 1: Introduction to Zoology and Sustainable Development **12 hrs/ 15 marks**

Concept and principles of sustainable development; Linkages between zoology, biodiversity, ecosystem health and food production system and nutrition; Relevance to SDGs (especially SDG 13, 14, 15); Role of animals in ecological balance and human well-being.

Unit 2: Wildlife Conservation and Natural Resource Management 12 hrs/ 15 marks

In-situ and ex-situ conservation methods; protected area networks and species recovery programs in the context of climate change; Human-wildlife conflict and mitigation; Community and indigenous traditional knowledge (ITK) based conservation.

Unit 3: Sustainable Aquaculture, Livestock, and Biocontrol 12 hrs/ 15 marks

Sustainable aquaculture practices; Conservation of indigenous breeds in fish and livestock farming; Principles of sustainable livestock management; waste to wealth; Role of insects in bio-control and pest management.

Unit 4: Climate Change and Species Vulnerability. 12 hrs/ 15 marks

Impact of climate change on species distribution and survival; Threats to faunal diversity: Habitat loss, degradation, fragmentation and environmental pollution; Monitoring and assessing species vulnerability and ecosystem resilience.

Unit 5: Zoology in Public Health, Ethics, and Policy 12 hrs/ 15 marks

Zoonotic diseases; One Health Approach; Ethical considerations in wildlife research and conservation; Role of zoologists in policy, education, and environmental awareness; Integration of science, society, and sustainability in development planning.

DISCIPLINE SPECIFIC ELECTIVE – III Practical
(Zoology in Sustainable Development)
Subject Code: ZOO803DP

Practical [Credit: 2] **30 hrs/50 marks**

1. Preparation of a species recovery/conservation action plan using local data.
2. Water/soil quality assessment in relation to faunal diversity and ecosystem health.
3. Insect Identification for Biocontrol (ladybugs, wasps, dragonflies).
4. Documentation of sustainable aquaculture/livestock farms.
5. Documentation of edible insects from the selected habitats
6. Field visit to a protected area, zoo to study *in-situ/ex-situ* conservation.
7. Survey on community awareness of zoonotic diseases and the One Health Approach.

Examination evaluation Structure:

1. Water/Soil quality analysis: Procedure & Result – 10 marks
2. Identification of biocontrol agents and edible insects. (3x3=9 marks)
3. Visit to a protected area, zoo to study in-situ/ex-situ conservation-5marks (Report)
4. Identification of common Zoonotic diseases. (3x3=9 marks)
5. Note Book: 7 marks (Based on the neatness, regularity, overall presentation)
6. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

The course will combine lectures, interactive discussions, case studies, and field-based activities to provide students with both theoretical knowledge and practical exposure. It will begin by introducing the principles of sustainable development and their connections to zoology, biodiversity, ecosystem health, and food systems, with a focus on global goals such as climate action, life below water, and life on land. These themes will be explored through multimedia presentations, group discussions, and real-world examples. Students will also engage in field visits to protected areas to understand conservation practices, analyse in-situ and ex-situ methods, and participate in role-play activities to address human–wildlife conflict. Sustainable aquaculture, livestock, and biocontrol practices will be taught through demonstrations, hands-on practicals, and identification exercises, with emphasis on indigenous biodiversity and environmentally responsible methods. The course will also address the impacts of climate change, pollution, and habitat degradation on species distribution and survival. Students will learn to analyse data, map species occurrences, and assess ecological resilience. Public health, ethics, and policy will be integrated through the

One Health approach, ethical debates in wildlife research, and guidance on drafting policy briefs for sustainability. Throughout, the course will adopt a blended learning style that integrates experiential activities, problem-solving, and community engagement, aiming to develop critical thinking, applied skills, and a holistic understanding of zoology's role in promoting sustainable development.

Assessment Methods:

Measures to be adopted for assessment are as follows:

- Class Tests: Regular class tests will judge the grasp of the topics by the students.
- Projects and Assignments: Individual/ group projects will inculcate independent thinking as well as teamwork skills among the students.
- Regular Presentation: Presentations by the students on a particular topic will enhance students' learning and confidence. The presentations will be assessed based on the content, novelty, explanation, and response to queries raised by peers.
- Viva voce: Viva voce is another critical component of the assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- Semester-end Examination: Semester-end examination and grading of students based on their performance in the examinations is an indicator of students' learning throughout the semester. A comparative assessment of students through final examinations analyses the comprehensive knowledge gained by each student.

