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(Accredited by NAAC with Grade A+)

GU/Acad –PG/BoS -NEP/2025-26/118 Date: 02.06.2026

CIRCULAR

Ref. No.: GU/Acad –PG/BoS -NEP/2025-26/548 dated 13.11.2025

In supersession to the above referred Circular, the syllabus of Semester III of the **Master of Science in Zoology** Programme approved by the Academic Council in its meeting held 24th February 2026, is attached.

Further, the Syllabus of Semester II approved earlier by the Academic Council in its meeting held on 13th September 2025 and the syllabus of Semester I approved earlier by the Standing Committee of the Academic Council in its meeting held on 24th & 25th June 2025 is also 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 V LAWANDE Digitally signed by ASHWIN V LAWANDE Date: 2026.06.02 17:44:42 +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:

3. Chairperson, BoS in Zoology, Goa University.
4. Programme Director, M.Sc. Zoology, Goa University.
5. Controller of Examinations, Goa University.
6. Assistant Registrar Examinations (PG), Goa University.
7. 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.

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	Advanced Molecular Biology	3	500
2	ZOO-5009	Practical in Advanced Molecular Biology	1	500
3	ZOO-5010	Human Genetics	3	500
4	ZOO-5011	Practical in Human Genetics	1	500
5	ZOO-5012	Advanced Developmental Biology	3	500
6	ZOO-5013	Practical in Advanced 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**	

SEMESTER III				
Research Specific Elective (RSE) Courses (12 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	ZOO-6000	Research Methodology	4	500
2	ZOO-6001	Neurophysiology	3	500
3	ZOO-6002	Practical in Neurophysiology	1	500
4	ZOO-6003	Ecotoxicology	3	500
5	ZOO-6004	Practical in Ecotoxicology	1	500
6	ZOO-6005	Herpetology	3	500
7	ZOO-6006	Practical in Herpetology	1	500
8	ZOO-6007	Developments in Aquaculture	2	500
9	ZOO-6008	Practical in Developments in Aquaculture	2	500
10	ZOO-6009	Nanomaterials and their interactions with Biological Systems	3	500
11	ZOO-6010	Practical in Nanomaterials and their interactions with Biological Systems	1	500
12	ZOO-6011	Marine Ecology	3	500
13	ZOO-6012	Practical in Marine Ecology	1	500
Total Credits for RSE Courses in Semester III			**12**	
Discipline Specific Vocational Elective (DSVE) Courses (8 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	ZOO-6401	Ecotourism	2T+2P	500
2	ZOO-6402	Ornamental Fish management and entrepreneurship	2T+2P	500
3	ZOO-6403	Processed Fish Products	2T+2P	500
4	ZOO-6404	Generative AI and Bioinformatics	2T+2P	500
5	ZOO-6405	Butterfly gardening	2T+2P	500
Total Credits in Semester III			**20**	

Discipline Specific Dissertation (DSD) (40 Credit Dissertation)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**ZOO-6501**	Dissertation	**40**	**500**

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

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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==

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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.

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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:	2.1 Taxonomic Procedures, Taxonomic Keys, Morphological and Anatomical Characters, Museum Collections and Type Specimens.	**4**	CO2, CO4	K4

Tools and Techniques in Systematics	2.2 Molecular Systematics: Molecular markers, SNPs, Allozyme, DNA Barcoding, DNA sequencing in taxonomy: mitochondrial genes (COI, 16S) and nuclear genes (18S, ITS), DNA barcoding and species delimitation.	**4**	CO2, CO3	K2
	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/

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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:	• To provide a comprehensive understanding of the principles and practices of animal classification and systematics. • To develop the ability to identify major faunal taxa using dichotomous and pictorial keys. • To enable Learners to construct and utilize taxonomic keys for selected animal groups • 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 classification and evolutionary biology		PSO 2, PSO 3	
	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/

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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.		PSO1, PSO2 & PSO4	
	CO 2. Analyze thermoregulatory and osmoregulatory mechanisms across environments, including desert, aquatic, and high-altitude habitats, and relate them to homeostasis and survival strategies.		PSO1, PSO2 & PSO3	
	CO 3. Evaluate the impact of environmental stressors such as climate change, heavy metals, and endocrine disruptors on organismal physiology using appropriate biomarkers.		PSO1, PSO3 & PSO4	
	CO 4. Interpret biological rhythms and their regulatory pathways, assessing how urbanization and global warming affect timing mechanisms such as reproduction and seasonal behaviour.		PSO2, PSO3 & PSO4	
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: Osmoregulation, Hydration Strategies, and Pollution Physiology	2.1 **Salinity Adaptation**- Osmotic and ionic stress- biochemical and physiological effects; Water and solute regulation mechanisms; Osmoregulatory organs (gills, kidneys, integument); Excretory products in different animal groups	**4**	CO2	K4
	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

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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	PO1

	through CTmax measurements and osmoregulatory evaluations.			
	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 7. Livingstone, D. R. (2001). Contaminant-induced oxidative stress and lipid peroxidation in marine invertebrates: A review. *Aquatic Toxicology*, *47*(1), 1–29. https://doi.org/10.1016/S0166-445X(99)00063-0 8. McKenzie, D. J., Taylor, E. W., & Claireaux, G. (2021). Effects of temperature on nitrogen metabolism in fish. *Fish Physiology and Biochemistry*, *47*(1), 1–17. https://doi.org/10.1007/s10695-020-00888-0 9. Mayer, C. M., Cooke, S. J., Lapointe, N. W. R., & Hasler, C. T. (2024). Thermal tolerance in Pacific salmon: A systematic review of species, populations, life stages and methodologies. *Fish and Fisheries*. https://doi.org/10.1111/faf.12808 10. Widdows, J., & Donkin, P. (1992). The effects of pollution on the physiology of marine bivalves. In D. M. Allen (Ed.), *Marine Ectotherms* (pp. 1–25). Springer. https://doi.org/10.1007/978-94-011-2876-3_1
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/

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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 biogeography, Nestedness and community structure, Island syndromes in species traits.	**03**	CO1, CO3	K2, K4
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 organisms and ecosystems, socio-ecological frameworks and policy integration for sustainable ecosystem governance.	**04**	CO2, CO4	K4, K5
	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

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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 ecosystem functionality.		PSO1, PSO3	
	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

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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/

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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/

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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 Plasticity	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
	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

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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 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)*]	**2**	CO4	K6
	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 circadian cycle using direct or video observation techniques-Day 1	**2**	CO4	K3

	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:	1. Sandi C. (2008). Understanding the neurobiological basis of behavior: a good way to go. *Frontiers in neuroscience*, *2*(2), 129–130.			

	2. Sweatt J. D. (2016). Neural plasticity and behavior - sixty years of conceptual advances. *Journal of neurochemistry, 139 Suppl 2*, 179–199. 3. 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/

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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/

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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/

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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, CO3	K4
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/

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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/ Readings:	1. Garjito, T.A., Susanti, L., Mujiyono, M., Prihatin, M.T., Susilo, D., Nugroho, S.S., Mujiyanto, M., Wigati, R.A., 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/

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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	3.1: Reproductive health and fertility awareness: animal and human parallels, links to education and outreach	**2**	CO4	K5

Perspectives on Reproduction	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

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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			

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SEMESTER II

Discipline Specific Core (DSC) Courses

Title of the Course	Advanced Molecular Biology
Course Code	ZOO-5008
Number of Credits	03
Theory/Practical	Theory
Level	500
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 elucidate the structural organization and dynamic regulation of DNA packaging in both prokaryotic and eukaryotic cells, including nucleoid architecture, chromatin remodeling, and the functional roles of nucleoprotein complexes such as nucleosomes, condensins, and cohesins. • To explore the molecular biology and biochemistry of telomeres and centromeres, emphasizing their roles in genome stability, chromosomal segregation, epigenetic regulation, and the pathological implications of telomere dysfunction and centromeropathies. • To impart an in-depth understanding of RNA biology, focusing on RNA structure, types of coding and non-coding RNAs, and their involvement in gene expression regulation, including canonical and non-canonical splicing mechanisms.

	• To examine the mechanisms and biological significance of various RNA and protein splicing pathways, such as spliceosomal, self-splicing, trans-splicing, and intein-mediated protein splicing, with an emphasis on their regulation and disease associations.			
Course Outcomes:	Students will be able to:		**Mapped to PSO**	
	CO 1. Describe the mechanisms of DNA condensation and chromatin organization in prokaryotic and eukaryotic cells, including the roles of histones, topoisomerases, nucleosomes, and chromatin-associated proteins. *(K2)*		PSO1	
	CO 2. Analyze the structural and functional dynamics of telomeres and centromeres, including their molecular components, epigenetic regulation, and clinical implications in genome instability and centromeropathies. *(K4)*		PSO1, PSO4	
	CO 3. Classify and evaluate different RNA types and their hierarchical structures, and assess their biological significance in gene regulation. *(K5)*		PSO1	
	CO 4. Explain and interpret diverse RNA and protein splicing mechanisms, and appraise their relevance to developmental regulation and disease pathogenesis. *(K5)*		PSO2, PSO3	
Content:	**Topic**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Chromatin Architecture and DNA Packaging	1.1: DNA condensation in prokaryotes – Supercoiling, NAPs, DNA looping	**4**	CO1	K2
	1.2: Topoisomerases – Types, mechanism, medical applications	**4**	CO1	K2
	1.3: Chromatin organization in eukaryotes – Chromatosomes to metaphase chromosomes	**3**	CO1	K2
	1.4: Condensins and cohesins – Structure, function, regulation	**3**	CO1	K2
	1.5: Sperm chromatin remodeling – Transition proteins and protamines	**3**	CO1	K2
	1.6: Histone structure, variants, and histone code	**3**	CO1	K2
Module 2: Telomeres and	2.1: Telomere and telomerase structure	**2**	CO2	K4
	2.2: Telomerase-mediated extension (canonical mechanism)	**2**	CO2	K4

Centromeres	2.3: Alternative Lengthening of Telomeres (ALT)	**2**	CO2	K4
	2.4: T-loop and D-loop formation (protective end structures)	**2**	CO2	K4
	2.5: Centromere structure – Satellite DNA, CENP-A, kinetochore	**3**	CO2	K4
	2.6: Epigenetic regulation of telomeres and centromeres	**2**	CO2	K4
	2.7: Centromeropathies: Molecular basis and clinical implications	**2**	CO2	K4
Module 3: RNA Biology and Splicing Mechanisms	3.1: RNA structure – Primary, secondary, tertiary levels	**2**	CO3	K2
	3.2: Types of RNA – Coding and non-coding (miRNA, lncRNA, piRNA, etc.)	**3**	CO3	K2
	3.3: Splicing mechanisms – Spliceosome, group I/II introns, tRNA splicing	**3**	CO4	K5
	3.4: Alternative and trans-splicing – Regulation and disease links	**3**	CO4	K5
	3.5: Protein splicing – Inteins, mechanisms, biological significance	**4**	CO4	K5
Pedagogy:	Lectures and Conceptual Discussions/ Case-Based Learning/ Research review-Integrated Learning/Student Seminars /Problem-Solving and Concept Mapping			
Texts:	1. Alberts, B., Johnson, A., Lewis, J., et al. (2022). *Molecular Biology of the Cell* (7th ed.). Garland Science. 2. Brown, T. A. (2016). *Gene Cloning and DNA Analysis* (7th ed.). Wiley-Blackwell. 3. Cooper, G. M., & Hausman, R. E. (2019). *The Cell: A Molecular Approach* (8th ed.). Oxford University Press. 4. Lewin, B., Krebs, J. E., Goldstein, E. S., & Kilpatrick, S. T. (2018). *Lewin's Genes XII*. Jones & Bartlett Learning. 5. Lodish, H., Berk, A., Kaiser, C. A., et al. (2021). *Molecular Cell Biology* (9th ed.). W.H. Freeman and Company. 6. Turner, B. M. (2023). *Chromatin and Gene Regulation: Molecular Mechanisms in Epigenetics* (2nd ed.). Wiley-Blackwell.			
References/ Readings:	1. Cech, T. R., & Steitz, J. A. (2004). *The RNA World* (3rd ed.). Cold Spring Harbor Laboratory Press. 2. Danckwardt, S., Hentze, M. W., & Kulozik, A. E. (2008). 3′ end mRNA processing: Molecular mechanisms and implications for health and disease. *EMBO Journal*, 27(3), 482–498. https://doi.org/10.1038/sj.emboj.7601932 3. de Lange, T. (2005). Shelterin: The protein complex that shapes and safeguards human telomeres. *Genes & Development*, 19(18), 2100–2110. https://doi.org/10.1101/gad.1346005 4. DePamphilis, M. L. (Ed.) (2017). *DNA Replication and Human Disease*. CRC Press. 5. Henikoff, S., & Smith, M. M. (2015). Histone variants and epigenetics. *Cold Spring Harbor Perspectives in Biology*, 7(1), a019364. https://doi.org/10.1101/cshperspect.a019364			

	6. Luger, K., Mäder, A. W., Richmond, R. K., Sargent, D. F., & Richmond, T. J. (1997). Crystal structure of the nucleosome core particle. *Nature*, 389(6648), 251–260. https://doi.org/10.1038/38444 7. Mattick, J. S., & Makunin, I. V. (2006). *Non-Coding RNA*. Human Molecular Genetics, 15(R1), R17–R29. 8. Rippe, K. (Ed.) (2021). *Genome Organization and Function in the Cell Nucleus*. Wiley-VCH. 9. Sharp, P. A. (2005). The discovery of split genes and RNA splicing. *Trends in Biochemical Sciences*, 30(6), 279–281. https://doi.org/10.1016/j.tibs.2005.04.004 10. Sinden, R. R. (2012). *DNA Structure and Function*. Academic Press. 11. Staley, J. P., & Woolford, J. L. (2009). Assembly of ribosomes and spliceosomes: Complex ribonucleoprotein machines. *Current Opinion in Cell Biology*, 21(1), 109–118. https://doi.org/10.1016/j.ceb.2008.01.004
Web Resources:	1. Alberts, B., Johnson, A., Lewis, J., et al. (2002). *Molecular biology of the cell* (4th ed.). Inflammation and immune system pathways. National Center for Biotechnology Information (NCBI). https://www.ncbi.nlm.nih.gov/books/NBK21070/ 2. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2002). *Molecular biology of the cell* (4th ed.). Garland Science. National Center for Biotechnology Information (US). https://www.ncbi.nlm.nih.gov/books/NBK21128/ 3. Epigenetics Literacy Project: https://www.geneticliteracyproject.org/topic/epigenetics/ 4. RNA Biology (Nature Scitable): https://www.nature.com/scitable/topicpage/rna-functions-352 5. SpliceAid Database (RNA Splicing): https://www.intron i.it/spliceaid.html

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Title of the Course	Practical in Advanced Molecular Biology
Course Code	ZOO-5009
Number of Credits	01
Theory/Practical	Practical
Level	500
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-5008) should be taken	
Course Objectives:	• To train students in preparation of essential reagents required for nucleic acid related experiments. • To impart hands-on skills in the extraction and analysis of histone proteins and total RNA from animal tissues, emphasizing integrity and purity in molecular biology workflows. • To expose students to essential molecular techniques including SDS-PAGE, RNA quantification, DNase treatment, and cDNA synthesis, reinforcing the understanding of nucleoprotein and RNA structure-function relationships. • To provide experimental skills for quantitative gene expression analysis via qPCR, primer design, and result interpretation, equipping students with foundational tools for gene regulation studies.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Prepare molecular biology-grade reagents and buffers required for nucleic acid based experiments. *(K3)*	PSO2
	CO 2. Execute standard protocols for cell lysis, histone isolation, and RNA extraction with awareness of molecular contamination control. *(K3)*	PSO2, PSO3

	CO 3. Analyze the quality and yield of extracted RNA and chromatin components using appropriate quantification and visualization tools. *(K4)*		PSO1, PSO3	
	CO 4. Interpret downstream applications such as cDNA synthesis and qPCR based on understanding of RNA and chromatin molecular biology. *(K5)*		PSO1, PSO3	
Content:	Topics	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module:	1.1. Isolation of nuclei from animal tissue using differential centrifugation with hypotonic treatment.	**4**	CO1	K3
	1.2. Acid extraction of histone proteins from isolated nuclei.	**2**	CO2	K4
	1.3. Estimation of protein concentration using the Bradford Assay, followed by setup of SDS-PAGE gel apparatus	**4**	CO2	K4
	1.4. SDS-PAGE Separation of histone proteins based on molecular weight and visualization of banding patterns.	**4**	CO2	K4
	1.5. Isolation of Total RNA Using Chaotropic Reagent-Based Organic Extraction Method (TRIzol/Phenol-Chloroform Method)	**2**	CO3	K3
	1.6. Purification of isolated total RNA through DNase treatment.	**2**	CO3	K4
	1.7. Validation of total RNA of concentration and purity using spectrophotometry (UV-visible double beam spectrophotometer/Nanodrop spectrophotometer)	**4**	CO3	K4
	1.8. mRNA enrichment from total RNA using oligo-dT or poly-A selection methods for gene expression studies.	**2**	CO3	K2
	1.9. cDNA synthesis by reverse transcriptase.	**2**	CO3	K3
	1.10. Primer design for qPCR using *in silico* tools to ensure specificity and efficiency in amplification of target genes.	**2**	CO4	K3
	1.11. qPCR thermal profiling and experimental run.	**2**	CO4	K4
Pedagogy:	Hands-on Practical Sessions/Demonstration-Based Learning/Collaborative Work/Problem-Solving laboratory activities/ Instructor Feedback & Peer Review			
Texts:	1. Ausubel, F. M. et al. (2002). *Short Protocols in Molecular Biology*. Wiley. 2. Beveridge, T. (2001). *Histones: Structure, Function and Role in Gene Regulation*. Academic Press.			

	3. Bustin, S. A. (2004). *A-Z of Quantitative PCR*. International University Line.. 4. Green, M. R., & Sambrook, J. (2012). *Molecular Cloning: A Laboratory Manual* (4th ed.). Cold Spring Harbor Laboratory Press. 5. Sambrook, J., & Russell, D. W. (2001). *Molecular Cloning: A Laboratory Manual* (3rd ed.). Cold Spring Harbor Laboratory Press. 6. Wilkinson, D. J. (2018). *RNA Techniques and Applications*. Springer.
References/ Readings:	1. Adams, M. E., Huang, D. Q., Yao, L. Y., & Sandell, L. J. (1992). Extraction and isolation of mRNA from adult articular cartilage. *Analytical biochemistry*, *202*(1), 89–95. 2. Cheng, M. Y., Tao, W. B., Yuan, B. F., & Feng, Y. Q. (2021). Methods for isolation of messenger RNA from biological samples. *Analytical methods : advancing methods and applications*, *13*(3), 289–298. 3. Shechter, D., Dormann, H. L., Allis, C. D., & Hake, S. B. (2007). Extraction, purification and analysis of histones. *Nature protocols*, *2*(6), 1445–1457.
Web Resources:	1. Addgene Molecular Biology Protocols – High-quality visual and text-based guides. https://www.addgene.org/protocols/ 2. https://www.thermofisher.com/in/en/home/life-science/learning-center.html 3. Protocols.io – Detailed user-submitted protocols for DEPC water, histone extraction, and RNA work https://www.protocols.io 4. Thermo Fisher Scientific Learning Center – qPCR tutorials, cDNA synthesis guides, and troubleshooting tools. 5. NCBI Primer-BLAST – Primer design tool used in in silico qPCR primer generation. https://www.ncbi.nlm.nih.gov/tools/primer-blast/

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Title of the Course	Human Genetics
Course Code	ZOO-5010
Number of Credits	3
Theory/Practical	Theory
Level	500
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 genetic principles and inheritance patterns in Human. • To analyze genetic disorders and their diagnosis using advanced genetic techniques. • To explore mechanisms of gene regulation and epigenetics and their implications for diseases, including cancer. • To evaluate applications of genetics in medicine and research.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Explain the principles of genetics and inheritance patterns, including molecular mechanisms of mutations and chromosomal variations (K2 – Understanding, K3 – Apply)	PSO 1, PSO 3
	CO 2. Analyze genetic data and perform diagnostic assessments using techniques such as karyotyping, FISH, and genome mapping to detect genetic disorders (K4 – Analysis, K5 – Evaluate)	PSO 2, PSO 3

	CO 3. Evaluate gene expression mechanisms, epigenetic modifications, and their relevance to human diseases, such as cancer and metabolic disorders (K4 – Analysis, K5 – Evaluate)		PSO 1, PSO 3	
	CO 4. Design research strategies using advanced genetic tools (e.g., CRISPR, GWAS) and critically appraise their application in gene therapy, pharmacogenomics, and personalized medicine (K5 – Evaluate, K6 Create)		PSO 1, PSO 3, PSO 4	
Content:	**Topic**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Chromosomes and inheritance patterns	1.1 Review on the basic principles of genetics, human genetic make-up, genes as factors controlling human traits, evolution of human genome, 2R hypothesis	**1**	CO 1	K1, K2, K3
	1.2 Organization of DNA/chromatin into chromosomes, nucleosomes and histones. Types of chromosomes; Human chromosome structure and types, centromere, telomere	**3**	CO 1	K1, K2
	1.3 Types of DNA sequences; transposable elements; role of chromosomes in genome evolution; human karyotype	**2**	CO 1	K1, K2
	1.4 Banding techniques, chromosome identification and nomenclature (ISCN)	**1**	CO 1	K2
	1.5 Molecular basis of Mutations and repair	**2**	CO 1	K2
	1.6 Chromosomal variation (structural and numerical; autosomal and X linked), their causes and role in genetic diseases	**2**	CO 1	K2, K3
	1.7 Congenital malformations / inborn errors of metabolism with examples.	**2**	CO 1	K2
	1.8 Human pedigree analysis, Principles and patterns of inheritance in man (autosomal / sex linked / dominant / recessive / mitochondrial inheritance) with examples of human genetic disorders; sex-influenced and sex-limited inheritance	**2**	CO 1	K2, K3
Module 2: Genetic Counselling and Methods of genetic analysis	2.1 Eugenics, euphenics and euthenics; genetic counselling	**1**	CO 2	K2
	2.2 Prenatal diagnosis of genetic disorders, cytogenetic, biochemical and ultrasonography techniques, amniocentesis, chorionic villus sampling, cordocentesis, biochemical markers for prenatal diagnosis, triple test for Down's syndrome	**2**	CO 2	K3, K4, K5

	2.3 Dermatoglyphics and its application in the diagnosis of human genetic disorders	**1**	CO 2	K2, K3, K4, K5
	2.4 Blotting techniques; principles of FISH, RFLP, & DNA fingerprinting / profiling, and their uses in human genetics	**2**	CO 2	K3, K4, K5
	2.5 Genetic models: mouse as a model mammal for genetic studies, transgenic, knockout animal models for human diseases	**1**	CO 2	K3, K4, K5
	2.6 Genomics: Mapping genomes: a) Genetic mapping – DNA markers - RFLPs, SSLPs, SNPs b) Physical mapping - Restriction mapping, fluorescence in situ hybridization (FISH), radiation hybrid mapping and sequence tagged site mapping	**2**	CO 2, CO 4	K3, K4, K5
	2.7 Genome-Wide Associated Study (GWAS), copy number variations, Expressed-sequence tags (EST); microarray analysis in gene expression	**1**	CO 2, CO 4	K3, K4, K5
	2.8 Recombination and gene mapping in Drosophila using two point and three point test crosses with an emphasis on interference and coefficient of coincidence	**1**	CO 2	K3, K4, K5
	2.9 DNA Sequencing and Next-Generation sequencing (NGS); Transcriptomics and Proteomics and its significance in genetics	**2**	CO 2, CO 4	K3, K4, K5
	2.10 Practical tools for genetic analysis: BLAST, Ensembl, Machine learning in genetics	**2**	CO 2, CO 4	K3, K4, K5
Module 3: Control of gene expression, epigenetic mechanisms and cancer genetics	3.1 Control of gene expression; Induction of transcriptional activity by environmental and biological factors-heat shock genes and signal molecules	**2**	CO 3	K2, K3, K4
	3.2 Overview of epigenetic mechanisms of gene expression	**4**	CO 3	K2, K3, K4, K5
	3.3 The epigenome; gene-environment interactions and their link to human disease; genome imprinting and uniparental disomy	**2**	CO 3	K3, K4
	3.4 Cancer genetics: Introduction and cellular aspects; types of cancers, causes of cancer; protooncogenes; oncogenes; tumor suppressor genes; inherited cancer genes (familial cancers) and Knudson's Two Hit Hypothesis; cell cycle dysregulation in	**3**	CO 3, CO 4	K2, K3, K4, K5

	cancer, chromosomal instability, viruses and cancer; roles of p21, p53, ATM, BRCA1/2 in preventing cancer			
	3.5 Diagnostics for cancer detection: imaging techniques, biochemical tests, cytology; treatment of cancer: radiotherapy, chemotherapy, hyperthermia, targeted drug therapy, immunotherapy	**2**	CO 3, CO 4	K3, K4, K5
	3.6 Personalized medicine for genetic diseases: gene therapy, gene editing, pharmacogenomics	**2**	CO 3, CO 4	K3, K4, K5
Pedagogy:	• Lectures to review and introduce core concepts • ICT-based learning using animations and illustrations to understand genetic mechanisms • Problem-based learning using case studies of diseases and application of methods of diagnosis and treatment. • Small group discussions to review and recommend effective treatment strategies for genetic diseases • Collaborative learning and group projects • Evaluation using quizzes and assignments			
Texts:	1. Brooker, R. J. (2020). Genetics: Analysis and principles (7th ed.). McGraw-Hill Education. 2. Brown, T. A. (2018). Genomes (4th ed.). Garland Science. 3. Griffiths, A. J. F., Doebley, J., Peichel, C., & Wassarman, D. A. (2020). Introduction to genetic analysis (12th ed.). W.H. Freeman & Company. 4. Lewin, B. (2017). Genes XII (12th ed.). Jones & Bartlett Learning. 5. Pierce, B. A. (2019). Genetics: A conceptual approach (6th ed.). W.H. Freeman and Company. 6. Russell, P. J. (2016). iGenetics: A molecular approach (3rd ed.). Pearson. 7. Snustad, D. P., & Simmons, M. J. (2016). Principles of genetics (7th ed.). Wiley. 8. Strachan, T., & Read, A. (2018). Human molecular genetics (5th ed.). Garland Science.			
References/ Readings:	1. Hannon, G. J. (2002). RNA interference. nature, 418(6894), 244-251. 2. Jiang, F., & Doudna, J. A. (2017). CRISPR–Cas9 structures and mechanisms. Annual review of biophysics, 46(1), 505-529. 3. Hu, T., Chitnis, N., Monos, D., & Dinh, A. (2021). Next-generation sequencing technologies: An overview. Human immunology, 82(11), 801-811. 4. Jones, P. A., & Baylin, S. B. (2007). The epigenomics of cancer. Cell, 128(4), 683-692.			

