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GU/Acad –PG/BoS -NEP/2025-26/238 Date: 09.07.2025

CIRCULAR

The Academic Council & Executive Council of the University has approved Ordinance OA-35A relating to PG Programmes offered at the University campus and its affiliated Colleges based on UGC 'Curriculum and Credit Framework for Postgraduate Programmes'. Accordingly, the University has proposed introduction of Ordinance OA-35A from the Academic year 2025-2026 onwards.

The Programme structure and syllabus of Semester I of the **Master of Science in Zoology** Programme approved by the Academic Council in its meeting held on 24th & 25th June 2025 is attached.

The Dean & Vice-Dean (Academic) of the School of Biological Sciences and Biotechnology are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

ASHWIN VYAS LAWANDE
Digitally signed by ASHWIN VYAS LAWANDE
Date: 2025.07.09 11:30:36 +05'30'

(Ashwin V. Lawande)
Deputy Registrar – Academic

To,
1. The Dean, School of Biological Sciences and Biotechnology, Goa University.
2. The Vice-Dean (Academic), School of Biological Sciences and Biotechnology, Goa University.

Copy to:
1. Chairperson, BoS in Zoology, Goa University.
2. Programme Director, M.Sc. Zoology, Goa University.
3. Controller of Examinations, Goa University.
4. Assistant Registrar Examinations (PG), Goa University.
5. Director, Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

GOA UNIVERSITY

MASTER OF SCIENCE IN ZOOLOGY

(Effective from the Academic Year 2025-2026)

ABOUT THE PROGRAMME

The Master of Science in Zoology is a comprehensive postgraduate programme that fosters a deep understanding of animal biology through a balanced integration of classical zoological principles and contemporary scientific advancements. Designed to cultivate intellectual curiosity, analytical thinking, and technical proficiency, the programme equips students with both theoretical knowledge and hands-on experience in key areas such as Biodiversity, Physiology, Molecular Biology, Ecology, Aquaculture and Animal Behaviour.

The curriculum is structured to support flexible, learner-centred education with a focus on interdisciplinary exploration and skill development. It includes foundational bridge courses, core discipline-specific modules, vocational and generic electives, as well as an intensive research component. Through laboratory work, field studies, internships, and dissertations, students gain practical exposure and are encouraged to engage with real-world ecological and biological challenges.

This programme also emphasizes academic rigour, scientific integrity, and professional preparedness. Learners are guided to develop independent research skills, data interpretation abilities, and sustainable thinking, enabling them to contribute effectively to scientific inquiry and societal needs. The diverse course offerings foster adaptability and prepare students for a wide range of career paths, including research, conservation, environmental consultancy, biotechnology, education, and public service.

Ultimately, the M.Sc. in Zoology programme provides a transformative learning experience that combines domain excellence with experiential learning, innovation, and a strong foundation for lifelong inquiry and leadership in the life sciences.

Approved by: Standing Committee of the Academic Council on 24th & 25th June 2025

OBJECTIVES OF THE PROGRAMME
1. To provide in-depth knowledge of zoological concepts, integrating classical and modern aspects of Biodiversity, Physiology, and Molecular Biology. 2. To equip students with practical skills through hands-on training, internships, and field-based experiences in areas like Aquaculture, Wildlife Biology, Ecotoxicology and Animal cell culture. 3. To foster a research-oriented mindset, encouraging exploration of nature and animal systems through dissertation work. 4. To prepare students to address societal and environmental challenges with innovative, sustainable solutions.

PROGRAMME SPECIFIC OUTCOMES (PSO)	
PSO 1.	To provide advanced knowledge of zoological concepts, blending classical and modern biology.
PSO 2.	To develop practical skills through fieldwork, internships, and hands-on training in diverse areas of zoology.
PSO 3.	To foster a research mindset, encouraging innovative approaches to study animal systems and ecosystems.
PSO 4.	To prepare students to address societal and environmental challenges with sustainable solutions.

PROGRAMME STRUCTURE

Master of Science in Zoology

Effective from Academic Year 2025-26

Bridge Course

Bridge Courses are being introduced specifically for **Cross-Disciplinary Track (CDT) students**. These courses are **not compulsory** for M.Sc. students and will not count towards degree credits.

Sr. No.	Course Code	Title of the Course	Credits
1	ZOO-1000	Comparative Anatomy and Physiology of Animals	2
2	ZOO-1001	Cell Biology and Genetics	1
3	ZOO-1002	Ecology and Biodiversity	1

SEMESTER I

Discipline Specific Core (DSC) Courses (16 credits)

Sr. No.	Course Code	Title of the Course	Credits	Level
1	ZOO-5000	Zoological Systematics and its Applications	3	400
2	ZOO-5001	Practical in Zoological Systematics and its Applications	1	400
3	ZOO-5002	Environmental Physiology and Adaptation in Animals	3	400
4	ZOO-5003	Practical in Environmental Physiology and Adaptation in Animals	1	400
5	ZOO-5004	Advanced Ecological Principles and Applications	3	400
6	ZOO-5005	Practical in Advanced Ecological Principles and Applications	1	400
7	ZOO-5006	Advanced Biochemistry	3	400
8	ZOO-5007	Practical in Advanced Biochemistry	1	400
Total Credits for DSC Courses in Semester I				**16**

Discipline Specific Elective (DSE) Course (4 credits)

Sr. No.	Course Code	Title of the Course	Credits	Level
1	ZOO-5201	Neural and Genetic Basis of Animal Behaviour	3	400

2	ZOO-5202	Practical in Neural and Genetic Basis of Animal Behaviour	1	400
3	ZOO-5203	Restoration Ecology	3	400
4	ZOO-5204	Practical in Restoration Ecology	1	400
5	ZOO-5205	Vector Biology	3	400
6	ZOO-5206	Practical in Vector Biology	1	400
7	ZOO-5207	Biology of Animal Reproduction	3	400
8	ZOO-5208	Practical in Animal Reproduction	1	400
Total Credits for DSE Courses in Semester I				**4**
Total Credits in Semester I				**20**

SEMESTER II				
Discipline Specific Core (DSC) Courses				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	ZOO-5008	Molecular organization of Genetic Material	3	500
2	ZOO-5009	Practical in Molecular Organization of Genetic Material	1	500
3	ZOO-5010	Animal and Human Genetics	3	500
4	ZOO-5011	Practical in Animal and Human Genetics	1	500
5	ZOO-5012	Molecular Mechanisms of Animal Development	3	500
6	ZOO-5013	Practical in Molecular mechanisms of Developmental Biology	1	500
7	ZOO-5014	Field Skills in Zoology (Practical)	4	500
Total Credits for DSC Courses in Semester II			**16**	
Discipline Specific Elective (DSE) Courses (4 Credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	ZOO-5209	Cellular and Molecular Immunology	4	400
2	ZOO-5210	Ornithology	3	400
3	ZOO-5211	Practical in Ornithology	1	400
4	ZOO-5212	Fundamentals and Emerging Approaches in Animal Cell Culture	1	400
5	ZOO-5213	Practical in Fundamentals and Emerging Approaches in Animal Cell Culture	3	400
6	ZOO-5214	Fishery Resource Management	3	400
7	ZOO-5215	Practical in Fishery Resource Management	1	400
8	ZOO-5216	Wildlife Biology and Conservation	3	400
9	ZOO-5217	Practical in Wildlife Biology and Conservation	1	400
10	ZOO-5218	Mammalogy	3	400
11	ZOO-5219	Practical in Mammalogy	1	400
Total Credits for DSE Courses in Semester II			**4**	
Total Credits in Semester II			**20**	

Blooms Taxonomy Cognitive Levels	
Cognitive Level	**Notations**
K1	Remembering
K2	Understanding
K3	Applying
K4	Analyzing
K5	Evaluating
K6	Create

BRIDGE COURSES

Title of the Course	Comparative Anatomy and Physiology of Animals
Course Code	ZOO-1000
Number of Credits	2
Theory/Practical	Theory
Level	100
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	Bridge Course
Course for advanced learners	No

Pre-requisites for the Course:	Nil
Course Objectives:	• To understand the structural organization of major organ systems in non-chordates and chordates. • To explain the physiological functions of animal systems in relation to their structure and habitat. • To compare anatomical and functional adaptations of various systems across different animal taxa. • To develop foundational insights into evolutionary trends in animal anatomy and physiology.
Course Outcomes:	Students will be able to:
	CO 1Identify and describe structural features of major organ systems across animal groups. (K1, K2**)**
	CO 2 Explain the physiological processes underlying major systems in chordates and non-chordates. (K2, K3**)**
	CO 3 Compare functional and anatomical adaptations of organ systems across taxa. (K2)

	CO 4 Analyse the evolutionary and ecological relevance of structural and physiological variations. (K2, K4**)**			
Unit/Module	**Content:**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Structural and Locomotory Systems in Animals	1.1 Skeletal and Muscular Systems Skeleton types: Hydrostatic, Exoskeleton, Endoskeleton; Skeletal structures in non-chordates; vertebrate axial and appendicular skeletons; Vertebral column plan and modifications Muscle types: skeletal, smooth, cardiac; Axial and appendicular musculature in vertebrates; Locomotion: annelids, insects, vertebrates	**5**	CO1, CO3	K1, K2
	1.2 Circulatory System Open vs closed circulation (invertebrates); Vertebrate heart structure and circulation; Portal and lymphatic systems in tetrapods; Composition and function of blood and lymph	**5**	CO1, CO3	K1, K2
	1.3 Respiratory System Respiratory structures in non-chordates: gills, tracheae, skin Gills in fishes; lungs in tetrapods Mechanism of breathing and gas exchange	**5**	CO2, CO3	K2
Module 2: Functional Systems in Animals	2.1 Nutrition and Digestive system Feeding types: filter, fluid, raptorial, etc. Digestive systems in non-chordates: coelenteronic, saccular, tubular Digestive anatomy of vertebrates Digestion, absorption, and role of gut microbiome and rumen fermentation	**5**	CO2, CO3, CO4	K2, K4
	2.2 Nervous and Sensory Systems Nervous system in non-chordates and chordates; Nerve impulse, reflexes Sensory organs: structure and types (e.g., photo-, mechano-, chemo-receptors)	**3**	CO1, CO2, CO3	K1, K2, K3
	2.3 Excretory System	**3**	CO1,	K1, K2

	Excretory organs: flame cells, nephridia, kidneys; Types of nitrogenous waste; Kidney structure, urine formation, and osmoregulation		CO2	
	2.4. Reproductive System Asexual and sexual reproduction across phyla; Reproductive structures in non-chordates and chordates; Basic overview of pregnancy and uterine function in mammals	**4**	CO2, CO3	K2
Pedagogy:	Interactive Lectures /Flipped Classrooms / Use of videos, animations /Group discussion/ presentations/ case discussion /debate			
Texts:	1. Evans, D. H., Claiborne, J. B., & Currie, S. (Eds.). (2017). The physiology of fishes (5th ed.). CRC Press. 2. Ghosh, S., & Bhattacharya, S. K. (2017). Comparative physiology. New Central Book Agency. 3. Hill, R. W., Wyse, G. A., & Anderson, M. (2016). Animal physiology (4th ed.). Sinauer Associates. 4. Hoar, W. S. (1966). General and comparative physiology. Englewood Cliffs: Prentice-Hall.Hoar, W. S., Randall, D. J., & Farrell, A. P. (Eds.). (1992). Fish physiology (Vol. 12). Academic Press. (For specialized osmoregulation and excretion topics) 5. Prosser, C. L., & Brown, F. A. (1961). Comparative animal physiology (3rd ed.). W.B. Saunders Company. 6. Randall, D., Burggren, W., French, K., & Eckert, R. (1997). Animal physiology: mechanisms and adaptations. Freeman. 7. Schmidt-Nielsen, K. (1997). Animal physiology: Adaptation and environment (5th ed.). Cambridge University Press. 8. Schulte, P. M. (2013). Principles of Animal Physiology: Pearson New International Edition. Pearson Education Limited. 9. Willmer, P., Stone, G., & Johnston, I. (2009). Environmental physiology of animals. John Wiley & Sons.			
References/ Readings:	1. Burggren, W. W., & Warburton, S. (2007). Amphibians as animal models for laboratory research in physiology. ILAR Journal, 48(3), 260–269. https://doi.org/10.1093/ilar.48.3.260 2. Carter, A. M., & Mess, A. (2007). Evolution of the placenta in eutherian mammals. Placenta, 28(4–5), 259–262. https://doi.org/10.1016/j.placenta.2006.04.011 3. El Jeni, R., Villot, C., Koyun, O. Y., Osorio-Doblado, A., Baloyi, J. J., Lourenco, J. M., Steele, M., & Callaway, T. R. (2024). Understanding rumen microbiology: An overview. Journal of Applied Microbiology, 4(1), 13. https://doi.org/10.3390/jam4010013 4. Evans, D. H. (2008). Teleost fish osmoregulation: What have we learned since August Krogh, Homer Smith, and Ancel Keys. American Journal of Physiology – Regulatory, Integrative and Comparative Physiology, 295(2), R704–			

	R713. https://doi.org/10.1152/ajpregu.90337.2008 5. Hughes, F. M., & Dufour, S. (2017). Comparative ovarian function and reproductive monitoring of endangered mammals. Birth Defects Research, 110(3), 163–189. https://doi.org/10.1002/bdr2.1102 6. Jami, E., & Mizrahi, I. (2012). Composition and similarity of bovine rumen microbiota across individual animals. PLoS ONE, 7(3), e33306. https://doi.org/10.1371/journal.pone.0033306 7. Kansagara, Y. K., Savsani, H. H., Chavda, M. R., Chavda, J. A., Belim, S. Y., Makwana, K. R., & Kansagara, B. K. (2022). Rumen microbiota and nutrient metabolism: A review. Bhartiya Krishi Anusandhan Patrika, 37(4), 320–327. https://doi.org/10.18805/BKAP486 8. Marshall, W. S., & Grosell, M. (2006). Ion transport, osmoregulation, and acid-base balance. The Physiology of Fishes, 3, 177–230. https://doi.org/10.1201/9781003067410 9. Milsom, W. K. (2012). Evolutionary and developmental bases for the emergence of respiratory rhythm generators in vertebrates. Respiratory Physiology & Neurobiology, 184(3), 84–91. https://doi.org/10.1016/j.resp.2012.05.004 10. O'Donnell, M. J., & McNamara, J. C. (2014). Osmoregulation and excretion. Comprehensive Physiology. https://doi.org/10.1002/cphy.c130016 11. Shabat, S. K. B., Sasson, G., Doron-Faigenboim, A., Durman, T., Yaacoby, S., Miller, M. E. B., ... & Mizrahi, I. (2016). Specific microbiome-dependent mechanisms underlie the energy harvest efficiency of ruminants. The ISME Journal, 10(12), 2958–2972. https://doi.org/10.1038/ismej.2016.62 12. Tattersall, G. J., Andrade, D. V., & Abe, A. S. (2009). Heat exchange from the toucan bill reveals a controllable vascular thermal radiator. Science, 325(5939), 468–470. https://doi.org/10.1126/science.1175553
Web Resources:	1. Arizona State University. (n.d.). *Explore animal physiology*. Ask A Biologist. https://askabiologist.asu.edu/explore/animal-physiology 2. EduRev. (n.d.). *Animal physiology and functional histology*. EduRev Learning Platform. https://edurev.in/courses/62_Animal-Physiology-and-Functional-Histology--I 3. LibreTexts Biology. (n.d.). Animal physiology and anatomy. https://bio.libretexts.org/Bookshelves/PhysiologyNational Center for Biotechnology Information (NCBI). (n.d.). Bookshelf – Physiology texts. https://www.ncbi.nlm.nih.gov/books/ 4. Nature Education. (n.d.). Scitable by Nature Education: Animal physiology topics. https://www.nature.com/scitable/topics/animal-physiology-14122666/ 5. Oxford University Press. (n.d.). *Animal physiology student resources*. Oxford Learning Link.

	https://learninglink.oup.com/access/butler-student-resources 6. The Biology Project. (n.d.). Physiology. University of Arizona. https://www.biology.arizona.edu/physiology/physiology.html

Title of the Course	Cell biology and Genetics
Course Code	ZOO-1001
Number of Credits	01
Theory/Practical	Theory
Level	100
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	Yes (Bridge Course)
Course for advanced learners	No