Recommended Books:

1. Hickman, C. P., Jr., Roberts, L. S., Larson, A., Eisenhour, D. J., & I'Anson, H. (2019). *Integrated principles of zoology* (18th ed.). McGraw-Hill Education.
2. Rogers, P. P., Jalal, K. F., & Boyd, J. A. (2008). *An introduction to sustainable development* (1st ed.). Routledge.
3. Sharma, H., & Sobti, T. (2018). *An Introduction to Sustainable Development Goals*. Independently Published.
4. Mathur, R. (2018). *Wildlife conservation and management*. Rastogi Publications; 1st Ed, 472 pp.
5. Tucker, C. S., & Hargreaves, J. A. (Eds.) (2008). *Environmental Best Management Practices for Aquaculture* (1st ed.). Wiley (in cooperation with the United States Aquaculture Society).
6. Wallace-Wells, D. (2019). *The Uninhabitable Earth: Life After Warming*. Tim Duggan Books.
7. Kolbert, E. (2014). *The Sixth Extinction: An Unnatural History*. Henry Holt and Company

8. Mann, M. E. (2021). *The New Climate War: The Fight to Take Back Our Planet*. PublicAffairs.
9. Rabinowitz, P. M., & Conti, L. A. (2010). Human-animal medicine: Clinical approaches to zoonoses, toxicants, and other shared health risks. Saunders Elsevier.
10. Sing, A. (Ed.). (2015). Zoonoses - Infections Affecting Humans and Animals: Focus on Public Health Aspects. Springer Dordrecht. (Note: There is also a second edition from 2023)
11. Bardosh, K. (Ed.). (2016). One health: Science, politics and zoonotic disease in Africa. Routledge.
12. National Centre for Disease Control (NCDC). (2016). Manual on zoonotic diseases of public health importance. NCDC, Directorate General of Health Services, Ministry of Health and Family Welfare, Government of India

MANIPUR UNIVERSITY
UG COURSE IN ZOOLOGY
Course Structure (REVISED)

(as per revised Ordinance for Undergraduate Programmes in Science, Arts and Commerce 2025)

1.1. Credit distribution for the course

VIII	Core Course-XVIII	**ZOO818C**	Biostatistics & Advanced Bioinformatics	4
	Core Course-XVIII Practical	**ZOO818CP**	,,	**2**
	Core Course-XIX	**ZOO819C**	Biological techniques & Bioinstrumentation	4
	Core Course-XIX Practical	**ZOO819CP**	,,	2
	Core Course-XX	**ZOO820C**	Ethnozoology	4
	Core Course-XX Practical	**ZOO820CP**	,,	2
	Discipline Specific Elective (DSE) Course-IV	**ZOO820D**	Advances in Zoology	4
	Discipline Specific Elective (DSE) Course-IV	**ZOO820DP**	,,	2
Discipline Specific Elective- IV is to be opted by those pursuing Bachelor's degree with Honours. Others who pursue BSc Honours with Research should complete the Dissertation/ Project (part II) on the area done in semester VII carrying 6 Credits in lieu of the Discipline Specific Elective. In such cases the student needs to make a PowerPoint presentation of the study in front of a committee. Credits may be distributed as follows: Study-4 Credits, Report compilation -1 Credit and PowerPoint Presentation-1 Credit. However, those pursuing Honours with Research shall have to score CGPA above 7.5 in all Semesters upto Semester VI.				
Award of Bachelor's Degree with Honours in Zoology / BSc Honours with Research in Zoology on completion of Courses equal to a minimum of 48 credits from the fourth year with a cumulative total of 188 Credits.				

CORE COURSE -XVIII:

Paper Title: Biostatistics & Advanced Bioinformatics (Theory)

Course Code: ZOO 818C

Objectives:

- Fundamental Data Analysis: To provide a strong foundation in descriptive statistics, data visualization, and measures of central tendency specific to biological data.
- Probabilistic & Inferential Logic: To introduce probability distributions (Normal, Binomial, Poisson) and the logic of hypothesis testing using parametric and non-parametric tests.
- Experimental Modeling: To teach the principles of experimental design (CRD, RBD) and the mathematical relationship between biological variables through ANOVA, correlation, and regression.
- Genomic & Proteomic Inquiry: To explore biological databases and computational methods for sequence alignment, phylogenetic reconstruction.