	5. Arya, R., Mallik, M., & Lakhotia, S. C. (2007). Heat shock genes—integrating cell survival and death. Journal of biosciences, 32, 595-610. 6. Yamazawa, K., Ogata, T., & Ferguson-Smith, A. C. (2010, August). Uniparental disomy and human disease: an overview. In American Journal of Medical Genetics Part C: Seminars in Medical Genetics (Vol. 154, No. 3, pp. 329-334). Hoboken: Wiley Subscription Services, Inc., A Wiley Company. 7. Bhat, G. M., Mukhdoomi, M. A., Shah, B. A., & Ittoo, M. S. (2014). Dermatoglyphics: in health and disease-a review. Int J Res Med Sci, 2(1), 31-7. 8. Lu, T. X., & Rothenberg, M. E. (2018). MicroRNA. Journal of allergy and clinical immunology, 141(4), 1202-1207. 9. Wang, K. C., & Chang, H. Y. (2011). Molecular mechanisms of long noncoding RNAs. Molecular cell, 43(6), 904-914. 10. Salzman, J. (2016). Circular RNA expression: its potential regulation and function. Trends in genetics, 32(5), 309-316.
Web Resources:	1. Learn Genetics (University of Utah) https://learn.genetics.utah.edu/ 2. OMIM (Online Mendelian Inheritance in Man):Database for human genes and genetic disorders https://omim.org/ 3. Orphanet: Database of rare genetic diseases https://www.orpha.net/ 4. The Animal Genome Database (Ensembl) https://www.ensembl.org/ 5. NCBI Genomes & GeneBank https://www.ncbi.nlm.nih.gov/genbank/ 6. Animal QTLdb https://www.animalgenome.org/QTLdb/

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Title of the Course	Practical in Human Genetics
Course Code	ZOO-5011
Number of Credits	1
Theory/Practical	Practical
Level	500
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 provide a comprehensive understanding of classical and molecular genetics, integrating theoretical and practical aspects for animal and human systems. • To develop technical skills in laboratory-based genetic methods, including chromosome analysis, genetic crossing, and molecular genetics techniques. • To cultivate a research-oriented mindset through the study of inheritance patterns, genetic mapping, and advanced diagnostic techniques. • To equip students with the ability to analyze genetic data, address environmental and societal challenges, and contribute to sustainable solutions.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain the fundamental principles of genetics and their relevance to zoological concepts (K1 – Remember, K2 – Understand)	PSO 1

	CO 2. Apply genetic techniques to analyze inheritance patterns and perform genetic diagnostics (K3 - Apply, K4 - Analyze)		PSO 2, PSO 3	
	CO 3. Design and conduct experiments to study genetic phenomena, including linkage mapping (K3 - Apply, K6 - Create)		PSO 2, PSO 3	
	CO 4. Evaluate genetic data to address societal and environmental challenges in sustainable contexts (K5 - Evaluate, K4 - Analyze)		PSO 4	
Content:	**Topic**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Practical	Construction of pedigree using software (CeGAT)	**2**	CO 1, CO 2	K3, K4
	Pedigree analysis of X-linked and autosomal recessive, dominant characteristics	**2**	CO 2, CO 3	K4, K5
	Preparation of metaphase plate from mammalian tissue	**2**	CO 2	K3
	G-banding of metaphase chromosomes	**2**	CO 2, CO 3	K3, K4
	Study / Induction of gene mutations using model organism (Drosophila)	**4**	CO 2	K2, K3
	Study of genetic crosses (monohybrid / dihybrid) using mutants / wild type model organism (Drosophila)	**4**	CO 2, CO 3	K3, K6
	Linkage mapping by two point test cross and three point test cross	**2**	CO 3	K3, K4
	Isolation of DNA from organisms and comparing their size using gel electrophoresis	**2**	CO 2	K3, K4
	Sister chromatid exchange assay	**2**	CO 2, CO 3	K3, K4
	Fluorescence staining of nuclei	**2**	CO 2, CO 3	K3, K4
	Fluorescence in situ hybridization (FISH)	**2**	CO 3	K3, K5
	Scanning electron microscopy of chromosomes (Demo)	**2**	CO 1, CO 3	K2, K4
	Comet Assay (Demo)	**2**	CO 1, CO 3	K2, K4
Pedagogy:	• Hands-On Practical Training • Problem-Based Learning			

	• Interactive Demonstrations • Teamwork and collaborative learning • ICT-Enhanced learning • Recording and Journal-keeping
Texts:	1. Wilson, K., & Walker, J. (2018). Principles and techniques of biochemistry and molecular biology (8th ed.). Cambridge University Press. 2. Plummer, D. T. (2017). An introduction to practical biochemistry (3rd ed.). McGraw-Hill. 3. Dhawan, A., & Bajpayee, M. (Eds.). (2013). Genotoxicity assessment: Methods and protocols (Vol. 1044). Springer. 4. Pierce, B. A. (2019). Genetics: A conceptual approach (6th ed.). W.H. Freeman and Company. 5. Snustad, D. P., & Simmons, M. J. (2016). Principles of genetics (7th ed.). Wiley.
References/ Readings:	Ashburner, M., & Roote, J. (2007). Maintenance of a Drosophila laboratory: general procedures. Cold Spring Harbor Protocols, 2007(3), pdb-ip35.
Web Resources:	1. Learn Genetics (University of Utah) https://learn.genetics.utah.edu/ 2. Pedigree Chart Designer https://cegat.com/diagnostics/general-information/pedigree-chart-designer/ 3. OMIM (Online Mendelian Inheritance in Man):Database for human genes and genetic disorders https://omim.org/ 4. Orphanet: Database of rare genetic diseases https://www.orpha.net/ 5. The Animal Genome Database (Ensembl) https://www.ensembl.org/ 6. NCBI Genomes & GeneBank https://www.ncbi.nlm.nih.gov/genbank/ 7. Animal QTLdb https://www.animalgenome.org/QTLdb/

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Title of the Course	Advanced Developmental Biology
Course Code	ZOO-5012
Number of Credits	03
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value-added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Basic understanding of cell biology, molecular biology, and developmental processes at the undergraduate level.	
Course Objectives:	• To explain the electrophysiological and molecular roles of ion channels in gamete maturation, fertilization, and zygotic activation in vertebrates. • To analyze the genetic and biochemical frameworks regulating the maternal-to-zygotic transition and post-fertilization developmental control. • To explore the mathematical, signaling, and mechanistic models that govern spatial and temporal patterning during animal development. • To evaluate the use of artificial embryo models and clinical insights into embryopathies for translational applications in developmental biology and regenerative medicine.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Describe the types and roles of ion channels in gamete activation, capacitation, fertilization, and oocyte signaling during early development. *(K2)*	PSO1

	CO 2. Analyze the molecular mechanisms underlying maternal-to-zygotic transition and interpret the role of post-translational and transcriptional control in early zygotic development. (K4)		PSO1, PSO3	
	CO 3. Evaluate different developmental patterning models, including gene regulatory networks and mechanical models, and their relevance in axis formation and tissue specification. (K5)		PSO1, PSO3	
	CO 4. Appraise the application of artificial embryo models and recognize key embryopathies with developmental and clinical implications. (K5)		PSO1, PSO4	
Content:	**Topic**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Ion Channel Dynamics in Fertilization	**1.1** Overview of Ion Channels in Gametes: Types of ion channels (voltage-gated, ligand-gated, stretch-activated, store-operated), Resting membrane potential of sperm and oocyte, Ion transporters, exchangers, and pumps (e.g., Na^+/K^+ ATPase, PMCA, NCX).	**1**	CO1	K2
	1.2. Ion Channel Function in Sperm Activation and Capacitation: CatSper Channels, (Ca^{2+} Channels Specific to Sperm)-Structure and activation by alkalinization and progesterone, Role in hyperactivated motility and chemotaxis. SLO3 Potassium Channels-Regulation of membrane potential during capacitation, Contribution to hyperpolarization and acrosome priming. Hv1 Proton Channels-Intracellular alkalinization and pH regulation, Interaction with CatSper for Ca^{2+} influx coordination Chloride and Sodium Channels-Involvement in osmoregulation and tail motility, Supportive roles in signaling integration	**4**	CO1	K2
	1.3. Ion Channels in Sperm–Egg Fusion and Oocyte Activation: IZUMO1–JUNO Interaction and Electrical Competence-Indirect triggering of calcium influx, Spatial polarization of fusogenic domains. PLCζ-Triggered IP_3R-Mediated Ca^{2+} Release-IP_3-induced Ca^{2+} oscillations from the ER, Repetitive Ca^{2+} transients and their temporal coding in mammals.	**4**	CO1	K2

	Store-Operated Ca^{2+} Entry (SOCE) and TRP Channels- Maintenance of calcium oscillations, STIM1/ORAI1 interactions at ER–plasma membrane junctions Zinc and Other Ion Transients-Zinc sparks and their electrophysiological correlation, Modulatory role in chromatin stabilization and cell cycle progression.			
	1.4. Maternal-to-Zygotic Transition mechanisms: Maternal Protein Degradation (Ubiquitin–Proteasome Pathway, Autophagy and Lysosomal Pathways), Regulatory Control of Maternal Protein Clearance (Zygotic Transcription-Dependent Regulation and Translational Shutoff), Functional Transition to Zygotic control (Emergence of Zygotic Transcription Factors, and Cell Cycle and Morphogenetic Shifts)	**6**	CO1, CO2	K3
Module 2: Conceptual Frameworks of Developmental Patterning	**2.1.** Positional Information Models: French Flag Model (Lewis Wolpert), Morphogen Gradient Models, Relay Models for Threshold-based fate specification.	**1**	CO3	K4
	2.2. Reaction–Diffusion Models: Turing Reaction–Diffusion Model (Alan Turing), Activator–Inhibitor Systems for Self-organizing chemical patterns.	**1**	CO3	K4
	2.3. Temporal Patterning Models: Clock and Wavefront Model, Segmentation Clock for Oscillatory dynamics, timing in patterning	**1**	CO3	K5
	2.4. Gene Regulatory Network (GRN) Models: Stable States (Attractors) in GRNs and Modular GRNs for Internal regulatory logic of fate decisions.	**2**	CO2	K5
	2.5. Community and Induction Models: Community Effect (John Gurdo) and Inductive Signaling Models for Cell–cell interaction and feedback.	**2**	CO3	K4
	2.6. Mechanical and Biophysical Models: Mechanotransduction Models and Epithelial Folding, Cell Migration, and Constriction models in morphogenesis for Biomechanical forces in shaping tissues.	**2**	CO3	K5
	2.7. Stochastic Models: Probabilistic Fate Decisions and Noise-buffering Mechanisms for variability and robustness in development.	**1**	CO3	K5
	2.8. Signal transduction pathways of pattern formation and cell fate : Axis Specification and Body Plan Patterning (Wnt/β-catenin: Anterior–posterior axis, BMP/TGF-β: Dorsal–ventral axis, Hedgehog: Left-right and posterior patterning), Germ Layer	**5**	CO3	K5

	Induction and Tissue Differentiation (FGF: Mesoderm induction, tissue migration, BMP/TGF-β: Ectoderm/mesoderm decision, Wnt/β-catenin: Endoderm and mesoderm specification), Fine-scale Patterning and Cell Fate Decisions (Notch/Delta: Lateral inhibition, asymmetric division, Hedgehog: Organ-specific patterning-e.g., digits, CNS)			
Module 3: Developmental Modeling and Disease Origins	**3.1** Artificial Embryo Models and Their Applications: Types of Artificial Embryo Models-Embryoid Bodies (EBs), Gastruloids, Blastoids, ETX Embryos and their applications.	**5**	CO4	K5
	3.2 Applications in Developmental Biology: Modeling Early Embryonic Events, Drug Screening and Toxicology, Regenerative Medicine, Comparative Embryology, Modeling Developmental Disorders.	**5**	CO4	K5
	3.3 Common Embryopathies: Neural Tube Defects (NTDs), Craniofacial Malformations, Cardiovascular Embryopathies, Limb and Skeletal Defects, Eye and Ear Defects, Teratogen-Induced Embryopathies and Chromosomal Embryopathies.	**5**	CO4	K5
Pedagogy:	Lectures/Model-Based Teaching/Case-Based Learning/Interactive Seminars and Tutorials/Video Demonstrations and Simulations/Student Presentations/Problem-Based Assignments/Review of landmark research papers and in-class critiques/Group discussions and interactive sessions.			
Texts:	1. Gilbert, S.F. & Barresi, M.J.F. (2020). *Developmental Biology* (12th ed.). Oxford University Press. 2. Slack, J.M.W. (2012). *Essential Developmental Biology* (3rd ed.). Wiley-Blackwell. 3. Wolpert, L. et al. (2015). *Principles of Development* (5th ed.). Oxford University Press. 4. Moody, S.A. (2020). *Principles of Developmental Genetics* (2nd ed.). Academic Press. 5. Lovtrup, S. (2011). *Epigenetics: A Challenge of the Modern Synthesis.* Springer. 6. Alberts, B. et al. (2022). *Molecular Biology of the Cell* (7th ed.). Garland Science. 7. Lodish, H. et al. (2021). *Molecular Cell Biology* (9th ed.). W. H. Freeman and Company. 8. Hille, B. (2001). *Ion Channels of Excitable Membranes* (3rd ed.). Sinauer Associates.			
References/ Readings:	1. Fluck, R. A., Miller, A. L., & Jaffe, L. F. (1991). Slow calcium waves accompany the fast block to polyspermy in frog eggs. Journal of Experimental Zoology, 258(2), 176–187.			

	2. Briggs, J. A., Weinreb, C., Wagner, D. E., et al. (2018). The dynamics of gene expression in vertebrate embryogenesis at single-cell resolution. Science, 360(6392), eaar5780. 3. Fleming, T. P., et al. (2016). Zygotic genome activation and maternal clearance in mammals: The one-two punch of transcription and mRNA decay. Molecular Reproduction and Development, 83(12), 993–1006. 4. Levine, M., & Davidson, E. H. (2005). Gene regulatory networks for development. Proceedings of the National Academy of Sciences, 102(14), 4936–4942. 5. Shahbazi, M. N., & Zernicka-Goetz, M. (2018). Deconstructing and reconstructing the mouse and human early embryo. Nature Cell Biology, 20(8), 878–887.
Web Resources:	1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2002). *Chromatin and epigenetic regulation*. In *Molecular biology of the cell* (4th ed., Chapter 4). Garland Science. National Center for Biotechnology Information (US). https://www.ncbi.nlm.nih.gov/books/NBK9983/ 2. Davidson Lab. (n.d.). *Developmental dynamics and GRN maps: Davidson Lab archives*. California Institute of Technology. http://www.its.caltech.edu/~mirsky/ 3. EMBL-EBI. (n.d.). *Reactome pathway database: Signal transduction*. https://reactome.org/ 4. Gene Ontology Consortium. (n.d.). *Gene ontology resource: Biological processes in development*. http://geneontology.org/ 5. Mouse Genome Informatics. (n.d.). *Mouse Genome Informatics (MGI)*. The Jackson Laboratory. http://www.informatics.jax.org 6. Mouse Genome Informatics. (n.d.). *Mouse Genome Informatics (MGI)*. The Jackson Laboratory. http://www.informatics.jax.org 7. National Human Genome Research Institute. (n.d.). *NIH epigenomics project portal*. https://www.genome.gov/Funded-Programs-Projects/Epigenomics 8. Society for Developmental Biology. (n.d.). *Society for Developmental Biology (SDB)*. https://www.sdbonline.org 9. VisEmbryo. (n.d.). *The virtual embryo: Human development stages*. https://www.visembryo.com/ 10. Zebrafish Model Organism Database. (n.d.). *ZFIN: Zebrafish Model Organism Database*. https://zfin.org

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Title of the Course	Practical in Advanced Developmental Biology
Course Code	ZOO-5013
Number of Credits	01
Theory/Practical	Practical
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Basic knowledge of embryology and laboratory safety Familiarity with microscopy and biological specimen handling Introductory skills in staining, dissection, and observation recording	
Course Objectives:	• To provide advanced laboratory exposure to molecular mechanisms regulating animal development. • To develop skills in experimental design through mini-project-based learning. • To investigate the role of key morphogens, and environmental agents affecting embryonic patterning. • To familiarize students with molecular tools for tissue analysis, gene regulation studies, and toxicological assessment.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Identify and classify key developmental stages in fish embryos, and relate them to morphogenetic events.(K3)	PSO1, PSO3
	CO 2. Design and execute experiments to study craniofacial anomalies and skeletal malformations using natural and chemical modulators. (K6)	PSO 2, PSO3

	CO 3. Perform and interpret histological, morphometric, and staining techniques to analyze embryonic tissue development. (K5)		PSO2, PSO3	
	CO 4. Evaluate molecular and physiological responses to environmental or dietary factors using in vitro and in ovo models. (K5)		PSO1, PSO4	
	CO 5. Analyze metabolic profiles of embryos at different developmental stages using advanced instrumentation (GC-MS). (K5)		PSO3, PSO4	
Content:	**Topics**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Practical	1.1: Identification and classification of the developmental stages in fish.	**2**	CO1, CO3	K3
	1.2: Setting up of the egg incubator and eggs for experimentation. And In-ovo injection techniques using chick embryo	**2**	CO2	K6
	1.3: Preparation of Alcian Blue–Alizarin Red dual staining solutions	**2**	CO3	K5
	1.4: Skeletal staining: Fixation and cartilage staining using Alcian Blue	**2**	CO3	K5
	1.5: Skeletal staining: Bone staining using Alizarin Red	**2**	CO3	K5
	1.6: Imaging and documentation of skeletal malformations	**2**	CO3	K5
	1.7: Selection and preparation of herbal/dietary bioactives (e.g., curcumin, resveratrol, gingerol)	**4**	CO3	K5
	1.8: In ovo administration of dietary bioactives to test groups	**2**	CO4	K5
	1.9: Morphometric assessment of craniofacial features (Fetal Alcohol Syndrome model)	**2**	CO2, CO3	K6
	1.10: Tissue homogenization and preparation for MDA assay	**2**	CO2, CO4	K6
	1.11: Spectrophotometric estimation of Malondialdehyde (MDA) for lipid peroxidation	**2**	CO5	K5
	1.12: To analyse the Metabolic profiles of embryos at different developmental stages using advanced instrumentation (GC-MS).	**4**	CO5	K5

	1.13: Compilation, comparative analysis, report generation and Discussion	**2**	CO1–CO5	K6
Pedagogy:	Hands-on Practical Learning/ Mini Projects/Data Analysis Skills-Training/Collaborative Learning.			
Texts:	1. Gilbert, S. F., & Barresi, M. J. F. (2020). Developmental Biology (12th Edition). Sinauer Associates / Oxford University Press. 2. Slack, J. M. W. (2012). Essential Developmental Biology (3rd Edition). Wiley-Blackwell. 3. Wolpert, L., Tickle, C., & Martinez Arias, A. (2015). Principles of Development (5th Edition). Oxford University Press.			
References/ Readings:	1. Hamburger, V., & Hamilton, H. L. (1951). A Series of Normal Stages in the Development of the Chick Embryo. Journal of Morphology. 2. Strachan, T., & Read, A. P. (2018). Human Molecular Genetics (5th Edition). Garland Science. 3. Selected review articles from journals like Development, Nature Reviews Molecular Cell Biology, Mechanisms of Development, and Genesis for current advancements.			
Web Resources:	1. Society for Developmental Biology. (n.d.). *Society for Developmental Biology (SDB)*. https://www.sdbonline.org 2. Howard Hughes Medical Institute. (n.d.). *Biointeractive virtual labs*. https://www.biointeractive.org/classroom-resources 3. Zebrafish International Resource Center. (n.d.). *Zebrafish International Resource Center*. https://zebrafish.org 4. OpenStax. (n.d.). *Biology*. OpenStax, Rice University. https://openstax.org/books/biology/pages/1-introduction			

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Title of the Course	Field Skills in Zoology (Practical)
Course Code	ZOO-5014
Number of Credits	4
Theory/Practical	Practical
Level	500
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:	• Introduce the concept of fieldwork in zoology • Equip students with field sampling techniques • Foster understanding of data management and analysis • Encourage exploration and documentation of biodiversity	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Explain the basic principles and ethics of fieldwork (K2 – Understand)	PSO 1
	CO 2. Demonstrate competence in sampling techniques and habitat profiling (K3 – Apply)	PSO 2
	CO 3. Analyze and interpret field data using statistical tools and software (K4 – Analyze)	PSO 3
	CO 4. Prepare detailed reports and identification guides based on field observations (K5 – Evaluate)	PSO 4

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1: Basics of field work, safety and habitats	1.1 Introduction to field work: Concept of 'field'	**2**	CO 1	K2
	1.2 Basic requirements for conducting field work	**4**	CO 1	K3
	1.3 Field Safety	**2**	CO 2	K3
	1.4 Field Ethics	**2**	CO 3	K5
	1.5 Habitat characterization; Habitats and ecosystems	**8**	CO 1	K4
	1.6 Abiotic and Biotic parameters	**6**	CO 1	K3
	1.7 Vegetation structure, soil / substrate profiling	**6**	CO 1	K3
Module 2: Sampling	2.1 Concept of sample and sampling	**2**	CO 1	K2
	2.2 Meiofauna: Quadrant sampling, sweep-net and light-trap, pitfall, leaf-litter extraction,	**4**	CO 2	K4
	2.3 Survey of insects (butterflies, moths, beetles, etc), malacofauna, crustaceans, identification guides and keys	**8**	CO 2	K3
	2.4 Macrofauna: visual encounter surveys, concept of transect, point count, survey of birds, mammals fish, herpetofauna, identification guides and keys	**10**	CO 3	K5
	2.5 Sampling of water: Planning, instrumentation and handling of samples.	**2**	CO 1	K3
	2.6 Sampling of soil: Planning, instrumentation and handling of samples.	**2**	CO 1	K3
	2.7 Sampling of air: Planning, instrumentation and sample analysis.	**2**	CO 1	K3
Module 3: Data collection,	3.1 Basics of image capturing: DSLR vs Mobile photography, Importance of camera settings, lighting, etc in image capture	**1**	CO 4	K3
	3.2 Basics of video recording using mobile camera and DSLR	**1**		

management and analysis	3.3 Camera trapping techniques	**2**	CO 4	K3
	3.4 Acoustic recordings and analysis	**4**	CO 4	K4
	3.5 Citizen science and crowdsourcing data (ex: iNaturalist)	**2**	CO 4	K5
	3.6 Mapping software (QGIS)	**4**	CO 3	K4
	3.7 Data management: Field datasheet creation, data input, arranging and collating data	**4**	CO 3	K4
	3.8 Data analysis using computer software (MS Excel,Ravenpro, Past)	**2**	CO 3	K4
	3.9 Bioinformatics for field data	**2**	CO 3	K4
	3.10 Basic statistics in data analysis	**2**	CO2	K3
	3.11 Survey of fauna in your locality (any two fauna); preparation and management of checklist data	**2**	CO 3	K5
	3.12 Indices of diversity, richness, evenness, dominance	**2**	CO 2	K3
Module 4: Field Learning	4.1 Preparation of standard guide for identification of any one taxa in the Goa University Campus	**2**		
	Field Study/Excursions	**30**	CO 2	K6
	4.2 Visit to Protected Areas within Goa and survey of fauna		CO 2	K3
	4.3 Visit to coastal area of Goa and survey of fauna		CO 2	K3
	4.4 Visit to mangroves in Goa and survey of fauna		CO 2	K3
	4.5 Visit to plateaus in Goa and survey of fauna		CO 2	K3
	4.7 Study tour outside Goa		CO 4	K6
	4.8 Preparation of detailed field trip reports and structuring fieldwork reports for publication or conservation management plans		CO 4	K6
Pedagogy:	• Hands-On Practical Sessions			

	• Field Trips and Surveys • Group Work • Presentations • Case Studies • ICT-mediated learning
Texts:	1. Karban, R., Huntzinger, M., & Pearse, I. S. (2014). *How to do ecology: A concise handbook* (2nd ed.). Princeton University Press. 2. Wheater, C. P., Bell, J. R., & Cook, P. A. (2020). Practical field ecology: a project guide. John Wiley & Sons. 3. Silvy, N. J. (Ed.). (2020). The Wildlife Techniques Manual: Volume 1: Research. Volume 2: Management. JHU Press. 4. Morrison, M. L., Block, W. M., Strickland, M. D., Collier, B. A., & Peterson, M. J. (2008). Wildlife study design. Springer Science & Business Media. 5. Morrison, M. L. (2013). Wildlife restoration: techniques for habitat analysis and animal monitoring (Vol. 1). Island Press. 6. Comer, C. E., Bolen, E. G., & Robinson, W. L. (2025). Wildlife ecology and management. Waveland Press. 7. Sutherland, W. J., Newton, I., & Green, R. (2004). Bird ecology and conservation: a handbook of techniques (No. 1). Oxford university press. 8. Sebastian, P. A., & Peter, K. V. (Eds.). (2009). Spiders of India. Universities press. 9. Ponder, W. F., Lindberg, D. R., & Ponder, J. M. (2019). Biology and evolution of the mollusca, volume 1. CRC Press. 10. Singh, R., Verma, A. K., Singh, B. B., & Singh, G. (2023). Spider fauna of India. *Asian Biological Research Foundation*. 11. Antram, C. B. (1924). Butterflies of India. Mittal Publications. 12. Beavan, R. (1877). Handbook of the freshwater fishes of India. L. Reeve & Company. 13. Alvi, M. (2016). A manual for selecting sampling techniques in research. 14. Carter, M. R., & Gregorich, E. G. (2007). *Soil sampling and methods of analysis*. CRC press. 15. Giere, O. (2008). Meiobenthology: the microscopic motile fauna of aquatic sediments. Springer Science & Business Media. 16. Mohan Joseph, M. (2007). Field guide to the common marine molluscs of India. 17. Sturm, C. F., Pearce, T. A., & Valdés, Á. (Eds.). (2006). The mollusks: a guide to their study, collection, and preservation. Universal-Publishers.