Pre-requisites for the Course:	Nil
Course Objectives:	• To reinforce and consolidate the understanding of prokaryotic and eukaryotic cell structure and function, with emphasis on major organelles and essential cellular processes. • To revisit and strengthen core concepts in molecular biology, focusing on the roles of DNA, RNA, and chromosomes in heredity and gene expression. • To refresh foundational knowledge of Mendelian genetics and inheritance patterns, enabling the development of analytical and problem-solving skills. • To orient students towards clinically significant genetic disorders and their diagnostic relevance, laying the groundwork for advanced studies in molecular and clinical genetics.
Course Outcomes:	Students will be able to:
	CO 1. Explain the structural organization and functional roles of key cellular components in prokaryotic and eukaryotic systems. (K2)

	CO 2. Summarize the molecular structure and inheritance-related functions of DNA, RNA, and chromosomes in gene expression and regulation. (K2)			
	CO 3. Apply Mendel's laws to analyze and solve problems related to simple inheritance patterns and genetic crosses. (K3)			
	CO 4. Identify and analyze common genetic disorders based on inheritance mechanisms, and relate them to clinical or diagnostic applications. (K3)			
Content:	**Topics**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Cell Structure, Genetics and Inheritance	1.1 Introduction to Cell Types: Prokaryotic vs. Eukaryotic cells: structure, size, examples, and key differences	**01**	CO1	K2
	1.2 Plasma Membrane: Structure (fluid mosaic model), transport mechanisms (diffusion, osmosis, active)	**01**	CO1	K2
	1.3 Cytoplasmic Organelles: Structure and functions of nucleus, mitochondria, ER, Golgi, lysosomes, peroxisomes	**02**	CO1	K2
	1.4 Cell Cycle and Division: Overview of mitosis and meiosis, significance of cell division, checkpoints	**02**	CO1	K2
	1.5 DNA, RNA & Chromosomes: Structure and functions of DNA and RNA; packaging of DNA into chromosomes	**02**	CO2	K2
	1.6 Central Dogma: Overview of replication, transcription, and translation	**03**	CO2	K2
	1.7 Mendelian Genetics: Mendel's laws of inheritance, monohybrid and dihybrid crosses	**02**	CO3	K3
	1.8 Genetic Disorders: Examples of autosomal dominant, recessive, and X-linked disorders	**02**	CO3, CO4	K3
Pedagogy:	Lectures/ Instructor-led demonstrations/Multimedia presentations/Cellular models/Simulated inheritance problems/Interactive tutorials/ Group discussions/Problem-solving sessions to reinforce concepts/Formative quizzes.			
Texts:	1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2015). *Molecular biology of the cell* (6th			

	ed.). Garland Science. 2. Arumugam, N. (2016). *Cell biology and genetics* (Revised ed.). Saras Publication. 3. Chaudhuri, S. K. (2018). *Concise medical genetics* (3rd ed.). New Central Book Agency. 4. Griffiths, A. J. F., Wessler, S. R., Carroll, S. B., & Doebley, J. (2019). *Introduction to genetic analysis* (12th ed.). W.H. Freeman. 5. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., & Scott, M. P. (2016). *Molecular cell biology* (8th ed.). W.H. Freeman.
References/ Readings:	1. Adrain, C., & Burbridge, E. (Eds.). (2022). *Organelle homeostasis* [Special issue]. *The FEBS Journal*, *289*(22), 6819–7255. https://doi.org/10.1111/febs.2022.289.issue-22 2. Hallworth, A., & Ventura, J. (2019). Organelle Biology and Medicine. *The Yale Journal of Biology and Medicine*, *92*(3), 367–368. 3. Mukhopadhyay, U., Mandal, T., Chakraborty, M., & Sinha, B. (2024). The Plasma Membrane and Mechanoregulation in Cells. *ACS omega*, *9*(20), 21780–21797. https://doi.org/10.1021/acsomega.4c01962
Web Resources:	1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2002). *Molecular biology of the cell* (4th ed.). Garland Science. https://www.ncbi.nlm.nih.gov/books/NBK21054/ 2. Cooper, G. M. (2000). *The cell: A molecular approach* (2nd ed.). Sinauer Associates. https://www.ncbi.nlm.nih.gov/books/NBK9839/ 3. UGC–ePG Pathshala. (n.d.). Cell biology module. INFLIBNET. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=2rAs1Puvga4LW93zMe83aA==

Title of the Course	Ecology and Biodiversity
Course Code	ZOO-1002
Number of Credits	1
Theory/Practical	Theory
Level	100
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	Yes
Course for advanced learners: Yes/No	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To develop the concepts of ecology and biodiversity • To outline ecosystem functioning • To identify the reasons for decline of biodiversity • To sensitize the learners of the issues arising from unsustainable development with respect to the global scenario and methods to tackle the problems.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Identify and describe key ecological concepts including levels of organization, biodiversity, and species interactions.	PSO1

	CO 2. Explain population parameters, demographic techniques, and the principles of population growth and regulation.		PSO2, PSO3	
	CO 3. Compare community structure, succession patterns, and factors influencing distribution and abundance.		PSO2, PSO3, PSO4	
	CO 4. Analyze human ecological impacts including population growth, resource use, pollution, and climate change.		PSO3, PSO4	
Content:	**Topics**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Basics to Ecology	1.1 Introduction: Historical overview of ecology, ecology and evolution, Ecological structure: Levels of organization, species abundance and composition, Biodiversity Ecological interactions: Positive interactions, Negative interactions.	**4**	CO1	K1, K2
	1.2 Population ecology: population parameters and demographic techniques, Population growth and regulation, Population studies and applications.	**4**	CO1	K2, K4
	1.3 Community ecology: Community nature and parameters, community changes and ecological succession, Community organization Distribution and abundance	**4**	CO2	K1, K4
	1.4 Human ecology: Introduction and impacts, Human population growth and food requirements, sustainable development, Ecology of change: oil spills, plastic and biodiversity, impacts of climate change, Biodiversity Act 2004 (BMC, PBR).	**3**	CO2	K2, K5
Pedagogy:	• Lectures using multimedia and visual aids to explain key ecological principles and case studies • Interactive tutorials focused on discussion of ecological models, population dynamics, and succession • Assignments and presentations based on current environmental issues and policy reviews (e.g., Biodiversity Act, climate reports) • Field studies for data collection on species abundance, community structure, or human impact assessments • Practical sessions including ecological sampling techniques, data analysis, and demographic calculations • Self-directed learning through review of scientific literature, documentaries, and online ecological databases (e.g.,			

	GBIF, IUCN)
References/ Readings:	1. J.V. Andel and J. Aronson, Restoration Ecology: The New Frontier, 2nd ed. Blackwell Publishing Ltd., 2012. 2. A.J. Baker, ed., Molecular Ecology, In Molecular Methods in Ecology. Blackwell Publishing, 2000. 3. J.L. Chapman, and M.J. Reiss, Ecology: Principles and Applications. Cambridge University Press, 1999. 4. A.R. Conklin, Field Sampling: Principles and Practices in Environmental Analysis, CRC Press, 2004. 5. T.J. Fahey, and A.K. Knapp, Principles and Standards for Measuring Primary Production. UK: Oxford University Press, 2007. 6. W.E Grant, and T.M. Swannack, Ecological Modeling. Blackwell, 2008. 7. E.P. Odum and G.W. Barrett, Basic Ecology: Fundamentals of Ecology, 5th ed. Oxford and IBH Publishing Co. Pvt, 2004. 8. M.R. Perrow, and A.J. Davy, Handbook of Ecological Restoration, Vol. 2. Restoration in Practice, Cambridge University Press, 2002. 9. W.J. Sutherland, Ecological Census techniques a handbook. Cambridge University Press, 2006 10. D.M. Wilkinson, Fundamental Processes in Ecology: An Earth system Approach. UK: Oxford University Press, 2007. 11. H. Heatwole, and J. Taylor, Ecology of Reptiles. Cocos (Keeling) Islands: Surrey Beatty and Sons, 1987. 12. R.A. Seigel, Snakes: Ecology and Behavior. UK: McGraw-Hill, 1993.

SEMESTER I

Discipline Specific Core Courses

Title of the Course	Zoological Systematics and its Applications
Course Code	ZOO-5000
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil
Course Objectives:	• To introduce learners to the fundamental principles, historical development, and philosophical foundations of animal systematics as a discipline within biological sciences. • To develop the ability to characterize and classify animal taxa using both classical morphological features and modern molecular systematics tools. • To enable learners to critically analyze and interpret phylogenetic data for reconstructing evolutionary relationships among taxa and for guiding evidence-based conservation and wildlife management decisions. • To apply systematic approaches to real-world issues in biodiversity research, conservation planning, and

	biogeographical studies, with an emphasis on integrative taxonomy and species delimitation.			
Course Outcomes:	Students will be able to:		**Mapped to PSO**	
	CO 1. Understand basic principles and history of systematics		PSO1	
	CO 2. Characterize and classify animals based on traditional and molecular techniques		PSO2, PSO3	
	CO 3. Analyze and interpret phylogenetic data to reconstruct evolutionary relationships and inform conservation and management decisions.		PSO2, PSO3, PSO4	
	CO 4. Apply systematics in biodiversity, conservation, and biogeography		PSO3, PSO4	
Content:	**Topic**	**No. of Hours**	**Mapped to CO**	**Cognitive level**
Module 1: Foundations of Zoological Systematics	1.1 Introduction to Systematics: Definitions and Scope, Taxonomy vs. Systematics vs. Phylogenetics.	**2**	CO1	K2
	1.2 Role of systematics in modern biology.	**1**	CO1	K2
	1.3 Principles of Classification and Taxonomic Ranks - Rules of naming: priority, availability, validity, Synonymy, homonymy, and nomen dubium, Naming new species: procedures and case studies, Gender agreement, Latinization, and etymology.	**3**	CO2	K3
	1.4 Taxonomic ranks: Kingdom to species, Linnaean system: binomial nomenclature and hierarchical classification, Monophyly, paraphyly, and polyphyly.	**2**	CO1, CO2	K3
	1.5 Species concepts (biological, morphological, phylogenetic, ecological), Typification and the concept of holotypes.	**4**	CO1, CO2	K3
	1.6 International Codes of Zoological Nomenclature (ICZN).	**3**	CO1, CO2	K3
Module 2: Tools and Techniques in Systematics	2.1 Taxonomic Procedures, Taxonomic Keys, Morphological and Anatomical Characters, Museum Collections and Type Specimens.	**4**	CO2, CO4	K4
	2.2 Molecular Systematics: Molecular markers, SNPs, Allozyme, DNA Barcoding, DNA sequencing in taxonomy: mitochondrial genes (COI, 16S) and nuclear genes	**4**	CO2, CO3	K2

	(18S, ITS), DNA barcoding and species delimitation.			
	2.3 Integrative taxonomy and the future of systematics, Cladistics and Evolutionary Trees Phylogenetic tree construction using Parsimony and Maximum Likelihood methods.	**4**	CO2, CO3	K5
	2.4 Software Tools and Artificial Intelligence for Taxonomy and Phylogenetics: BOLD SYSTEMS Global Biodiversity Information Facility, WoRMs, GenBank, TreeBASE, MEGA, MrBayes, RAxML	**3**	CO2, CO3	K2
Module 3: Applications of Zoological Systematics	3.1 Importance of accurate taxonomy in conservation (IUCN, CITES), Cryptic species and conservation status, Indicator species and biodiversity hotspots.	**3**	CO2, CO3, CO4	K3
	3.2 The taxonomic impediment and capacity building Case Study: Misidentification and conservation mismanagement.	**2**	CO4	K2
	3.3 Biodiversity Assessment and Species Inventories, Conservation Systematics: Red Lists and Phylogenetic Diversity, Biogeography and Speciation Patterns, Systematics and ecological niches, Species distributions and historical biogeography.	**4**	CO2, CO3, CO4	K5
	3.4 Environmental monitoring and biomonitoring (e.g., using macroinvertebrates), Systematics in Invasive Species Management and Wildlife Forensics, Role of Systematics in Environmental Impact Assessments (EIAs).	**3**	CO2, CO3, CO4	K5
	3.5 Emerging Trends: eDNA, Citizen Science.	**3**	CO2, CO4	K3
Pedagogy:	Interactive lectures / Field excursions and biodiversity surveys/ Project-based learning / Integration of current research articles and case studies /Inquiry-based and problem-centered learning/ Seminar-led critical discussions/ Integration of databases and digital resources/ Mentored student-led mini-symposia or colloquia/ Reflective assignments, portfolios, and continuous formative assessments			
Texts:	1. Futuyma, D. J. (2013). *Evolution* (3rd ed.). Sinauer Associates. Quicke, D. L. J. (2014). *Principles and techniques of contemporary taxonomy* (Revised ed.). Wiley-Blackwell.			

	2. Garamszegi, L. Z. (Ed.). (2014). *Modern phylogenetic comparative methods and their application in evolutionary biology*. Springer. 3. Hillis, D. M., Moritz, C., & Mable, B. K. (Eds.). (2019). *Molecular systematics* (2nd ed.). Sinauer Associates. 4. Johnson, N., & Triplehorn, C. A. (2004). *Borror and DeLong's introduction to the study of insects* (7th ed.). Brooks/Cole. 5. Lynch, K. D., & Vogel, J. S. (2023). *Animal systematics: A phylogenetic approach* (Latest ed.). Publisher. 6. Mayr, E. (1999). *Systematics and the origin of species* (Revised ed.). Harvard University Press. 7. Mayr, E., & Ashlock, P. D. (1991). Principles of systematic zoology (2nd ed.). McGraw-Hill. 8. Nei, M., & Kumar, S. (2000). *Molecular evolution and phylogenetics*. Oxford University Press. 9. Rupert, E. E., Fox, R. S., & Barnes, R. D. (2003). Invertebrate zoology (7th ed.). Brooks/Cole. 10. Simpson, G. G. (1961). *Principles of animal taxonomy*. Columbia University Press. 11. Wiley, E. O., & Lieberman, B. S. (2011). *Phylogenetics: Theory and practice of phylogenetic systematics* (2nd ed.). Wiley-Blackwell. 12. Winston, J. E. (1999). *Describing species: Practical taxonomic procedure for biologists*. Columbia University Press
References/ Readings:	1. Avise, J. C. (2012). *Molecular markers, natural history and evolution*. Springer Science & Business Media. 2. International Commission on Zoological Nomenclature (ICZN). (1999). International code of zoological nomenclature (4th ed.). International Trust for Zoological Nomenclature. 3. Kumar, A., Walker, S. A. L. L. Y., & Molur, S. (2000). Prioritisation of endangered species. *Setting biodiversity priorities for India. New Delhi: World Wide Fund for Nature, India*, 341-425. 4. Miralles, A., Puillandre, N., Vences, M. (2024). DNA Barcoding in Species Delimitation: From Genetic Distances to Integrative Taxonomy. In: DeSalle, R. (eds) DNA Barcoding. Methods in Molecular Biology, vol 2744. Humana, New York, NY. https://doi.org/10.1007/978-1-0716-3581-0_4 5. Nicolas Hubert, Robert Hanner. DNA Barcoding, species delineation and taxonomy: a historical perspective. DNA Barcodes, 2015, 3 (1), 10.1515/dna-2015-0006. hal-01958691 6. Tikader, B.K.D. (1983). *Threatened animals of India*. In *Threatened animals of India*. Zoological Survey of India, Calcutta. 7. Zrzavý, J. (2018). Phylogeny and classification of the animal kingdom. Springer.
Web Resources:	1. Integrated Taxonomic Information System (ITIS). Available at: https://www.itis.gov/ 2. Tree of Life Web Project. Available at: http://tolweb.org/tree/ 3. Barcode of Life Data Systems (BOLD). Available at: http://www.boldsystems.org/

	4. Catalogue of Life. Available at: https://www.catalogueoflife.org/ 5. Global Biodiversity Information Facility (GBIF). Available at: https://www.gbif.org/ 6. Biodiversity Heritage Library (BHL). Available at: https://www.biodiversitylibrary.org/ 7. International Code of Zoological Nomenclature (ICZN) 8. https://www.iczn.org/the-code/