Outcomes:

- Upon successful completion of this course, students will be able to:
- Summarize Biological Data: Apply appropriate statistical measures (Mean, SD, Kurtosis) and graphical tools to describe complex biological datasets.
- Conduct Hypothesis Testing: Execute and interpret t-tests, Chi-square tests, and ANOVA to validate experimental results and biological observations.
- Retrieve Genomic Information: Navigate major biological databases (NCBI, GenBank, PDB) to mine nucleic acid and protein sequences.
- Perform Sequence & Structural Analysis: Use tools like BLAST, FASTA, and ClustalW for alignments.
- Model Molecular Interactions: Construct phylogenetic trees to determine evolutionary relationships.

Course Content:

Theory [Credits: 4] 60 hrs

Unit 1: Introduction to Biostatistics 12 hrs

Introduction, History, Scope, application of biostatistics in Bio-Sciences, Variables, attributes, Population and Sample, Types of data, Classification, Summarization, Diagrammatic and graphic presentation of data; measurement of central tendency - Mean, Median Mode, Coefficient of variation, Skewness and Kurtosis.

Unit 2: Probability, Variables, Distribution, Sampling, Standard error and Statistical tests 12 hrs

Introduction to probability and application of probability laws in Biology; Random variable & Probability distribution, Normal, Binomial and Poisson distribution, their application in Biology; Sampling methods in Biology, Sampling distribution, measure of dispersion, Standard deviation, Standard error, testing of Hypothesis, chi-square rest, t-

test and F-test.

Unit 3: Experimental designs, analysis of variance (ANOVA), Correlation and regression analysis **12 hrs**

Basic principles of experimental design, completely randomized design, randomized block design; analysis of variance – one and two way ANOVA, Pearson correlation and regression analysis.

Unit 4: Advanced Bioinformatics I **12 hrs**

Biological databases – NCBI, GenBank, EMBL, DDBJ, Swiss-Prot; computational methods – Nucleic acid and protein sequence databases, data mining methods for sequence analysis and web-based tools for sequence searches; Sequence alignment concept: pairwise alignment, BLAST, FASTA.

Unit 5: Advanced Bioinformatics II **12 hrs**

Protein Structural databases- PDB; Protein classification systems - SCOP, CATH; Protein Visualization Tools: RASMOL, Swiss-PDB Viewer; Molecular Phylogeny: Molecular phylogeny vs. Species Phylogeny; tree construction methods, software tools.

CORE COURSE –XVIII Practical:

Paper Title: Biostatistics & Advanced Bioinformatics (Practical)

Course Code: ZOO 815CP

Practical [Credits: 2] **30 hrs**

A. Biostatistics:

i. Construction of frequency distribution tables, diagrammatic and graphic representation of data
ii. Computation of various measures of Central tendency and measures of dispersion with examples
iii. Practical use of Random numbers and randomization technique for assignment of treatments in experimental designs (CRD & RBD)
iv. Practical application of Probability laws and goodness of fit test for binominal and Poisson probability distributions.
v. Computation and tests of significance for correlation & regression coefficients.
vi. Tests of hypothesis for small samples and two population variances, Computation of one way and two way ANOVA, Microsoft excel**.**

B. Bioinformatics:

i. Retrieval and analysis of Biological data from NCBI, GenBank, EMBL, DDBJ
ii. Phylogenetic Tree construction from multiple sequences using MEGA Software and Interpretation.
iii. Demonstration of BLAST, FASTA

Examination evaluation Structure:

1. Biostatistics : 3 experiments from among the VI provided in Syllabus
2. Bioinformatics: Tree Construction, Data analysis

(Presentation, procedure, result/ comment)

3. Note Book
4. Viva-Voce

Recommended Books:

- Whitlock, M. & Schluter, D (2004) The analysis of Biological data. 2nd edition, Macmillan
- Zar, J. H. (2009) Biostatistical analysis,5th edition, Pearson
- Rosner, B. (2015) Fundamentals of Biostatistics, 8th edition, Brooks Cole
- Richard C. Sprinthall (2011) Basic Statistical analysis.9th edition, Pearson
- Sundaralingam, R., Arumugam, N., Kumaresan,V., Gopi, A & Meena,A. (2015) Biostatistics, Computer application and Bioinformatics. Saras Publication
- Raman, K. (2023) An introduction to Computational systems Biology systems- Level modelling of Cellular works. Chapman & Hall

Suggested Readings:

- Gupta, S. C. (1992) Fundamentals of Statistics. Himalaya Publishing house
- Das, N. G. (2022) Statistical methods, MC Graw Hill
- Jagiraju, D.V. L. N, Srikala, C. & Rajkumar, L.P. (2022) Descriptive Statistics and Probability. Kalyani Publishers
- Bairam,R. (2021) A textbook of Biostatistics and Research methodology. SIA Publishers and distributors Pvt. Ltd.