	18. Tripathy, B., Sajan, S. K., & Mukhopadhyay, A. (2018). Mollusca. Faunal Diversity of Indian Himalaya, Eds. K. Chandra, D. Gupta, KC Gopi, B. Tripathy, and V. Kumar, 785-796. 19. Wheater, C. P., Bell, J. R., & Cook, P. A. (2020). *Practical field ecology: a project guide*. John Wiley & Sons.
References/ Readings:	1. Gupta, N., & Siliwal, M. (2012). A checklist of spiders (Arachnida: Araneae) of Wildlife Institute of India campus, Dehradun, Uttarakhand, India. Indian Journal of Arachnology, 1(2), 73-91. 2. Erickson, A. J., Weiss, P. T., Gulliver, J. S., Erickson, A. J., Weiss, P. T., & Gulliver, J. S. (2013). Water sampling methods. Optimizing Stormwater Treatment Practices: A Handbook of Assessment and Maintenance, 163-192. 3. Bezanson, M., Stowe, R., & Watts, S. M. (2013). Reducing the ecological impact of field research. American Journal of Primatology, 75(1), 1-9. 4. James, D. W., & Wells, K. L. (1990). Soil sample collection and handling: Technique based on source and degree of field variability. Soil testing and plant analysis, 3, 25-44. 5. Wulfsohn, D. (2010). Sampling techniques for plants and soil. Advanced Engineering Systems for Specialty Crops: A Review of Precision Agriculture for Water, Chemical, and Nutrient Application, and Yield Monitoring, 3-30. 6. Somerfield, P. J., & Warwick, R. M. (2013). Meiofauna techniques. Methods for the study of marine benthos, 253-284. 7. Biju Kumar, A., & Ravinesh, R. (2015). Taxonomy of marine molluscs of India: status and challenges ahead. In *Nandan, SB, Oliver, PG, Jayachandran, PR Asha, CV (eds.). Training manual-1st International Training Workshop on Taxonomy of Bivalve Molluscs. CUSAT, Kochi, India* (pp. 67-87). 8. Nandan, S. B., Jayachandran, P. R., & Asha, C. V. (2016). Sampling Techniques for molluscan fauna. In *Training Manual-1 St International Training Workshop On Taxonomy of Bivalve Molluscs* (pp. 107-116). Kochi, India: Cochin University of Science & Technology.
Web Resources:	1. https://www.antwiki.org/wiki/Welcome_to_AntWiki 2. https://spiderid.com/ 3. https://www.insectidentification.org/ 4. https://www.marinespecies.org/ 5. https://www.decanet.info/ 6. https://www.ifoundbutterflies.org/ 7. https://www.indianodonata.org/

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Discipline Specific Elective (DSE) Courses

Title of the Course	Cellular and Molecular Immunology
Course Code	ZOO-5209
Number of Credits	4
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 explore advanced cellular and molecular mechanisms governing innate and adaptive immune responses. • To examine the structural and functional intricacies of antigen recognition, lymphocyte activation, receptor signaling, and differentiation pathways in humoral and cellular immunity. • To understand the mechanisms underlying immune pathologies including autoimmunity, hypersensitivities, immunodeficiencies, and their molecular diagnostics and therapeutic approaches. • To evaluate immunological technologies and translational applications such as cancer immunotherapy, neuroimmunology, mucosal immunity, and computational tools in immune research.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Explain advanced concepts in intercellular immune signaling, immunometabolism, and trained immunity with relevance to host defense. *(K2)*	PSO1

	CO 2. Analyze molecular interactions in antigen recognition, receptor signaling cascades, and lymphocyte differentiation under physiological and pathological conditions. *(K4)*		PSO1, PSO3	
	CO 3. Evaluate immune dysfunctions such as autoimmunity, hypersensitivity, immunodeficiencies, and their diagnostic and therapeutic frameworks. *(K5)*		PSO1, PSO4	
	CO 4. Assess recent innovations in immunotherapy, neuroimmunology, mucosal immunity, and computational immunology for translational and research applications. *(K5)*		PSO1, PSO3, PSO4	
Content:	**Topic**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Advanced Cellular and Molecular Basis of Immunity	1.1 Systems Immunology and Intercellular Signaling: Cross-talk between innate and adaptive cells, Role of DAMPs and Alarmins, Cytokine and chemokine networks, GALT, BALT, MALT,	**3**	CO1	K2
	1.2 Immunometabolism: Metabolic reprogramming in immune activation, Warburg effect in T cells, Lipid metabolism and trained immunity	**3**	CO1	K2
	1.3 Innate Lymphoid Cells (ILCs) and NK Cell Biology: Types and functions (ILC1–3), NK cell education, ADCC, cytotoxicity, Memory-like NK cells	**3**	CO1	K2
	1.4 Trained Immunity and Epigenetic Reprogramming: Innate immune memory, Histone modification and metabolic-epigenetic coupling, Vaccine and host defense implications	**3**	CO1	K2
	1.5 Cell Death Pathways in Immunity: Apoptosis, pyroptosis, necroptosis, Caspases, inflammasomes, gasdermins, Immunogenic vs non-immunogenic cell death	**3**	CO1	K2
Module 2: Antigen Recognition, Lymphocyte Dynamics and Signaling Cascades	2.1 Molecular Recognition by Immune Receptors: TCR-peptide-MHC and BCR-antigen structure, Germline vs somatic models, Superantigens and immune deviation	**3**	CO2	K4
	2.2 Signal Transduction in Lymphocytes: BCR and TCR signaling pathways, Kinases: Lck, ZAP70, Syk, MAPK, NFAT, NF-κB, mTOR roles	**3**	CO2	K4
	2.3 T Cell Subsets and Functional Plasticity: Th1, Th2, Th17, Treg, Tfh and their cytokines, CD8+ cytotoxic memory, Tissue-resident memory and trained T cells	**3**	CO2	K4
	2.4 B Cell Activation and Germinal Center Dynamics: T cell-dependent vs independent B cell activation, Somatic hypermutation and affinity maturation, Plasma vs memory B cell	**3**	CO2	K4

Module 3: Immunopathology and Immune Dysregulation	3.1 Autoimmunity and Immune Tolerance: Central vs peripheral tolerance, AIRE, Tregs, anergy, T1D, MS, SLE; mechanisms of immune dysregulation	**3**	CO3	K5
	3.2 Allergy and Hypersensitivity: Gell and Coombs Types I–IV, IgE, mast cells, eosinophils, Diagnostics and desensitization	**3**	CO3	K5
	3.3 Immunodeficiency Syndromes: SCID, XLA, CVID, Hyper-IgM, HIV and acquired immunodeficiencies, Immune profiling and markers	**3**	CO3	K5
	3.4 Chronic Inflammation and Cancer Immunity: TNF-α, IL-6, CRP in chronic diseases, Tumor immunoediting, T cell exhaustion, Immunosuppressive microenvironment	**3**	CO3	K5
	3.5 Vaccination and Immunoprophylaxis: Vaccine types: live, killed, mRNA, Adjuvants and herd immunity, Cold chain and policy implications	**3**	CO3	K5
Module 4: Translational and Emerging Frontiers in Immunology	4.1 Cancer Immunotherapy: Checkpoint inhibitors (PD-1, CTLA-4), CAR-T therapy, adoptive transfer, Personalized vaccines	**3**	CO4	K5
	4.2 Neuroimmunology: CNS immune privilege, Microglia, astrocytes in neuroinflammation, MS, Alzheimer's disease	**3**	CO4	K5
	4.3 Mucosal and Barrier Immunity: Microbiota-immune interactions, Mucosal vaccines and epithelial defenses	**3**	CO4	K5
	4.4 Immunogenetics and Single-Cell Immunology: HLA polymorphism and graft rejection, Single-cell RNA-seq for immune profiling, Precision diagnostics	**3**	CO4	K5
	4.5 Synthetic and Computational Immunology: Epitope prediction tools, Artificial lymphoid systems, CRISPR diagnostics and immune biosensors	**3**	CO4	K5
Pedagogy:	Lectures/Interactive Tutorials/Research Paper Reviews/Concept Mapping & Infographics/Problem-Based Learning (PBL)/Flipped Classroom/Group Projects & Presentations/Use of ICT Tools			
Texts:	1. Delves, P. J., Martin, S. J., Burton, D. R., & Roitt, I. M. (2021). *Roitt's Essential Immunology* (14th ed.). Wiley-Blackwell. 2. Janeway, C. A., et al. (2017). *Immunobiology: The Immune System in Health and Disease* (9th ed.). Garland Science. 3. Kindt, T. J., Goldsby, R. A., & Osborne, B. A. (2007). *Kuby Immunology* (6th ed.). W.H. Freeman. 4. Male, D., Brostoff, J., Roth, D., & Roitt, I. (2012). *Immunology* (8th ed.). Mosby – Strong focus on clinical			

	applications. 5. Murphy, K., & Weaver, C. (2022). *Janeway's Immunobiology* (10th ed.). Garland Science. 6. Murphy, K., Weaver, C. (2016). *Janeway's Immunobiology* – Detailed mechanistic insights into signaling and cellular responses. 7. Parham, P. (2020). *The Immune System* (5th ed.). Garland Science. 8. Paul, W. E. (Ed.) (2012). *Fundamental Immunology* (7th ed.). Lippincott Williams & Wilkins – For in-depth molecular detail and immunogenetics. 9. Punt, J., Stranford, S., Jones, P., & Owen, J. A. (2018). *Kuby immunology* (8th ed.). W.H. Freeman and Company.Abbas, A. K., Lichtman, A. H., & Pillai, S. (2022). *Cellular and Molecular Immunology* (10th ed.). Elsevier. 10. Sompayrac, L. (2019). *How the Immune System Works* (6th ed.). Wiley-Blackwell – Conceptual clarity with simplified illustrations.
References/ Readings:	1. Barrett, T., & Bennett, C. (2016). Single-cell immunology: Technology and applications. *Nature Reviews Immunology*, *16*(3), 169–182. 2. Murray, P. J. (2015). Metabolic reprogramming of macrophages and T cells in inflammation. *Journal of Clinical Investigation*, *125*(2), 511–520. 3. Netea, M. G., Joosten, L. A. B., Latz, E., et al. (2016). Trained immunity: A program of innate immune memory in health and disease. *Science*, *352*(6284), aaf1098. 4. Pardoll, D. M. (2012). The blockade of immune checkpoints in cancer immunotherapy. *Nature Reviews Cancer*, *12*(4), 252–264. 5. Turvey, S. E., & Broide, D. H. (2010). Innate immunity. *Journal of Allergy and Clinical Immunology*, *125*(2 Suppl 2), S24–S32.
Web Resources:	1. Alberts, B., Johnson, A., Lewis, J., et al. (2002). *Molecular biology of the cell* (4th ed.). Inflammation and immune system pathways. National Center for Biotechnology Information (NCBI). https://www.ncbi.nlm.nih.gov/books/NBK21070/ 2. Centers for Disease Control and Prevention (CDC). (2015). *Epidemiology and prevention of vaccine-preventable diseases* (13th ed.). Public Health Foundation. National Center for Biotechnology Information (NCBI). https://www.ncbi.nlm.nih.gov/books/NBK285557/ 3. Ewald, P. W. (2004). *Immunology and evolution of infectious disease*. Oxford University Press. https://www.ncbi.nlm.nih.gov/books/NBK2394/

	4. Gerriets, V., Anderson, J., & Nappe, T. M. (2021, July 3). *Acetaminophen*. In *StatPearls*. StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK532327/ 5. Janeway, C. A., Travers, P., Walport, M., & Shlomchik, M. J. (2001). *Immunobiology: The immune system in health and disease* (5th ed.). Garland Science. https://www.ncbi.nlm.nih.gov/books/NBK10757/

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Title of the Course	Ornithology
Course Code	ZOO-5210
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 bird biology • To summarize the methods in bird studies • To evaluate varied aspects of applied ornithology • To relate recent research in the field of ornithology and contribution of citizen science	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Comprehensive understanding of bird biology *(K2 – Understanding)*	PSO1
	CO 2. Evaluate methods in ornithology (K5 – evaluating)	PSO1, PSO3
	CO 3. Apply the knowledge gained in Ornithology (K3 – Applying)	PSO2, PSO3
	CO 4. Apply the knowledge for bird conservation and social awareness. (K5 – Evaluating)	PSO2, PSO4

Content:	Topic	No of hours	Mapped to CO	Cognitive Level
Module 1: Avian evolution, systematics, anatomy and physiology:	1.1 Avian Evolution Diversification of modern birds. Speciation and adaptive radiation in birds	**2**	CO1	K2
	1.2 Avian classification, Diversity and Distribution of birds of India. Endemism in Indian avifauna – Endemic Bird Areas of India.	**3**	CO1	K2
	1.3 Flightless birds and adaptations Flight Adaptations - morphological, anatomical, and physiological	**2**	CO1	K2
	1.4 Topography of bird, types of beaks, types of feet Biology of molting in birds (periodic and forced molting).	**3**	CO1	K2
	1.5 Types of feathers, types of pigments, visual functions of plumage Colour physiology of iridescent and non- iridescent feathers and gloss production	**2**	CO1	K2
	1.6 Flight: forms, mechanisms & energetics, Thermoregulatory mechanisms	**2**	CO1	K2
	1.7 vocal organs, vocalization, neurophysiology of song control system Analysis of bird song using softwares. Avian eye and its adaptations.	**2**	CO1	K2
Module 2 Avian Ecology:	2.1 Avian food and foraging - diversity of foods, foraging behaviors, Feeding specialization and generalization, resource partitioning	**3**	CO1	K2
	2.2 Avian communication, inter and intraspecific interactions, colonial behaviour, cooperation, competition, and conflicts	**3**	CO1	K2
	2.3 Breeding- nesting territories, communal nesting, bird songs, courtship, mating systems, types of nests, clutch size, parental care, nest parasitism.	**4**	CO1	K2
	2.4 Migration - types of migration, flyways of migrations, physiological aspects of migration, orientation & navigation in migratory birds, threats to migratory bird populations.	**3**	CO1	K2
	3.1 Roosting behaviour, Ecology of bird population	**2**	CO1	K2
	3.2 Importance of bird population monitoring; Role of citizen science in bird conservation, social awareness for bird conservation. Conservation of threatened avifauna - Captive breeding & ex- situ conservation of critically endangered birds.	**2**	CO3, CO4	K3, K5

Module 3 Applied ornithology:	3.3 Types of bird studies (field base- observational, census and population, habitat assessment; lab based- morphology, parasitology, molecular and physiological) and methods adopted for data collection and ethics. Birds as indicators of environmental health – Merits and limitations of birds as ecological indicators.	**2**	CO2, CO3	K3, K5
	3.4 Basic principles of avian veterinary care, rehabilitation, and ethics Bird taxidermy and preservation	**2**	CO3	K3
	3.5 Birds as model systems in applied genetic studies. Birds as pests in agriculture, pisciculture, apiculture, sericulture, and free-ranging poultry farms	**2**	CO3	K3
	3.6 Ecosystem services provided by birds. Birdwatching as an emerging eco-tourism venture, Bird photography	**2**	CO3	K3
	3.7 Birds as vectors of pathogens and parasites – Zoonoses. Bird strike hazards to aircraft & their management	**2**	CO3	K3
	3.8 Biomimicry and birds, Application of artificial intelligence for bird conservation	**2**	CO3, CO4	K3, K5
	3.9 Recent research in the field of ornithology.	**1**	CO4	K5
Pedagogy:	Hands on training, experiments, case-studies, group discussions, field visits, surveys			
Texts:	1. F. B. Gill, Ornithology. (3rd ed.) New York, NY. W. H. Freeman and Company, 2007 2. P. Goodfellow, Birds as Builders. New York, Arco Publishing Co., 1977 3. J. Lovette and J. W. Fitzpatrick, Handbook of Bird biology (3rd Ed) Wiley publishers. 2016			
References	1. S. Ali, The Book of Indian Birds. India, Bombay Natural History Society nd Oxford University Press, 2016. 2. C. J. Bibby, N.D. Burgess, A. Hill, Bird Census Techniques. UK, Academic 3. M. S. Brainard, and A. J. Doupe,. Auditory feedback in learning and 4. C Inskipp, R Grimmett and T Inskipp, Birds of the Indian Subcontinent, 5. D.B. Meyer, The Avian Eye and its Adaptations. In: Crescitelli F. (eds) 6. P. D. Sturkie, Sturkie's Avian Physiology. 5th Edition. San Diego, 7. Berlin, Heidelberg Springer,. 1977 8. Academic Press, 1998. maintenance of vocal behavior. (1, 31-40) Nature Rev. Neurosci, 2000 Press, 1992. Princeton University Press2011.			

	9. The Visual System in Vertebrates. Handbook of Sensory Physiology, (vol
Web Sources	1. Birds of the World (Cornell Lab of Ornithology)**:** https://birdsoftheworld.org/bow/home 2. The Cornell Lab of Ornithology**:** https://www.allaboutbirds.org/ 3. BirdLife International: https://www.birdlife.org/

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Title of the Course	Practical in Ornithology
Course Code	ZOO-5211
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-5210) should be taken	
Course Objectives:	Enable learners to: • develop on-field bird identification skills • provide knowledge on statistical and acoustic analysis of data using software • evaluate methods of bird data collection • create social awareness and bird conservation	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Skill development in bird identification. *(K2 – Understanding)*	PSO1, PSO2
	CO 2. Evaluating data using software (K5 – evaluating)	PSO2, PSO3
	CO 3. Evaluating methods of bird data collection (K3 – Applying)	PSO2, PSO3
	CO 4. Creating social awareness and bird conservation (K5 – creating)	PSO2, PSO4

Content:	Topic	No. of hours	Mapped to CO	Cognitive Level
Module 1:	1. Identification of birds on the field, based on colour, size, flight, and call.	1	CO1	K2
	2. Comparative study of resident and migratory birds with respect to habitats (Plateau, Forest, and Wetland).	1	CO1	K3
	3. Analysis of ornithological data using statistical software.	1	CO2	K4
	4. Study of nesting behaviour of Crow.	1	CO3	K4
	5. Study of feeding behaviour of birds.	1	CO3	K4
	6. Acoustic data collection and analysis	2	CO2	K4
	7. Structural and functional analysis of avian feathers.	1	CO3	K2
	8. Anatomy of bird (poultry chicken): flight muscles, digestive system, respiratory system, urinogenital system, skeletal system, and brain.	1	CO3	K2
	9. Bird Photography	2	CO3	K6
	10. Morphometry and Taxidermy of poultry bird	1	CO3	K2, K3
	11. Preparation of catalogue of birds in a selected area and create local awareness	2	CO4	K6
Pedagogy:	Hands on training, dissection, field visits, interaction with local community, self-study, project based			
Texts:	1. J. Faborg and S. B. Chaplin, Ornithology: an Ecological Approach. New Jersey, Prentice Hall Inc. 1988. 2. F. B. Gill, Ornithology. (3rd ed.) New York, NY. W. H. Freeman and Company, 2007 3. J. Lovette and J. W. Fitzpatrick, Handbook of Bird biology (3rd Ed) Wiley publishers. 2016			
References	1. S. Ali, The Book of Indian Birds. India, Bombay Natural History Society nd Oxford University Press, 2016. 2. C. J. Bibby, N.D. Burgess, A. Hill, Bird Census Techniques. UK, Academic Press, 1992. 3. M. S. Brainard, and A. J. Doupe,. Auditory feedback in learning and maintenance of vocal behavior. (1, 31-40) Nature Rev. Neurosci, 2000 4. C Inskipp, R Grimmett and T Inskipp, Birds of the Indian Subcontinent, Princeton University Press, 2011.			
Web sources	1. Birds of the World (Cornell Lab of Ornithology): https://birdsoftheworld.org/bow/home 2. The Cornell Lab of Ornithology: https://www.allaboutbirds.org/ 3. BirdLife International: https://www.birdlife.org/			

Title of the Course	Fundamentals and Emerging Approaches in Animal Cell Culture
Course Code	ZOO-5212
Number of Credits	1
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	Yes (Revised 60%)
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To explain the basic principles, historical development, and ethical framework of animal cell culture. • To describe the components and conditions necessary for successful in vitro animal cell growth. • To discuss the classification, maintenance, and preservation of different types of cell lines. • To analyze current trends and theoretical applications of cell culture in research and biotechnology.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. **Describe** the foundational concepts, historical development, and ethical considerations of animal cell culture (K1**,** K2**)**	PSO1
	CO 2. **Explain** the components of culture media and the environmental conditions essential for maintaining viable animal cell cultures in vitro. (K2, K3)	PSO1
	CO 3. **Classify** different types of animal cell lines and summarize their maintenance, preservation, and authentication techniques. (K2, K4, K3)	PSO1 & PSO3

	CO 4. **Evaluate** recent advances and theoretical applications of animal cell culture in biomedical research and biotechnology. (K5, K4, K6)		PSO1, PSO3 & PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Animal Cell Culture: Basics to Breakthroughs	1.1 **Introduction to Animal Cell Culture:** Evolution of animal cell culture; Relevance in modern biology, medicine, and biotechnology; Ethical considerations and regulatory guidelines.	**2**	CO1	K1, K2
	1.2 **Laboratory Infrastructure and Aseptic Practices:** Core equipment: biosafety cabinets, CO_2 incubators, sterilization units; Inverted microscope; other critical laboratory instruments; Principles of aseptic technique and contamination prevention; Good Cell Culture Practices (GCCP)	**3**	CO2	K2, K4
	1.3 **Culture Media and Environmental Conditions:** Composition and types of media (serum-based, serum-free), Role of supplements, antibiotics, and buffering systems; Optimal conditions: temperature, pH, CO_2 levels, and osmolality	**3**	CO2	K2, K4
	1.4 **Cell Lines: Handling, Subculturing, and Maintenance:** Classification: primary, finite, continuous lines; subculturing, cell viability, growth curve, cell line authentication	**3**	CO3	K2, K4
	1.5 **Cryopreservation and storage:** Principles of cryopreservation, cryoprotectants, storage techniques, and thawing process	**2**	CO3	K2, K3
	1.6 **Advanced Trends and Applications in Cell Culture:** 3D cell culture and organoids; Applications in drug development, vaccine production, and regenerative medicine; Automation, bioreactors, and future directions in cell culture technology	**2**	CO4	K4, K5
Pedagogy:	Lectures /Interactive Discussions /Case Studies & Examples /Q&A Sessions/ Assigned Readings /Periodic Assessments.			
Texts:	1. Davis, J. M. (2019). *Animal cell culture: Essential methods* (2nd ed.). Wiley-Blackwell. 2. Freshney, R. I. (2016). *Culture of animal cells: A manual of basic technique and specialized applications* (7th ed.). Wiley-Blackwell. 3. Butler, M. (Ed.). (2004). *Animal cell culture and technology*. Garland Science.			