Title of the Course	Practical in Zoological Systematics and its Applications
Course Code	ZOO-5001
Number of Credits	1
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	1. To provide a comprehensive understanding of the principles and practices of animal classification and systematics. 2. To develop the ability to identify major faunal taxa using dichotomous and pictorial keys. 3. To enable Learners to construct and utilize taxonomic keys for selected animal groups 4. To enhance appreciation for biodiversity documentation and its relevance to ecology, conservation, and biological research.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Apply systematic methods to distinguish and identify animal taxa using appropriate taxonomic tools and literature.	PSO 1
	CO 2. Design and apply taxonomic keys for accurate identification of animal taxa.	PSO 1, PSO2, PSO3
	CO 3. Competence in critical thinking and observational skills relevant to zoological	PSO 2, PSO 3

	classification and evolutionary biology			
	CO 4. Create taxonomic baselines essential for biodiversity studies, ecological research, and conservation		PSO 2, PSO3, PSO 4	
Content:	Topics	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Practical Learning in Animal Taxonomy and systematics	1.1 Taxonomic identification and classification of invertebrates up to class using published keys • Porifera, • Cnidaria • Arthropoda • Mollusca	**8**	CO1, CO2	K3
	1.2 Identification and classification of major vertebrate classes using established keys • Fishes • Amphibians • Reptiles • Birds • Mammals	**4**	CO1, CO2	K3
	1.3 Construction of taxonomic Dichotomous Keys using known specimens	**2**	CO1, CO2	L3
	1.4 Creation of Taxonomic keys for field based identification of selected faunal group	**4**	CO2, CO3	K6
	1.5 Collection and Preservation Techniques (Wet and Dry)	**2**	CO1, CO2	K3
	1.6 Curation and Museum Techniques - Cataloguing specimens and preventing damage.	**2**	CO1, CO2	K6

	1.7 Construct phylogenetic trees using simulated data	**2**	CO1	K6
	1.8 Interpret evolutionary relationships and tree topologies using simulated data	**2**	CO4	K6
	1.9 Create a conservation prioritization framework for a selected area by integrating field based taxonomic identification and IUCN Red List assessments.	**4**	CO4	K6
Pedagogy:	Research integrated laboratory practical/ Field excursions and biodiversity surveys / Project-based learning/ Inquiry-based and problem-centered learning/ Seminar-led critical discussions / Integration of global systematics databases and digital resources/ Mentored student-led mini-symposia or colloquia			
Texts:	1. Futuyma, D. J. (2013). *Evolution* (3rd ed.). Sinauer Associates. 2. Garamszegi, L. Z. (Ed.). (2014). *Modern phylogenetic comparative methods and their application in evolutionary biology*. Springer 3. Hillis, D. M., Moritz, C., & Mable, B. K. (Eds.). (2019). *Molecular systematics* (2nd ed.). Sinauer Associates 4. Johnson, N., & Triplehorn, C. A. (2004). *Borror and DeLong's introduction to the study of insects* (7th ed.). Brooks/Cole. 5. Lynch, K. D., & Vogel, J. S. (2023). *Animal systematics: A phylogenetic approach* (Latest ed.). Publisher 6. Mayr, E. (1999). *Systematics and the origin of species* (Revised ed.). Harvard University Press. 7. Nei, M., & Kumar, S. (2000). *Molecular evolution and phylogenetics*. Oxford University Press. 8. Quicke, D. L. J. (2014). *Principles and techniques of contemporary taxonomy* (Revised ed.). Wiley-Blackwell. 9. Simpson, G. G. (1961). *Principles of animal taxonomy*. Columbia University Press. 10. Wiley, E. O., & Lieberman, B. S. (2011). *Phylogenetics: Theory and practice of phylogenetic systematics* (2nd ed.). Wiley-Blackwell. 11. Winston, J. E. (1999). *Describing species: Practical taxonomic procedure for biologists*. Columbia University Press			
References/ Readings:	1. Dayrat, B. (2005). Towards integrative taxonomy. *Biological Journal of the Linnean Society, 85*(3), 407–415. https://doi.org/10.1111/j.1095-8312.2005.00503.x 2. de Queiroz, K. (2007). Species concepts and species delimitation. *Systematic Biology, 56*(6), 879–886. https://doi.org/10.1080/10635150701701083 3. Padial, J. M., Miralles, A., De la Riva, I., & Vences, M. (2010). The integrative future of taxonomy. *Frontiers in Zoology, 7*, 16. https://doi.org/10.1186/1742-9994-7-16 4. Tautz, D., et al. (2003). A plea for DNA taxonomy. *Trends in Ecology & Evolution, 18*(2), 70–74. https://doi.org/10.1016/S0169-5347(02)00041-1			

Web Resources:	1. Integrated Taxonomic Information System (ITIS). Available at: https://www.itis.gov/ 2. Tree of Life Web Project. Available at: http://tolweb.org/tree/ 3. Barcode of Life Data Systems (BOLD). Available at: http://www.boldsystems.org/ 4. Catalogue of Life. Available at: https://www.catalogueoflife.org/ 5. Global Biodiversity Information Facility (GBIF). Available at: https://www.gbif.org/ 6. Biodiversity Heritage Library (BHL). Available at: https://www.biodiversitylibrary.org/ 7. International Code of Zoological Nomenclature (ICZN) https://www.iczn.org/the-code/

Title of the Course	Environmental Physiology and Adaptation in Animals
Course Code	ZOO-5002
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025 -2026
New Course	Yes (Revised 70%)
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To understand the nature and mechanisms of physiological and molecular adaptations across multiple levels of biological organization in response to environmental stressors. • To examine thermal, osmotic, and water balance adaptations and their regulatory mechanisms in animals facing diverse and extreme environmental challenges. • To explore the physiological effects of climate change and pollutants, emphasizing stress biomarkers, thermoregulation, and osmoregulation. • To investigate chronobiological rhythms and their disruption by anthropogenic changes, with focus on adaptations to extreme and urban habitats.	
Course Outcomes:		**Mapped to PSO**

	CO 1. Explain and differentiate among various types of physiological adaptation across molecular, cellular, organismal, and ecological levels.		PO1, PO2 & PO4	
	CO 2. Analyze thermoregulatory and osmoregulatory mechanisms across environments, including desert, aquatic, and high-altitude habitats, and relate them to homeostasis and survival strategies.		PO1, PO2 & PO3	
	CO 3. Evaluate the impact of environmental stressors such as climate change, heavy metals, and endocrine disruptors on organismal physiology using appropriate biomarkers.		PO1, PO3 & PO4	
	CO 4. Interpret biological rhythms and their regulatory pathways, assessing how urbanization and global warming affect timing mechanisms such as reproduction and seasonal behaviour.		PO2, PO3 & PO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Principles of Environmental Adaptation and Stress Physiology	1.1 **Nature and Levels of Adaptation**: Molecular, cellular, organismal, ecological levels of adaptation. Acclimatization, acclimation, phenotypic plasticity, and evolutionary adaptation	**4**	CO1	K2
	1.2 **Mechanisms of Stress Response:** Homeostasis and allostasis; Oxidative stress, heat shock proteins, and stress biomarkers & Epigenetic regulation of stress tolerance	**4**	CO2	K4
	1.3 **Thermal Physiology and Thermoregulation:** Biochemical and physiological effects of temperature; Heat exchange mechanisms: conduction, convection, radiation, evaporation; Neural and endocrine control of thermoregulation; Dubois temperature balance; Homeoviscous adaptation of membranes.	**4**	CO2	K4
	1.4 **Climate Change and Thermal Stress** -Critical thermal limits (CTmax and CTmin); Impact of climate variability on thermoregulatory capacity	**3**	CO2, CO3	K4, K5
Module 2:	2.1 **Salinity Adaptation-** Osmotic and ionic stress- biochemical and physiological effects; Water and solute regulation mechanisms; Osmoregulatory organs (gills,	**4**	CO2	K4

Osmoregulation, Hydration Strategies, and Pollution Physiology	kidneys, integument); Excretory products in different animal groups			
	2.2 **Environmental Strategies of Osmoregulation**-Marine, estuarine, freshwater, and terrestrial adaptations; Role of aquaporins, ion channels, and transporters; Euryhaline vs. stenohaline organisms	**4**	CO2	K4
	2.3 **Water Conservation Mechanisms**- Physiological and behavioral adaptations in desert and xeric animals; Strategies for water retention and conservation	**3**	CO1	K2
	2.4 **Impact of Environmental Pollutants**- Effects of heavy metals, microplastics, pesticides, and endocrine disruptors; Physiological toxicity; Use of biomarkers in ecotoxicological assessment	**4**	CO3	K5
Module 3: Adaptation to Extreme Environments and Chronophysiology	3.1 **Adaptation to Extreme Habitats**- Physiological and morphological adaptations in: Polar and alpine regions (cold and hypoxia); Deep Sea (pressure, low light); Deserts (temperature, dehydration); High altitudes (hypoxia tolerance)	**4**	CO1 &CO2	K2, K4
	3.2 **Urban Environmental Physiology**- Adaptation to urban stressors: noise, heat islands, artificial light; Urban wildlife physiology and behavior	**3**	CO3, CO4	K4, K5
	3.3 **Chronobiology and Biological Rhythms**- Circadian, ultradian, and infradian rhythms; Molecular basis of circadian rhythms (clock genes); Endogenous vs. environmental entrainment	**3**	CO4	K4
	3.4 **Climate Change and Biological Timing**- Disruption of rhythms due to anthropogenic factors; Impacts of global warming on biological timing; Seasonal adaptations and reproductive timing under shifting climates	**3**	CO4	K4
	3.5 **AI in Monitoring Biological Rhythms**- Application of artificial intelligence for analyzing circadian and seasonal activity patterns in animals	**2**	CO4	K3, K4
Pedagogy:	Interactive Lectures/ Case-Based Learning/ Flipped Classrooms /videos**,** animations**,** and virtual labs /Data-based projects /Group discussions**,** peer presentations/ debates /Problem-solving tasks /Infographics**,** flowcharts, or models /Research article reviews/Mini-projects			
Texts:	1. Ali, M. A. (Ed.). (1992). Environmental physiology of fishes. Springer. 2. Bijlani, R. L., & Manjunatha, S. (2010). *Understanding medical physiology: A textbook for medical students* (4th			

	ed.). Jaypee Brothers Medical Publishers. 3. Bradshaw, W. E., & Holzapfel, C. M. (2011). Evolution of biological timing. Cold Spring Harbor Laboratory Press. 4. Carey, C. (2012). Biology of stress in fish: Environmental and physiological consequences. CRC Press. 5. Cheung, S. S., & Ainslie, P. N. (2021). *Advanced environmental exercise physiology* (2nd ed.). Human Kinetics. 6. Collier, R. J., & Collier, J. L. (2012). *Environmental physiology of livestock* (1st ed.). Wiley-Blackwell. 7. Fuller, P. M., Lu, J., & Saper, C. B. (2008). Chronobiology and sleep-wake regulation. Springer Handbook of Sleep Disorders. 8. Hill, R. W., Wyse, G. A., & Anderson, M. (2016). Animal physiology (4th ed.). Sinauer Associates. 9. Hochachka, P. W., & Somero, G. N. (2002). *Biochemical adaptation: Mechanism and process in physiological evolution* (1st ed.). Oxford University Press. 10. Nelson, R. J., & Kriegsfeld, L. J. (2017). An introduction to behavioral endocrinology (5th ed.). Sinauer Associates. 11. Opatz, O. (Ed.). (2017). *Human physiology in extreme environments* (1st ed.). Elsevier. 12. Prosser, C. L. (Ed.). (1991). Environmental and metabolic animal physiology (4th ed.). Wiley-Liss. 13. Randall, D. J., Burggren, W. W., French, K., & Eckert, R. (2002). Eckert Animal Physiology: Mechanisms and adaptations (5th ed.). W.H. Freeman.
References/ Readings:	1. Angilletta, M. J., Jr., Niewiarowski, P. H., & Navas, C. A. (2002). The evolution of thermal physiology in ectotherms. Journal of Thermal Biology, 27(4), 249–268. https://doi.org/10.1016/S0306-4565(01)00094- 2. Bozinovic, F., & Pörtner, H. O. (2015). Physiological ecology meets climate change. Ecology and Evolution, 5(5), 1025–1030. https://doi.org/10.1002/ece3.1403 3. Campbell, L. M., & Drevnick, P. E. (2015). Mercury in fish: An overview of exposure and health risks. Environmental Health Perspectives, 123(1), 1–3. https://doi.org/10.1289/ehp.1409549 4. Deutsch, C. A., Tewksbury, J. J., Huey, R. B., Sheldon, K. S., Ghalambor, C. K., Haak, D. C., & Martin, P. R. (2008). Impacts of climate warming on terrestrial ectotherms across latitude. Proceedings of the National Academy of Sciences, 105(18), 6668–6672. https://doi.org/10.1073/pnas.0709472105 5. Evans, D. H., Piermarini, P. M., & Choe, K. P. (2005). The multifunctional fish gill: Dominant site of gas exchange, osmoregulation, acid-base regulation, and excretion. Physiological Reviews, 85(1), 97–177. https://doi.org/10.1152/physrev.00050.2003 6. Galloway, T. S., & Lewis, C. N. (2016). Marine microplastics spell big problems for future generations. Proceedings

	of the National Academy of Sciences, 113(9), 2331–2333. https://doi.org/10.1073/pnas.1600715113 7. Ghalambor, C. K., McKay, J. K., Carroll, S. P., & Reznick, D. N. (2007). Adaptive versus non-adaptive phenotypic plasticity and the potential for contemporary adaptation in new environments. Functional Ecology, 21(3), 394–407. https://doi.org/10.1111/j.1365-2435.2007.01283.x 8. Grosell, M., & Brix, K. V. (2009). Ionic and osmotic regulation. In J. H. Thorp & A. P. Covich (Eds.), Ecology and Classification of North American Freshwater Invertebrates (3rd ed., pp. 525–561). Academic Press. 9. Gunderson, A. R., & Stillman, J. H. (2015). Plasticity in thermal tolerance has limited potential to buffer ectotherms from global warming. Proceedings of the Royal Society B: Biological Sciences, 282(1808), 20150401. https://doi.org/10.1098/rspb.2015.0401 10. Kültz, D. (2015). Physiological mechanisms used by fish to cope with salinity stress. Journal of Experimental Biology, 218(12), 1907–1914. https://doi.org/10.1242/jeb.118695
Web Resources:	1. Intergovernmental Panel on Climate Change. (2023). Sixth Assessment Report (AR6). IPCC. https://www.ipcc.ch 2. National Center for Biotechnology Information. (n.d.). NCBI. U.S. National Library of Medicine. https://www.ncbi.nlm.nih.gov 3. Nature Education. (n.d.). Scitable: A collaborative learning space for science. Nature Publishing Group. https://www.nature.com/scitable/ 4. NOAA Fisheries. (n.d.). Fish physiology and environmental change. National Oceanic and Atmospheric Administration. https://www.fisheries.noaa.gov 5. PubMed Central. (n.d.). Free full-text archive of biomedical and life sciences journal literature. National Institutes of Health. from https://www.ncbi.nlm.nih.gov/pmc/ 6. Society for Research on Biological Rhythms. (n.d.). SRBR: Advancing biological rhythm research. https://srbr.org 7. The Washington Post. Clownfish shrinkage during heat waves. https://www.washingtonpost.com/climate-solutions/2025/05/21/clownfish-shrink-climate-warming-water/ 8. United Nations Environment Programme. (n.d.). UNEP: Science, policy and action for the environment. https://www.unep.org

Title of the Course	Practical in Environmental Physiology and Adaptation
Course Code	ZOO-5003
Number of Credits	1
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To evaluate thermal and salinity tolerance in fish and bivalves through CTmax determination and analysis of osmoregulatory adaptations. • To examine behavioral responses to environmental stress by monitoring shell closure in bivalves and circadian activity rhythms in fish. • To assess excretory responses in fish under thermal stress, focusing on changes in nitrogenous waste excretion. • To detect biochemical and molecular stress markers in aquatic organisms exposed to pollutants.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Demonstrate the ability to assess thermal and salinity tolerance in aquatic organisms through CTmax measurements and osmoregulatory evaluations.	PO1