Online Tools and Web Resources:

- https://whitlockschluter.zoology.ubc.ca
- http://assets.vmou.ac.in
- https://brainly.in
- https://apps.dtic.mil>sti>pdf

Teaching and Learning Process:

Information and concepts about Statistics and Computer will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject and through observations through experimental models. Blended learning using chalk-n-talk method and e-learning using presentations, animations, simple animal model systems, etc. would be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, group discussions and round tables on the various aspects of biostatistics and computer modelling would be created to ensure effective learning and understanding of the concepts. Curriculum-related assignments would improve the reading, writing and abstracting skills and enhance the critical thinking of the students. After completion of each unit there should be a doubt clearing session/class in order to test whether the teaching imparted had been followed by the students. Power point presentation

on any topic of the Unit (both theory and practical syllabi) are suggested for all the Students.

Assessment Methods:

Measures to be adopted for assessment are as follows.

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students.
- **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.
- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
- ***Viva-voce****: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- **Semester-end Examination**: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

CORE COURSE –XIX:

Paper Title: Biological Techniques & Bioinstrumentation (Theory)

Course Code: ZOO819C

Objectives:

- Master Imaging Principles: To understand the fundamental physics of light and electron microscopy, including resolution limits and specialized imaging modes.
- Analyze Molecular Tools: To gain theoretical and practical knowledge of protein separation, primer design, and immunological techniques used in biotechnology.
- Study Separation Sciences: To explore the principles of chromatography and electrophoresis for the purification and identification of biological molecules.
- Understand Spectroscopy: To internalize the laws of light absorption and the instrumentation of spectrophotometers used for quantitative and structural analysis.
- Explore Diagnostic Tracers: To learn the application of radioisotopes and immunoassay techniques (ELISA, RIA) in medical diagnostics and research.

Outcomes:

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

- Operate Microscopes: Demonstrate proficiency in various microscopy techniques and perform accurate micrometer calibrations for specimen measurement.
- Execute Molecular Protocols: Design primers for PCR and perform protein analysis using SDS-PAGE and Isoelectric focusing.
- Perform Chemical Separations: Select and apply appropriate chromatographic methods (HPLC, GC-MS, HPTLC) to isolate biological compounds.

- Quantify Biological Samples: Utilize UV-Visible and Atomic Absorption spectrophotometry to determine concentrations based on Beer-Lambert's Law.
- Conduct Immunological Assays: Implement diagnostic tools like ELISA and Radioimmunoassay to detect pathogens or quantify physiological markers.
- Handle Radioisotopes Safely: Apply the principles of tracer techniques and autoradiography while adhering to safety standards for measuring radioactivity.

Course Content:
Theory [Credits: 4] 60 hrs

Unit 1: Microscopy **12hrs**

Basic principles and types of Microscopes, Bright field, Dark field, Phase contrast, Fluorescence, Transmission and Scanning electron microscopy, Numerical aperture & limits of resolution. Calibration of Micrometer.

Unit 2: Tools for Molecular biology & Biotechnology **12hrs**

Electrophoresis, types of electrophoresis, Agarose, PAGE: Native and SDS PAGE, Isoelectric focusing, Immunoelectrophoresis, Primer designing.

Unit 3: Chromatography **12hrs**

Paper and thin layer Chromatography; Coloumn Chromatography, HPTLC, GCMS and HPLC

Unit 4: Spectrophotometry and Flow Cytometry **12hrs**

Beer-Lambert's Law, basic ideas on the working principles and instrumentation of UV-visible Spectrophotometer, Flame Photometer, Flow Cytometry.

Unit 5: **Radio-Tracer & Some other diagnostic techniques** **12hrs**

Measurement of radioactivity; Basic ideas of Tracer techniques, Autoradiography, Radioimmunoassay; Introductory ideas of Enzyme – linked Immunosorbent assay (ELISA) and Indirect Haemagglutination Assay (IHA).