	4. Vo-Dinh, T. (Ed.). (2013). *Animal cell culture: Methods and protocols* (Vol. 945). Springer. https://doi.org/10.1007/978-1-62703-119-4 5. Lanza, R., Langer, R., & Vacanti, J. (Eds.). (2013). *Principles of tissue engineering* (4th ed.). Academic Press. 6. Helgason, C. D., & Miller, C. L. (Eds.). (2014). *Basic cell culture protocols* (3rd ed.). Humana Press. 7. Butler, M. (2009). *Cell culture bioprocess engineering*. Wiley.
References/ Readings:	1. Singh, S., & Kumar, A. (2023). Comparative cryopreservation of bovine and porcine primary hepatocytes. Frontiers in Veterinary Science, 10, Article 1211135. https://doi.org/10.3389/fvets.2023.1211135 2. Smith, J., Lee, H., & Johnson, M. (2023). Modular 3D printed platform for fluidically connected human brain organoid culture. Biofabrication, 15(2), 025006. https://doi.org/10.1088/1758-5090/ad0c2c 3. Zhang, X., Wang, Y., & Chen, L. (2023). Advances in 3D organoid models for stem cell-based cardiac regeneration. International Journal of Molecular Sciences, 24(6), 5188. https://doi.org/10.3390/ijms24065188 4. Patel, R., & Singh, D. (2025). Cryopreservation of biological materials: Applications and economic perspectives. In Vitro Cellular & Developmental Biology - Animal. Advance online publication. https://doi.org/10.1007/s11626-025-01027-0 5. Kim, S., & Park, J. (2022). Recent advances in organoid engineering: A comprehensive review. Applied Materials Today, 27, 101462. https://doi.org/10.1016/j.apmt.2022.101462 6. Freshney, R. I., & Stacey, G. N. (2021). Advances in serum-free media formulations for animal cell culture. Cytotechnology, 73(2), 193–205. https://doi.org/10.1007/s10616-020-00421-3 7. Zhang, Y., Jiang, L., & Gao, X. (2022). Impact of culture conditions on stem cell differentiation in 3D systems. Stem Cell Research & Therapy, 13(1), 149. https://doi.org/10.1186/s13287-022-02811-0 8. Lee, J. H., & Kim, H. S. (2023). Application of bioreactors in large-scale animal cell culture for vaccine production. *Biotechnology Advances*, *61*, 108031. https://doi.org/10.1016/j.biotechadv.2023.108031 9. Santos, R., & Oliveira, M. (2020). Cryopreservation strategies for animal cell lines: A review. *Cryobiology*, *94*, 11–20. https://doi.org/10.1016/j.cryobiol.2020.01.002 10. Wang, T., & Zhang, Q. (2021). Organoid technology: Applications and challenges in regenerative medicine. *Biomaterials*, *276*, 121022. https://doi.org/10.1016/j.biomaterials.2021.121022
Web Resources:	1. NPTEL. (n.d.). Cell culture technologies [Online course]. Indian Institute of Technology Kanpur. https://onlinecourses.nptel.ac.in/noc22_bt64/preview 2. Amrita Vishwa Vidyapeetham. (n.d.). Cell culture and animal lab [Course module]. https://www.amrita.edu/course/cell-culture-and-animal-lab

	3. ATCC. (n.d.). Animal cell culture guide. American Type Culture Collection. https://www.atcc.org/~/media/pdfs/culture%20guides/animcellculture_guide.ashx 4. Sigma-Aldrich. (n.d.). Fundamental techniques in cell culture [PDF]. https://www.sigmaaldrich.com/content/dam/sigma-aldrich/docs/Sigma-Aldrich/General_Information/1/fundamental-techniques-in-cell-culture.pdf 5. Corning Life Sciences. (n.d.). *Cell culture contamination guide*. https://www.corning.com/worldwide/en/products/life-sciences/resources/webforms/cell-culture-contamination-guide.html 6. Cell Culture Dish. (n.d.). *The Cell Culture Dish podcast*. https://cellculturedish.podbean.com/ 7. Talking Biotech Podcast. (n.d.). *Talking Biotech with Kevin Folta*. https://www.talkingbiotechpodcast.com/ 8. Speaking Science Podcast. (n.d.). *Speaking Science*. https://speakingsciencepodcast.com/page/2/ 9. Thermo Fisher Scientific. (2018, August 1). *Introduction to cell culture* [Video]. YouTube. https://www.youtube.com/watch?v=C0lMrp_ySg8

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Title of the Course	Practical in Fundamentals and Emerging Approaches in Animal Cell Culture
Course Code	ZOO-5213
Number of Credits	3
Theory/Practical	Practical
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:	Corresponding theory paper (ZOO-5212) should be taken	
Course Objectives:	• To develop proficiency in laboratory setup, aseptic handling, and sterilization techniques essential for animal cell and tissue culture. • To acquire hands-on experience in isolating and culturing primary cells from aquatic invertebrates and vertebrates. • To understand and apply primary cell culture techniques in avian models, including fibroblasts, embryonic stem cells, and mesenchymal progenitors. • To implement quality control measures and contamination monitoring within a cell culture setting, while adhering to Good Laboratory Practices (GLP).	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Demonstrate aseptic techniques and sterilization methods essential for preparing and maintaining a contamination-free cell culture laboratory environment (K2**,** K3**,** K4**)**.	PSO1& PSO2

	CO 2. Prepare and sterilize various cell culture media and buffers, and handle reagents and instruments using proper aseptic practices (K3, K6, K2).		PSO1& PSO2	
	CO 3. Isolate and culture primary cells from aquatic invertebrates and fish using mechanical, enzymatic, and explant techniques (K3, K4, K6).		PSO1, PSO2, PSO3 & PSO4	
	CO 4. Isolate, culture, and maintain avian fibroblasts, embryonic stem cells, and mesenchymal progenitor cells from various chick embryo tissues (K3, K6, K5).		PSO1, PSO2 & PO3	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Laboratory Setup, Media Preparation & Aseptic Techniques	1.1 Planning and Zoning of Sterile Areas in Tissue Culture Lab	**2**	CO1	K2, K3
	1.2 Protocols for Disinfection and Sterile Room Preparation	**2**	CO1	K3, K4
	1.3 Setup, Operation, and Safety in Laminar Air Flow (LAF) Cabinet	**2**	CO1	K3
	1.4 Autoclave Operation and Sterilization: Instrument Preparation and Validation	**2**	CO1	K3
	1.5 Hot Air Oven Sterilization: Principles and Practice	**2**	CO1	K2, K3
	1.6 Aseptic Liquid Handling and Sterile Culture Vessel Manipulation Practice under Laminar Flow Hood	**2**	CO1	K3, K4
	1.7 Preparation of Cell Culture Media: L-15, DMEM, RPMI, MEM	**2**	CO2	K3, K6
	1.8 Buffer Preparation: PBS, HEPES, Citrate, Tris Buffer	**2**	CO2	K3, K6
	1.9 Preparation of Working Cell Culture Media: Addition of Antibiotics, Serum; pH and Osmolarity Adjustment	**2**	CO2	K3, K6
	1.10 Filter Sterilization Technique of media and buffers	**2**	CO2	K3
	1.11 Monitoring Microbial Contamination in Cell Culture: Comparing normal vs contaminated culture	**2**	CO1	K3, K4
	1.12 Collagen Coating of Petri Plates for Enhanced Cell Adhesion	**2**	CO2	K3, K6
	1.13 Laminin Coating for Neuronal or Stem Cell Culture	**2**	CO2	K3, K6
	1.14 Cell Counting Using Hemocytometer and Calculating Cells for Seeding	**2**	CO2	K3, K4

	1.15 Disposal of contaminated cell cultures and decontamination of culture plates.	**2**	CO3	K3
Module 2: Primary Cell Culture from Aquatic Invertebrates and vertebrates	2.1 Preparation for Gill Cell Isolation: Media, Buffers, and Sterile Glassware	**2**	CO3	K2, K3
	2.2 Gill Cell Isolation from Bivalves via Mechanical Dissociation	**2**	CO3	K3, K6
	2.3 Assessment of Cell Viability Using Trypan Blue Staining	**2**	CO3	K3, K4
	2.4 Preparatory Steps for Mantle Tissue Explant Culture: Media, Buffers, and Sterile Equipment	**2**	CO3	K2, K3
	2.5 Mantle Tissue Dissection from bivalve and Explant Preparation for Culture	**2**	CO3	K3, K6
	2.6 Maintenance of Explant Cultures and Monitoring Cell Migration	**2**	CO3	K3, K4
	2.7 Preparation for Enzymatic Isolation of Siphon Cells: Media, Buffers, and Trypsin Solutions	**2**	CO3	K3, K2
	2.8 Enzymatic Dissociation of Siphon Tissue: Dissection, Trypsinization, and Cell Collection and inoculation	**2**	CO3	K3, K6
	2.9 Assessment of Trypsinization Efficiency: Cell Viability and Morphology	**2**	CO3	K4, K3
	2.10 Media Preparation for Culturing Crustacean Hepatopancreas Cells	**2**	CO3	K3, K6
	2.11 Dissection and Isolation of Hepatopancreas from Crustaceans: Cell Dissociation and Inoculation	**2**	CO3	K3, K6
	2.12 Morphological Characterization of Hepatopancreatic Cells from Crustaceans.	**2**	CO3	K4, K3
	2.13 Media and Buffer Preparation for Fish Hepatocyte Culture	**2**	CO3	K3, K2
	2.14 Isolation of Fish Hepatocytes Using Non-Perfusion Method: Dissociation and Seeding	**2**	CO3	K3, K6
	2.15 Assessment of Fish Hepatocyte Viability, Density, and Morphology	**2**	CO3	K4, K3
Module 3: Avian Embryo-Derived Primary, Progenitor, and	3.1 Preparation of Media, Buffers, and Sterile Equipment for Fibroblast Culture	**2**	CO4	K2, K3
	3.2 Isolation of Primary Fibroblasts via Mechanical and Enzymatic Dissociation from Chick Embryo	**2**	CO4	K3, K6
	3.3 Media and Buffer Preparation for Chick Embryo Bone Marrow Suspension Culture	**2**	CO4	K3, K2

Stem Cell Culture	3.4 Isolation and Culturing of Hematopoietic and Stromal Cells from Embryonic Bone Marrow (Suspension culture).	**2**	CO4	K3, K6
	3.5 Preparation of Culture Media and Reagents for Chick Embryonic Stem Cell Isolation	**2**	CO4	K2, K3
	3.6 Blastoderm Isolation and ESC Culture Initiation Using Mechanical and Enzymatic Techniques	**2**	CO4	K3, K6
	3.7 Morphological Identification and Characterization of Chick Embryonic Stem Cells	**2**	CO4	K5, K4
	3.8 Preparation of Media and Buffers for Cartilage Progenitor Culture	**2**	CO4	K3, K2
	3.9 Cartilage Progenitor Cell Isolation from Chicken Embryo -Dissection, Enzymatic Digestion, and Isolation of Cartilage Progenitor Cells from Chick Embryo	**2**	CO4	K3, K6
	3.10 Media and Buffer Preparation for Compact Bone-Derived MSC Isolation	**2**	CO4	K3, K2
	3.11 Isolation of Mesenchymal Stem Cells from Chick Compact Bone via Mechanical Disruption	**2**	CO4	K3, K6
	3.12 Media and Buffer Preparation for Dermis-Derived MSC Isolation	**2**	CO4	K3, K2
	3.13 Isolation and Culture of Dermis-Derived Mesenchymal Progenitor Cells from Chick Skin	**2**	CO4	K3, K6
	3.14 Preparation of Cryopreservation Media and Reagents	**2**	CO4	K3, K2
	3.15 Cryopreservation of Cultured Cells Using Cryoprotective Agents and Freezing Protocols	**2**	CO4	K3, K6, K5
Pedagogy:	Pre-Practical Briefing / Demonstration / Hands-on Practical Work/ Immediate Feedback & Troubleshooting/ Group Discussion & Analysis /Practical Record Keeping/ Peer Learning & Collaboration/ Regular Skill Assessment/ Use of Visual Aids & SOPs.			
Texts:	1. Butler, M. (2004). Animal cell culture and technology (2nd ed.). Taylor & Francis. 2. Davis, J. M. (2011). Animal cell culture: Essential methods (1st ed.). Wiley-Blackwell. 3. Freshney, R. I. (2016). Culture of animal cells: A manual of basic technique and specialized applications (7th ed.). Wiley-Blackwell. 4. Humason, G. L. (1997). Animal tissue techniques (5th ed.). W.H. Freeman.			

	5. Kaltschmidt, B., & Kaltschmidt, C. (Eds.). (2006). Avian embryology (2nd ed.). Humana Press.Masters, J. R. W. (2000). Animal cell culture: A practical approach (3rd ed.). Oxford University Press. 6. Moore, M. N., Depledge, M. H., & Readman, J. W. (2003). Cells in the aquatic environment. Cambridge University Press. 7. Pörtner, R. (2007). *Animal cell biotechnology: Methods and protocols* (2nd ed.). Humana Press.
References/ Readings:	1. Bai, C., Hou, L., Ma, Y., Chen, L., Zhang, M., & Guan, W. (2013). Isolation and characterization of mesenchymal stem cells from chicken bone marrow. Cell and tissue banking, 14, 437-451. 2. Dessai, S. N. (2012). Primary culture of mantle cells of bivalve mollusc, Paphia malabarica. In Vitro Cellular & Developmental Biology-Animal, 48, 473-477. 3. Faure-Dupuy, S., Vegna, S., Aillot, L., Dimier, L., Esser, K., Broxtermann, M., Bonnin, M., Bendriss-Vermare, N., Rivoire, M., Passot, G., Lesurtel, M., Mabrut, J. Y., Ducerf, C., Salvetti, A., Protzer, U., Zoulim, F., Durantel, D., & Lucifora, J. (2018). Isolation and culture of primary hepatocytes from resected human liver tissue. Journal of Innate Immunity, 10(4), 339–348. https://doi.org/10.1159/000489966 4. Gao, Y., Bai, C., Xiong, H., Li, Q., Shan, Z., Huang, L., ... & Guan, W. (2013). Isolation and Characterization of Chicken Dermis-Derived Mesenchymal Stem/Progenitor Cells. BioMed research international, 2013(1), 626258. 5. Gerbal-Chaloin, S., Duret, C., Raulet, E., Navarro, F., Blanc, P., Ramos, J., Maurel, P., & Daujat-Chavanieu, M. (2010). Isolation and culture of adult human liver progenitor cells: In vitro differentiation to hepatocyte-like cells. In M. Guguen-Guillouzo & A. Guillouzo (Eds.), Methods in Molecular Biology: Volume 640 (pp. 247–260). Humana Press. https://doi.org/10.1007/978-1-60761-688-7_12 6. Hattori, N., & Yoshida, M. (2018). Effects of various culture conditions on pluripotent stem cell derivation from chick embryos. Poultry Science, 97(11), 3813–3822. https://doi.org/10.3382/ps/pey265PubMed 7. Lee, D.-H., & Lee, K.-W. (2014). Hepatocyte isolation, culture, and its clinical applications. Hanyang Medical Reviews, 34(4), 165–172. https://doi.org/10.7599/hmr.2014.34.4.165 8. Li, L., Ma, Y., Li, X., Li, X., Bai, C., Ji, M., ... & Li, J. (2015). Isolation, culture, and characterization of chicken cartilage stem/progenitor cells. BioMed Research International, 2015(1), 586290. 9. Moore, D. T., Purdy, P. H., & Blackburn, H. D. (2006). A method for cryopreserving chicken primordial germ cells. Poultry science, 85(10), 1784-1790. 10. Nandi, S., Whyte, J., Taylor, L., Sherman, A., Nair, V., Kaiser, P., & McGrew, M. J. (2016). Cryopreservation of specialized chicken lines using cultured primordial germ cells. Poultry science, 95(8), 1905-1911.Sashikumar, A., &

	Desai, P. V. (2008). Development of primary cell culture from Scylla serrata: primary cell cultures from Scylla serrata. Cytotechnology, 56, 161-169. 11. Shashikumar, A., & Desai, P. V. (2011). Development of cell line from the testicular tissues of crab Scylla serrata. Cytotechnology, 63, 473-480. 12. Su, S., Di Poto, C., Roy, R., Liu, X., Cui, W., Kroemer, A., & Ressom, H. W. (2019). Long-term culture and characterization of patient-derived primary hepatocytes using conditional reprogramming. Experimental Biology and Medicine, 244(11), 857–864. https://doi.org/10.1177/1535370219855398 13. Tripathi, M., Yen, P. M., & Singh, B. K. (2020). Protocol to generate senescent cells from the mouse hepatic cell line AML12 to study hepatic aging. *STAR Protocols*, *1*(2), 100064. https://doi.org/10.1016/j.xpro.2020.100064
Web Resources:	1. National Center for Biotechnology Information. (2013). Basic pluripotent stem cell culture protocols. NCBI Bookshelf. Retrieved May 27, 2025, from https://www.ncbi.nlm.nih.gov/books/NBK133258/ 2. Notes for Biology. (n.d.). Primary cell culture: Preparation of primary chick embryo fibroblast culture. Retrieved May 27, 2025, from https://notesforbiology.com/primary-cell-culture-preparation-of-primary/Online Biology Notes. (n.d.). Primary cell culture: Preparation of primary chick embryo fibroblast (CEF) culture. Retrieved May 27, 2025, from https://www.onlinebiologynotes.com/primary-cell-culture-preparation-of-primary-chick-embryo-fibroblast-cef-culture/ 3. PubMed. (2006). Establishment of an in vitro culture system for chicken preblastodermal cells. Retrieved May 27, 2025, from https://pubmed.ncbi.nlm.nih.gov/16425235/ 4. PubMed. (2012). Simple methods for generating neural, bone and endodermal cell types from chick embryonic stem cells. Retrieved May 27, 2025, from https://pubmed.ncbi.nlm.nih.gov/23047046/ 5. R&D Systems. (n.d.). Protocol: Culturing embryonic chick dorsal root ganglion neurons. Retrieved May 27, 2025, from https://www.rndsystems.com/resources/protocols/protocol-culturing-embryonic-chick-dorsal-root-ganglion-neurons.

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Title of the Course	Fishery Resource Management
Course Code	ZOO-5214
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 foundational and applied knowledge of inland, marine, and brackishwater fishery resources with a focus on India and Goa. • To equip students with skills to assess, evaluate, and manage fish stocks using biological, ecological, and statistical tools. • To introduce key legal, institutional, and community frameworks relevant to sustainable fisheries. • To understand the threats to fishery resources and explore strategies for conservation, policy-making, and ecosystem-based management.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Understand fishery resources and their ecological and economic roles, particularly in the context of Goa. (K2- Understanding)	PSO1
	CO 2. Apply stock assessment methods to evaluate fish resource sustainability. (K3 - Applying)	PSO 2

	CO 3. Analyze population parameters and interpret fishery data. (K4 -Analyzing)		PSO1, PSO3	
	CO 4. Evaluate fishery policies, management frameworks, and governance models. (K5-Evaluating)		PSO3, PSO4	
	CO 5. Propose conservation strategies for vulnerable stocks under human and climate pressure. (K5 – Evaluating)		PSO4	
Content:	**Topics**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Fishery Resources – Ecology, Economics, and Emerging Challenges	1.1: Types and classification of fishery resources – Inland, marine, and estuarine; Fishery zones of India and Goa.	**3**	CO1	K2
	1.2: Biodiversity and endemism in Indian fisheries; Role of indicator and threatened species	**3**	CO1	K2
	1.3: Socio-economic significance of fisheries; role in livelihoods and coastal economy	**2**	CO1	K2
	1.4: Climate change, invasive species, and habitat degradation affecting fisheries; Ghost fishing- Overexploitation, Overcapacity, pollution, Interlinking of rivers, Environmental flows, Fishing conflicts, boundary issues, IUU fishing, Bycatch and discards.	**4**	CO5	K5
	1.5: Sustainable fishing: Components of sustainability, Indicators and goals of sustainability, Eco-friendly fishing, Ecosystem-Based Fisheries Management, Resilient fishery system	**3**	CO5	K5
Module 2: Fish Population Dynamics and Resource Assessment	2.1: Fish growth models – von Bertalanffy, exponential; mortality and recruitment rates	**4**	CO2	K4
	2.2: Stock-recruitment relationships and yield-per-recruit analysis	**4**	CO2	K4
	2.3: Data collection methods: Catch Per Unit Effort (CPUE), tagging, length-weight analysis	**4**	CO3	K3
	2.4: FiSAT II and stock assessment software; Indian case studies	**3**	CO3	K3

Module 3: Fishery Governance, Management Tools, and Sustainability	3.1: Fishery management strategies:Maximum Sustainable Yield (MSY), Maximum Economic Yield (MEY), Total Allowable Catch (TAC), gear regulations, Marine Protected Areas (MPAs)	**3**	CO4	K5
	3.2: Fisheries Policy Frameworks: MFRA, NFDB, CRZ, and INCOIS Roles. Technical Guidelines of CCRF for responsible fishing; National and International treaties (National policy on marine fisheries-2017; National policy on inland fisheries-2019; UNCLOS ; UNFSA; IOTC)	**4**	CO4	K5
	3.3: Community-based fisheries and co-management approaches	**2**	CO4	K5
	3.4: Bycatch Reduction and Regulatory Approaches in Fishery Management: Strategies for bycatch reduction and gear selectivity; Rebuilding fisheries and depleted stocks through science-based measures Co-management approaches and the role of communities; Input controls Include Fishing effort limitation, mesh size regulation, seasonal bans, and licensing, as well as capital investments. Output controls (Catch quotas, minimum legal size, and species-specific restrictions)	**4**	CO5	K5
	3.5: Ecosystem-Based Fishery Management (EBFM) and Indicators of Sustainability; Right-Based Fishing: Catch Sharing Access Rights - Balanced Fishing.	**3**	CO5	K5
Pedagogy:	• Concept-Oriented Lectures – Systematic explanation of fishery science principles, including governance frameworks, biodiversity management, and sustainability models. • Visual and Analytical Aids – Use of graphs, charts, and animated simulations to explain fish growth models, gear impacts, and ecosystem-based management. • Hands-on Software Applications – Guided exercises using FiSAT II and other open-source tools for fish stock assessment, CPUE analysis, and yield modeling. • Histological Investigations – Practical demonstration of fish gill and gonad tissue preparation and microscopy for assessing physiological responses to environmental conditions. • Policy Debates and Simulations – Role-playing and structured debates on fisheries regulations (e.g., MFRA, CRZ) to develop policy literacy and stakeholder perspectives. • Case-Based Learning – Regional and national fisheries case studies to critically examine conservation outcomes, governance lapses, and recovery strategies.			