	CO 2. Interpret behavioral responses to environmental stressors, including shell closure in bivalves and shifts in circadian rhythms in fish.		PO2	
	CO 3. Evaluate changes in excretory patterns under thermal stress, focusing on nitrogenous waste products and related physiological parameters.		PO3	
	CO 4. Apply biochemical and molecular techniques to detect stress biomarkers such as HSP70, MDA, and GST in fish and bivalves exposed to pollutants.		PO3 & PO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Practical techniques in environmental physiology under stress	1.1 Thermal Tolerance in Fish (CTmax)- Determination of Critical Thermal Maximum (CTmax)	**2**	CO1	K3, K4
	1.2 Thermal Tolerance in Fish (CTmax)- CTmax comparison in acclimated vs. non-acclimated fish.	**2**	CO1	K4
	1.3 Thermal Tolerance in Fish (CTmax)- Recovery assessment post thermal stress	**2**	CO1	K4, K5
	1.4 Effect of Salinity on Osmoregulation in Bivalves or Fish- Hemolymph/osmolarity measurement in bivalves exposed to varying salinities	**2**	CO1	K3, K4
	1.5 Effect of Salinity on Osmoregulation in Bivalves or Fish- Gill Na^+/K^+-ATPase activity in fish under hypo- and hyper-osmotic stress	**2**	CO1	K3, K4
	1.6 Effect of Salinity on Osmoregulation in Bivalves or Fish-Morphological changes in chloride cells under salinity shifts	**2**	CO1	K2, K4
	1.7 Shell Closure Behavior in Bivalves Under Pollutant Stress- Measurement of Valve Closure/Siphon Opening Frequency	**2**	CO2	K3, K4
	1.8 Shell Closure/ Siphon opening behavior in Bivalves Under Pollutant Stress- Response latency and recovery period post exposure to heavy metals.	**2**	CO2	K4, K5

	1.9 Shell Closure Behavior in Bivalves Under Pollutant Stress- Comparative analysis of shell closure under different pollutants (e.g., pesticides vs. oil)	**2**	CO2	K4, K5
	1.10 Determination of Excretory Products in Fish upon Thermal Stress (Ammonotelism)	**2**	CO3	K3, K4
	1.11 Detection of Stress Biomarkers in Bivalve/Fish Exposed to Pollutants- Heat shock proteins (HSP70) quantification in gill or muscle tissue	**2**	CO4	K3, K4
	1.12 Detection of Stress Biomarkers in Bivalve/Fish Exposed to Pollutants- Measurement of malondialdehyde (MDA) as lipid peroxidation marker	**2**	CO4	K3, K4
	1.13 Detection of Stress Biomarkers in Bivalve/Fish Exposed to Pollutants- Glutathione S-transferase (GST) activity (detoxification enzyme) assay in liver tissue	**2**	CO4	K3, K4
	1.14 Monitoring Shifts in Circadian Rhythm in Fish Under Environmental Stress- behavioral rhythms tied to light cycle/dark cycle in control fish.	**2**	CO2	K3, K4
	1.15 Monitoring Shifts in Circadian Rhythm in Fish Under Environmental Stress- behavioral rhythms tied to light cycle/dark cycle in pollutant exposed fish.	**2**	CO2	K4, K5
Pedagogy:	Pre-lab Briefings and Conceptual Demonstrations /Guided Hands-on Experiments /Observation and Recording / Group-Based Learning and Peer Collaboration /Data Analysis and Interpretation / Post-lab Discussions / Scientific Reflection /Ethical and Biosafety Training			
Texts:	1. Beitinger, T. L., Bennett, W. A., & McCauley, R. W. (2000). *Temperature Tolerances of North American Freshwater Fishes Exposed to Dynamic Changes in Temperature*. Environmental Biology of Fishes, 58(3), 237–275 2. Bradshaw, S. D. (2003). *Vertebrate Ecophysiology: An Introduction to its Principles and Applications*. Cambridge University Press. 3. Evans, D. H., Claiborne, J. B., & Currie, S. (2013). *The physiology of fishes* (4th ed.). CRC Press. 4. Heath, A. G. (1995). *Water Pollution and Fish Physiology* (2nd ed.). CRC Press. 5. Hochachka, P. W., & Somero, G. N. (2002). *Biochemical adaptation: Mechanism and process in physiological evolution*. Oxford University Press.			

	6. Nelson, J. S., Grande, T. C., & Wilson, M. V. H. (2016). *Fishes of the world* (5th ed.). Wiley. 7. Pörtner, H. O., Farrell, A. P., & Randall, D. J. (Eds.). (2006). *Fish Physiology: The Physiology of Polar Fishes* (Vol. 22). Academic Press. 8. Prosser, C. L. (Ed.). (1991). *Comparative Animal Physiology: Environmental and Metabolic Animal Physiology* (4th ed.). Wiley-Liss. 9. Randall, D., Burggren, W., French, K., & Eckert, R. (2002). *Eckert animal physiology: Mechanisms and adaptations* (5th ed.). W.H. Freeman. 10. Sejian, V., Gaughan, J., Baumgard, L., & Prasad, C. S. (2018). *Climate change impact on livestock: Adaptation and mitigation*. Springer Nature. 11. Walker, C. H., Sibly, R. M., Hopkin, S. P., & Peakall, D. B. (2012). *Principles of ecotoxicology* (4th ed.). CRC Press. 12. Withers, P. C., Cooper, C. E., Maloney, S. K., Bozinovic, F., & Cruz-Neto, A. P. (2016). *Ecological and environmental physiology of mammals* (2nd ed.). Oxford University Press.
References/ Readings:	1. Bamber, R. N. (1990). The effects of pollutants on the behavior and physiology of bivalve molluscs. In R. N. Gibson & M. Barnes (Eds.), *Behavior and physiology of marine animals* (pp. 1–25). Springer. https://doi.org/10.1007/978-1-4612-3130-4_1 2. Bianchini, A., & Wood, C. M. (2008). The effects of salinity on the physiology of aquatic animals. *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology, 151*(3), 1–10. https://doi.org/10.1016/j.cbpa.2008.02.001 3. Desforges, J.-P. W., et al. (2023). The ecological relevance of critical thermal maxima methodology for fishes. *Journal of Fish Biology*. https://doi.org/10.1111/jfb.15368 4. Gauthier, J. M., & Vijayan, M. M. (2015). Physiological responses of marine invertebrates to salinity stress. *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology, 190*, 1–10. https://doi.org/10.1016/j.cbpa.2015.07.001 5. Gauthier, J. M., Vijayan, M. M., & Moon, T. W. (2015). Ammonia excretion and nitrogen metabolism in fish exposed to thermal stress. *Journal of Experimental Biology, 218*(15), 2345–2353. https://doi.org/10.1242/jeb.118244 6. Gauthier, J. M., Vijayan, M. M., & Moon, T. W. (2015). Biomarkers of oxidative stress in fish exposed to environmental pollutants. *Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology, 171*, 1–10. https://doi.org/10.1016/j.cbpc.2014.11.001

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Web Resources:	1. Intergovernmental Panel on Climate Change. (2023). *Climate change 2023: The physical science basis*. IPCC. https://www.ipcc.ch/report/ar6/wg1/ 2. Marine Biological Association. (n.d.). *Physiology and adaptation of marine organisms*.https://www.mba.ac.uk/research/research-themes/physiologyNational Center for Biotechnology Information. (n.d.). *PubMed Central: Free full-text archive of biomedical and life sciences journal literature*. U.S. National Library of Medicine. https://www.ncbi.nlm.nih.gov/pmc/ 3. Nature Education. (n.d.). *Scitable: A collaborative learning space for science*. Nature Publishing Group. https://www.nature.com/scitable/ 4. NOAA Fisheries. (n.d.). *Fish physiology and environmental change*. National Oceanic and Atmospheric Administration. https://www.fisheries.noaa.gov/topic/fish-physiology-environmental-change 5. Society for Experimental Biology. (n.d.). *Environmental physiology of animals*. https://www.sebiology.org/environmental-physiology 6. Society for Research on Biological Rhythms. (n.d.). *SRBR: Advancing biological rhythm research*. https://srbr.org/ 7. United Nations Environment Programme. (n.d.). *Science, policy, and action for the environment*. https://www.unep.org/

Title of the Course	Advanced Ecological Principles and Applications
Course Code	ZOO-5004
Number of Credits	03
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites For the Course:	Nil	
Course Objectives:	• To provide comprehensive understanding of ecological concepts, including population dynamics, community structure, and ecosystem function. • To develop the skills to design and implement ecological research studies, including data collection, analysis, and interpretation. • To examine complex ecological interactions and relationships, including the impact of human activities on ecosystems. • To foster critical thinking and problem-solving skills, allowing them to apply ecological principles and methods to real-world environmental challenges.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**

	CO 1. Explain the fundamental principles of ecology, including population dynamics and community structure, to demonstrate a thorough understanding of ecological systems		PSO1	
	CO 2. Design and implement research studies using various ecological methods, such as field experiments and statistical analysis, to investigate ecological phenomena and address real-world problems		PSO2	
	CO 3. Examine complex ecological data to identify patterns, trends, and relationships, and draw meaningful conclusions about ecological systems		PSO3	
	CO 4. Assess the effectiveness of conservation strategies and management practices in maintaining ecosystem health and biodiversity, and make informed recommendations for improvement		PSO4	
Content:	**Module**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Ecological Theory and Principles	1.1 Introduction to Ecology: Overview of Ecology, Natural History.	**01**	CO1, CO3	K2, K4
	1.2 Population ecology: Distribution and spatial structure of population, Macroecology and population density, Ecological niche modelling, Population growth and regulation.	**04**	CO1, CO3	K2, K4
	1.3 Community ecology: Foundations of Community Ecology**:** Concepts of community: definitions, boundaries, and scales, Functional and phylogenetic approaches to community assembly, Metacommunity theory: patch dynamics, species sorting, mass effects.	**04**	CO1, CO3	K2, K4
	1.4 Landscape ecology and habitat heterogeneity, Beta diversity: turnover and nestedness, Edge effects and matrix quality in fragmented habitats.	**03**	CO1, CO3	K2, K4
	1.5 Concept of Island Biogeography: Theory of Island Biogeography, Empirical tests and predictions: immigration, extinction, area, and isolation, Extensions of island	**03**	CO1, CO3	K2, K4

	biogeography, Nestedness and community structure, Island syndromes in species traits.			
Module 2: Climate-Responsive and Technological Applications in Ecology	2.1 Integrated Approaches in Applied Ecology: Scope and importance of applied ecology in the Anthropocene, Spatial ecology: analysing habitat fragmentation, edge effects, and landscape permeability, Process-based and mechanistic modeling of ecological interactions.	**04**	CO2, CO3	K3, K4
	2.2 Ecological responses to climate change: range shifts, phenology, extinction risks, Modelling species distributions under future climates (SDMs), GIS and remote sensing in ecological monitoring.	**04**	CO2, CO3	K3, K4
	2.3Disease ecology and zoonotic spillover. Ecological economics and valuation of ecosystem services, Ecosystem-based adaptation (EbA).	**02**	CO2, CO3	K3, K4
	2.4 Ecological Informatics & Statistical Ecology: Experimental design for multifactorial and long-term ecological research and Machine learning applications in species distribution modelling (SDM), ecological forecasting, Lotka-Volterra models (predator-prey, competition)	**05**	CO2, CO3	K3, K4
Module 3: Integrative Approaches in Biodiversity Conservation and Ecosystem Resilience	3.1Conservation biology: principles and applications: Population viability analysis (PVA): demographic and genetic models, extinction risk assessment, Metapopulation and landscape ecology approaches: managing fragmented populations across dynamic landscapes, Case studies: application of advanced tools and frameworks in biodiversity hotspots.	**03**	CO2, CO4	K4, K5
	3.2Mechanisms of Species Interactions and Community Structure: Effects of interactions on community assembly, species coexistence, and niche differentiation, Role of trait-mediated and density-mediated interactions in shaping biodiversity patterns, Interaction strength and context-dependency in ecological networks.	**04**	CO2, CO4	K4, K5
	3.3 Resilience, Adaptation, and System-Level Responses: Concepts of ecological resilience, resistance, and regime shifts in complex systems, Adaptive capacity in	**04**	CO2, CO4	K4, K5

	organisms and ecosystems, socio-ecological frameworks and policy integration for sustainable ecosystem governance.			
	3.4 Ecosystem Functioning under Environmental Change: Functional diversity and redundancy as buffers against environmental change, integrating ecosystem function with landscape-scale conservation and restoration strategies, Influence of global change drivers on ecosystem processes, Impacts of altered disturbance regimes.	**04**	CO2, CO4	K4, K5
Pedagogy:	• Lectures to review key concepts, theories, and principles in ecology, using visual aids, examples, and case studies. • Case studies to illustrate ecological concepts and principles, and encourage students to analyze and discuss the cases. • Group discussions to facilitate critical thinking, problem-solving, and collaboration among students, focusing on topics such as conservation strategies, ecological management, and environmental policy. • Hands-on activities, such as field trips, experiments, and data collection, to provide students with practical experience in ecological research and methods. • Use a variety of assessment tools, including quizzes, exams, research papers, and presentations, to evaluate student learning and provide constructive feedback.			
Texts:	Smith, T. M., & Smith, R. L. (2020). Elements of Ecology (9th ed.). Pearson.			
References/ Readings:	1. Krebs, C. J. (2018). Ecological Methodology (3rd ed.). Addison-Wesley. 2. Quinn, G. P., & Keough, M. J. (2018). Experimental Design and Data Analysis for Biologists (2nd ed.). Cambridge University Press. 3. Primack, R. B. (2019). Essentials of Conservation Biology (7th ed.). Sinauer Associates. 4. Molles, M. C. (2020). *Ecology: Concepts and Applications* (8th ed.). McGraw-Hill Education. 5. Wright, R. T., & Boorse, D. F. (2020). Environmental Science: Toward a Sustainable Future (14th ed.). Pearson. 6. Cain, M. L., Bowman, W. D., & Hacker, S. D. (2017). *Ecology* (4th ed.). Sinauer Associates. 7. Tilman, D. (1999).*The ecological consequences of changes in biodiversity: a search for general principles*. Ecology, 80(5), 1455–1474. 8. Hubbell, S. P. (2001).*The Unified Neutral Theory of Biodiversity and Biogeography*. Princeton University Press.			

	9. Schluter, D. (2000).*The Ecology of Adaptive Radiation*. Oxford University Press. 10. Primack, R. B. (2022). *Essentials of Conservation Biology* (7th ed.). Oxford University Press. 11. Groom, M. J., Meffe, G. K., & Carroll, C. R. (2006). *Principles of Conservation Biology* (3rd ed.). Sinauer Associates. 12. Chapin III, F. S., Matson, P. A., &Vitousek, P. M. (2011). *Principles of Terrestrial Ecosystem Ecology* (2nd ed.). Springer. 13. Sutherland, W. J. (2006). *Ecological Census Techniques: A Handbook* (2nd ed.). Cambridge University Press.
Web Resources:	1. PubMed Central (free full-text biomedical and ecological literature) https://www.ncbi.nlm.nih.gov/pmc/ 2. PLOS Biology & PLOS ONE – Open-access journals with many ecology and evolution articles https://journals.plos.org/plosbiology/ 3. GBIF (Global Biodiversity Information Facility) https://www.gbif.org/ 4. IUCN Red List – Global database of threatened species https://www.iucnredlist.org/ 5. Tree of Life Web Project – Phylogeny browser http://tolweb.org/tree/ 6. Encyclopedia of Life (EOL) – Aggregated species information https://eol.org/ 7. iNaturalist – Biodiversity observations and citizen science https://www.inaturalist.org/ 8. Phylogeny Programs List (Joseph Felsenstein, U. of Washington) http://evolution.genetics.washington.edu/phylip/software.html 9. Evolution 101 by UC Berkeley https://evolution.berkeley.edu/evolibrary/article/evo_01 10. Understanding Evolution (Teacher-friendly portal) https://evolution.berkeley.edu

Theory/Practical	Practical in Advanced Ecological Principles and Applications
Code	ZOO-5005
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites For the Course:	Nil	
Course Objectives:	• Understand ecological methods and metrics. • Quantify ecosystem functions. • Apply ecological survey methods to collect and interpret data. • Promote sustainability and conservation and recommend mitigation strategies based on ecological principles.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain key ecological principles such as community structure and diversity indices, and their applications in understanding ecosystems.	PSO1, PSO3
	CO 2. Measure and analyze ecological parameters, including primary productivity and biodiversity metrics, using appropriate field and analytical tools.	PSO2, PSO3
	CO 3. Evaluate field data collected from ecological surveys to assess species distributions and	PSO1, PSO3

	ecosystem functionality.			
	CO 4. Design and recommend sustainable solutions to mitigate human impacts on ecosystems based on ecological assessments.		PSO3, PSO4	
Content:	**Modules**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1. Analysing community structure using species-area curve.	**04**	CO1, CO2	K2, K3
	2. Measuring Functional Trait and Link traits to ecosystem processes like productivity or resilience.	**04**	CO1, CO2	K2, K3
	3. Analyzing ecological data using Alpha and Beta diversity.	**06**	CO2, CO3	K3, K4
	4. Conducting bird survey using point count method.	**04**	CO2, CO3	K3, K4
	5. Conducting an ecological field trip to a nearby ecosystem.	**08**	CO3, CO4	K5, K4
	6. Citizen Science Data Evaluation: Use open biodiversity databases (eBird, iNaturalist, GBIF) and Evaluate bias, data quality, and spatial resolution.	**06**	CO3, CO4	K5, K4
Pedagogy:	• Field-based learning • Hands-on practical's to introduce key concepts, theories, and principles in ecology, using visual aids, examples, and case studies. • Case studies to illustrate ecological concepts and principles, and encourage students to analyze and discuss the cases. • Group discussions to facilitate critical thinking, problem-solving, and collaboration among students, focusing on topics such as conservation strategies, ecological management, and environmental policy. • Hands-on activities, such as field trips, experiments, and data collection, to provide students with practical experience in ecological research and methods. • Use a variety of assessment tools, including quizzes, exams, research papers, and presentations, to evaluate student learning and provide constructive feedback.			