CORE COURSE –XIX:

Paper Title: Biological Techniques & Bioinstrumentation (Practical)

Course Code: ZOO819CP

Practical [Credits: 2] **30 hrs**

1. Identification of the parts of a Compound Microscope.
2. Principle & Calculation of numerical aperture of different lens.
3. Calibration of Microscope
4. Verification of Beer-Lambert's Law using UV-Vis Spectrophotometer.
5. Demonstration of Agarose gel electrophoresis
   (Principle and procedure)
6. Demonstration of SDS PAGE
7. Demonstration of Primer designing
8. Demonstration of ELISA
9. Separation of Amino Acids/chlorophyll pigment using Paper Chromatography.

(Principle & procedure, Display, Observation & calculation)

10. Visit and exposure to Bioengineering facility
11. Note Book.
12. Viva-Voce.

Recommended Books:

1. Attwood, T. K & Parry Smith, D. J. (2006) Introduction to Bioinstrumentation. Pearson Education Ltd.
2. Bajpai, P. K. (2006) Biological instrumentation and methodology. S. Chand Pub.
3. Chetan, D. M. & Bommegowda, K. P. (2023) Bio-medical Instruments and its applications. IP Innovative Pub.Pvt.Ltd.
4. Veerakumari, L. (2011) Bioinstrumentation. MJP publishers.

Online Tools and Web Resources:

- https://whitlockschluter.zoology.ubc.ca
- http://assets.vmou.ac.in
- https://brainly.in
- https://apps.dtic.mil>sti>pdf

Teaching and Learning Process:

Information and concepts about various techniques and instruments in Biology will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject and through observations through experimental models. Blended learning using chalk-n-talk method and e-learning using presentations, animations, simple animal model systems, etc. would be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, group discussions and round tables on the various aspects of biological techniques and instruments would be created to ensure effective learning and understanding of the concepts. Curriculum-related assignments would improve the reading, writing and abstracting skills and enhance the critical thinking of the students. After completion of each unit there should be a doubt clearing session/class in order to test whether the teaching imparted had been followed by the students. Power point presentation on any topic of the Unit (both theory and practical syllabi) are suggested for all the Students.

Assessment Methods:

Measures to be adopted for assessment are as follows.

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students.
- **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.
- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
- ***Viva-voce****: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- **Semester-end Examination**: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning

throughout the semester. A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

Core Course XX:

Paper Title: **Ethnozoology (Theory)**

Course Code: ZOO820 C

Objectives:

- To understand the scope, significance, and role of Ethnozoology in studying human–animal relationships and biodiversity conservation.
- To examine the cultural, religious, and symbolic roles of animals in indigenous knowledge systems, traditions, and belief systems.
- To understand the use of animals and animal products in traditional medicinal practices and their scientific and ethical implications.
- To explore the traditional ethnozoological knowledge, hunting, fishing practices, and community-based conservation among tribes of Northeast India.
- To understand the economic importance of animals in traditional livelihoods and the need for their sustainable use and biocultural conservation

Outcomes:

Upon completion of the course, students shall be able to

- Understand and explain the fundamental concepts of ethnozoology and the relationships between human societies and animal biodiversity.
- Analyze the cultural and traditional significance of animals in indigenous knowledge systems, religion, mythology, and social practices.
- Evaluate the role of animals in traditional medicine (zootherapy) and assess their scientific relevance, ethical concerns, and conservation implications.
- Examine ethnozoological practices in Northeast India, including traditional fishing, hunting, and community-based conservation approaches.
- Recognize the economic and ecological importance of animals in traditional livelihoods and appreciate the need for sustainable use and biocultural conservation.

Course Content:

Theory [Credits: 4] 60 hrs

Unit 1: Introduction to ethnozoology **12hrs**

Definition, meaning and scope of Ethnozoology, historical development of Ethnozoology, relationship between humans and animals, branches of Ethnozoology, Importance of Ethnozoology in modern science, role in biodiversity conservation.

Unit 2: Animals in Traditional Knowledge, Religion and Mythology: **12hrs**

Introduction to Indigenous knowledge systems (IKS), Indigenous classification systems (folk taxonomy), role of animals in tribal and rural life, sacred and totemic animals, cultural significance of animals in India, animal symbolism in festivals and rituals, mythical creatures in cultural belief systems, Animals in art, folklore, and storytelling, Clan and tribal

emblems, Animals in proverbs and idioms.

Unit3: Zootherapy (Animals in traditional medicine) 12hrs

Concept of zootherapy, animal-based medicines in Ayurveda and folk practices, use of insects, fishes, reptiles, birds and mammals in traditional healing, scientific validation of traditional medicines, ethical issues in zootherapy.