	• Field Visits and Ethnographic Interviews – Observing fish landing practices and conducting structured interactions with fisherfolk, hatchery technicians, and officials to bridge academic knowledge with community practices. • Data Interpretation Projects – Student-led mini-projects analyzing secondary data from CMFRI, INCOIS, or FAO, culminating in presentations and reporting.
Texts:	1. CMFRI. (2022). *Marine Fisheries Atlas of India* (Latest ed.). Kochi: Central Marine Fisheries Research Institute. 2. FAO. (2020). *The State of World Fisheries and Aquaculture (SOFIA)*. Rome: FAO. 3. FAO. (2021). *FAO Guidelines for Sustainable Fisheries*. Rome: Food and Agriculture Organization. 4. ICAR-CIFE. (2023). *Manual on Fish Stock Assessment and Fisheries Data Analysis*. Mumbai: CIFE Publication Series. 5. King, M. (2023). *Fisheries Biology, Assessment and Management* (3rd ed.). Wiley-Blackwell.
References/ Readings:	1. Bal, D.V., & Rao, K.V. (1990). Marine Fishes of India (1st Revised Ed.). Tata McGraw Hill. 2. Bhatta, R., & Rao, M. (2020). Fisheries Governance in Coastal India: Lessons and Reflections. Journal of Coastal Research, 36(3), 512–520. 3. Blaber, J.M. (1997). Fish and Fisheries in Tropical Estuaries. Chapman and Hall. 4. Chakraborty, S.K. (2021). Marine Fisheries Management in Indian Waters – Current Challenges and Policy Needs. CMFRI Policy Brief. 5. Chandra, P. (2007). Fishery Conservation, Management and Development. SBS Publishing. 6. CMFRI. (Annual). Fisheries Policy Series & Annual Technical Reports. Central Marine Fisheries Research Institute. 7. FAO. Technical Papers on Freshwater Fisheries. Food and Agriculture Organization. 8. Greene, C.M., & Pess, G.R. (2009). Multi-species modeling for salmon: alternatives, challenges, and opportunities. 9. Hilborn, R.C., & Walters, C.J. (1992). Quantitative Fisheries Stock Assessment. Chapman and Hall. 10. Jhingran, V.G. (1991). Fish and Fisheries of India (3rd Ed.). Hindustan Publishing Corporation. 11. Knudsen, E.E., & McDonald, D. (1999). Sustainable Fisheries Management: Pacific Salmon (1st Ed.). CRC Press. 12. Knudsen, E.E., & Michael, J.H. Jr. (Eds.), Pacific Salmon Environmental and Life History Models (pp. 429–454). American Fisheries Society Symposium 71, Bethesda, Maryland. 13. Kurup, B.M., & Ranjeet, K. (2022). Ecological Trends in Estuarine Fisheries of the West Coast of India. ICAR-CIFT Technical Series. 14. Moyle, P.B., & Cech, J.J. Jr. (2000). Fishes: An Introduction to Ichthyology (4th Ed.). Prentice Hall. 15. Murawski, S.A., & Matlock, G.C. (2006). Ecosystem science capabilities required to support NOAA's mission in the year 2020. NOAA Tech Memo NMFS-F/SPO-74. 16. Peter, B.M., & Cech, J.J. Jr. (2000). *Fishes: An Introduction to Ichthyology* (4th Ed.). Prentice Hall.

	17. Salagrama, V. (2022). *Climate Resilience in Marine Fisheries: Perspectives from Coastal India*. Bay of Bengal Programme Publication. 18. Samuel, C.T. (1968). *Marine Fisheries in India*. Narendra Publishing House. 19. Sugunan, V.V. (1997). *Reservoir Fisheries of India*. Daya Publishing House. 20. Yadav, B.N. (1997). *Fish and Fisheries* (2nd Ed.). Daya Publishing House.
Web Resources:	1. Central Marine Fisheries Research Institute – https://www.cmfri.org.in 2. FishBase – https://www.fishbase.se 3. Food and Agriculture Organization – https://www.fao.org/fishery/en 4. National Fisheries Development Board – https://nfdb.gov.in 5. Indian National Centre for Ocean Information Services (INCOIS) – https://incois.gov.in/portal/gis.jsp 6. CMFRI E-Library – http://eprints.cmfri.org.in 7. Bay of Bengal Programme – https://bobpigo.org 8. The State of World Fisheries and Aquaculture (SOFIA), FAO – https://www.fao.org/publications/sofia 9. Indian Council of Agricultural Research – https://icar.org.in 10. FAO FishStatJ software (for fisheries data analysis) – https://www.fao.org/fishery/statistics/software/fishstatj/en 11. Directorate of Fisheries, Government of Goa – https://www.fisheries.goa.gov.in 12. ICAR-Central Coastal Agricultural Research Institute (ICAR-CCARI), Goa – https://ccari.icar.gov.in 13. Fishery Survey of India (FSI) – https://fsi.gov.in

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Title of the Course	Practical in Fishery Resource Management
Course Code	ZOO-5215
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-5214) should be taken	
Course Objectives:	• To develop practical competencies in fishery species profiling, stock assessment, and population analysis through field and lab-based training. • To expose students to applied tools such as FiSAT II and length-weight analysis for understanding population dynamics. • To train students in histological techniques for assessing fish health and stressors. • To promote critical evaluation and synthesis of fishery management issues through field observations and community engagement. • To prepare students for research and policy-oriented roles in sustainable fisheries by equipping them with analytical and reporting skills.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Identify and evaluate the diversity of fishery species and their ecological roles using field and image-based resources. K3 – Applying	PSO1

	CO 2. Apply data tools and software to analyze fish population parameters and stock sustainability. K3 – Applying		PSO 2, PSO3	
	CO 3. Conduct histological and observational assessments to evaluate fish health and resource stressors. K4 – Analyzing		PSO1, PSO4	
	CO 4. Design and present a case-based assessment on local fishery challenges and policy-based solutions. K5 – Evaluating		PSO3, PSO4	
Content:	Topics	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Practical	1.1: Functional Profiling of Fishery Species	**2**	CO1	K4
	1.2: Trophic Category Assessment and Feeding Habit Analysis	**2**	CO1	K4
	1.3: Geo-spatial Mapping of Fishery Zones in Goa- I	**2**	CO2	K3
	1.4: Geo-spatial Mapping of Fishery Zones in Goa- II	**2**		
	1.5: Length-Weight Relationship and Condition Factor (FiSAT II)	**2**	CO2	K3
	1.6: Fleet and Gear Capacity Documentation	**2**	CO3	K5
	1.7: Community Interaction and Ethnographic Insights- I	**2**	CO4	K5
	1.8: Community Interaction and Ethnographic Insights- II	**2**		
	1.9: Histological Evaluation of Stress Impact in Fish Tissues- I	**2**	CO3	K4
	1.10: Histological Evaluation of Stress Impact in Fish Tissues-II	**2**		
	1.11: Assessment of Fishery Biodiversity through Landing Centre Visit and Analytical Reporting- I	**2**	CO3	K5
	1.12: Assessment of Fishery Biodiversity through Landing Centre Visit and Analytical Reporting- II	**2**		
	1.13: Assessment of Fishery Biodiversity through Landing Centre Visit and Analytical Reporting- III	**2**		

	1.14: Mini-Project: Designing a Fishery Resource Management Plan Integrating Reproduction, Conservation, and Sustainable Harvest Strategies- I	**2**	CO4	K6
	1.15: Mini-Project: Designing a Fishery Resource Management Plan Integrating Reproduction, Conservation, and Sustainable Harvest Strategies- II	**2**		
	1.15: Mini-Project: Designing a Fishery Resource Management Plan Integrating Reproduction, Conservation, and Sustainable Harvest Strategies- III	**2**		
Pedagogy:	• Field Immersion Training: Multi-site visits to coastal and inland landing centres, fish sanctuaries, and hatcheries with species documentation, stakeholder engagement, and issue identification. • Hands-on Tools Application: Use of calipers, measuring boards, GPS, and portable microscopes for biometric and field data collection. • Species Diversity Analysis: Use of Shannon-Weaver and Simpson indices to assess biodiversity based on collected field data. • Stakeholder Engagement: Structured ethnographic interviews with fisherfolk, co-operatives, fisheries officials, and women entrepreneurs. • Mini-Project Based Learning: Guided student-led research on resource use, policy mapping, or local gear efficiency tied to conservation outputs. • Peer Review and Reporting: Drafting of management proposals and presentation of key findings using statistical and geospatial outputs. • Data Analysis Workshops: Training in Excel, FishStat J, and FiSAT II for stock assessment, yield modeling, and visual analytics.			
Texts:	1. CMFRI. (2022). Manual on Fishery Survey Techniques and Stock Assessment. Kochi: Central Marine Fisheries Research Institute. 2. ICAR-CIFE. (2023). Manual on Fish Stock Assessment and Fisheries Data Analysis. Mumbai: CIFE Publication Series. 3. FAO. (2021). FAO Guidelines for Practical Fishery Resource Evaluation. Rome: Food and Agriculture Organization. 4. King, M. (2023). Fisheries Biology, Assessment and Management (3rd ed.). Wiley-Blackwell. 5. Hilborn, R. & Walters, C. J. (1992). Quantitative Fisheries Stock Assessment: Choice, Dynamics and Uncertainty. Chapman and Hall.			
References/ Readings:	1. Bhatta, R. & Rao, M. (2020). Fisheries Governance in Coastal India: Lessons and Reflections. Journal of Coastal Research, 36(3), 512–520.			

	2. Chakraborty, S.K. (2021). Marine Fisheries Management in Indian Waters – Current Challenges and Policy Needs. CMFRI Policy Brief. 3. Jhingran, V.G. (1991). Fish and Fisheries of India (3rd Ed.). Hindustan Publishing Corporation. 4. Kurup, B.M. & Ranjeet, K. (2022). Ecological Trends in Estuarine Fisheries of the West Coast of India. ICAR-CIFT Technical Series. 5. Sugunan, V.V. (1997). *Reservoir Fisheries of India*. Daya Publishing House.
Web Resources:	1. Directorate of Fisheries, Government of Goa https://www.fisheries.goa.gov.in 2. ICAR-Central Coastal Agricultural Research Institute (ICAR-CCARI), Goa – https://ccari.icar.gov.in 3. Fishery Survey of India (FSI) – https://fsi.gov.in 4. CMFRI E-Library – http://eprints.cmfri.org.in 5. FAO FishStatJ Software – https://www.fao.org/fishery/statistics/software/fishstatj/en 6. FiSAT II Software – https://www.fao.org/fishery/topic/16072/en

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Title of the Course	Wildlife Biology and Conservation
Course Code	ZOO-5216
Number of Credits	3
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:	• Gain a comprehensive understanding of the ecological and biological principles that govern wildlife populations and ecosystems. • Learn about the various strategies and techniques used in wildlife management and conservation, including habitat management, species conservation, and protected area management. • Analyze the threats to wildlife, including anthropogenic and natural factors, and develop conservation plans to mitigate these threats. • Evaluate the effectiveness of conservation approaches and policies, including protected areas, laws, and international conventions, and develop recommendations for improvement.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Explain the principles of wildlife ecology, including population dynamics and habitat interactions. (K2: Understanding)	PSO1

	CO 2. Apply conservation strategies, including habitat management and species conservation, to manage wildlife populations. (K3: Applying)		PSO2	
	CO 3. Analyze the threats to wildlife, including anthropogenic and natural factors, and develop strategies to mitigate them. (K4: Analyzing)		PSO3	
	CO 4. Evaluate the effectiveness of conservation approaches, including protected areas and laws, and develop recommendations for improvement. (K5: Evaluating)		PSO4	
Content		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Introduction to Wildlife Biology	Introduction: Definition and scope; historical development; Indian wildlife; Zoogeographical distribution of fauna; Significance of wildlife in ecosystems, Global biodiversity patterns and macroecological rules (Rapoport's, Bergmann's, Allen's)	**4**	CO1, CO2	K2, K3, K4
	Animal Ecology and Ethology: Niche, habitat, and ecosystem interactions; Adaptations in wild animals (morphological, physiological, behavioural); Social structures, territoriality, and migratory behaviour	**4**	CO1, CO2	K2, K3, K4
	Methods of population estimation (census, camera traps, distance sampling), Movement ecology: migration, dispersal syndromes, metapopulation theory.	**4**	CO1, CO2	K2, K3, K4
	Carrying capacity, minimum viable population (MVP)	**3**	CO3, CO4	K5, K6
Module 2: Wildlife Management and Conservation	Wildlife Management: Wildlife management: culling, reintroduction, supplementation; Habitat types: terrestrial, aquatic, montane, coastal; Habitat fragmentation, edge effects, and corridors; Land-use change and its impact on wildlife.	**5**	CO3, CO4	K4, K5
	Habitat Ecology and Landscape Conservation: GIS and remote sensing in wildlife habitat monitoring; Habitat management strategies; Landscape conservation approaches; Case studies of successful habitat conservation. Remote sensing for habitat quality: NDVI, EVI, LiDAR, SAR	**5**	CO2, CO3	K3, K4

	Wildlife Health and Disease Ecology: Pathogen surveillance: PCR, metagenomics, microbiome sequencing, Immunogenetics and disease resistance alleles, Wildlife epidemiology models (SIR, SEIR, Agent-based models),Zoonotic spillover and the One Health framework, Sentinel species and bioindicators of ecosystem health.	**5**	CO3, CO4	K4, K5, K6
Module 3: Conservation Tools, Laws, and Ethics	Transdisciplinary Conservation Planning, Conservation planning tools: Marxan, Zonation, ConsNet,Ecosystem-based adaptation (EbA) and Nature-based Solutions (NbS), Integrated landscape approaches: mosaic governance, adaptive co-management, Connectivity conservation under climate change scenarios (SDG integration), Ecosystem service valuation: TEEB, InVEST, ARIES.	**4**	CO2, CO3	K3, K4, K5
	Legal Instruments, Compliance, and Digital Enforcement: Legal-tech tools: blockchain for wildlife trade tracking, AI and NLP in automated legal document analysis, Conservation law enforcement: cyber-forensics, digital surveillance networks, Global frameworks: Nagoya Protocol, Post-2020 Biodiversity Framework, IPBES, UNDRIP, REDD+ and biodiversity offset policies.	**5**	CO2	K3, K4
	Ethics: Ethical issues in wildlife conservation; Case studies of conservation conflicts and resolutions.	**2**	CO2, CO3	K3, K4, K5
	Conservation tools: Advanced Monitoring and Data Science in Conservation: Deep learning in species recognition (YOLO, TensorFlow), Citizen science platforms and real-time biodiversity dashboards, Environmental DNA (eDNA) pipelines for large-scale monitoring, AI-powered biodiversity monitoring platforms (WildMe, PAWS, SMART), Decision-support systems for protected area zoning and threat prioritization	**4**	CO2, CO3	K3, K4, K5
Pedagogy:	• Lectures to introduce key concepts and theories. • Case studies to illustrate successful conservation projects and strategies. • group discussions to foster critical thinking and problem-solving. • Organize field visits to protected areas and conservation projects. • Variety of assessment tools, including quizzes, exams, projects, and presentations, to evaluate student learning and provide constructive feedback.			

Texts:	1. *Conservation Biology for All* – Sodhi & Ehrlich 2. *Wildlife Forensics: Methods and Applications* – Huffman & Wallace 3. Journals: *Conservation Science and Practice*, *Ecological Applications*, *Nature Ecology & Evolution* 4. Tools: MaxEnt, QGIS, Marxan, FRAGSTATS, SMART, GenAlEx, R, Python
References/ Readings:	1. Primack, R. B. (2014). Essentials of Conservation Biology (6th ed.). Sinauer Associates. 2. Caughley, G., & Gunn, A. (1996). Conservation Biology in Theory and Practice. Blackwell Science. 3. Sutherland, W. J. (2006). Ecological Census Techniques: A Handbook. Cambridge University Press. 4. unter, M. L., & Gibbs, J. P. (2007). Fundamentals of Conservation Biology (3rd ed.). Wiley-Blackwell. 5. Groom, M. J., Meffe, G. K., & Carroll, C. R. (2006). Principles of Conservation Biology (3rd ed.). Sinauer Associates. 6. Meffe, G. K., & Carroll, C. R. (1997). Principles of Conservation Biology (2nd ed.). Sinauer Associates. 7. Sodhi, N. S., & Ehrlich, P. R. (2010). Conservation Biology for All. Oxford University Press.
Web Resources:	1. Movebank – Animal movement data platform: https://www.movebank.org 2. Animal Behaviour Society – Educational Resources: https://www.animalbehaviorsociety.org/web/education.php 3. Bio-Logging Science Gateway – Sensors for wildlife monitoring: https://www.bio-logging.net 4. Wildlife Acoustics – Passive monitoring tools: https://www.wildlifeacoustics.com 5. Global Forest Watch – Real-time habitat loss tracking: https://www.globalforestwatch.org 6. NASA EarthData (MODIS, Landsat) – Satellite imagery for habitat change: https://earthdata.nasa.gov 7. GBIF (Global Biodiversity Information Facility) – Species occurrence data: https://www.gbif.org 8. WildMe.org – AI-based species recognition platforms: https://www.wildme.org 9. EcoHealth Alliance – Zoonotic disease ecology: https://www.ecohealthalliance.org 10. SMART (Spatial Monitoring and Reporting Tool): https://smartconservationtools.org

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Title of the Course	Practical in Wildlife Biology and Conservation
Course Code	ZOO-5217
Number of Credits	1
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-5216) should be taken	
Course Objectives:	• Understand ecological and conservation principles. • Develop technical and analytical skills such as camera trapping, GIS, and conservation genetics for wildlife monitoring and conservation planning. • Address conservation challenges and assess wildlife-human conflicts, protected area management, and conservation policies to propose practical solutions. • Formulate conservation strategies and design species-specific or ecosystem-wide conservation plans that integrate habitat protection, management strategies, and conflict mitigation.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Explain key principles of wildlife conservation, including habitat analysis, population estimation, and behavioral ecologyK1: Remembering, K2: Understanding)	PSO1, PSO3

	CO 2. Analyze data collected from field and lab exercises using techniques such as camera trapping, GIS, and genetic analysis to understand wildlife populations and their habitats. (K3: Applying, K4: Analyzing)		PSO2, PSO3	
	CO 3. Evaluate conservation challenges, including wildlife-human conflicts and protected area management, and propose effective solutions. (K5: Evaluate)		PSO3, PSO4	
	CO 4. Design conservation strategies for species or ecosystems that address threats and promote sustainable management practices. (K5: Evaluating, K6: Create)		PSO3, PSO4	
Content		**No of hours**	**Mapped to CO**	**Cognitive Level**
	Habitat Analysis: Conduct habitat analysis of a local ecosystem, including vegetation sampling, habitat mapping, and identification of habitat features.	**4**	CO1, CO2	K2, K3, K4
	Population Estimation using Distance Sampling Transect method and: Estimate population size of a selected mammalian or avian species, Camera trap survey (photo capture–recapture using CAPTURE or MARK software), Use of Spatially Explicit Capture-Recapture Models (SECR) for density estimation	**4**	CO1, CO2	K2, K3, K4
	Behavioural Observation and Ethogram Construction Record and analyze behaviour of a focal species in natural settings Techniques Used: Focal animal sampling and continuous recording Development of ethograms	**4**	CO1, CO2	K2, K3, K4
	Conservation Planning: Develop a conservation plan for a local wildlife species or ecosystem, including identification of threats, conservation goals, and management strategies.	**2**	CO3, CO4	K5, K6
	Protected Area Management: Conduct a case study of a protected area, including analysis of management strategies, habitat features, and wildlife populations.	**4**	CO3, CO4	K4, K5
	Wildlife-Human Conflict Mitigation: Develop strategies for mitigating wildlife-human conflict, including identification of conflict hotspots, development of conflict mitigation plans, and evaluation of effectiveness.	**2**	CO2, CO3	K3, K4
	Camera Trap Survey: Conduct a camera trap survey to monitor wildlife populations, including camera trap placement, data analysis, and identification of species.	**4**	CO3, CO4	K4, K5, K6
	GIS and Remote Sensing: Use GIS and remote sensing tools to analyze habitat features, landscape connectivity, and wildlife habitat use.	**2**	CO2, CO3	K3, K4, K5

	Conservation Genetics: Conduct a laboratory exercise on conservation genetics, including DNA extraction, PCR, and genetic analysis of wildlif samples.	**4**	CO2	K3, K4
Pedagogy:	• Field-based learning. • Case studies to illustrate successful conservation projects and strategies. • group discussions to foster critical thinking and problem-solving. • Organize field visits to protected areas and conservation projects. • Variety of assessment tools, including quizzes, exams, projects, and presentations, to evaluate student learning and provide constructive feedback.			
Texts:	1. *Conservation Biology for All* – Sodhi & Ehrlich 2. *Wildlife Forensics: Methods and Applications* – Huffman & Wallace 3. Journals: *Conservation Science and Practice*, *Ecological Applications*, *Nature Ecology & Evolution* 4. Tools: MaxEnt, QGIS, Marxan, FRAGSTATS, SMART, GenAlEx, R, Python			
References/ Readings:	1. Primack, R. B. (2014). Essentials of Conservation Biology (6th ed.). Sinauer Associates. 2. Caughley, G., & Gunn, A. (1996). Conservation Biology in Theory and Practice. Blackwell Science. 3. Sutherland, W. J. (2006). Ecological Census Techniques: A Handbook. Cambridge University Press. 4. unter, M. L., & Gibbs, J. P. (2007). Fundamentals of Conservation Biology (3rd ed.). Wiley-Blackwell. 5. Groom, M. J., Meffe, G. K., & Carroll, C. R. (2006). Principles of Conservation Biology (3rd ed.). Sinauer Associates. 6. Meffe, G. K., & Carroll, C. R. (1997). Principles of Conservation Biology (2nd ed.). Sinauer Associates. 7. Sodhi, N. S., & Ehrlich, P. R. (2010). Conservation Biology for All. Oxford University Press.			
Web Resources:	1. Movebank – Animal movement data platform: https://www.movebank.org 2. Animal Behaviour Society – Educational Resources: https://www.animalbehaviorsociety.org/web/education.php 3. Bio-Logging Science Gateway – Sensors for wildlife monitoring: https://www.bio-logging.net 4. Wildlife Acoustics – Passive monitoring tools: https://www.wildlifeacoustics.com 5. Global Forest Watch – Real-time habitat loss tracking: https://www.globalforestwatch.org 6. NASA EarthData (MODIS, Landsat) – Satellite imagery for habitat change: https://earthdata.nasa.gov 7. GBIF (Global Biodiversity Information Facility) – Species occurrence data: https://www.gbif.org 8. WildMe.org – AI-based species recognition platforms: https://www.wildme.org 9. EcoHealth Alliance – Zoonotic disease ecology: https://www.ecohealthalliance.org 10. SMART (Spatial Monitoring and Reporting Tool): https://smartconservationtools.org			

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Title of the Course	Mammalogy
Course Code	ZOO-5218
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 evolutionary origins and phylogenetic relationships of mammals • To explore mammalian anatomy, physiology, and behavioural adaptations in the context of ecological pressures and evolutionary history. • To analyze complex behavioural and ecological patterns such as reproduction, social organization, communication, and migration in mammals. • To apply knowledge of mammalian ecology and behaviour to real-world conservation problems, including captive breeding, wildlife conflict mitigation, and management in zoological settings.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Explain the evolutionary history and classification of mammals using current systematics and molecular phylogenetic techniques.	PSO1, PSO2
	CO 2. Interpret and evaluate mammalian behaviour and social structures, from an ecological perspective.	PSO2, PSO3

	CO 3. Apply behavioural and ecological principles to assess the survival strategies of mammals and predict responses to environmental change.		PSO2, PSO3, PSO4	
	CO 4. Design and propose conservation strategies including captive breeding, ex situ and in situ management, and population monitoring using modern tools.		PSO3, PSO4	
Content:	**Topic**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Evolutionary Biology and Systematics of Mammals	**1.1. Significance of Mammalian Studies -** Importance in ecological balance, human society, and evolutionary studies. Historical perspectives and milestones in mammalogy	**1**	CO1	K2
	1.2. Mammalian Characteristics and Diversity - Defining features of mammals, thermoregulation Overview of extant mammalian orders with key representative species	**2**	CO1	K2
	1.3. Evolution and Phylogeny - Evolutionary origins from synapsids, Fossil record and transitional forms, Radiation and adaptive divergence of major mammalian lineages	**3**	CO2	K2
	1.4. Systematics and Classification - Modern taxonomic principles, recent revisions in mammalian taxonomy	**1**	CO1, CO2	K2
	1.5. Molecular Techniques in Mammalian Phylogeny - DNA barcoding, genomic sequencing, and comparative genomics, Mitochondrial vs. nuclear DNA analysis, Applications in resolving cryptic species and evolutionary relationships.	**3**	CO1, CO2, CO3	K3
	1.6. Mammalian Biogeography - Patterns of distribution: continental drift, dispersal, and vicariance, Island biogeography and endemism, Case studies: marsupial vs. placental mammals	**3**	CO1, CO2	K3
	1.7. Comparative Anatomy and Physiology - Nervous system, sensory adaptations, Digestive and circulatory adaptations across dietary and ecological guilds.	**2**	CO2, CO3	K2
Module 2: Behavioral and Ecological	**2.1. Mammalian Behavioural Ecology -** Foraging strategies and optimality models, Activity patterns: circadian and seasonal rhythms, Intraspecific and interspecific communication.	**3**	CO2, CO3, CO4	K4