Texts:	Smith, T. M., & Smith, R. L. (2020). Elements of Ecology (9th ed.). Pearson.
References/ Readings:	1. Krebs, C. J. (2018). Ecological Methodology (3rd ed.). Addison-Wesley. 2. Quinn, G. P., & Keough, M. J. (2018). Experimental Design and Data Analysis for Biologists (2nd ed.). Cambridge University Press. 3. Primack, R. B. (2019). Essentials of Conservation Biology (7th ed.). Sinauer Associates. 4. Molles, M. C. (2020). *Ecology: Concepts and Applications* (8th ed.). McGraw-Hill Education. 5. Wright, R. T., & Boorse, D. F. (2020). Environmental Science: Toward a Sustainable Future (14th ed.). Pearson. 6. Cain, M. L., Bowman, W. D., & Hacker, S. D. (2017). *Ecology* (4th ed.). Sinauer Associates. 7. Tilman, D. (1999).*The ecological consequences of changes in biodiversity: a search for general principles*. Ecology, 80(5), 1455–1474. 8. Hubbell, S. P. (2001).*The Unified Neutral Theory of Biodiversity and Biogeography*. Princeton University Press. 9. Schluter, D. (2000).*The Ecology of Adaptive Radiation*. Oxford University Press. 10. Primack, R. B. (2022). *Essentials of Conservation Biology* (7th ed.). Oxford University Press. 11. Groom, M. J., Meffe, G. K., & Carroll, C. R. (2006). *Principles of Conservation Biology* (3rd ed.). Sinauer Associates. 12. Chapin III, F. S., Matson, P. A., &Vitousek, P. M. (2011). *Principles of Terrestrial Ecosystem Ecology* (2nd ed.). Springer. 13. Sutherland, W. J. (2006). *Ecological Census Techniques: A Handbook* (2nd ed.). Cambridge University Press.
Web Resources:	1. PubMed Central (free full-text biomedical and ecological literature) https://www.ncbi.nlm.nih.gov/pmc/ 2. PLOS Biology & PLOS ONE – Open-access journals with many ecology and evolution articles https://journals.plos.org/plosbiology/ 3. GBIF (Global Biodiversity Information Facility) https://www.gbif.org/ 4. IUCN Red List – Global database of threatened species https://www.iucnredlist.org/ 5. Tree of Life Web Project – Phylogeny browser http://tolweb.org/tree/ 6. Encyclopedia of Life (EOL) – Aggregated species information https://eol.org/ 7. iNaturalist – Biodiversity observations and citizen science https://www.inaturalist.org/

	8. Phylogeny Programs List (Joseph Felsenstein, U. of Washington) http://evolution.genetics.washington.edu/phylip/software.html 9. Evolution 101 by UC Berkeley https://evolution.berkeley.edu/evolibrary/article/evo_01 10. Understanding Evolution (Teacher-friendly portal) https://evolution.berkeley.edu

Title of the Course	Advanced Biochemistry
Course Code	ZOO-5006
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To understand the fundamental principles of biochemistry. • To analyze the biochemical pathways underlying metabolism and energy production in animals. • To assess the medical significance of metabolic processes, including their implications in diseases. • To introduce modern techniques for biochemical analysis.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Understand biochemical principles	PSO 1
	CO 2. Illustrate metabolic pathways and their interrelations	PSO 2
	CO 3. Determine the medical implications of metabolism	PSO 4
	CO 4. Utilize techniques for biochemical analysis	PSO 3

Content:	Topic	No of hours	Mapped to CO	Cognitive Level
Module 1:	1.1 Structural Basis of Enzyme Function: Overview of enzyme classes (IUBMB classification), Domain architecture and modularity of enzymes Active site structure and substrate binding models (lock & key, induced fit)	**2**	CO1	K2, K3
	1.2 Enzyme Catalysis Mechanisms: Chemical strategies - acid-base, covalent, metal-ion catalysis; Transition state theory and energy profile diagrams, examples: chymotrypsin, lysozyme, enolase, aldolase	**2**	CO 1	K2, K3
	1.3 Cofactors and Coenzymes: Metal cofactors, prosthetic groups, vitamins as coenzymes; Role of NAD^+/$NADP^+$, FAD, PLP, TPP, biotin in enzymatic reactions	**2**	CO 1	K2, K3
	1.4 Allosteric Regulation and Cooperativity; Homotropic and heterotropic effectors; MWC ((Monod–Wyman–Changeux Model) and KNF (Koshland–Némethy–Filmer Model) models; Case studies: ATCase, phosphofructokinase	**2**	CO 1	K2, K3
	1.5 Enzyme Isoforms and Multienzyme Complexes: Functional specialization of isoenzymes (e.g., LDH); Pyruvate dehydrogenase complex: structure and mechanism; Substrate channeling and metabolon organization	**2**	CO 1	K2, K3
	1.6 Overview of enzyme kinetics: Derivation and assumptions of the Michaelis–Menten equation; Rapid equilibrium vs steady-state approximation; Lineweaver–Burk plots	**1**	CO 1	K2
	1.7 Enzyme inhibition: Reversible and irreversible, covalent modification, suicide inactivtors; Enzyme inhibitors as important medical drugs, examples: aspirin, ibuprofen, penicillin, difluoromethylornithine	**2**	CO 1	K3, K4
	1.8 Kinetics of Multi-Substrate Reactions: Sequential (ordered/random) and ping-pong mechanisms; Case studies: hexokinase, aspartate transaminase	**2**	CO 2	K3, K4
Module 2:	2.1 Key regulatory enzymes in glycolysis, TCA, gluconeogenesis; ATP-producing and rate-limiting enzymes: hexokinase, PFK-1, citrate synthase, etc. Feedback inhibition and hormonal control	**2**	CO 2	K3

	2.2 Post-Translational Modifications (PTMs) of Enzymes: Phosphorylation, acetylation, ubiquitination PTMs in metabolic regulation (examples: glycogen phosphorylase, AMPK)	**2**	CO 2	K3
	2.3 Diagnostic enzymes: CK-MB, ALT, AST, GGT	**1**	CO 2	K3, K4
	2.4 Synthesis of fatty acids, steroid hormones; Eicosanoids: types, outline of biosynthesis and their physiological importance	**2**	CO 2	K2, K3
	2.5 Lipoprotein Transport Systems: Chylomicrons, VLDL, LDL, HDL – apolipoproteins, receptor-mediated endocytosis; Cholesterol Homeostasis and Feedback Regulation: Role of SREBPs, LDL receptor recycling, ACAT, LXR pathways.	**2**	CO2	K3, K4
	2.5 Implications of glucose in medical conditions: hyperglycemia, diabetes, cancer, metabolic ketoacidosis; mechanism of action of important drugs in controlling and managing these conditions	**2**	CO 3	K3, K4, K5
	2.6 Implications of protein and nucleotide in medical conditions: edema, kwashiorkor, gout, renal calculi; mechanism of action of important drugs in controlling and managing these conditions	**2**	CO 3	K3, K4, K5
	2.7 Implications of fatty acids and cholesterol in medical conditions: atherosclerosis, heart attack and stroke, metabolic syndrome, obesity; mechanism of action of important drugs in controlling and managing these conditions	**2**	CO 3	K3, K4, K5
Module 3: Biosignaling, Membrane transport and Biochemical Techniques	3.1 Biosignaling: Signal transduction, G protein-coupled receptors and secondary messengers, receptor tyrosine kinases	**3**	CO 2	K3, K4
	3.2 Membrane transport: transporters - active and passive transport, glucose transporter, chloride-bicarbonate exchanger, ATPases; inhibitors of transporters	**2**	CO 2	K3, K4
	3.3 Membrane transport: channels – ion-selective, voltage-gated, aquaporins, consequences of defective channels.	**2**	CO 2	K3, K4
	3.4 Working with biomolecules: purification, separation and quantification techniques and qualitative analyses of carbohydrates, proteins and lipids	**4**	CO 4	K4, K5

	3.5 Determination of carbohydrate, protein and lipid sizes and structures using mass spectrometry, next generation sequencing, nuclear magnetic resonance, X-ray diffraction, Electron microscopy	**4**	CO 4	K4, K5
Pedagogy:	• Lectures to review and introduce core concepts • ICT-based learning using animations and illustrations to understand mechanisms of action • Problem-based learning using case studies of diseases and application of core concepts • Small group discussions to review and recommend effective treatment strategies for metabolic diseases • Collaborative learning and group projects • Evaluation using quizzes and assignments			
Texts:	1. Berg, J. M., Gatto, G. J., Hines, J. K., Tymoczko, J. L., & Stryer, L. (2023). Biochemistry (10th ed.). W.H. Freeman and Company. 2. Hofmann, A., & Clokie, S. (2018). Wilson & Walker's Principles and techniques of biochemistry and molecular biology (8th ed.). Cambridge University Press. 3. Malik, D., Narayanasamy, N., Pratyusha, V. A., Thakur, J., & Sinha, N. (2023). Textbook of nutritional biochemistry (1st ed.). Springer Nature Singapore. 4. Nelson, D. L., & Cox, M. M. (2021). Lehninger principles of biochemistry (8th ed.). W.H. Freeman and Company. 5. Papachristodoulou, D., Snape, A., Elliott, W. H., & Elliott, D. C. (2018). Biochemistry and molecular biology (6th ed.). Oxford University Press. 6. Rodwell, V. W., Bender, D. A., Botham, K. M., Kennelly, P. J., & Weil, P. A. (2021). Harper's illustrated biochemistry (32nd ed.). McGraw Hill. 7. Voet, D., Voet, J. G., & Pratt, C. W. (2021). Fundamentals of biochemistry: Life at the molecular level (6th ed.). Wiley.			
References/ Readings:	1. Akram, M., Munir, N., Daniyal, M., Egbuna, C., Găman, M. A., Onyekere, P. F., & Olatunde, A. (2020). Vitamins and Minerals: Types, sources and their functions. Functional foods and nutraceuticals: bioactive components, formulations and innovations, 149-172. 2. Copeland, R. A., Harpel, M. R., & Tummino, P. J. (2007). Targeting enzyme inhibitors in drug discovery. Expert opinion on therapeutic targets, 11(7), 967-978.			

	3. Ferreira, C. M., Pinto, I. S., Soares, E. V., & Soares, H. M. (2015). (Un) suitability of the use of pH buffers in biological, biochemical and environmental studies and their interaction with metal ions–a review. RSC Advances, 5(39), 30989-31003. 4. Hanna, M., Jaqua, E., Nguyen, V., & Clay, J. B. (2022). Vitamins: functions and uses in medicine. Perm. J, 26(2), 89-97. 5. Howell, S., & Kones, R. (2017). "Calories in, calories out" and macronutrient intake: the hope, hype, and science of calories. American Journal of Physiology-Endocrinology and Metabolism. 6. Li, D., Yi, J., Han, G., & Qiao, L. (2022). MALDI-TOF mass spectrometry in clinical analysis and research. ACS measurement science au, 2(5), 385-404. 7. Ludwig, D. S., & Ebbeling, C. B. (2018). The carbohydrate-insulin model of obesity: beyond "calories in, calories out". JAMA internal medicine, 178(8), 1098-1103. 8. National Institute of Nutrition. (2024). Dietary guidelines for Indians - 2024. Indian Council of Medical Research. 9. Saini, R. K., Prasad, P., Shang, X., & Keum, Y. S. (2021). Advances in lipid extraction methods—a review. International Journal of Molecular Sciences, 22(24), 13643. 10. Song, Y., Liu, J., Zhao, K., Gao, L., & Zhao, J. (2021). Cholesterol-induced toxicity: An integrated view of the role of cholesterol in multiple diseases. Cell metabolism, 33(10), 1911-1925. 11. Wang, D., & DuBois, R. N. (2010). Eicosanoids and cancer. Nature Reviews Cancer, 10(3), 181-193. 12. Willett, W. C., Koplan, J. P., Nugent, R., Dusenbury, C., Puska, P., & Gaziano, T. A. (2006). Prevention of chronic disease by means of diet and lifestyle changes. Disease Control Priorities in Developing Countries. 2nd edition.
Web Resources:	1. Basic concepts in chemistry https://chem.libretexts.org/Bookshelves 2. Cell Signalling Pathways https://www.cellsignal.com/pathways?srsltid=AfmBOopGR_WXX78qeZdjMDS6vnGQGvnMkTwwGgDYTMwN4pXBhOrWSfr6 3. Enzyme data base https://www.brenda-enzymes.org/ 4. National Institute of Nutrition. (2024). Dietary guidelines for Indians - 2024. Indian Council of Medical Research. https://efi.org.in/journal/index.php/JEFI/article/download/42/48 5. Protein data bank https://www.rcsb.org/ 6. Resources to Teach and Learn Chemistry https://chemcollective.org/

	7. The Human Metabolome data base https://hmdb.ca/

Title of the Course	Practical in Advanced Biochemistry
Course Code	ZOO-5007
Number of Credits	1
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• Understand the Basics of Biochemical Techniques • Quantify Biomolecules in Biological Samples • Analyze Enzyme Activity and Kinetics • Apply Advanced Techniques for Biochemical Studies	
Course Outcomes:		**Mapped to PSO**
	CO 1. Prepare Buffers and Reagents with Precision	PSO2
	CO 2. Estimate and Quantify Biomolecules in Tissues	PSO2, PSO3
	CO 3. Evaluate Enzyme Activity and Environmental Effects	PSO3
	CO 4. Apply Advanced Analytical Techniques	PSO2, PSO3

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1: Practicals	1.1 Preparation of biological buffers and standard reagents	**2**	CO 1	K3
	1.2 Extraction of major biomolecules from different tissues of fish.	**2**	CO 2	K4
	1.3 Estimation of total proteins in different tissues of fish	**2**	CO 2	K4
	1.4 Estimation of total carbohydrates in different tissues of fish	**2**	CO 2	K4
	1.5 Estimation of cholesterol in egg and different tissues of fish	**2**	CO 2	K4
	1.6 Estimation of total lipid content from the extracted samples of fish	**2**	CO 2	K4
	1.7 Estimation of amino acid content in different tissues of fish	**2**	CO 2	K4
	1.8 Estimation of reducing sugars from given samples using Dinitrosalicylic Acid method, Fehling's test and Benedict's test	**2**	CO 2	K4
	1.9 Estimation of catalase by decomposition of hydrogen peroxide	**2**	CO 2	K5
	1.10 Titration of an acid with conjugated base and determination of equivalence point / pKa	**2**	CO 3	K5
	1.11 Determination of Km and Vmax of Na+ -K + - ATPase/ Acetylcholinesterase.	**2**	CO 3	K5
	1.12 Protein purification techniques (salt precipitation, dialysis, chromatography)	**2**	CO 3	K5
	1.13 Fractionation of Lipid moieties through TLC (demo).	**2**	CO 4	K5
	1.14 Electrophoresis of proteins using SDS-PAGE (demo)	**2**	CO 4	K5
	1.15 Isoelectric Focusing (IEF) of Amino Acids or Proteins (demo)	**2**	CO 4	K5
Pedagogy:	• Hands-On Practical Training • Problem-Based Learning • Interactive Demonstrations • Teamwork and collaborative learning • ICT-Enhanced learning			