Unit 4: Ethnozoological Practices in Northeast India 12hrs

Traditional hunting practices in North east India, comparative ethnozoology among different tribes in NE India, Traditional fishing calendars and techniques, traditional conservation practices and taboos, community-based conservation, endangered species and traditional beliefs.

Unit 5: Animals in Economic Roles and sustainable use 12hrs

Animals in trade and barter systems, silk, wool, and leather production, draught animals in agriculture. Bio-preservation techniques: fish, soyabean, bamboos shoots. Climate change and its effect on ethnozoological practices, impact of modernization on traditional knowledge, biocultural conservation.

Core Course XX Practical

Paper Title: **Ethnozoology (Practical)**

Course Code: ZOO820CP

Practical [Credits: 2] 30 hrs

1. Identification of commonly used ethnozoological animals (insects, fishes, birds, mammals).
2. Observation and identification of animal-derived materials such as shells, horns, bones, silk, wool, honey, lac, etc.
3. Identification and description of indigenous fishing gears, traps, nets and hunting implements used by local communities.
4. Documentation of tribal knowledge related to wildlife use, conservation and taboos.
5. Collection and documentation of information/data on animal based medicines from local communities.
6. Collection and interpretation of proverbs, idioms, and folklore related to animals.
7. Study of traditional beliefs or community rules that protect certain animal species.
8. Preparation of charts/models showing animal products used in traditional healing.
9. Ethnozoological survey and preparation of field report based on interviews, questionnaires with local communities regarding human-animal interactions, traditional medicines and healers.

Examination evaluation Structure:

1. Identification of commonly used ethnozoological animals, (Identification, comments part

2. Identification of indigenous fishing gears, traps, nets and hunting implements used by local communities
3. Submission of ethnozoological models for traditional conservation practices/animal products used in traditional healing/ fishing and hunting gears.
4. Field report of ethnozoological survey
5. Note Book
6. Viva-Voce

Recommended Books:

1. Alves, R. R. N., & Albuquerque, U. P. (Eds.). (2017). Ethnozoology: Animals in our lives. Academic Press.
2. Albuquerque, U. P., de Medeiros, P. M., & Casas, A. (Eds.). (2017). Methods and techniques in ethnobiology and ethnoecology. Springer.
3. Anderson, E. N., Pearsall, D. M., Hunn, E. S., & Turner, N. J. (Eds.). (2011). Ethnobiology. Wiley-Blackwell.
4. Hosey, G., & Melfi, V. (Eds.). (2019). Anthrozoology: Human-animal interactions in domesticated and wild animals. Oxford University Press.
5. Pattazhy, S. (2011). An introduction to ethnozoology: A case analysis. LAP Lambert Academic Publishing.
6. Stepp, J. R., Wyndham, F. S., & Zarger, R. K. (Eds.). (2002). Ethnobiology and biocultural diversity: Proceedings of the Seventh International Congress of Ethnobiology. University of Georgia Press.

Teaching and Learning Process:

Information and concepts about Ethnozoology will be imparted through classroom lectures to inculcate a conceptual base among the students about the subject and through observations through experimental models. Blended learning using chalk-n-talk method and e-learning using presentations, animations, simple animal model systems, etc. would be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, group discussions and round tables on the various ethnozoological aspects would be created to ensure effective learning and understanding of the concepts. Curriculum-related assignments would improve the reading, writing and abstracting skills and enhance the critical thinking of the students. After completion of each unit there should be a doubt clearing session/class in order to test whether the teaching imparted had been followed by the students. Power point presentation on any topic of the Unit (both theory and practical syllabi) are suggested for all the Students.

Assessment Methods:

Measures to be adopted for assessment are as follows.

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students.
- **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.
- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed

based on the content, novelty, explanation and response to queries raised by peers.

- ***Viva-voce****: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- **Semester-end Examination**: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

DISCIPLINE SPECIFIC ELECTIVE (DSE) - IIV

(Advances in Zoology)

Subject Code: ZOO804D

Objectives:

- To develop an understanding of modern molecular approaches in zoology, including genome organization, omics technologies, epigenetics, and their applications in studying animal biology and genetic disorders.
- To explain the principles of evolutionary biology, speciation, and integrative taxonomy in order to understand patterns of animal diversity and their significance in biodiversity conservation.
- To introduce recent advances in developmental biology, neurobiology, and behavioural science, focusing on stem cells, regenerative mechanisms, neural organization, and the evolutionary basis of animal behaviour.
- To familiarize students with contemporary tools and approaches in conservation zoology, including biodiversity monitoring, conservation genetics, ecological modelling, big data, artificial intelligence, eDNA, and the One Health approach.
- To understand the applications of biotechnology and applied zoology in areas such as transgenic animals, cloning, biomedical models, vaccine development, spillover biology, climate-resilient livestock, and sustainable aquaculture systems.