Adaptations of Mammals	**2.2. Reproductive Strategies and Parental Investment** Mating systems, Ecological drivers of reproductive timing and investment, Cooperative breeding, alloparenting, and lactation biology.	**3**	CO2, CO3, CO4	K4
	2.3. Social Organization and Territoriality - Group living, dominance hierarchies, kinship structures, Territorial marking, home range dynamics, communal living, Migration: drivers, mechanisms, and conservation implications	**3**	CO2, CO3, CO4	K4
	2.4. Adaptations to Extreme Environments - Hibernation, torpor, aestivation: physiological mechanisms and ecological significance, Thermoregulation and water economy in arid and cold climates, Adaptive locomotion strategies	**2**	CO2, CO3, CO4	K5
	2.5. Ecological Specializations - Habitat-specific adaptations: aquatic, desert, polar, and cave-dwelling mammals, Convergent evolution across niches, Sensory and feeding adaptations in specialist and generalist species	**2**	CO2, CO3, CO4	K5
	2.6. Acoustic Adaptations - Echolocation in bats: mechanisms, call variation, and ecological functions, Biosonar in cetaceans: communication, navigation, prey detection, Impact of anthropogenic noise on acoustic ecology	**2**	CO2, CO3, CO4	K4
Module 3: Mammalian Conservation Biology	**3.1. Conservation Biology of Mammals -** Global mammalian diversity and extinction patterns, IUCN Red List criteria and threat assessment, Endangered species case studies (e.g., pangolins, big cats, primates)	**3**	CO3, CO4	K3
	3.2. Human-Wildlife Interface - Conflict, coexistence, and mitigation strategies, Disease ecology: zoonoses and transmission dynamics, Urban ecology and mammalian adaptation to anthropogenic landscapes	**4**	CO3, CO4	K5
	3.3. Ex Situ and In Situ Conservation Strategies - Role of zoos and zoological parks in conservation, Captive breeding: genetic management, behavioral enrichment, and reintroduction, Assisted reproductive technologies (ART) in mammalian conservation	**3**	CO3, CO4	K5
	3.4. Conservation Planning and Ethics Wildlife legislation, protected areas, and corridors, Community-based conservation and indigenous, knowledge, Ethical issues: animal welfare, de-extinction, and bioprospecting	**3**	CO3, CO4	K6

	3.5. Contemporary Issues and Innovations Use of technology: camera traps, GPS telemetry, drones, AI and machine learning in mammal population monitoring, Conservation genomics and citizen science in mammalogy	**2**	CO3, CO4	K3
Pedagogy:	Interactive lectures/ Field excursions and biodiversity surveys / Project-based learning /Inquiry-based and problem-centered learning.			
Texts:	1. Bronson, F. H. (1985). Mammalian reproduction: an ecological perspective. *Biology of reproduction*, *32*(1), 1-26. 2. Feldhamer, G. A. (2007). Mammalogy: adaptation, diversity, ecology. JHU press. 3. Francis, C. M. (2019). Field guide to the mammals of South-east Asia. Bloomsbury Publishing. 4. Jefferson, T. A., Webber, M. A., & Pitman, R. L. (2011). Marine mammals of the world: a comprehensive guide to their identification. Elsevier. 5. Setzer, H. W., & Meester, J. (1971). The mammals of Africa: an identification manual. Smithsonian Institution Washington, Part, 1-15. 6. Solari, S., & Baker, R. J. (2007). Mammal species of the world: a taxonomic and geographic reference by DE Wilson; DM Reeder. 7. Vaughan, T. A., Ryan, J. M., & Czaplewski, N. J. (2013). Mammalogy. Jones & Bartlett Publishers. 8. Wilson, D. E., & Reeder, D. M. (Eds.). (2005). *Mammal species of the world: a taxonomic and geographic reference* (Vol. 1). JHU press.			
References/ Readings:	1. Care, A., & Use Committee. (1998). Guidelines for the capture, handling, and care of mammals as approved by the American Society of Mammalogists. *Journal of Mammalogy*, 1416-1431. 2. Clutton-Brock, T. (2009). Structure and function in mammalian societies. Philosophical Transactions of the Royal Society B: Biological Sciences, 364(1533), 3229-3242. 3. Lawrence, M. A. (1993). Catalog of Recent mammal types in the American Museum of Natural History. Bulletin of the AMNH; no. 217. 4. Lukas, D., & Clutton-Brock, T. (2012). Cooperative breeding and monogamy in mammalian societies. Proceedings of the Royal Society B: Biological Sciences, 279(1736), 2151-2156. 5. Martin, R. E., Pine, R. H., & DeBlase, A. F. (2011). A manual of mammalogy: with keys to families of the world. Waveland Press. 6. Negi, S. S. (2002). Handbook of national parks, wildlife sanctuaries, and biosphere reserves in India. Indus publishing.			

	7. Sail, P., Borkar, M. R., Shaikh, I., & Pal, A. (2021). Faunal diversity of an insular crepuscular cave of Goa, India. Journal of Threatened Taxa, 13(2), 17630-17638. 8. Sharma, G., Kamalakannan, M., & Venkataraman, K. (2015). A checklist of mammals of India with their distribution and conservation status. *Zool Surv India*, *111*.
Web Resources:	1. https://www.mammalsofindia.org/ 2. https://animaldiversity.org/ 3. https://ielc.libguides.com/sdzg/guides/animals/mammals

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Title of the Course	Practical in Mammalogy
Course Code	ZOO-5219
Number of Credits	1
Theory/Practical	Practical
Level	
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-5218) should be taken	
Course Objectives:	• To identify mammalian species using diagnostic morphological features such as dentition, skull shape, and hair patterns. • To explore comparative mammalian anatomy and physiology with emphasis on adaptations to ecological niches and environmental pressures. • To develop competence in field-based mammalian research techniques, including species tracking, indirect sign identification, and behavioral sampling. • To apply mammalogical knowledge to contemporary conservation challenges, such as species management, human-wildlife conflict, and ex situ conservation planning.	
Course Outcomes:	Students will be able to:	**Mapped to PSO**
	CO 1. Identify mammalian species using diagnostic morphological features	PSO1, PSO2

	CO 2. Conduct behavioral sampling, and documenting field observations from an ecological perspective.		PSO2, PSO3	
	CO 3. Interpret spatial data to analyze home range, movement patterns, and habitat use of mammals through tracking and sign surveys.		PSO2, PSO3, PSO4	
	CO 4. Design and propose conservation recommendation		PSO3, PSO4	
Content:	Topics	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Experimental approaches in the field of Mammalogy	1.1 Comparative Morphology of Mammalian Dentition	**2**	CO1	K3
	1.2 Comparative Cranial Morphology and Sensory Adaptations	**2**	CO1	K3
	1.3 Hair Microscopy for Species Identification	**2**	CO1	K3
	1.4 Taxonomic Identification of Mammals using dichotomous and interactive keys	**2**	CO1	K5
	1.5 Creation of a diagnostic key for local Mammals/ of a selected area	**2**	CO1	K6
	1.6 Spectrogram analysis in Bats and Cetaceans.	**2**	CO3	K3
	1.7 Examine anatomical adaptations mammalian locomotion	**2**	CO2	K4
	1.8 Study of mammalian organ systems using preserved specimens or models	**2**	CO1	K4
	1.9 Analysis of Camera trap images/ published ethograms to compare activity patterns in mammals	**2**	CO3	K5
	1.10 Field Identification of Mammals of a selected area using indirect signs	**2**	CO2	K5
	1.11 Creation of a species conservation profile for mammals of a selected area	**2**	CO2, CO3	K6
	1.12 Using real-world data, categorize threat status of selected mammalian species.	**2**	CO3	K5
	1.13 Visit to the local zoo to catalogue mammalian behaviors.	**4**	CO3, CO4	K4

	1.14 Construct an ethogram for a selected species (using video footage or zoo observations) and analyze frequency and duration of behaviors	**2**	CO4	K6
Pedagogy:	Research integrated laboratory practical/ Field excursions and biodiversity surveys /Project-based / Inquiry-based and problem-centered learning.			
Texts:	1. Feldhamer, G. A. (2007). *Mammalogy: adaptation, diversity, ecology*. JHU press. 2. Francis, C. M. (2019). *Field guide to the mammals of South-east Asia*. Bloomsbury Publishing. 3. Martin, R. E., Pine, R. H., & DeBlase, A. F. (2011). A manual of mammalogy: with keys to families of the world. Waveland Press. 4. McCleery, R., Monadjem, A., Conner, L. M., Austin, J. D., & Taylor, P. J. (2022). Methods for ecological research on terrestrial small mammals. JHU Press. 5. Nagorsen, D. W., & Peterson, R. L. (1920). Mammal collectors manual. Life Science miscellaneous publications. 6. Ryan, J. M. (2018). Mammalogy techniques lab manual. Johns Hopkins University Press. 7. T.A. Vaughan, J.M. Ryan, N. J. Czaplewski Mammology, USA, Jones and Barlett publisher, 2011 8. Vaughan, T. A., Ryan, J. M., & Czaplewski, N. J. (2013). *Mammalogy*. Jones & Bartlett Publishers.			
References/ Readings:	1. Ashby, K. R. (1972). Patterns of daily activity in mammals. *Mammal Review*, *1*(7-8), 171-185. 2. Barnett, A., & Dutton, J. (1995). Small mammals. Expedition Field Techniques series, Expedition Advisory Centre, Royal Geographical Society. London. 3. Bridges, A. S., & Noss, A. J. (2011). Behavior and activity patterns. In Camera traps in animal ecology: methods and analyses (pp. 57-69). Tokyo: Springer Japan. 4. Halle, S., & Stenseth, N. C. (Eds.). (2012). Activity patterns in small mammals: an ecological approach (Vol. 141). Springer. 5. Hoffmann, A., Decher, J., Rovero, F., Schaer, J., Voigt, C., & Wibbelt, G. (2010). Field methods and techniques for monitoring mammals. *Manual on field recording techniques and protocols for all taxa biodiversity inventories*, *8*(part 2), 482-529.			
Web Resources:	1. https://www.mammalsofindia.org/ 2. https://animaldiversity.org/ 3. https://ielc.libguides.com/sdzg/guides/animals/mammals			

SEMESTER III

Research Specific Elective (RSE) Courses

Title of the Course	Research Methodology
Course Code	ZOO-6000
Number of Credits	4
Theory	Theory
Level	500
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	NIL	
Course Objectives:	• To introduce students to the principles of scientific inquiry and research design in biological sciences. • To train students in data collection, analysis, and interpretation using appropriate statistical tools. • To develop competence in scientific writing, presentation, and ethical publication practices. • Design end-to-end data-analysis workflows and critically evaluate results for sustainable solutions	
Course Outcomes:	**Student will be able to:**	**Mapped to PSO**
	CO1: Identify and formulate research problems, hypotheses, and designs relevant to biological	PSO1,

	sciences.			
	CO2: Apply suitable data collection and sampling techniques for obtaining reliable and valid data.		PSO1, PSO4	
	CO3: Analyze and interpret biological data using descriptive and inferential statistical methods and tools.		PSO1, PSO3	
	CO4: Demonstrate skills in scientific communication, report writing, and ethical publication.		PSO1,	
Content:	**Topic**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1	1.1 Concept and Scope of Research: Nature, objectives, and characteristics of scientific research; types of research (basic, applied, qualitative, quantitative, experimental, descriptive).	**3**	CO1	K1, K2
	1.2 Research Problem Identification and Formulation: Selection and delimitation of research problems; defining variables; review of literature and gap analysis.	**3**	CO1	K1, K3
	1.3 Hypothesis Development and Testing: Definition, characteristics, and formulation of good hypotheses; null and alternative hypotheses; logic in scientific reasoning (deductive and inductive approaches).	**3**	CO1	K1, K3
	1.4 Research Design: Elements and classification of research designs; experimental, descriptive, and exploratory frameworks; validity and reliability considerations.Research ethics, safety in field and laboratory oriented research	**3**	CO1 CO3	K1, K4
	1.5 Research Opportunities and Funding: Overview of national fellowships (CSIR-NET, GATE, ICMR, DBT, SERB, etc.); career pathways in biological research and science communication.	**3**	CO1	K1, K2
Module 2	2.1 Data Sources and Types: Primary, secondary, and tertiary data; qualitative vs. quantitative data; scales of measurement (nominal, ordinal, interval, ratio).	**2**	CO2	K2
	2.2 Methods of Data Collection: Observation, fieldwork, experiments, surveys, interviews, and case studies; use of digital tools in data collection.	**3**	CO2	K3

	2.3 Sampling Design: Population, sample, sampling frame, sample size determination, and sampling error.	**3**	CO2	K3
	2.4 Probability and Non-Probability Sampling: Simple random, stratified, cluster, systematic, convenience, purposive, and snowball sampling methods.	**3**	CO2	K3
	2.5 Data Reliability, Bias, and Compilation: Detection and minimization of sampling and non-sampling errors; data coding, tabulation, and preparation for analysis.	**4**	CO2 CO3	K4
Module 3	3.1 Descriptive statistics (Mean, median. Mode, variance, range, etc) for sample data, statistical hypothesis testing	**1**	CO 2	K3
	3.2 Distribution of data and types; Testing of normality and homogeneity of variances	**1**	CO 2	K3
	3.3 Parametric tests vs non-parametric tests, one-tailed and two-tailed tests	**1**		
	3.4 T-tests and non-parametric equivalents (Mann-Whitney test, Wilcoxon signed-rank test)	**2**	CO 2	K3
	3.5 One-way ANOVA (ordinary and Welch's), Two-way ANOVA and Kruskal-Wallis test and post-hoc analyses	**2**	CO 2	K3
	3.6 Pearson's and Spearman's correlation	**1**	CO 2	K3
	3.7 Linear and multiple regression	**1**	CO 2	K3
	3.8 Chi square tests of independence and Goodness of fit	**2**	CO 2, CO 4	K4
	3.9 Richness, Diversity and community-dissimilarity Indices	**2**	CO 2, CO 4	K4
	3.10 Dimension reduction (Principle Components analysis, Linear Discriminant Analysis)	**2**	CO 3, CO 4	K4
Module 4	4.1 Scientific Communication: Principles of effective writing; types of scientific reports; IMRaD format of research papers; oral and poster presentation techniques.	**3**	CO4	K5
	4.2 Data Representation and Discussion: Graphical and tabular representation;	**3**	CO3	K5

	interpretation of findings, discussion, and conclusion formulation.		CO4	
	4.3 Citation and Bibliographic Management: Reference styles (APA, Harvard, Vancouver); reference management tools (Zotero, Mendeley, EndNote).	**3**	CO4	K3
	4.4 Publication Ethics and Authorship: Responsibilities of authorship; plagiarism, data fabrication, falsification, duplication, and salami slicing; identification of predatory journals.	**3**	CO4	K5
	4.5 Journal Publication Process: Peer review system, journal indexing (Web of Science, PubMed, Scopus), journal metrics (Impact Factor, CiteScore).	**3**	CO4	K4
Pedagogy:	Lectures/ Conceptual animations/videos/Case-based learning, Computational activities, Group discussions/Formative quizzes, Presentations.			
Texts:	1. Creswell, J. W., & Creswell, J. D. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (5th ed.). SAGE Publications. 2. Daniel, W. W., & Cross, C. L. (2018). *Biostatistics: A Foundation for Analysis in the Health Sciences* (11th ed.). Wiley. 3. Kothari, C. R., & Garg, G. (2019). *Research Methodology: Methods and Techniques* (4th ed.). New Age International. 4. Suresh, K. (2014). *An Introduction to Biostatistics and Research Methods* (4th ed.). Jaypee Brothers.			
References/ Readings:	1. Panneerselvam, R. (2014). *Research Methodology*. PHI Learning Pvt. Ltd. 2. Thyer, B. A. (Ed.). (2010). *The Handbook of Social Work Research Methods* (2nd ed.). SAGE Publications. 3. Gupta, S. P. (2012). *Statistical Methods*. Sultan Chand & Sons. 4. Rumsey, D. J. (2021). *Statistics for Dummies* (3rd ed.). Wiley. 5. Field, A. (2017). *Discovering Statistics Using IBM SPSS Statistics* (5th ed.). SAGE Publications. 6. Glass, D. J. (2014). *Experimental Design for Biologists* (2nd ed.). Cold Spring Harbor Laboratory Press. 7. Day, R. A., & Gastel, B. (2016). *How to Write and Publish a Scientific Paper* (8th ed.). Cambridge University Press. 8. COPE (2023). *Code of Conduct and Best Practice Guidelines for Journal Editors*. Committee on Publication Ethics.			
Web Resources:	1. Elsevier Researcher Academy: https://researcheracademy.elsevier.com 2. COPE (Committee on Publication Ethics): https://publicationethics.org 3. NCBI Statistics Handbook: https://www.ncbi.nlm.nih.gov/books/NBK305			

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Title of the Course	Neurophysiology
Course Code	ZOO-6001
Number of Credits	3
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	NIL	
Course Objectives:	• To impart integrated knowledge of neuronal structure, membrane physiology, and myelination related to excitability and conduction. • To explain ion channel mechanisms, synaptic transmission, and neurotransmitter dynamics in neural communication. • To elucidate the neurophysiological basis of learning, memory, pain, sensory processing, balance, and sleep within experimental and translational contexts. • To develop research-oriented thinking for interpreting and correlating neurophysiological mechanisms with behaviour and disease.	
Course Outcomes:	Student will be able to:	**Mapped to PSO**
	CO 1. Apply concepts of membrane and ion channel physiology to explain neuronal excitability and conduction.	PSO1, PSO2
	CO 2. Analyze neurotransmission and synaptic modulation as bases of neural circuit function	PSO1, PSO3

	and adaptability.			
	CO 3. Evaluate neurophysiological mechanisms underlying learning, memory, pain, and neurodegenerative disorders.		PSO1, PSO3, PSO4	
	CO 4. Integrate research tools and electrophysiological methods to explore neural activity and dysfunction.		PSO1, PSO2, PSO3	
Content:	**Topic**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module I: Neural Structure, Membrane Physiology, and Electrophysiological Techniques	**1.1 Neuronal Architecture and Functional Specialization:** Review and classification of neurons and glial cells; correlation of neuronal morphology with function; structure–function adaptations underlying excitability, integration, and transmission.	**1**	CO1	K1, K2, K3
	1.2 Neuronal Membrane Physiology and Ion Channel Dynamics: Biophysical properties of neuronal membranes; ionic basis of resting and action potentials; ion channel types, gating mechanisms, and their physiological and pathological significance (channelopathies).	**3**	CO1	K1, K2, K3
	1.3 Conduction Mechanisms and Myelin Organization: Myelin ultrastructure and Nodes of Ranvier; principles of impulse propagation in myelinated and unmyelinated fibers; experimental models for assessing conduction velocity and efficiency; influence of temperature, axon diameter, and myelination.	**3**	CO1	K1, K2, K3
	1.4 Blood–Brain Barrier and Neurophysiological Homeostasis: Structure, function, and selective permeability of the blood–brain barrier; cerebrospinal fluid formation and circulation; research relevance in drug delivery, neuroinflammation, and barrier dysfunctions.	**4**	CO1	K2, K3, K4
	1.5 Experimental Electrophysiology and Data Analysis: Comparative electrophysiology of neurons (squid giant axon vs. mammalian neurons); introduction to advanced recording methods—voltage-clamp and patch-clamp techniques; quantification of excitability and response patterns through experimental data	**4**	CO4	K2, k3, K4, K5,K6

	interpretation.			
Module II: Synaptic Physiology, Neurotransmission, and Neural Circuit Integration	**2.1 Synaptic Organization and Circuit Dynamics:** Structural and functional types of synaptic connections (axosomatic, axodendritic, dendrodendritic, axoaxonal); mechanisms of synaptic transmission; neural circuit motifs—diverging, converging, and reverberating pathways—and their roles in information processing and network modulation.	**3**	CO2	K2, K3, K4
	2.2 Chemical and Electrical Synapses: Mechanisms and Comparative Features: Molecular basis of chemical and electrical synaptic transmission; synaptic vesicle cycling, quantal release, and gap junction coupling; excitatory and inhibitory balance; experimental and computational models for studying synaptic efficacy and temporal summation.	**3**	CO2	K2, K3, K4
	2.3 Neurotransmitters, Neuropeptides, and Receptor Mechanisms: Classification of classical neurotransmitters, neuropeptides, and gaseous messengers; receptor families (ionotropic, metabotropic) and intracellular signaling pathways; receptor mapping and ligand-binding assays as research tools; receptor modulation in disease models.	**3**	CO2	K2, K3, K4
	2.4 Neurotransmitter Dynamics and Research Applications: Life cycle of neurotransmitters—synthesis, vesicular storage, release, reuptake, and degradation; experimental designs to study synaptic dysfunction, neurotoxicity, or pharmacological modulation; case analyses of major neurotransmitter systems (Acetylcholine, Glutamate, GABA, Dopamine, Serotonin, Nitric Oxide) in physiological and pathological contexts.	**3**	CO2, CO4	K2, K3, K4, K5
	2.5 Synaptic Plasticity and Experimental Approaches: Mechanisms of short- and long-term plasticity (facilitation, depression, potentiation, and long-term potentiation / depression); experimental paradigms for assessing plasticity using electrophysiological and imaging methods; molecular regulation of synaptic strength and learning-related modifications.	**3**	CO2, CO4	K3, K4, K5, K6
Module III:	**3.1 Neural and Cellular Basis of Learning and Memory:**	**2**	CO3	K2, K3,