	• Recording and Journal-keeping
Texts:	1. Nelson, D. L., & Cox, M. M. (2021). Lehninger principles of biochemistry (8th ed.). W.H. Freeman and Company. 2. Plummer, D. T. (2017). An introduction to practical biochemistry (3rd ed.). McGraw-Hill. 3. Voet, D., Voet, J. G., & Pratt, C. W. (2021). Fundamentals of biochemistry: Life at the molecular level (6th ed.). Wiley. 4. Wilson, K., & Walker, J. (2018). Principles and techniques of biochemistry and molecular biology (8th ed.). Cambridge University Press.
References/ Readings:	1. Aebi, H. E. (1984). Catalase in vitro. Methods in Enzymology, 105, 121-126. 2. Caruso, G., Floris, R., Serangeli, C., & Di Paola, L. (2020). Fishery wastes as a yet undiscovered treasure from the sea: Biomolecules sources, extraction methods and valorization. Marine drugs, 18(12), 622. 3. Chakravarti, D. N., Chakravarti, B., & Mallik, B. (2014). Reagent preparation: Theoretical and practical discussions. Current Protocols Essential Laboratory Techniques, 9(1), 3-1. 4. Li, L. H., Dutkiewicz, E. P., Huang, Y. C., Zhou, H. B., & Hsu, C. C. (2019). Analytical methods for cholesterol quantification. Journal of food and drug analysis, 27(2), 375-386. 5. Lowry, O. H., Rosebrough, N. J., Farr, A. L., & Randall, R. J. (1951). Protein measurement with the Folin phenol reagent.
Web Resources:	1. Basic concepts in chemistry and tutorials https://chem.libretexts.org/Bookshelves 2. Biochemical Protocols https://www.protocols.io/

Discipline Specific Elective Courses

Title of the Course	Neural and Genetic Basis of Animal Behaviour
Course Code	ZOO-5201
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil
Course Objectives:	• To introduce students to the evolutionary, neural, and genetic foundations of animal behaviour, emphasizing the integration of Tinbergen's framework with modern ethological and neurogenetic approaches. • To explain how neural circuits and sensory pathways underlie behavioural responses, including reflexes, complex behaviours, and the influence of neurotransmitters and brain regions on motivation, learning, and memory. • To examine the genetic and epigenetic architecture of behaviour, using case studies from model organisms to explore how genes, environment, and developmental cues shape social, reproductive, and cognitive behaviours. • To familiarize students with experimental tools and model systems used in behavioural neuroscience, including ethograms, electrophysiology, molecular techniques, and transgenic animals for studying the brain-behaviour

	interface.			
Course Outcomes:	Students will be able to:		**Mapped to PSO**	
	CO 1. Explain the evolutionary foundations, neural systems, and gene-environment interactions that shape animal behaviour.		PSO1	
	CO 2. Analyze the role of neural circuits, neurotransmitters, and brain regions in regulating behavioural processes such as learning, aggression, and parental care.		PSO1, PSO3	
	CO 3. Evaluate how specific genes and epigenetic modifications influence complex behaviours, including circadian rhythms, migration, and social interactions.		PSO1, PSO3	
	CO 4. Apply behavioural research tools (e.g., ethograms, gene databases, activity tracking) to investigate neurogenetic patterns through field, lab, and computational approaches.		PSO2, PSO3	
Content:	**Topic**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Foundations of Neurogenetics and Behavioural	1.1: Overview of Ethology and Tinbergen's Four Questions – Proximate and ultimate causes, natural selection and behavioural evolution	**4**	CO1	K2
	1.2: Neuroethology and Genoethology – Linking behaviour to neural circuits and genes	**4**	CO1	K2
	1.3: Techniques to Study Behaviour – Ethograms, knockout models, transcriptomics	**4**	CO2	K3
	1.4: Model Systems in Behavioural Biology – Mice (*Mus musculus*), Rat (*Rattus norvegicus),* Drosophila (*Drosophila melanogaster*), Nematode worm (*Caenorhabditis elegans*).	**3**	CO1, CO2	K3
Module 2: Neural Circuits and Behavioural	2.1: Neural Organisation – Neurons, reflex circuits, locomotion, Central Pattern Generators (CPGs)	**4**	CO2	K4
	2.2: Sensory Processing – Visual, auditory, mechanosensory, olfactory; case studies	**4**	CO2	K4

Plasticity	2.3: Neuromodulation – Neurotransmitters, brain regions in behaviour	**4**	CO2	K4
	2.4: Neuroplasticity and Learning – Learning, memory, imprinting, vocal learning	**3**	CO2	K4
Module 3: Genetic Architecture of Behaviour	3.1: Genetic Architecture –Mendelian and Polygenic Inheritance of Behaviour, Qantitative trail Loci (QTL), Genome-Wide Association Studies (GWAS), candidate genes	**4**	CO3	K5
	3.2: Genes in Social & Reproductive Behaviour – Case studies on Oxytocin (OXT), Fruitless (fru), Vasopressin Receptor (AVPR1A), Estrogen Receptor (ESR1), Doublesex (dsx), and Neuroligin-3 (NLGN3).	**4**	CO3	K5
	3.3: Circadian & Migration Genetics – clock genes, photoperiodism	**3**	CO3	K5
	3.4: Epigenetics & Behavioural Plasticity – Stress imprinting, gene methylation	**4**	CO3	K5
Pedagogy:	Lectures/ Conceptual animations/videos/Case-based learning, Computational activities, Group discussions/Formative quizzes, Presenations.			
Texts:	1. Kandel, E. R., Schwartz, J. H., Jessell, T. M., Siegelbaum, S. A., & Hudspeth, A. J. (2013). *Principles of neural science* (5th ed.). McGraw-Hill Education. 2. Zupanc, G. K. H. (2010). *Behavioral neurobiology: An integrative approach*. Oxford University Press. 3. Plomin, R., DeFries, J. C., Knopik, V. S., & Neiderhiser, J. M. (2016). *Behavioral genetics* (7th ed.). Worth Publishers. 4. Cryan, J. F., & Reif, A. (Eds.). (2012). *Behavioral neurogenetics*. Springer. 5. Ewert, J. P. (1980). *Neuroethology: An introduction to the neurophysiological fundamentals of behavior*. Springer-Verlag. 6. Moore, D. S. (2015). *The developing genome: An introduction to behavioral epigenetics*. Oxford University Press. 7. Katz, P. S. (Ed.). (1999). *Beyond neurotransmission: Neuromodulation and its importance for information processing*. Oxford University Press.			
References/ Readings:	1. Bateson, P. (2022). Sixty years of Tinbergen's four questions and their continued relevance. *Behavioral Sciences*, 12(2), 24. https://doi.org/10.3390/bs12020024 2. Johnson, Z. V., & Young, L. J. (2022). The neuroethology of social behavior. *Frontiers in Neural Circuits*, 16,			

897273. https://doi.org/10.3389/fncir.2022.897273

3. Kornfeld, J., & Marder, E. (2018). Linking genes, circuits, and behavior: Network connectivity as a key determinant of behavioral phenotypes. *Current Opinion in Neurobiology*, 52, 133–140. https://doi.org/10.1016/j.conb.2018.05.008
4. de Rosa, G., Calamari, L., Nanni Costa, L., & Ronchi, B. (2023). Evaluating qualitative behavioral assessment and ethogram methodologies. *Applied Animal Behaviour Science*, 258, 105773. https://doi.org/10.1016/j.applanim.2023.105773
5. Bohnslav, J. P., Wimalasena, N. K., Claar, L. D., Varman, B., Dardani, C. J., & Gifford, D. (2021). DeepEthogram: A machine learning pipeline for supervised behavior classification. *eLife*, 10, e63377. https://doi.org/10.7554/eLife.63377
6. Brown, R. E., Corey, S. C., & Moore, A. K. (2004). Mouse behavioral analysis in systems biology. *Current Opinion in Neurobiology*, 14(2), 217–224. https://doi.org/10.1016/j.conb.2004.03.001
7. Kiehn, O. (2016). Decoding the organization of spinal circuits that control locomotion. *Nature Reviews Neuroscience*, 17(4), 224–238. https://doi.org/10.1038/nrn.2016.9
8. Tavassoli, T., Miller, L. J., Schoen, S. A., Nielsen, D. M., & Baron-Cohen, S. (2014). Sensory over-responsivity in adults with autism spectrum conditions. *Autism*, 18(4), 428–432. https://doi.org/10.1177/1362361313477246
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10. Marder, E. (2012). Neuromodulation of neuronal circuits: Back to the future. *Neuron*, 76(1), 1–11. https://doi.org/10.1016/j.neuron.2012.09.010
11. Zatorre, R. J., Fields, R. D., & Johansen-Berg, H. (2012). Plasticity in gray and white: Neuroimaging changes in brain structure during learning. *Nature Neuroscience*, 15(4), 528–536. https://doi.org/10.1038/nn.3045
12. Kolb, B., & Gibb, R. (2014). Searching for the principles of brain plasticity and behavior. *Cortex*, 58, 251–260. https://doi.org/10.1016/j.cortex.2013.11.012
13. Uffelmann, E., Huang, Q. Q., Munung, N. S., Ghoorah, A. W., Okada, Y., Martin, A. R., ... & Posthuma, D. (2021). Genome-wide association studies. *Nature Reviews Methods Primers*, 1(1), 1–21. https://doi.org/10.1038/s43586-021-00056-9
14. Robinson, G. E., Fernald, R. D., & Clayton, D. F. (2008). Genes and social behavior. *Science*, 322(5903), 896–900. https://doi.org/10.1126/science.1159277
15. Yamamoto, D., Koganezawa, M., & Kohatsu, S. (2014). Insect pheromone behavior: Fruitless and doublesex go solo in Drosophila courtship. *Current Opinion in Neurobiology*, 28, 49–56. https://doi.org/10.1016/j.conb.2014.05.005

	16. Wood, S. H., Christian, H. C., & Loudon, A. S. (2015). The role of the circadian clock in seasonal reproduction. *Journal of Endocrinology*, 224(2), R1–R16. https://doi.org/10.1530/JOE-14-0356 17. Nestler, E. J., Peña, C. J., Kundakovic, M., Mitchell, A., & Akbarian, S. (2016). Epigenetic basis of mental illness. *The Neuroscientist*, 22(5), 447–463. https://doi.org/10.1177/1073858415608147 18. Walum, H., Westberg, L., Henningsson, S., Neiderhiser, J. M., Reiss, D., Igl, W., ... & Lichtenstein, P. (2008). Genetic variation in the vasopressin receptor 1a gene (AVPR1A) associates with pair-bonding behavior in humans. *Proceedings of the National Academy of Sciences*, 105(37), 14153–14156. https://doi.org/10.1073/pnas.0803081105 19. Canli, T., & Lesch, K. P. (2007). Long story short: The serotonin transporter in emotion regulation and social cognition. *Nature Neuroscience*, 10(9), 1103–1109. https://doi.org/10.1038/nn1964 20. Jaaro-Peled, H., Ayhan, Y., & Sawa, A. (2010). Animal models of gene-environment interactions in schizophrenia. *Trends in Neurosciences*, 33(9), 457–467. https://doi.org/10.1016/j.tins.2010.06.004 21. Lehner, P. N. (1996). *Handbook of ethological methods* (2nd ed.). Cambridge University Press. 22. Wark, J. D., & Cronin, K. A. (2021). Ethograms: Using behavioral observations to quantify animal welfare. *Journal of Applied Animal Welfare Science*, 24(4), 371–384. https://doi.org/10.1080/10888705.2020.1867188 23. Takahashi, J. S., Hong, H. K., Ko, C. H., & McDearmon, E. L. (2008). The genetics of mammalian circadian order and disorder: Implications for physiology and disease. *Nature Reviews Genetics*, 9(10), 764–775. https://doi.org/10.1038/nrg2430
Web Resources:	1. Institute of Medicine (US) Committee on Assessing Interactions Among Social, Behavioral, and Genetic Factors in Health. (2006). *Genes, behavior, and the social environment: Moving beyond the nature/nurture debate*. National Academies Press (US). https://www.ncbi.nlm.nih.gov/books/NBK19929/ 2. de Waal, F. B. M., & Tyack, P. L. (Eds.). (2014). *Neuroethology of primate social behavior – In the light of evolution*. National Academies Press (US). https://www.ncbi.nlm.nih.gov/books/NBK231635/ 3. Menini, A. (Ed.). (2010). *The neurobiology of olfaction*. CRC Press/Taylor & Francis. https://www.ncbi.nlm.nih.gov/books/NBK55980/ 4. Moore, D. S., & Stoltenberg, S. F. (Eds.). (2006). *Genes, environments, and mouse behavior: Interactions and implications*. National Academies Press (US). https://www.ncbi.nlm.nih.gov/books/NBK25420/ 5. National Research Council (US) Committee on Population. (2010). *Applying genetic study designs to social and behavioral research*. National Academies Press (US). https://www.ncbi.nlm.nih.gov/books/NBK110052/ 6. Animal Behavior Society. (n.d.). *Educational resources*. https://www.animalbehaviorsociety.org/web/education.php

Title of the Course	Practical in Neural and Genetic Basis of Animal Behaviour
Course Code	ZOO-5202
Number of Credits	1
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To introduce students to behaviour-related genetic databases and tools for mining key genes involved in social, aggressive, and communicative behaviours. • To train students in constructing ethograms and collecting behavioural data through structured observation and data compilation using local animal models. • To familiarize students with circadian behaviour tracking and actogram analysis, highlighting the molecular links to genes. • To develop research communication and interpretation skills through gene-behaviour mapping, comparative analysis, and reflective reporting on neurogenetic case studies.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**

	CO 1. Explain the use of behavioural genetics databases and identify the functions of key genes involved in social and communicative behaviour.		PSO1	
	CO 2. Apply field-based observational techniques to construct ethograms and categorize behavioural patterns in animals.		PSO2, PSO3	
	CO 3. Analyze circadian activity data using actograms and relate it to molecular circadian regulators such as per, tim, and clock.		PSO1, PSO3	
	CO 4. Compile and present gene-behaviour reports and behavioural-genomic correlations through comparative analysis and structured reflection.		PSO3, PSO4	
Content:	**Topic**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Practical Applications in Behavioural Neurogenetics	1.1: Analysis of two-photon calcium imaging data from the Allen Brain Observatory's Visual Behavior – 2P dataset in order to explore neural activity patterns or using FlyBase software.	**2**	CO4	K3
	1.2: To retrieve, compare, and interpret gene-specific information for MAOA and AVPR1a from online databases such as NCBI, Ensembl, and GeneCards, with emphasis on their roles in regulating behaviour.	**2**	CO4	K3
	1.3: To mine and interpret genomic and functional information related to the SLC6A4 and FOXP2 genes using bioinformatics databases, with a focus on their roles in mood regulation and language-related behaviours.	**2**	CO4	K3
	1.4: Execution of comparative genomic analysis of selected behavioural genes across multiple species using bioinformatics tools, in order to examine evolutionary conservation, gene structure variation, and functional divergence relevant to behavioural traits.	**2**	CO4	K4
	1.5: Mining and comparison of the clock gene sequences and annotations from a	**2**	CO4	K6

	mammal (mouse), a non-migratory bird, and a migratory bird using bioinformatics databases, and to prepare a gene–behaviour report that highlights their structural variations and behavioural correlates with respect to circadian and seasonal activities. [Clock genes:(period *(per)*, clock *(clk)*, cycle *(cyc)*, timeless *(tim)*]			
	1.6: Identification, and categorization of distinct behavioural patterns observed in fish and cockroach/ any insect, and to organize these behaviours into standardized categories for systematic behavioural analysis.	**2**	CO4	K3
	1.7: Designing a standardized ethogram templates for systematic behavioural data recording by incorporating behavioural categories, operational definitions, time intervals, and observational cues in fish and cockroach/ any insect.	**2**	CO4	K4
	1.8: Observation, identification and categorization of distinct behavioural patterns in locally available animal species in a natural setting, and to organize these behaviours into standardized ethological categories for systematic behavioural analysis.	**2**	CO4	K3
	1.9: Observation, identification and categorization of distinct behavioural patterns in locally available animal species in a semi-natural setting, and to organize these behaviours into standardized ethological categories for systematic behavioural analysis.	**2**	CO4	K3
	1.10: Development of Ethograms and Data Analysis for the observed behavioural patterns in locally available animal species in a semi-natural and natural setting,	**2**	CO4	K4
	1.11: Development of a structured observation schedule for tracking rhythmic behavioural activity across light-dark cycles, with appropriate time intervals, behavioural parameters, and environmental controls.	**2**	CO4	K4
	1.12: Monitoring and recording a time-based behavioural activity of fish over a defined	**2**	CO4	K3

	circadian cycle using direct or video observation techniques-Day 1			
	1.13: Monitoring and recording a time-based behavioural activity of fish over a defined circadian cycle using direct or video observation techniques-Day 2	**2**	CO4	K3
	1.14: Construction of actograms based on observed behavioural data, and to analysis of the periodicity, phase shifts, and activity patterns to interpret circadian rhythmicity.	**2**	CO4	K5
	1.15: To explore research studies related to animal behaviour analysis using ethograms and actograms, and to present student observations in comparison with established findings through visual and oral presentation formats.	**2**	CO4	K6
Pedagogy:	Database Exploration & Digital Learning, Students are introduced to behavioural gene databases Field-Based Observation, Group-Based Peer Learning, Hands-On Computational Tools, Reflective Journaling and guided feedback.			
Texts:	1. Bateson, M., & Nettle, D. (2013). *Ethological and evolutionary approaches to behaviour*. Palgrave Macmillan. 2. Brown, G. R., & Ladle, R. J. (2009). *Ethology: A laboratory manual*. Oxford Education Press. 3. Delgado, M. M., & Sih, A. (2018). *Practical animal behaviour: A field guide for biologists*. University of California Publications. 4. Freeman, S., Quillin, K., Allison, L. A., Black, M., Podgorski, G., Taylor, E., & Carmichael, J. (2020). *Biological science* (6th ed.). Pearson. 5. Griffiths, A. J. F., Wessler, S. R., Carroll, S. B., & Doebley, J. (2020). *Genetics: Analysis of genes and genomes* (10th ed.). Jones & Bartlett Learning. 6. Kalat, J. W. (2018). *Biological psychology* (13th ed.). Cengage. 7. Kalueff, A. V., & Tuohimaa, P. (2005). *Experimental models in behavioural neuroscience*. Springer. 8. Martin, P., & Bateson, P. (2007). *Measuring behaviour: An introductory guide* (3rd ed.). Cambridge University Press. 9. Nelson, R. J. (2017). *An introduction to behavioral endocrinology* (5th ed.). Sinauer Associates. 10. Squire, L. R., Berg, D., Bloom, F. E., du Lac, S., Ghosh, A., & Spitzer, N. C. (2013). *Fundamental neuroscience* (4th ed.). Academic Press. 11. Zupanc, G. K. H. (2010). *Behavioral neurobiology: An integrative approach*. Oxford University Press.			