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

- To understand and interpret the organization of animal genomes and the applications of modern omics technologies such as transcriptomics, proteomics, metabolomics, metallomics, and metagenomics in animal biology and genetic disorders.
- To analyse evolutionary relationships, explain mechanisms of speciation, and apply integrative taxonomy and evolutionary principles in understanding animal diversity and biodiversity conservation.
- To behavioural science, including stem cell biology, regenerative mechanisms, neural organization, animal cognition, and behavioural genetics.
- To apply modern tools such as conservation genetics, biodiversity monitoring, big data analysis, artificial intelligence, remote sensing, and environmental DNA in wildlife conservation within a One Health framework.

- To understand the applications of biotechnology and applied zoology in areas such as transgenic animals, cloning technologies, biomedical models, vaccine development, spillover biology, climate-resilient livestock, and sustainable aquaculture systems.

Course Content:

Theory [Credits: 4] 60 hrs

Unit 1: Molecular Zoology, Genomics and Metallomics 12hrs
Animal genome organization, comparative genomics; Omic technologies: transcriptomics, proteomics, metabolomics, Kleiber's law, metallomics, and metagenomics; Epigenetics, RNA interference (RNAi) and gene silencing, Genetic Disorders.

Unit 2: Evolutionary Biology and Animal Systematics 12hrs
Principles of molecular evolution, evolutionary developmental biology (Evo-Devo), speciation mechanisms, species delimitation, integrative taxonomy, evolutionary patterns in animal diversity and applications of evolutionary studies in biodiversity conservation.

Unit 3: Developmental Biology, Neurobiology and Behavioural Science
12 hrs
Advances in stem cell biology, regenerative mechanisms in animals, molecular regulation of development, neurobiology and neural organization, animal cognition, behavioural genetics and evolutionary basis of animal behaviour, behavioural and physiological responses of animals to Climate Change

Unit 4: Conservation Zoology, Computational and Quantitative Zoology
12 hrs
Principles of conservation biology, biodiversity monitoring ecological, use of big data in biodiversity research, conservation genetics, artificial intelligence and remote sensing in wildlife tracking, eDNA in conservation, one health approach in conservation.

Unit 5: Biotechnology and Applied Zoology 12 hrs
Transgenic animals, animal cloning technologies, biomedical animal models in research, vaccine development and biopharmaceutical production, nanotechnology and its applications in Zoological Sciences, biology of spillover and one health approach; climate-resilient livestock breeds, adaptive aquaculture systems and ecosystem-based resource management.

DISCIPLINE SPECIFIC ELECTIVE (DSE) – IV Practical
(Advances in Zoology)
Subject Code: ZOO804DP

Practical [Credit: 2] 30 hrs

1. Study of animal genome organization using genome databases (NCBI/Ensembl).
2. Calculation and graphical representation of Kleiber's Law (metabolic scaling) using animal body mass and metabolic data.

3. Study of metagenomics and microbiome analysis through published datasets or software demonstrations.
4. Construction of Pedigree- Autosomal Dominant and Recessive / Construction of Pedigree- X-linked and Y-linked.
5. Identification of species using integrative taxonomy approaches (morphological vs molecular characters)**.**
6. Comparative study of evolutionary relationships among selected animal taxa**.**
7. Observation and identification of developmental stages in model organisms (e.g., frog or chick embryo charts/models).
8. Demonstration of animal behaviour experiments (orientation, feeding behaviour or learning behaviour).
9. Study of neurobiological organization using brain models or diagrams.
10. Biodiversity assessment exercise using field survey data and species diversity indices.
11. Case study on environmental DNA (eDNA) applications in biodiversity monitoring**.**
12. Identification and discussion of biomedical animal models used in research**.**
13. Analysis of spillover events and zoonotic disease transmission pathways (One Health approach).
14. Documentation of climate-resilient livestock breeds or sustainable aquaculture practices in the local region.