Cognitive, Sensory, and Integrative Neural Pathways	Molecular and electrophysiological mechanisms underlying short-term and long-term memory; synaptic plasticity, long-term potentiation (LTP), and long-term depression (LTD); model systems for learning and memory research (*Aplysia*, *Drosophila*, honeybee, and mammalian hippocampus); experimental paradigms for quantifying memory formation and consolidation.			K4, K5
	3.2 Neurophysiology of Pain and Analgesia: Anatomical and physiological pathways of nociception; neurotransmitters and modulators in pain processing; endogenous opioid and non-opioid analgesic systems; experimental and clinical models for pain assessment (thermal, mechanical, inflammatory, neuropathic models); evaluation of pharmacological and neuromodulatory interventions.	**3**	CO3	K2, K3, K4, K5
	3.3 Sensory Integration and Cognitive Processing Mechanisms of mechanoreception, photoreception, and chemoreception; encoding and decoding of sensory stimuli; cross-modal sensory integration and perception; experimental and comparative studies on neural representation of stimuli and behavioral responses; insights from cognitive and systems neuroscience.	**3**	CO3	K2, K3, K4
	3.4 Vestibular Physiology, Balance, and Postural Control Organization of the vestibular apparatus and central pathways; neural integration of vestibular, visual, and proprioceptive inputs; mechanisms of equilibrium and orientation; electrophysiological and behavioral approaches to study motor coordination and ataxic conditions.	**2**	CO3	K2, K3, K4, K5
	3.5 Neurophysiology of Neurodegenerative Disorders: Cellular and synaptic mechanisms underlying Alzheimer's, Parkinson's, Huntington's, and Amyotrophic Lateral Sclerosis (ALS); alterations in neurotransmission, plasticity, and network connectivity; electrophysiological and imaging correlates of motor and cognitive dysfunction; experimental models and translational therapeutic approaches.	**3**	CO3, CO4	K5, K6
	3.6 Neurophysiology of Sleep and Biological Rhythms: Neural circuits regulating sleep–wake cycles; EEG signatures of sleep stages and their functional significance; circadian and ultradian rhythm generation; experimental frameworks for studying sleep deprivation, arousal regulation, and memory consolidation	**2**	CO3	K2, K3, K4, K5

	during sleep; clinical perspectives on sleep disorders.			
Pedagogy:	Lectures/ Conceptual animations/videos/Case-based learning, Group discussions/Formative quizzes, Presentations.			
Texts:	1. Aidley, D. J. (2022). *The Physiology of Excitable Cells* (5th ed.). Cambridge University Press. 2. Bear, M. F., Connors, B. W., & Paradiso, M. A. (2020). *Neuroscience: Exploring the Brain* (5th ed.). Wolters Kluwer. 3. Hammond, C. (2015). *Cellular and Molecular Neurophysiology* (4th ed.). Academic Press. 4. Scott, G., Siegel, R. W., Albers, D. L., & Price, D. L. (Eds.). (2011). *Basic Neurochemistry: Principles of Molecular, Cellular, and Medical Neurobiology* (8th ed.). Academic Press.			
References/ Readings:	1. Gadhave, D. G., et al. (2024). *Neurodegenerative disorders: Mechanisms, models and therapeutic implications.* Progress in Neurobiology, 240, 102475. https://doi.org/10.1016/j.pneurobio.2024.102475 2. Henstridge, C. M., Pickett, E., & Spires-Jones, T. L. (2021). *Synaptic loss and neurodegeneration.* Frontiers in Cellular Neuroscience, 15, 681029. https://www.frontiersin.org/articles/10.3389/fncel.2021.681029/full 3. Kandel, E. R., Koester, J. D., Mack, S. H., & Siegelbaum, S. A. (2021). *Principles of Neural Science* (6th ed.). McGraw-Hill Education. 4. Magee, J. C., & Grienberger, C. (2020). *Synaptic plasticity: Forms and functions.* Annual Review of Neuroscience, 43, 95–117. https://doi.org/10.1146/annurev-neuro-090919-022842 5. Marttinen, M., Paananen, J., Nykänen, N. P., & Tanila, H. (2015). *Synaptic dysfunction and septin protein family members in neurodegenerative diseases.* Molecular Neurodegeneration, 10, 16. 6. Nicholls, J. G., Martin, A. R., Fuchs, P. A., Brown, D. A., Diamond, M. E., & Weisblat, D. A. (2011).*From Neuron to Brain* (5th ed.). Sinauer Associates. 7. Purves, D., Augustine, G. J., Fitzpatrick, D., Hall, W. C., LaMantia, A.-S., & White, L. E. (2018). *Neuroscience* (6th ed.). Oxford University Press. 8. Sheng, M., & Sabatini, B. L. (2018). *Synaptic dysfunction in neurodegenerative and neurodevelopmental diseases.* Nature Neuroscience, 21(10), 1350–1359. https://pmc.ncbi.nlm.nih.gov/articles/PMC6170506/ 9. Tononi, G., & Cirelli, C. (2020). *Experience- and sleep-dependent synaptic plasticity: From structure to function.* Philosophical Transactions of the Royal Society B: Biological Sciences, 375(1799), 20190234. https://royalsocietypublishing.org/doi/10.1098/rstb.2019.023			
Web Resources:	1. Centre for NeuroScience, Indian Institute of Science. *Centre for NeuroScience, Indian Institute of Science*. https://cns.iisc.ac.in/			

	2. Neuroscience-Online. *Neuroscience-Online YouTube playlist*. https://www.youtube.com/playlist?list=PLeRCSVJpV37Iqv6w0p8hiuCYTBLutCqId 3. Neurotorium. *Neurotorium: Free educational material about the brain*. https://neurotorium.org/

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Title of the Course	Practical in Neurophysiology
Course Code	ZOO-6002
Number of Credits	1
Theory/Practical	Practical
Level	500
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	ZOO-6001 Neurophysiology (Theory)	
Course Objectives:	• To train in the identification and interpretation of neuronal and glial structures through histological and histochemical analyses, correlating microanatomy with neurophysiological function. • To develop competency in establishing and maintaining primary neuronal cultures for examining neuronal morphology, growth, and differentiation. • To build proficiency in the quantitative estimation of key neurotransmitters and interpretation of excitatory–inhibitory balance in relation to synaptic physiology. • To provide understanding of behavioral and sensory-based experimental paradigms related to learning, memory, balance, and photoreception, emphasizing their neurophysiological mechanisms.	
Course Outcomes:	Student will be able to:	**Mapped to PSO**
	CO 1. **Demonstrate** neurophysiological techniques—histology, primary neuron culture, and virtual patch clamp—to study neuronal excitability and transmission.	PSO2, PSO3

	CO 2. **Analyze** neurotransmitter and synaptic markers through biochemical and histochemical methods to relate structure with function.		PSO1, PSO2,	
	CO 3. **Evaluate** behavioral and physiological models of learning, memory, pain, and sensory perception to explain integrative neural functions.		PSO1, PSO3, PSO4	
	CO 4. **Integrate** cellular, biochemical, and behavioral data to interpret neural activity and dysfunction in research contexts.		PSO1, PSO3, PSO4	
Content:	**Topic**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1	1.1 Histological Examination of Neuronal and Glial Architecture using Printed Micrographs	**2**	CO1	K1, K2, K3
	1.2 Primary Culture of Neurons from the Chicken Brain	**4**	CO1	K1, K2, K3
	1.3 Primary culture of Neuronal Progenitor Cells from chick embryo brain	**4**	CO1	K1, K2, K3, K4
	1.4 Virtual Patch-Clamp Experiment (Voltage Clamp): Separating I_{Na} and I_K with Pharmacological Block	**4**	CO1, CO4	K1, K2, K3, K4
	1.5 Estimation of Glutamate and GABA from brain tissue (chicken head)	**4**	CO2	K1, K2, K3, K4
	1.6 Histochemical and Immunohistochemical Analysis of Synaptic and Neurotransmitter Localization Using Printed Micrographs	**2**	CO2	K1, K2, K3, K4
	1.7 Numerical and pictorial memory analysis using a memory drum	**2**	CO3	K1, K2, K3, K4, K5
	1.8 Learning and short-term memory formation analysis.	**2**	CO3	K1, K2, K3, K4, K5
	1.9 Pressure phosphene and balancing analysis using human subjects	**2**	CO3	K1, K2, K3, K4, K5
	1.10 Visual test analysis for photoreception in human subjects	**2**	CO3	K1, K2, K3,

				K4, K5
	1.11 Assessment of Mechanical Nociception in *Drosophila* Larvae (Von Frey Assay).	**2**	CO3, CO4	K1, K2, K3, K4, K5, K6
Pedagogy:	Hands-on, tool-based learning through demonstrations, guided exercises, mini-projects, and reflective practice			
Texts:	1. Banker, G., & Goslin, K. (1998). *Culturing nerve cells* (2nd ed.). MIT Press. 2. Fischbach, F. T., & Fischbach, M. A. (2017). *Fischbach's Manual of Laboratory and Diagnostic Tests* (10th ed.). Lippincott Williams & Wilkins (LWW). 3. Menzel, R., & Benjamin, P. R. (Eds.). (2013). *Invertebrate learning and memory*. Academic Press. 4. Pagana, K. D., Pagana, T. J., & Pagana, T. N.(2021). *Mosby's Manual of Diagnostic and Laboratory Tests* (8th ed.). Mosby.			
References/ Readings:	1. Das, K. P., & Barone, S. Jr. (2021). *Neural cell culture: Methods and protocols* (3rd ed., Neuromethods Series). Springer Nature. 2. Haines, D. E. (2017). *Neuroanatomy: An atlas of structures, sections, and systems* (10th ed.). Lippincott Williams & Wilkins. 3. Hall, J. E., & Guyton, A. C. (2020). *Guyton and Hall textbook of medical physiology* (14th ed.). Elsevier. 4. Lechner, H. A., Squire, L. R., & Byrne, J. H. (1999). 100 years of consolidation — Remembering Müller and Pilzecker. *Learning & Memory, 6*(2), 77–87. 5. Magee, J. C., & Grienberger, C. (2020). Synaptic plasticity: Forms and functions. *Annual Review of Neuroscience, 43*, 95–117. 6. Neckel, P. H., Mattheus, U., Hirt, B., Just, L., Mack, A. F., & May, C. A. (2016). Immunohistochemical techniques for neurotransmitter localization in neural tissue. *Frontiers in Neuroanatomy, 10*, 25. https://doi.org/10.3389/fnana.2016.00025 7. Neely, G. G., Hess, A., Costigan, M., Keene, A. C., Goulas, S., Langeslag, M., Griffin, R. S., Belfer, I., Dai, F., Smith, S. B., Diatchenko, L., Tegeder, I., Smith, R., Tracey, W. D., Woolf, C. J., & Garrity, P. A. (2010). A genome-wide Drosophila screen for heat nociception identifies α2δ3 as an evolutionarily conserved pain gene. *Cell, 143*(4), 628–638. https://doi.org/10.1016/j.cell.2010.09.047 8. Tsubota, T., & Kawano, K. (2013). Sensory integration in balance and posture control. *Frontiers in Physiology*, *4*, 81. https://doi.org/10.3389/fphys.2013.00081			

Web Resources:	1. Abcam. (n.d.). *Neuroscience: Technical resources and research tools*. https://www.abcam.com/en-us/technical-resources/research-areas/neuroscience 2. Allen Institute for Brain Science. (n.d.). *Brain Knowledge Platform*. https://brain-map.org/bkp 3. American University. (n.d.). *OpenBehavior: Open-source tools for behavioral neuroscience research*. https://edspace.american.edu/openbehavior/tools/

Title of the Course	Ecotoxicology (Theory)
Course Code	ZOO-6003
Number of Credits	3
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• Analyze mechanistic pathways of contaminant fate, exposure, and toxicity from molecular to ecosystem levels. • Outline the ecotoxicology of various substances. • Evaluate ecotoxicological data using quantitative tools (dose–response modelling, group comparisons, survival analysis) to inform risk assessment. • Synthesize regulatory frameworks and communicate sustainable, science-based management recommendations for environmental challenges.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Critically analyze mechanistic pathways of contaminant fate, exposure, and toxicity from molecular to ecosystem scales.	PSO1
	CO 2. Interpret the toxic outcomes of environmental exposures.	PSO2
	CO 3. Evaluate ecotoxicological datasets using quantitative tools to inform ecological risk	PSO3

	assessments.			
	CO 4. Integrate regulatory frameworks with experimental findings to develop and communicate sustainable, science-based management recommendations for environmental challenges		PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Foundations, Fate and Exposure, toxicity testing	1.1 Scope, history and scales of ecotoxicology (molecule to ecosystem).	**2**	CO 1	K1, K2
	1.2 Key terms, units and measurement conventions used in the field.	**1**	CO 1	K1
	1.3 Contaminant Uptake: Uptake Routes (skin, lungs, gills, gastrointestinal), Biotransformations and elimination	**2**	CO 1	K1, K2
	1.4 Toxicokinetics: One compartment model, two compartment model	**2**	CO 1	K3
	1.5 Guidelines in toxicity testing: Organisation for Economic Co-operation and Development (OECD), United Nations Environmental Protection Agency (UNEPA), Food & Drug Administration (FDA), Food Safety and Standards Authority of India (FSSAI)	**3**	CO 2	K3
	1.6 Toxicity testing in Model organisms (Daphnia, Fish, Rodents): Maintenance, ethics, euthanasia	**2**	CO 4	K2
	1.7 Dose–response fundamentals: EC50, LC50, LD50, NOEC, LOEC and slope interpretation.	**2**	CO 3	K2
	1.8 Alternative models in toxicity testing: in silico toxicology	**1**	CO 3	K4
Module 2: Ecotoxicology of substances	2.1 Ecotoxicology of metals and metalloids (Hg, Pb, Cd, As, Cu)	**3**	CO 1, CO 2	K2, K3, K4
	2.2 Ecotoxicology of organic compounds (pesticides, flame retardants, perfluoroalkyl compounds)	**2**	CO 1, CO 2	K2, K3, K4
	2.3 Ecotoxicology of endocrine disrupting compounds (estrogenic compounds, BPA)	**2**	CO 1, CO 2	K2, K3, K4
	2.4 Ecotoxicology of plastic (macroplastics, microplastics, nanoplastics)	**2**	CO 1,	K2, K3,

			CO 2	K4
	2.5 Ecotoxicology of toxins (harmful algal blooms, bacteria and fungi)	**2**	CO 1, CO 2	K2, K3, K4
	2.6 Ecotoxicology of radiation (ionizing, non-ionizing)	**2**	CO 1, CO 2	K2, K3, K4
	2.7 Ecotoxicology of engineered nanomaterials	**2**	CO 1, CO 2	K2, K3, K4
Module 3: Methods in Ecotoxicology	3.1 Regulatory frameworks and dossiers: REACH, OECD, EPA and national contexts.	**2**	CO 4	K2, K3, K4
	3.2 Ecological risk assessment framework: problem formulation to risk characterisation.	**2**	CO 4	K3, K4
	3.3 Field testing: Planning and sample collection	**2**	CO 3	K3, K4
	3.4 Field testing: Biomarkers of toxicity	**3**	CO 3	K3, K4
	3.5 Field testing: Analytical methods and instrumentation for various contaminants and quality control (GC-MS, UHPLC, ICP-MS, AAS)	**2**	CO 3, CO 4	K3, K4
	3.6 Hazard indices: Bioconcentration factor (BCF), Bioaccumulation factor (BAF), Trophic transfer, Estimated Daily Intake (EDI), Pollution Load Index (PLI), Total Hazard Quotient (THQ)	**2**	CO 4	K3, K4, K5
	3.7 Chemical management and regulation: importance of regulatory mechanisms	**2**	CO 4	K3, K4, K5
Pedagogy:	Lectures, ICT-based learning, Case-based problems: real-world			
Texts:	1. Campbell, P. G. C., Hodgson, P. V., Welbourn, P. M., & Wright, D. A. (2022). Ecotoxicology (1st ed). Cambridge University Press. 2. Hauser-Davis, R. A., & Parente, T. E. (Eds.). (2018). Ecotoxicology: Perspectives on key issues (1st ed). CRC Press. 3. Moriarty, F. (1999). Ecotoxicology: The study of pollutants in ecosystems (3rd ed). Academic Press. 4. Newman, M. C. (2019). Fundamentals of ecotoxicology: The science of pollution (5th ed). CRC Press. 5. Walker, C. H., Sibly, R. M., Hopkin, S. P., & Peakall, D. B. (2012). Principles of ecotoxicology (4th ed.). CRC Press.			

References/ Readings:	1. Amobonye, A., Bhagwat, P., Raveendran, S., Singh, S., & Pillai, S. (2021). Environmental impacts of microplastics and nanoplastics: a current overview. Frontiers in microbiology, 12, 768297. 2. Khan, B. A., Nadeem, M. A., Nawaz, H., Amin, M. M., Abbasi, G. H., Nadeem, M., & Ayub, M. A. (2023). Pesticides: impacts on agriculture productivity, environment, and management strategies. In Emerging contaminants and plants: Interactions, adaptations and remediation technologies (pp. 109-134). Cham: Springer International Publishing. 3. Martínez-Alcalá, I., & Bernal, M. P. (2020). Environmental impact of metals, metalloids, and their toxicity. Metalloids in plants: advances and future prospects, 451-488.
Web Resources:	1. ECHA EUROPA information on chemicals. https://echa.europa.eu/information-on-chemicals 2. Toxicological Profiles (peer-reviewed summaries on hazardous substances) and health assessments related to polluted sites https://www.atsdr.cdc.gov/ 3. Summaries on emerging environmental health topics https://www.niehs.nih.gov/health/topics 4. Publications and reports related to global environmental issues https://www.unep.org/publications-data

Title of the Course	Practical in Ecotoxicology
Course Code	ZOO-6004
Number of Credits	1
Theory/Practical	Practical
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners:	No

Pre-requisites for the Course:	ZOO-6003 Ecotoxicology (Theory).	
Course Objectives:	• Demonstrate advanced understanding of ecotoxicological mechanisms affecting aquatic organisms. • Apply analytical techniques to quantify pollutants in biological and environmental samples. • Analyze toxicological and biochemical data to assess ecological risk. • Evaluate and integrate ecotoxicology findings into sustainable environmental management strategies.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Identify and explain ecotoxicological effects of pollutants on fauna.	PSO 1
	CO 2. Employ advanced laboratory methods for pollutant analysis.	PSO 2
	CO 3. Analyze toxicity data to determine ecological risk.	PSO 3
	CO 4. Evaluate hazard indices and synthesize results into recommendations for sustainable management.	PSO 4

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1: Practicals	1.1 Detection of toxic metals (Pb/Cd/Hg) using AAS / AES from fish/ bivalves collected from the environment	**2**	CO 1	K1, K3
	1.2 Detection of metals in water samples using flame photometry	**2**	CO 2	K1, K3
	1.3 Effect of metal pollution in the osmoregulatory process in crabs/fishes (lab-based scenario)	**2**	CO 2	K1, K3
	1.4 Detection of microplastics from fish/ bivalves collected from the environment	**2**	CO 2	K1, K3
	1.5 Detection of microplastics in water samples (tap / well / spring / river water)	**2**	CO 3	K1, K4
	1.6 Determination of LD_{50} from given data using Probit analysis.	**2**	CO 2	K1, K3
	1.7 Determination of 24 – 96h LC_{50} of waterborne pollutants (heavy metals/ microplastics/ pesticides) in Daphnia	**6**	CO 3	K1, K4
	1.8 Estimation of oxidative damage in fish/Bivalves exposed to heavy metals/ microplastics/ pesticides	**2**	CO 3	K1, K4
	1.9 Effect of pesticide pollution physiological process in crabs/fishes/bivalves/Daphnia	**2**	CO 1	K3
	1.10 Detection of pesticide residues from contaminated soil or water using TLC/Column chromatography	**2**	CO 2	K3
	1.11 Genotoxic effects of environmental contaminants (heavy metals / microplstics / pesticides) on blood parameters in fishes	**2**	CO 2	K3
	1.12 Quantification of silica from contaminated water samples using spectrophotometer	**2**	CO 3	K4
	1.13 Calculations of hazard indices (Trophic Transfer, Bioaccumulation factor, Bioconcentration factor, Estimated Daily Intake, Pollution Load Index) from data	**2**	CO 4	K4
Pedagogy:	Hands-On Practical Training, Problem-Based Learning, Interactive Demonstrations			
Texts:	1. Ballantyne, B. Mars, T. and P. Turner (1993) General & Applied Toxicology.Eds, Vol I & II, ISBN: 0333498011, McMillon, Stockton Press.			

	2. Basu M. and S. Xavier (2016) Environmental Studies Cambridge University Press, Delhi. 3. Gad. S. C. and Chengelis, C. P (1998) Animal Models in Toxicology, ISBN: 0824784561. 4. Sharma, S. P., Rastogi and Lamporary (1994) Environmental Biology & Toxicology.Sood A Swarup and Sons, New Delhi
References/ Readings:	1. Amobonye, A., Bhagwat, P., Raveendran, S., Singh, S., & Pillai, S. (2021). Environmental impacts of microplastics and nanoplastics: a current overview. Frontiers in microbiology, 12, 768297. 2. Hamed, M., Soliman, H. A. M., Osman, A. G. M., & Sayed, A. E.-D. H. (2019). Assessment the effect of exposure to microplastics in Nile Tilapia (*Oreochromis niloticus*) early juvenile: I. blood biomarkers. *Chemosphere*, *228*, 345–350. https://doi.org/10.1016/j.chemosphere.2019.04.153 3. Khan, B. A., Nadeem, M. A., Nawaz, H., Amin, M. M., Abbasi, G. H., Nadeem, M., & Ayub, M. A. (2023). Pesticides: impacts on agriculture productivity, environment, and management strategies. In Emerging contaminants and plants: Interactions, adaptations and remediation technologies (pp. 109-134). Cham: Springer International Publishing. 4. Lambert, S., Sinclair, C., & Boxall, A. (2014). *Occurrence, Degradation, and Effect of Polymer-Based Materials in the Environment* (pp. 1–53). https://doi.org/10.1007/978-3-319-01327-5_1 5. Martínez-Alcalá, I., & Bernal, M. P. (2020). Environmental impact of metals, metalloids, and their toxicity. Metalloids in plants: advances and future prospects, 451-488.
Web Resources:	1. ECHA EUROPA information on chemicals. https://echa.europa.eu/information-on-chemicals 2. Toxicological Profiles (peer-reviewed summaries on hazardous substances) and health assessments related to polluted sites https://www.atsdr.cdc.gov/ 3. Summaries on emerging environmental health topics https://www.niehs.nih.gov/health/topics 4. Publications and reports related to global environmental issues https://www.unep.org/publications-data

Title of the Course	Herpetology
Course Code	ZOO-6005
Number of Credits	03
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites For the Course:	NIL	
Course Objectives:	● To develop understanding of the evolution, diversity, and adaptive strategies of amphibians and reptiles. ● To examine the ecological, physiological, and behavioral mechanisms shaping herpetofaunal life histories. ● To evaluate the conservation challenges, anthropogenic pressures, and disease dynamics affecting herpetofaunal populations. ● To integrate traditional ecological knowledge, cultural perspectives, and modern scientific tools for conservation and management of herpetofauna.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Apply Taxonomic, evolutionary and ecological principles to interpret herpetofaunal diversity, systematics, and functional adaptations.	PSO1, PSO2
	CO 2. Examine the ecological, behavioral, and physiological adaptations that enhance survival of amphibians and reptiles across ecosystems.	PSO2, PSO3

	CO 3. Evaluate environmental, anthropogenic, and pathological factors influencing herpetofaunal population trends and conservation priorities.		PSO2, PSO3, PSO4	
	CO 4. Evaluate conservation challenges, including human–wildlife interactions and design integrative conservation frameworks incorporating citizen science.		PSO2, PSO3, PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Introduction to Herpetology: Evolution, Systematics, and Functional Diversity	1.1 Defining characters, evolutionary origins, fossil records, biogeographic distribution, and phylogenetic relationships	**03**	CO1, CO2	K1, K3, K4
	1.2 Systematics and diversity of Amphibians: Caudata (paedomorphosis, lungless forms), Anura (vocal sac diversity, explosive breeding), Gymnophiona (fossoriality, sensory tentacles)	**03**	CO1, CO2	K1, K4
	1.3 Systematics and diversity of Reptiles: Squamata (venom evolution, limb loss, thermal adaptations), Testudines (shell morphology, longevity, sex determination).	**03**	CO1, CO2	K1, K4
	1.4 Crocodilia and Sphenodontia (living fossils, nocturnal adaptations), comparative morphology and evolutionary trends	**03**	CO1, CO2	K1, K4
	1.5 Feeding ecology and prey specialization, types of snake teeth (Aglyphous, Opisthoglyphous, Proteroglyphous, Solenoglyphous), venom gland structure, and venom composition	**03**	CO1, CO2, CO3	K3, K4
Module 2: Ecology, Physiology, and Behavior	2.1 Ecological interactions: foraging strategies, predator–prey dynamics (chemical defenses, mimicry, autotomy), niche partitioning, and coexistence	**03**	CO1, CO2, CO4	K3, K4
	2.2 Locomotion in terrestrial, aquatic, and arboreal forms; types of movements and biomechanical adaptations	**03**	CO1, CO2, CO4	K4
	2.3 Communication and social behavior: acoustic signalling, visual displays, pheromonal communication, social hierarchies, territoriality, and mating systems	**03**	CO2, CO3	K3, K4
	2.4 Reproduction: oviparity, ovoviviparity, viviparity, metamorphosis in amphibians	**03**	CO2,	K4

	(hormonal and ecological regulation), parental care strategies		CO3	
	2.5 Thermal and water relations: thermoregulation strategies, physiological and behavioral adaptations, dormancy mechanisms	**03**	CO1, CO2,	K3, K4
Module 3: Community and Herpetofauna	3.1 Herpetofaunal declines, emerging diseases (chytridiomycosis, ranavirus), and conservation tools (Pit tagging, radio telemetry, GIS)	**03**	CO2, CO3	K4
	3.2 Climate change and anthropogenic impacts; human–reptile interaction and mitigation case studies	**03**	CO3	K3, K4
	3.3 Fear, perception, and attitudes toward herpetofauna; myths, misconceptions, and cultural roots	**03**	CO3, CO4	K3, K4
	3.4 Traditional ecological knowledge and indigenous conservation practices (sacred groves, taboos, local beliefs)	**03**	CO4	K4
	3.5 Community-based conservation and citizen science: participatory models, livelihood linkages	**03**	CO4	K4, K5
Pedagogy:	Interactive lectures/ Case study analysis/ Research assignments/ Seminars and group presentations/ Group discussions/problem-solving.			
Texts:	1. Pough, F. H., Andrews, R. M., Crump, M. L., Savitzky, A. H., Wells, K. D., & Brandley, M. C. (2016). *Herpetology* (4th ed.). Sinauer Associates. 2. Vitt, L. J., & Caldwell, J. P. (2014). *Herpetology: An Introductory Biology of Amphibians and Reptiles* (4th ed.). Academic Press. 3. Wells, K. D. (2007). *The Ecology and Behavior of Amphibians.* University of Chicago Press. 4. Whitaker, R., & Captain, A. (2004). *Snakes of India: The Field Guide.* Draco Books. 5. Zug, G. R., Vitt, L. J., & Caldwell, J. P. (2001). *Herpetology: An Introductory Biology of Amphibians and Reptiles* (2nd ed.). Academic Press.			
References/ Readings:	1. Duellman, W. E., & Trueb, L. (1994). *Biology of Amphibians.* Johns Hopkins University Press. 2. Gower, D. J., & Wilkinson, M. (2005). Conservation biology of caecilian amphibians. *Conservation Biology, 19*(1), 45–55. 3. Heatwole, H. (2013). *Amphibian Biology.* Surrey Beatty & Sons.			