References/ Readings:	12. Sandi C. (2008). Understanding the neurobiological basis of behavior: a good way to go. *Frontiers in neuroscience*, *2*(2), 129–130. 13. Sweatt J. D. (2016). Neural plasticity and behavior - sixty years of conceptual advances. *Journal of neurochemistry*, *139 Suppl 2*, 179–199. 14. Walsh, R. N., & Cummins, R. A. (1976). The open-field test: A critical review. *Psychological Bulletin*, *83*(3), 482–504.
Web Resources:	1. BioClock Studio. (n.d.). *Teaching resources*. University of California, San Diego. Retrieved May 20, 2025, from https://bioclock.ucsd.edu/teaching-resources/ 2. BrainFacts.org. (n.d.). *Society for Neuroscience*. https://www.brainfacts.org 3. Chronobiology. (n.d.). *Chronobiology* [YouTube playlist]. YouTube. Retrieved May 20, 2025, from https://www.youtube.com/playlist?list=PLcwurkLpSE4YXO6MrF1C_6wLAudxRHkiv 4. Circadian Physiology. (n.d.). *Circadian Physiology* [YouTube channel]. YouTube. Retrieved May 20, 2025, from https://www.youtube.com/@circadianphysiology2863 5. de Waal, F. B. M., & Tyack, P. L. (Eds.). (2014). *Neuroethology of primate social behavior – In the light of evolution*. National Academies Press (US). https://www.ncbi.nlm.nih.gov/books/NBK231635/ 6. Institute of Medicine (US) Committee on Assessing Interactions Among Social, Behavioral, and Genetic Factors in Health. (2006). *Genes, behavior, and the social environment: Moving beyond the nature/nurture debate*. National Academies Press (US). https://www.ncbi.nlm.nih.gov/books/NBK19929/ 7. Menini, A. (Ed.). (2010). *The neurobiology of olfaction*. CRC Press/Taylor & Francis. https://www.ncbi.nlm.nih.gov/books/NBK55980/ 8. Moore, D. S., & Stoltenberg, S. F. (Eds.). (2006). *Genes, environments, and mouse behavior: Interactions and implications*. National Academies Press (US). https://www.ncbi.nlm.nih.gov/books/NBK25420/ 9. National Research Council (US) Committee on Population. (2010). *Applying genetic study designs to social and behavioral research*. National Academies Press (US). https://www.ncbi.nlm.nih.gov/books/NBK110052/

Title of the Course	Restoration Ecology
Course Code	ZOO-5203
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To introduce restoration Ecology. • To explain restoration techniques. • To create plans and designs for restoration. • To evaluate socioeconomic aspects of restoration	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Understanding principles of restoration ecology.*ing)*	PSO1
	CO 2. Analyzing varied restoration techniques	PSO1, PSO3

	CO 3. Application of knowledge gained, in planning and designing restoration projects.		PSO2, PSO3	
	CO 4. Evaluating socioeconomic aspects of restoration.		PSO2, PSO4	
Content:	**Topic**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Introduction to Restoration Ecology	1.1: Definition and history of restoration ecology	**3**	CO1	K2
	1.2: Causes of ecosystem degradation	**5**	CO1	K2
	1.3: Importance of restoration ecology	**4**	CO1	K2
	1.4: Principles of restoration ecology	**3**	CO1	K2
	1.5 Types of Ecological models relevant to restoration	**5**	CO1	K5
Module 2: Restoration Techniques, planning, and design	2.1: Revegetation and reforestation with native plant species	**3**	CO2	K4
	2.2: Wetland restoration, Stream and river restoration, Coastal ecosystem	**4**	CO2	K4
	2.5: Soil remediation and Air quality restoration	**3**	CO2	K4
	2.7: Assessing ecosystem degradation, Urban Greening	**3**	CO2, CO3	K3, K4
	2.8: Setting restoration goals and objectives. Designing restoration projects	**3**	CO2 CO3	K3, K4
Module 3: Social and Economic Aspects of Restoration	3.1: Community engagement and participation	**2**	CO4	K5
	3.2: Economic benefits of restoration	**4**	CO4	K5
	3.3: Policy and legislation supporting restoration	**4**	CO4	K5

	3.4: Restoration Ethics	**3**	CO4	K5
	3.5: Case studies (Global, National, Regional) on Ecosystem restoration	**2**		K5
Pedagogy:	Lectures, videos, case-studies, group discussions, presentations, field visits.			
Texts:	1. Akshat Uniyal, Isha Sharma and Indu Tiwari (Ed.). (2025). Soil restoration: assessment and reclamation. AGROBIOS RESEARCH An Imprint of AGROBIOS (INDIA) Jodhpur. ISBN 978-93-94380-21-9 2. Elliot, R. (1997). Faking nature: The Ethics of Environmental Restoration. Psychology Press. 3. Squires, V. R. (2016). Ecological restoration: Global Challenges, Social Aspects, and Environmental Benefits. 4. Van Andel, J., & Aronson, J. (2012). Restoration ecology: The New Frontier. John Wiley & Sons.			
References/ Readings	1. Owell, E. A., Harrington, J. A., & Glass, S. B. (2012). Introduction to restoration Ecology 2. Odum, E. P. (2005). Fundamentals of Ecology. 3. Perrow, M. R., & Davy, A. J. (2002). Handbook of Ecological Restoration. Cambridge University Press. 4. Rieger, J., Stanley, J., & Traynor, R. (2014). Project planning and management for ecological restoration. In Island Press/Center for Resource Economics eBooks. https://doi.org/10.5822/978-1-61091-566-3			
Web Sources	1. https://Yellowstone National Park Wolf Reintroduction (USA)cases.open.ubc.ca/w17t2cons200-18/#:~:text=Through%20the%20trophic%20cascade%20following,was%20able%20to%20alter%20the 2. https://oceangrants.org.uk/projects/community-based-mangrove-restoration-and-livelihoods-in-sundarbans-region-of-bangladesh/ 3. https://earth5r.org/mandovi-river-eco-revival/#:~:text=Ecological%20Restoration%20for%20Mandovi%20River,provide%20habitat%20for%20diverse%20species. 4. International Principles and Standards for the Practice of Ecological Restoration https://www.fs.usda.gov/rm/pubs_journals/2019/rmrs_2019_gann_g002.pdf 5. Society for Ecological Restoration (SER): https://www.ser.org/ 6. Ecological Restoration Alliance - India (ERA-India) https://era-india.org/			

Title of the Course	Practical in Restoration Ecology
Course Code	ZOO-5204
Number of Credits	1
Theory/Practical	Practical
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Corresponding theory paper (ZOO 5203) should be taken	
Course Objectives:	To enable learners to: • To identify the ecosystem degradation • To evaluate restoration techniques • To create plans and designs for restoration • To evaluate socioeconomic aspects of restoration	
Course Outcomes:		**Mapped to PSO**
	CO 1. Assessment of ecological degradation.	PSO1
	CO 2. Evaluating restoration techniques	PSO1, PSO3

	CO 3. Application of knowledge gained, in planning and designing restoration projects.		PSO2, PSO3	
	CO 4. Evaluating socioeconomic aspects of restoration.		PSO2, PSO4	
Content:	**Topic**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1. Assessment to identify the causes of degradation and potential of restoration of habitat (wetland/ Forest/ Plateau)	**4**	CO1	K2
	2. Assess the impact of Re-introduction of native species (Comparative study on biodiversity assessment of indigenous and exotic plant species)	**2**	CO2	K2
	3. Techniques to improve soil health (addition of organic matter)	**2**	CO2	K2
	4. Assessment of water quality to support aquatic life	**2**	CO1	K2
	5. Assessment of air quality	**2**	CO1	K2
	6. Case-study based restoration plan	**2**	CO3	K6
	7. Community awareness and involvement in restoration	**1**	CO4	K2, K5
Pedagogy:	Lectures, videos, case-studies, group discussions, presentations, field visits.			
Texts:	1. Akshat Uniyal, Isha Sharma and Indu Tiwari (Ed.). (2025). Soil restoration: assessment and reclamation. AGROBIOS RESEARCH An Imprint of AGROBIOS (INDIA) Jodhpur. ISBN 978-93-94380-21-9 2. Elliot, R. (1997). Faking nature: The Ethics of Environmental Restoration. Psychology Press. 3. Squires, V. R. (2016). Ecological restoration: Global Challenges, Social Aspects, and Environmental Benefits. 4. Van Andel, J., & Aronson, J. (2012). Restoration ecology: The New Frontier. John Wiley & Sons.			
References/ Readings	1. Owell, E. A., Harrington, J. A., & Glass, S. B. (2012). Introduction to restoration Ecology 2. Odum, E. P. (2005). Fundamentals of Ecology. 3. Perrow, M. R., & Davy, A. J. (2002). Handbook of Ecological Restoration. Cambridge University Press. 4. Rieger, J., Stanley, J., & Traynor, R. (2014). Project planning and management for ecological restoration. In Island Press/Center for Resource Economics eBooks. https://doi.org/10.5822/978-1-61091-566-3			

Web Sources	1. https://Yellowstone National Park Wolf Reintroduction (USA)cases.open.ubc.ca/w17t2cons200-18/#:~:text=Through%20the%20trophic%20cascade%20following,was%20able%20to%20alter%20the 2. https://oceangrants.org.uk/projects/community-based-mangrove-restoration-and-livelihoods-in-sundarbans-region-of-bangladesh/ 3. https://earth5r.org/mandovi-river-eco-revival/#:~:text=Ecological%20Restoration%20for%20Mandovi%20River,provide%20habitat%20for%20diverse%20species. 4. International Principles and Standards for the Practice of Ecological Restoration https://www.fs.usda.gov/rm/pubs_journals/2019/rmrs_2019_gann_g002.pdf 5. Society for Ecological Restoration (SER): https://www.ser.org/ 6. Ecological Restoration Alliance - India (ERA-India) https://era-india.org/

Title of the Course	Vector Biology
Course Code	ZOO-5205
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To understand the biology and ecology of arthropod vectors. • To study vector-pathogen-host interactions. • To examine vector control strategies including chemical, biological, and genetic approaches. • To equip learners with practical skills for vector sampling, identification, and laboratory handling.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Explain the biology, morphology, and life cycles of major arthropod vectors	PSO1, PSO3, PSO4
	CO 2. Analyze the ecological factors that influence vector population dynamics and disease transmission.	PSO3, PSO4
	CO 3. Interpret vector-pathogen-host interactions and differentiate between various modes of disease transmission.	PSO3

	CO 4. Critically assess and compare various vector control methods including chemical, biological, environmental, and genetic strategies.		PSO3, PSO4	
Content:	**Topic**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Introduction to vector biology	Definition and importance of Vectors Historical aspects of vector-borne diseases	**2**	CO1	K2
	Major Vector Groups: Mosquitoes, sandflies, blackflies, tsetse flies, fleas, lice, ticks, mites, and triatomines	**3**	CO1	K2
	Vector Morphology and Life Cycle Comparative anatomy and metamorphosis	**4**	CO1	K2
	Vector Ecology with Special reference to mosquitoes: Breeding habitats, environmental influences, Vector population dynamics and seasonality	**3**	CO2	K3
	Host-seeking and Feeding Behaviour: Mechanisms of host detection and blood-feeding	**3**	CO2, CO3	K3
Module 2: Vector-pathogen Interactions and Disease Transmission	Types of Vector-Pathogen Relationships: Mechanical vs biological transmission, Propagative, cyclopropagative, and cyclodevelopmental transmission	**3**	CO3	K4
	Pathogens Transmitted by Vectors: Viruses (e.g., dengue, Zika, Chikungunya), bacteria (e.g., plague, Lyme,), protozoa (e.g., malaria, Leishmania), helminths (e.g., filariasis). Symptoms, Prophylaxis, treatment.	**4**	CO2, CO3	K4
	Molecular Basis of Vector Competence: genetic factors, Environmental influences, pathogen-vector interactions, Receptors, immune pathways, microbiome influence	**3**	CO3, CO4	K3
	Epidemiology of Vector-Borne Diseases: Outbreak patterns, transmission dynamics, and surveillance	**3**	CO2, CO3	K5
	Zoonoses and Reservoir Hosts: Role of animals in disease cycles	**2**	CO2,	K4

			CO3	
Module 3: Vector Control and management	Traditional Vector Control Methods: Insecticides, larvicides, environmental management	**2**	CO2, CO3, CO4	K3
	Biological Control: Use of natural predators, entomopathogenic fungi/bacteria	**2**	CO2, CO3, CO4	K3
	Genetic Control Strategies: Sterile insect technique, gene drives, transgenics	**3**	CO2, CO3, CO4	K4
	Insecticide Resistance Mechanisms, detection, and management	**3**	CO2, CO3, CO4	K3
	Modern Tools in Vector Surveillance and Research: GIS and remote sensing, molecular diagnostics, bioinformatics	**2**	CO2, CO3, CO4	K4
	Public Health Strategies and Integrated Vector Management (IVM)	**3**	CO2, CO3, CO4	K3
Pedagogy:	Concept-driven, interactive lectures/ Inquiry-based learning and problem-solving sessions /Research-integrated laboratory practical/ Field-based experiential learning modules / Seminar-led discussions and case study analyses/ Advanced workshops on vector control methodologies/ Integration of current scientific literature, WHO guidelines, and global vector control frameworks / Collaborative, project-based learning / Reflective assignments, portfolios, and continuous formative assessments.			
Texts:	1. Beaty, B. J., & Marquardt, W. C. (Eds.). (1996). *The biology of disease vectors*. University Press of Colorado. 2. Clements, A. N. (1992–2012). *The biology of mosquitoes* (Vols. 1–3). CABI Publishing. 3. Eldridge, B. F., & Edman, J. D. (Eds.). (2004). *Medical entomology: A textbook on public health and veterinary problems caused by arthropods* (Revised ed.). Springer.			