Examination evaluation Structure:

1. Preparation of developmental stages in model organisms.
2. Construction of Pedigree- Autosomal Dominant and Recessive / Construction of Pedigree- X-linked and Y-linked.

OR

Calculation and graphical representation of Kleiber's Law (metabolic scaling) using animal body mass and metabolic data.

3. Identification of common biomedical animal models/ Spillover zoonotic diseases
4. Field survey for biodiversity assessment and calculation of species diversity indices.
5. Note Book.
6. Viva-Voce.

Teaching and Learning Process:

The teaching–learning process will combine lectures, discussions, case studies, and research-based learning to develop conceptual understanding and analytical skills. Foundational topics in animal genomics, comparative genomics, and omics technologies will be taught through lectures supported by visual presentations and scientific examples, including concepts such as metabolic scaling and epigenetic regulation. Evolutionary principles, speciation, and integrative taxonomy will be explained through interactive discussions and case studies to help students understand patterns of animal diversity and their relevance to biodiversity

conservation. Concepts related to development, neurobiology, and animal behaviour will be introduced using multimedia resources and examples from current research. Contemporary approaches in biodiversity monitoring will be highlighted through discussions on conservation genetics, big data, artificial intelligence, remote sensing, and environmental DNA, along with the integration of ecological and health perspectives through the One Health framework. Applied dimensions of zoology, including animal biotechnology, biomedical models, vaccine development, spillover biology, climate-resilient livestock, and adaptive aquaculture systems, will be discussed through case-based learning. Seminars, literature reviews, and assignments will be used to strengthen critical thinking, scientific communication, and the application of knowledge in research and conservation.

Assessment Methods:

Measures to be adopted for assessment are as follows:

- Class Tests: Regular class tests will judge the grasp of the topics by the students.
- Projects and Assignments: Individual/ group projects will inculcate independent thinking as well as teamwork skills among the students.
- Regular Presentation: Presentations by the students on a particular topic will enhance students' learning and confidence. The presentations will be assessed based on the content, novelty, explanation, and response to queries raised by peers.
- Viva voice: Viva voice is another critical component of the assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- Semester-end Examination: Semester-end examination and grading of students based on their performance in the examinations is an indicator of students' learning throughout the semester. A comparative assessment of students through final examinations analyses the comprehensive knowledge gained by each student.

Recommended Books:

1. Agarwal, V. K. (2019). *Zoology for B.Sc. students (Including molecular biology & genetics).* S. Chand Publishing.
2. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2015). *Molecular biology of the cell* (6th ed.). Garland Science.
3. Arora, H., & Arora, M. P. (2019). *A textbook of molecular biology.* Himalaya Publishing House.
4. Arruda, M. A. Z. (Ed.). (2012). *Metallomics: The science of biometals.* Springer.
5. Fan, T. W.-M., Lane, A. N., & Higashi, R. M. (Eds.). (2012). *The handbook of metabolomics.* Humana Press.
6. Futuyma, D. J., & Kirkpatrick, M. (2017). *Evolution* (4th ed.). Oxford University Press.
7. Kandel, E. R., Koester, J. D., Mack, S. H., & Siegelbaum, S. A. (2021). *Principles of neural science* (6th ed.). McGraw-Hill.

8. Kandel, E. R., Koester, J. D., Mack, S. H., & Siegelbaum, S. A. (2021). *Principles of neural science* (6th ed.). McGraw-Hill Education.
9. Krebs, C. J. (2016). *Ecology: The experimental analysis of distribution and abundance* (7th ed.). Pearson.
10. Maret, W. (2016). *Metallomics: A primer of integrated biometal sciences.* Imperial College Press.
11. Nei, M., & Kumar, S. (2000). *Molecular evolution and phylogenetics.* Oxford University Press.
12. Primack, R. B. (2014). *Essentials of conservation biology* (6th ed.). Sinauer Associates.
13. Singh, B. D., Singh, M. K., & Gupta, K. C. (2015). *Zoology: Molecular biology, bio-instrumentation and bio-techniques.* Kalyani Publishers.
14. Squire, L. R., Berg, D., Bloom, F. E., du Lac, S., Ghosh, A., & Spitzer, N. C. (Eds.). (2013). *Fundamental neuroscience* (4th ed.). Academic Press.
15. Sussulini, A. (Ed.). (2017). *Metabolomics: From fundamentals to clinical applications.* Springer.
16. Willis, E. L. (2017). *Animal form and function: Fundamentals of animal morphology.* Cambridge University Press.