	4. Gullan, P. J., & Cranston, P. S. (2024). *The insects: An outline of entomology* (6th ed.). Wiley-Blackwell. 5. Lehane, M. J. (2005). *The biology of blood-sucking in insects* (2nd ed.). Cambridge University Press. 6. Marquardt, W. C. (Ed.). (2005). *Biology of disease vectors* (2nd ed.). Elsevier Academic Press. 7. Mullen, G. R., & Durden, L. A. (Eds.). (2019). *Medical and veterinary entomology* (3rd ed.). Academic Press. 8. Service, M. W. (2012). *Medical entomology for students* (5th ed.). Cambridge University Press.
References/ Readings:	1. Rueda, L. M. (2020). Global diversity of mosquitoes (Diptera: Culicidae): Update from 2010. *Journal of Medical Entomology*, *57*(5), 1705–1712. https://academic.oup.com/jme/article/57/5/1705/5837641 2. Tolle, M. A. (2009). Mosquito-borne diseases. *Current Problems in Pediatric and Adolescent Health Care, 39*(4), 97–140. https://www.sciencedirect.com/science/article/abs/pii/S153854420800159X 3. Wilson, A. L., et al. (2020). The importance of vector control for the control and elimination of vector-borne diseases. *PLoS Neglected Tropical Diseases, 14*(1), e0007831. https://journals.plos.org/plosntds/article?id=10.1371/journal.pntd.0007831
Web Resources:	1. World Health Organization (WHO) — Vector-borne Diseases https://www.who.int/news-room/fact-sheets/detail/vector-borne-diseases 2. VectorBase — Bioinformatics Resource for Invertebrate Vectors https://vectorbase.org/ 3. CDC — Division of Vector-Borne Diseases (DVBD) https://www.cdc.gov/ncezid/dvbd/ 4. Malaria Atlas Project https://malariaatlas.org/

Title of the Course	Practical in Vector Biology
Course Code	ZOO-5206
Number of Credits	1
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Corresponding theory paper (ZOO 5205) should be taken	
Course Objectives:	• To introduce learners to field and laboratory techniques for the collection of vector species using standard entomological tools. • To develop skills in morphological identification of key vectors of medical importance • To Provide hands-on training in rearing and observing the life cycle of mosquito vectors. • To enable learners to perform insecticide susceptibility assays using standard WHO bioassay techniques.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Demonstrate the ability to collect vector specimens using appropriate tools.	PSO2, PSO3
	CO 2. Develop skills to identify different vectors	PSO2, PSO3, PSO4
	CO 3. Conduct and interpret insecticide bioassays and assess vector susceptibility	PSO1, PSO3, PSO4

	CO 4. Apply practical skills in vector sampling, identification, and laboratory techniques used in vector biology research		PSO3, PSO4	
Content:	**Topics**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Collection of insect vectors and mosquito larvae (use of light trap, aspirators)	**4**	CO1, CO4	K3
	Identification of Vectors (mosquitoes – *Aedes, Anopheles* sp., *Culex* sp.) Ticks Lice	**10**	CO2, CO4	K3
	Rearing mosquito larvae and documenting life stages	**6**	CO4	K4
	Insecticide Bioassay Techniques	**4**	CO3, CO4	K5
	Surveillance of Parasitic Disease Outbreaks Using regional / state epidemiological datasets	**2**	CO3, CO4	K5
	Visit to Vector Control Lab or Public Health Entomology Unit	**4**	CO4	K2
Pedagogy:	Integration of current scientific literature, WHO guidelines, and global vector control frameworks/ Collaborative, project-based learning /Reflective assignments, portfolios, and continuous formative assessments /Mentored student-led colloquia.			
Texts:	1. Gerberg, E.J., Barnard, D.R. and Ward, R.A., 1994. *Manual for mosquito rearing and experimental techniques* (pp. iv+-98). 2. Charlwood, J.D. ed., 2024. *Practical Control of Mosquito Disease Vectors*. CABI. 3. Kline, D.L., 2006. Traps and trapping techniques for adult mosquito control. *Journal of the American Mosquito Control Association*, *22*(3), pp.490-496. 4. Das, S., Garver, L. and Dimopoulos, G., 2007. Protocol for mosquito rearing (A. gambiae). *Journal of Visualized Experiments: JoVE*, (5), p.221.			
References/	1. Garjito, T.A., Susanti, L., Mujiyono, M., Prihatin, M.T., Susilo, D., Nugroho, S.S., Mujiyanto, M., Wigati, R.A.,			

Readings:	Satoto, T.B.T., Manguin, S. and Gavotte, L., 2021. Assessment of mosquito collection methods for dengue surveillance. *Frontiers in Medicine*, *8*, p.685926. 2. James, S.P., 1899. Collection of Mosquitos and Their Larvæ. *The Indian Medical Gazette*, *34*(12), p.431. 3. Yssouf, A., Almeras, L., Raoult, D. and Parola, P., 2016. Emerging tools for identification of arthropod vectors. *Future Microbiology*, *11*(4), pp.549-566.
Web Resources:	1. World Health Organization (WHO) — Vector-borne Diseases https://www.who.int/news-room/fact-sheets/detail/vector-borne-diseases 2. VectorBase — Bioinformatics Resource for Invertebrate Vectors https://vectorbase.org/ 3. CDC — Division of Vector-Borne Diseases (DVBD) https://www.cdc.gov/ncezid/dvbd/ 4. Malaria Atlas Project https://malariaatlas.org/

Title of the Course	Biology of Animal Reproduction
Course Code	ZOO-5207
Number of Credits	03
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To explore the biological, ecological, and socio-cultural dimensions of animal reproduction. • To compare reproductive strategies across taxa and link them to evolutionary fitness and survival. • To critically evaluate traditional, indigenous, and applied knowledge systems in reproduction. • To build scientific understanding of reproductive health, ethics, and conservation.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Explain the diversity of reproductive systems and cycles across animal taxa.	PSO1
	CO 2. Analyze the ecological, seasonal, and behavioral contexts of animal reproduction.	PSO1, PSO3
	CO 3. Evaluate traditional and indigenous knowledge systems related to reproduction.	PSO1, PSO4

	CO 4. Apply reproductive biology to address societal concerns, conservation, and reproductive health issues.		PSO2, PSO4	
	CO 5. Interpret and discuss social constructs, taboos, myths, and ethics in reproductive biology.		PSO4	
Content:	**Topics**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Diversity and Cycles in Reproduction	1.1: Overview of reproductive systems in invertebrates and vertebrates – diversity, anatomy, and adaptations	**3**	CO1	K2
	1.2: Types of reproductive cycles: continuous, seasonal, opportunistic breeding; environmental influences	**3**	CO2	K4
	1.3: Gametogenic patterns and gonadal structures across phyla	**2**	CO1	K2
	1.4: Courtship, copulatory behavior, and pheromonal communication in animals	**2**	CO2	K4
	1.5: Reproductive success and fitness: evolutionary significance	**2**	CO2	K4
	1.6: Adaptations to extreme environments: examples from desert, polar, and aquatic animals	**3**	CO2	K4
Module 2: Applied and Indigenous Dimensions of Reproduction	2.1: Female and male anatomical defects, Assisted reproductive techniques (ARTs): IVF, ICSI, embryo transfer, surrogacy, Artificial insemination in livestock: principles and protocols.	**4**	CO4	K3
	2.2: Hormonal control and induction of breeding	**2**	CO4	K3
	2.3: Traditional knowledge in animal reproduction: case studies from India and global indigenous practices	**2**	CO3	K5

	2.4: Ethnozoological uses of reproductive organs and beliefs in fertility rituals	**2**	CO3	K5
	2.5: Role of nutrition and herbal remedies in enhancing fertility – traditional vs. scientific views	**3**	CO4	K3
	2.6: Community-based livestock breeding programs and local governance in animal fertility	**2**	CO4	K5
Module 3: Societal, Ethical and Medical Perspectives on Reproduction	3.1: Reproductive health and fertility awareness: animal and human parallels, links to education and outreach	**2**	CO4	K5
	3.2: Reproductive taboos, myths, and folklore: cultural beliefs surrounding menstruation, conception, and fertility	**2**	CO5	K5
	3.3: Reproductive ethics and conservation: population control, surrogacy, contraception, Gender identity, animal cloning, legal aspects of wildlife conservation.	**4**	CO5	K5
	3.4: Reproductive cancers and diseases: Molecular biology of reproductive pathologies	**2**	CO5	K5
	3.5: Future of Reproduction: Artificial Gametes and Bioethical Challenges.	**2**	CO5	K5
	3.6: Reproductive Genomics and Gene Editing: Applications of CRISPR-Cas9 in Reproductive Biology and Gene Editing for trait improvement in animals.	**3**	CO5	K5
Pedagogy:	• Illustrated lectures and concept maps for anatomy and physiology • Comparative study models across taxa using charts, diagrams, and videos • Case studies on reproductive technologies and conservation strategies • Mini assignments on reproductive adaptations and research highlights • Group discussion and presentation on ethical issues in reproduction and technology			
Texts:	1. Carlson, B.M. (2013). *Human Embryology and Developmental Biology* (5th ed.). Elsevier Mosby.			

	2. Gilbert, S.F. & Barresi, M.J.F. (2019). *Developmental Biology* (12th ed.). Oxford University Press. 3. Hafez, E.S.E. & Hafez, B. (2000). *Reproduction in Farm Animals* (7th ed.). Wiley-Blackwell. 4. Knobil, E. & Neill, J.D. (2006). *The Physiology of Reproduction* (2nd ed., Vols. I & II). Academic Press. 5. Norris, D.O. (2006). *Vertebrate Endocrinology* (4th ed.). Academic Press. 6. Wolpert, L., Tickle, C. & Arias, A.M. (2019). *Principles of Development* (6th ed.). Oxford University Press.
References/ Readings:	1. Austad, S. N. (2009). Why We Age: *What Science Is Discovering About the Body's Journey Through Life*. John Wiley & Sons. Available as e-book: https://www.wiley.com. 2. Crews, D. & Moore, M.C. (1986). "Evolution of mechanisms controlling mating behavior." *Science*, 231(4745), 121–125. 3. Devlin, R.H. & Nagahama, Y. (2002). "Sex determination and sex differentiation in fish." *Aquaculture*, 208(3–4), 191–364. 4. Fritz, M. A., & Speroff, L. (2010). *Clinical Gynecologic Endocrinology and Infertility* (8th ed.). Lippincott Williams & Wilkins. https://www.lww.com. 5. Hafez, E. S. E., & Hafez, B. (2021). *Reproduction in Farm Animals* (8th ed.). Wiley-Blackwell. https://www.wiley.com. 6. Harvey, P. H., & Pagel, M. D. (1991). *The Comparative Method in Evolutionary Biology*. Oxford University Press. https://global.oup.com. 7. Johnson, M. H., & Everitt, B. J. (2018). *Essential Reproduction* (8th ed.). Wiley-Blackwell.: https://www.wiley.com. 8. Nelson, R.J. (2011). *An Introduction to Behavioral Endocrinology* (4th ed.). Sinauer Associates. 9. Norris, D. O., & Lopez, K. H. (2011). *Hormones and Reproduction of Vertebrates* (Vol. 1-5). Academic Press. Available on ScienceDirect: https://www.sciencedirect.com. 10. Plant, T. M., & Zeleznik, A. J. (2015). *Knobil and Neill's Physiology of Reproduction* (4th ed.). Elsevier. https://www.elsevier.com. 11. Reichlin, S. (1998). "Neuroendocrinology: A turning point in understanding reproduction." *Endocrine Reviews*, 19(3), 249–270. 12. Waberski, D., & Luther, A. M. (Eds.). (2021). *Reproduction in Domestic Animals* (Vol. 1-5). Springer Nature.: https://www.springernature.com. 13. WHO & UNFPA. (2010). *Reproductive Health Indicators: Guidelines for their generation, interpretation, and*

	analysis. World Health Organization.
Web Resources:	1. PubMed Central – Open-access Reproduction Research https://www.ncbi.nlm.nih.gov/pmc 2. Society for Developmental Biology (SDB) https://www.sdbonline.org 3. UNSW Embryology (Australia) – Reproductive Systems, Cycles, Fertility https://embryology.med.unsw.edu.au/embryology/index.php/Main_Page 4. WHO – Reproductive Health and Rights: https://www.who.int/health-topics/sexual-health#tab=tab_1 5. UNFPA – Fertility, Family Planning, Cultural Perspectives: https://www.unfpa.org 6. Population Council – Reproductive Research, Culture, Gender https://www.popcouncil.org

Title of the Course	Practical in Animal Reproduction
Course Code	ZOO-5208
Number of Credits	01
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Corresponding theory paper (ZOO 5207) should be taken	
Course Objectives:	• To impart hands-on skills related to anatomy, physiology, and endocrinology of reproduction in animals. • To explore reproductive strategies across taxa using dissection, microscopy, and image analysis. • To integrate traditional knowledge and field-based observations with experimental biology. • To foster critical and ethical thinking through interactive activities and mini-projects.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Identify and describe reproductive organs and gametes across taxa using dissection and microscopy. (K3- Applying)	PSO1
	CO 2. Perform staining and quantitative assays to assess reproductive physiology and hormonal changes. (K4- Analyzing)	PSO2
	CO 3. Analyze local ethno-biological practices, reproductive myths, and apply scientific methods to assess them. (K5 -Evaluating)	PSO3, PSO4

	CO 4. Design and execute small-scale projects related to fertility control, ARTs, or seasonal reproduction. (K6 – Creating)		PSO2, PSO3	
Content:	**Topics**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Practical	1.1: Dissection and identification of reproductive organs in selected invertebrates	**2**	CO1	K4
	1.2 : Dissection and identification of reproductive organs in selected vertebrates	**2**		
	1.3: Preparation of histological slides of Ovaries/Testes of a vertebrate animal model (using previously preserved specimens)- I	**2**	CO1	K4
	1.4: Preparation of histological slides of Ovaries/Testes of a vertebrate animal model (using previously preserved specimens)- II	**2**		
	1.5: Preparation of histological slides of Ovaries/Testes of a vertebrate animal model (using previously preserved specimens) – III	**2**		
	1.6: Staging of the oestrous cycle (Permanent slides)- I	**2**	CO2	K3
	1.7: Staging of the oestrous cycle (Permanent slides)- II	**2**		
	1.8: Study of structure and motility of vertebrate sperm	**2**	CO2	K3
	1.9: case-study on reproductive myths and beliefs (Group discussions/ community engagement programmes)- I	**2**	CO3	K6
	1.10: Case-study on reproductive myths and beliefs (Group discussions/ community engagement programmes)- II	**2**		
	1.11: Case-study on reproductive myths and beliefs (Group discussions/ community engagement programmes)- III	**2**		
	1.12: Visit to a livestock breeding/IVF center-I	**2**	CO3	K5
	1.13: Visit to a livestock breeding/IVF center-II	**2**		
	1.14: Visit to a livestock breeding/IVF center- III	**2**		

	1.15: Visit to a livestock breeding/IVF center- IV	**2**		
Pedagogy:	• Laboratory work, microscopy, dissection • Interactive models, group activities, and discussions • Community engagement (field survey, documentation) • Problem-solving and reflection-based learning			
Texts:	1. Norris, D.O. (2020). *Vertebrate Endocrinology*. 5th ed., Academic Press. 2. Carlson, B.M. (2013). *Human Embryology and Developmental Biology*. 5th ed., Elsevier. 3. Gilbert, S.F. & Barresi, M.J.F. (2019). *Developmental Biology*. 12th ed., Oxford University Press. 4. Hafez, E.S.E. & Hafez, B. (2000). *Reproduction in Farm Animals*. 7th ed., Wiley-Blackwell.			
References/ Readings:	1. Ratnasabapathi, D. (2012). *Practical Zoology: Vertebrates. S. Chand Publishing.* 2. Barman, H. K., Sundaray, J. K., & Sahoo, L. (2014). *Fish Reproductive Biology Techniques*. Springer. 3. Hafez, E. S. E., & Hafez, B. (2000). *Reproduction in Farm Animals* (7th ed.). Wiley-Blackwell. 4. Williamson, C. M., & Lee, P. S. (2011). *Mammalian Reproduction: Biology and Medical Applications*. Cambridge Scholars Publishing. 5. Wyatt, T. D. (2014). *Pheromones and Animal Behavior: Chemical Signals and Signatures*. Cambridge University Press.			
Web Resources:	1. UNSW Embryology – Histology, Gonad Development: https://embryology.med.unsw.edu.au/embryology/index.php/Main_Page 2. Virtual Labs – Animal Reproductive Biology Experiments: https://vlab.amrita.edu 3. PubMed Central – Research Articles on Reproductive Histology: https://www.ncbi.nlm.nih.gov/pmc 4. UNFPA – Fertility, Family Planning, Cultural Perspectives: https://www.unfpa.org 5. Population Council – Reproductive Research, Culture, Gender https://www.popcouncil.org			