	4. Shine, R. (2005). Life-history evolution in reptiles. *Annual Review of Ecology, Evolution, and Systematics, 36*, 23–46. 5. Wells, K. D. (2010). *Behavioral Ecology and Social Organization of Amphibians.* Oxford University Press. 6. Whitaker, R., & Captain, A. (2019). *Field Guide to the Reptiles of India.* Oxford University Press.
Web Resources:	1. **AmphibiaWeb** – Database of amphibian species, natural history, and conservation. https://amphibiaweb.org/ 2. **The Reptile Database** – Global database of reptile taxonomy and distribution. https://reptile-database.reptarium.cz/ 3. **IUCN Red List of Threatened Species** – Amphibian and reptile conservation status. https://www.iucnredlist.org/ 4. **India Biodiversity Portal** – Species data and citizen science platform. https://indiabiodiversity.org/ 5. **HerpMapper** – Open-access herpetofaunal data collection platform. https://www.herpmapper.org/ 6. **Society for the Study of Amphibians and Reptiles (SSAR)** – Research resources and open-access archives. https://ssarherps.org/ 7. **Amphibian Specialist Group (IUCN SSC)** – Global amphibian conservation resources. https://amphibians.org/

Title of the Course	Practical in Herpetology
Course Code	ZOO-6006
Number of Credits	1
Theory/Practical	Practical
Level	500
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites For the Course:	ZOO-6005	
Course Objectives:	• To train students in field and laboratory techniques for the identification, measurement, and analysis of amphibians and reptiles. • To develop proficiency in handling, data recording, and morphometric assessment of herpetofauna. • To enhance analytical and spatial skills through biodiversity estimation and habitat mapping. • To integrate field data with ecological interpretation and conservation applications.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Apply field and laboratory techniques for identifying and classifying amphibians and reptiles using morphological characteristics.	PSO1, PSO2
	CO 2. Analyze morphometric, acoustic, and ecological datasets to evaluate species diversity and distribution patterns.	PSO2, PSO3

	CO 3. Evaluate habitat attributes and biodiversity indices using geospatial and statistical tools.		PSO3, PSO4	
	CO 4. Design and execute field-based herpetological surveys integrating ethical handling, data interpretation, and conservation perspectives.		PSO3, PSO4	
Module 1: Field and Analytical Techniques in Herpetology	**Content**	**No of hours**	**Mapped to CO**	**Cognitive Level**
	1.1 Identification of Amphibians using external morphological features in field	2	CO1	K1, K3
	1.2 Identification of Reptiles using external morphological features in field	2	CO1	K1, K3
	1.3 Morphometric analysis in frogs and toads (snout–vent length, limb ratio, weight)	4	CO2	K1, K4
	1.4 Reptile scale morphology and counting (dorsal, ventral, subcaudal scales etc)	4	CO1, CO2	K1, K4
	1.5 Handling techniques of Amphibians and Reptiles (ethical and safety protocols)	2	CO1, CO4	K4
	1.6 Beta diversity of Herpetofauna in the field	6	CO2, CO3	K3, K4
	1.7 Amphibian bioacoustics and monitoring (field recording, spectrogram analysis)	6	CO2, CO3	K3, K4
	1.8 Habitat mapping using QGIS (integration of field GPS data, land cover layers)	4	CO3, CO4	K4, K5
Pedagogy:	Field-based experiential learning/ nocturnal sampling/ Laboratory sessions/ Bioacoustics/ GIS-based data visualization/ Student mini-projects			
Texts:	1. Heyer, W. R., Donnelly, M. A., McDiarmid, R. W., Hayek, L. A., & Foster, M. S. (1994). *Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians.* Smithsonian Institution Press. 2. Pough, F. H., Andrews, R. M., Crump, M. L., Savitzky, A. H., Wells, K. D., & Brandley, M. C. (2016). *Herpetology* (4th ed.). Sinauer Associates. 3. Vitt, L. J., & Caldwell, J. P. (2014). *Herpetology: An Introductory Biology of Amphibians and Reptiles* (4th ed.). Academic Press. 4. Whitaker, R., & Captain, A. (2004). *Snakes of India: The Field Guide.* Draco Books. 5. Zug, G. R., Vitt, L. J., & Caldwell, J. P. (2001). *Herpetology: An Introductory Biology of Amphibians and Reptiles* (2nd ed.). Academic Press.			

References/ Readings:	1. Sutherland, W. J. (Ed.). (2006). *Ecological Census Techniques: A Handbook* (2nd ed.). Cambridge University Press. 2. Wells, K. D. (2007). *The Ecology and Behavior of Amphibians.* University of Chicago Press. 3. Gower, D. J., & Wilkinson, M. (2005). Conservation biology of caecilian amphibians. *Conservation Biology, 19*(1), 45–55. 4. Mohanty, N. P., & Measey, G. J. (2018). The global amphibian pet trade. *Biological Conservation, 236*, 366–375. 5. Sharma, S. K., & Whitaker, R. (2020). *Field Guide to Snakes of India.* BNHS Publication.
Web Resources:	1. **AmphibiaWeb** – Species accounts, distribution, and conservation resources. https://amphibiaweb.org/ 2. **The Reptile Database** – Global taxonomy and phylogeny. https://reptile-database.reptarium.cz/ 3. **India Biodiversity Portal** – Citizen-science data and species checklists. https://indiabiodiversity.org/ 4. **HerpMapper** – Collaborative platform for recording herpetofaunal occurrences. https://www.herpmapper.org/ 5. **RavenLite and Audacity** – Free software for acoustic data recording and analysis. https://ravensoundsoftware.com/ https://www.audacityteam.org/ 6. **QGIS** – Open-source platform for ecological and spatial mapping. https://qgis.org/ 7. **IUCN SSC Amphibian Specialist Group** – Global resources and conservation frameworks. https://amphibians.org/

Title of the Course	Developments in Aquaculture
Course Code	ZOO-6007
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To familiarize students with emerging technologies in aquaculture development. • To understand breeding, nutrition, disease management, and biotechnology in aquaculture. • To explore sustainable practices and environmental management in aquaculture systems. • To enable students to critically evaluate socio-economic and policy dimensions of aquaculture growth.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain aquaculture systems, including recirculating and integrated models.	PSO1, PSO3
	CO 2. Analyze breeding and hatchery innovations for sustainable aquaculture productivity.	PSO1, PSO3
	CO 3. Evaluate biotechnological and nutritional advancements enhancing aquaculture yield.	PSO1, PSO2, PSO3
	CO 4. Assess environmental, ethical, and socio-economic aspects of aquaculture development.	PSO3, PSO4

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1: Advanced Technologies and Systems in Aquaculture	1.1 Important Aquaculture Species : overview of economically significant finfish and shellfish, criteria for species selection; genetic diversity and stock improvement programs.	**2**	CO1, CO2	K1, K2, K4
	1.2 Evolution of Aquaculture: Systems – traditional vs modern systems; trends in global and national aquaculture.	**2**	CO1, CO3	K1, K4
	1.3 Integrated Aquaculture Systems : principles and practices of integrated fish farming with agriculture, livestock, and horticulture; polyculture and multitrophic aquaculture; ecosystem-based management and circular bioeconomy approaches.	**3**	CO1, CO2, CO4	K1, K3, K5
	1.4 Modern Aquaculture System: Recirculating Aquaculture Systems (RAS), Biofloc Technology (BFT), and Aquaponics design, operation, and efficiency.	**2**	CO1, CO3	K3,K5
	1.5 Hatchery Technology : induced breeding, cryopreservation, broodstock management, larval rearing techniques.	**3**	CO1, CO2	K3,K4
	1.6 Aquaculture Biotechnology : genetic improvement, molecular diagnostics, transgenic approaches, omics applications.	**2**	CO2,CO3	K4,K6
	1.7 Feed and Nutrition Innovations : nutrigenomics, probiotics, biofloc-based feeds, and waste-to-feed valorization.	**2**	CO3	K4,K5
Module 2: Sustainability, Health Management, and Policy Frameworks	2.1 Aquatic Animal Health: pathogen surveillance, vaccines, nanotechnology in disease management.	**3**	CO1,CO2, CO3	K4,K6
	2.2 Environmental Impact and Sustainability: water reuse, effluent treatment, biodiversity conservation.	**3**	CO3, CO4	K3,K5
	2.3 Climate Change and Aquaculture: adaptive strategies, carbon-neutral aquaculture systems	**3**	CO3, CO4	K4–K6
	2.4 Socio-economic Perspectives: livelihood diversification, gender inclusion, entrepreneurship opportunities.	**3**	CO4	K4–K6

	2.5 Governance, Certification, and Policy: Blue Revolution, FAO (India), Coastal Regulation Zone (CRZ), **Ministry of Environment, Forest and Climate Change (MoEFCC) and** Sustainable Development Goals (SDGs) in aquaculture.	**3**	CO4	K5,K6
Pedagogy:	Interactive lectures, research discussions, case studies, virtual labs, simulations, field visits, problem-based learning, project work and AI analytics.			
Texts:	1. Baird, D., & Beveridge, M. (2020). Aquaculture and the Environment. Wiley-Blackwell. 2. Boyd, C. E., & Tucker, C. S. (2014). Handbook for Aquaculture Water Quality. Springer. 3. FAO. (2023). The State of World Fisheries and Aquaculture 2023. Food and Agriculture Organization of the United Nations. 4. Pandey, P. K., & Meena, D. K. (2019). Recent Advances in Aquaculture. New India Publishing Agency. 5. Timmons, M. B., & Ebeling, J. M. (2021). Recirculating Aquaculture Systems. Ithaca Publishing Company.			
References/ Readings:	1. Dasgupta, S., & Sarkar, B. (2023). Nanotechnology in Aquaculture: Disease Prevention and Feed Improvement. Aquaculture Reports, 29, 101684. 2. FAO. (2021). Guidelines for Sustainable Aquaculture Intensification. FAO Technical Paper. 3. Kumar, V., Roy, S., & Ghosh, A. (2022). Aquaculture Innovations for Sustainable Development. Journal of Applied Aquaculture, 34(2), 115–137. 4. Paulraj, R. (2020). Biofloc Technology: Current Trends and Future Prospects. Indian Journal of Fisheries, 67(1), 1–15. 5. Rao, A. S., & Pillai, P. (2024). Genetic and Molecular Tools in Aquaculture. Aquaculture Biotechnology, 3(4), 200–223.			
Web Resources:	1. https://tal.ifas.ufl.edu/research/aquaculture-production-research/ 2. https://www.fao.org/4/ac169e/ac169e00.html 3. https://foodsystems.community/aquaculture-sdgs			

Title of the Course	Practical in Developments in Aquaculture
Course Code	ZOO-6008
Number of Credits	2
Theory/Practical	Practical
Level	500
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	ZOO-6007	
Course Objectives:	• To familiarize students with modern and emerging technologies in aquaculture development. • To understand advances in breeding, nutrition, disease management, and biotechnology in aquaculture. • To explore sustainable practices and environmental management in aquaculture systems. • To enable students to critically evaluate socio-economic and policy dimensions of aquaculture growth.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Demonstrate advanced hatchery and breeding practices in finfish and shellfish.	PSO1, PSO2
	CO 2. Apply nutritional and environmental management strategies for aquaculture productivity.	PSO1, PSO3
	CO 3. Evaluate technological innovations for efficient system performance	PSO1, PSO2, PSO3
	CO 4. Design and propose sustainable aquaculture models with entrepreneurial potential.	PSO3, PSO4

		No of hours	Mapped to CO	Cognitive Level
Content:	1.1 Observation and handling of broodstock and larval stages in finfish and shellfish.	**4**	CO1	K4
	1.2 Demonstration of induced breeding techniques	**8**	CO1, CO2	K4-K5
	1.3 Water quality assessment and optimization for hatchery operations.	**6**	CO1, CO3	K4,K6
	1.4 Study of fish larval nutrition and live feed culture (Artemia, rotifers, algae).	**6**	CO2	K3,K5
	1.5 Demonstration of Biofloc, Aquaponics and RAS units design, setup, and operation.	**8**	CO3	K4,K5
	1.6 Feed formulation and proximate composition analysis.	**8**	CO3	K4,K5
	1.7 Data recording and analysis of growth rate and FCR.	**6**	CO3	K4,K5
	1.8 Visit to hatchery and aquaculture farm	**6**	CO1, CO2	K5,K6
	1.9 Use of sensors for monitoring aquaculture parameters	**4**	CO4	K5,K6
	1.10 Case studies - Model integrating innovation and entrepreneurship.	**4**	CO4	K5,K6
Pedagogy:	Demonstrations, lab work, field visits, data-driven analysis, digital tools, problem-based learning, mini-projects, case studies, entrepreneurship, peer evaluation, reflective journals.			
Texts:	1. Boyd, C. E. (2022). *Water Quality in Aquaculture.* Springer. 2. Timmons, M. B., & Ebeling, J. M. (2021). *Recirculating Aquaculture Systems.* Ithaca Publishing Company. 3. Rao, A. S. (2023). *Aquaculture Techniques and Management.* CBS Publishers. 4. FAO (2023). *Aquaculture Innovation and Technology Transfer.* FAO Technical Manual.			
References/ Readings:	1. Allan, G., & Burnell, G. (Eds.). (2013). Advances in aquaculture hatchery technology. Woodhead Publishing. 2. M. Iniyan Arasu, S. Subha Rani, K. Thiyagarajan, & A. Ahilan (2024). AquaSense: Aquaculture water quality monitoring framework using autonomous sensors. Aquaculture International, 32, 9119–9135. 3. M. Iniyan Arasu, S. Subha Rani, K. Thiyagarajan, & A. Ahilan (2024). AquaSense: Aquaculture water quality monitoring framework using autonomous sensors. Aquaculture International, 32, 9119–9135.			

	4. Daniel Benetti (2025). Hatchery technology of marine fish (Technical bulletin). U.S. Soybean Export Council; University of Miami. 5. Ahmed Nasir, Deokjai Choi, & Sungyoung Lee (2019). IoT-based smart aquaculture monitoring system. Journal of Sensors, 2019, 1–12. 6. R. R. Rajput, & S. S. Korde (2020). Water quality monitoring system for aquaculture using IoT. International Journal of Scientific & Technology Research, 9(3), 540–544. 7. S. N. M. Shah, M. A. Rahman, & M. R. Islam (2018). Design and implementation of smart aquaculture system using IoT. International Journal of Computer Applications, 180(40), 1–6.
Web Resources:	1. https://thefishsite.com/articles/biofloc-technology-practical-guide 2. https://www.feedipedia.org/content/formulating-fish-feed 3. https://www.aquaiot.io/resources

Title of the Course	Nanomaterials and their interactions with Biological Systems
Course Code	ZOO-6009
Number of Credits	3
Theory/Practical	Theory
Level	500
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 concepts and interdisciplinary nature of nanoscience and nanotechnology. • To learn various types of nanomaterials, their synthesis methods, and characterization techniques. • To explore biomedical, agricultural, and environmental applications of nanomaterials. • To examine nanomaterial toxicity, exposure risks, and strategies for ensuring biocompatibility and safety.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain the principles of nanoscience and distinguish between different types of nanomaterials based on their composition and properties.	PSO1
	CO 2. Describe synthesis and characterization techniques used to produce and analyze nanomaterials.	PSO1, PSO2

	CO 3. Evaluate the application of nanomaterials in drug delivery, diagnostics, agriculture, and environmental systems.	PSO3, PSO4		
	CO 4. Assess the toxicological effects and ecological impact of nanomaterials, and propose strategies for improving their safety and biocompatibility.	PSO3, PSO4		
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Nanoscience and Nanomaterials	1.1 Nanoscience and nanotechnology- concepts, scope, historical development, and interdisciplinary nature of nanoscience	**2**	CO1	K2, K3
	1.2 Types of nanomaterials: metallic, polymeric, lipid-based, quantum - their composition, synthesis approaches, and functional properties.	**3**	CO1	K2, K3
	1.3 Physical and chemical properties relevant to biological interactions-size, shape, surface charge, solubility, reactivity, and surface functionalization — how all affect nanomaterial interaction with cells and biological systems.	**4**	CO1 CO3	K2, K3, K4 K5
	1.4 Methods of nanomaterial synthesis: top-down and bottom-up approaches- physical and chemical methods including mechanical milling, sol-gel, precipitation, and green synthesis.	**3**	CO2	K3, K4, K5
	1.5 Techniques for characterization (SEM, TEM, DLS, FTIR, XRD and Zeta potential)-tools used for determining size, shape, surface area, and chemical composition of nanomaterials	**3**	CO2	K3, K4, K5
Module 2: Nanomaterials in Biomedical and Environmental Applications	2.1 Nanomaterials in Cancer Therapy and Drug Delivery- Applications of nanomaterials in targeted and controlled drug delivery for cancer treatment; advantages over conventional methods; overcoming drug resistance; use in photothermal therapy; examples of nanomedicine formulations improving treatment efficacy.	**3**	CO3	K3, K4, K5
	2.2 Nano-based diagnostics and imaging-Use of nanomaterials in biosensors, imaging contrast agents, and real-time diagnostics (e.g., using quantum dots, magnetic nanomaterials, and gold nanoshells)	**3**	CO3	K3, K4, K5

	2.3 Applications in agriculture, aquaculture, and environment-Use of nanomaterials in nano-fertilizers, nano-pesticides, water purification systems, disease detection, and environmental monitoring	**3**	CO3	K3, K4, K5
	2.4 **N**anomaterials in Tissue Engineering, Regeneration, and Implants- Role of nanomaterials in scaffold design, cell signalling, and enhancing tissue repair—particularly in bone and nerve regeneration; applications in improving the biocompatibility, durability, and antimicrobial properties of prosthetics and biomedical implants.	**3**	CO3	K3, K4, K5
	2.5**.** Advanced Nanomaterials for Therapy and Diagnostics- Developments in smart nanocarriers and nano-biomaterials responsive to stimuli **(**pH, temperature, enzymes**)**, Multifunctional nanomaterials with combined drug delivery, imaging, and therapeutic functions, Applications in personalized and precision medicine through integrated diagnostics and treatment	**3**	CO3	K3, K4, K5
Module 3: Nanotoxicology and Safety Assessment	3.1 Nanotoxicology: cellular and systemic effects- Mechanisms of nanomaterial-induced toxicity — including oxidative stress, DNA damage, inflammation, and apoptosis	**3**	CO4	K3, K4, K5, K6
	3.2 Sources of nanomaterials and exposure routes- Identification of natural and engineered nanomaterial sources; exposure through inhalation, ingestion, dermal contact, and environmental routes in animals and humans.	**3**	CO4	K3, K4, K5, K6
	3.3 Nanopollution and ecological impact -Assessment of nanomaterial accumulation in ecosystems, bioaccumulation in aquatic and terrestrial species, and disruption of food chains.	**3**	CO4	K3, K4, K5, K6
	3.4 Toxicity assessment and risk evaluation -Methods for evaluating nanomaterial toxicity (in vitro and in vivo); frameworks for hazard identification, risk analysis, and regulatory guidelines.	**3**	CO4	K4, K5, K6
	3.5 Biocompatibility and toxicity mitigation strategies -factors influencing nanomaterial safety, such as surface coatings, biodegradable materials, and design strategies to reduce toxicity.	**3**	CO4	K4, K5, K6
Pedagogy:	Interactive Lectures, Case-Based Learning, Flipped Classrooms, videos, virtual simulations, discussion**,** presentations, debates, Problem-solving tasks, project-based learning.			

Texts:	1. Aimé, C., & Coradin, T. (Eds.). (2017). Bionanocomposites: Integrating Biological Processes for Bioinspired Nanotechnologies (1st ed.). John Wiley & Sons. 2. Arakha, M., & Pradhan, A. K. (Eds.). (2025). *Nanomaterials in biological milieu: Biomedical applications and environmental sustainability* (1st ed.). Bentham Science Publishers. 3. Houdy, P., Lahmani, M., & Marano, F. (Eds.). (2011). *Nanoethics and nanotoxicology* (1st ed.). Springer Science & Business Media. 4. Wang, X., & Chen, X. (Eds.). (2018). *Novel nanomaterials for biomedical, environmental and energy applications* (1st ed.). Elsevier. 5. Zucolotto, V. (2013). *Nanotoxicology: materials, methodologies, and assessments* (1st ed.). Springer Science & Business Media.
References/ Readings:	1. Altammar, K. A. (2023). A review on nanoparticles: characteristics, synthesis, applications, and challenges. *Frontiers in microbiology*, *14*, 1155622. 2. Egbuna, C., Parmar, V. K., Jeevanandam, J., Ezzat, S. M., Patrick-Iwuanyanwu, K. C., Adetunji, C. O., & Ibeabuchi, C. G. (2021). Toxicity of nanoparticles in biomedical applications: nanotoxicology. *Journal of toxicology*, *2021*(1), 9954443. 3. Khan, S. H., Fulekar, M. H., & Pathak, B. (2015). Nanotoxicology-health and environmental impacts: A review. *J Environ Nanotechnol*, *4*(3), 55-72. 4. Monteiro-Riviere, N. A., & Tran, C. L. (Eds.). (2007). *Nanotoxicology: characterization, dosing and health effects* (1st ed.). CRC Press. 5. Sahu, S. C., & Casciano, D. A. (Eds.). (2014). *Handbook of nanotoxicology, nanomedicine and stem cell use in toxicology* (1st ed.) (pp. 75-76). Hoboken, NJ, USA: Wiley. 6. Thu, H. E., Haider, M., Khan, S., Sohail, M., & Hussain, Z. (2023). Nanotoxicity induced by nanomaterials: A review of factors affecting nanotoxicity and possible adaptations. *OpenNano*, *14*, 100190. 7. Zhu, S., Meng, H., Gu, Z., & Zhao, Y. (2021). Research trend of nanoscience and nanotechnology–A bibliometric analysis of Nano Today. *Nano Today*, *39*, 101233.
Web Resources:	1. Argonne National Laboratory. (n.d.). *What is nanoscience?* https://www.anl.gov/science-101/nanoscience 2. European Observatory for Nanomaterials (EUON). (n.d.). *Nanomaterials: Practical applications*. https://euon.echa.europa.eu/uses

	3. Encyclopedia Britannica. (n.d.). *Overview of Nanotechnology*. https://www.britannica.com/technology/nanotechnology/Overview-of-nanotechnology 4. European Observatory for Nanomaterials (EUON). (n.d.). *Nanoparticle Safety*. https://euon.echa.europa.eu/safety 5. National Library for Medicine. The History of Nanoscience and Nanotechnology. PMC. https://pmc.ncbi.nlm.nih.gov/articles/PMC6982820/

Title of the Course	Practical in Nanomaterials and their interactions with Biological Systems
Course Code	ZOO-6010
Number of Credits	1
Theory/Practical	Practical
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	ZOO-6009	
Course Objectives:	• To synthesize nanomaterials via green and chemical methods. • To acquire skills to characterize nanomaterials using various techniques. • To evaluate the biological activity of nanomaterials. • To assess the biocompatibility and toxicity of nanomaterials	
Course Outcomes:		**Mapped to PSO**
	CO 1. Demonstrate the synthesis of nanomaterials using both green and chemical methods.	PSO1, PSO2, PSO3, PSO4
	CO 2. Characterize and interpret nanomaterial data	PSO1, PSO2, PSO3
	CO 3. Evaluate and interpret the biological activity of nanomaterials	PSO1, PSO2, PSO3, PSO4
	CO 4. Conduct biocompatibility and toxicity assays for nanomaterials.	PSO1, PSO2, PSO3, PSO4

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1: Experimental Techniques in Nanomaterial Synthesis, Characterization, and Biological Evaluation	1.1 Synthesis of Silver/Iron Nanomaterials Using Plant/Animal (Green Synthesis)	**4**	CO1	K3, K4
	1.2 Chemical Synthesis of Silver/Iron Nanomaterials	**4**	CO1	K3, K4
	1.3 Characterization of Nanomaterials Using UV-Visible Spectroscopy	**2**	CO2	K3, K4, K5
	1.4 XRD Analysis of Synthesized Nanomaterials (Data Interpretation)	**2**	CO2	K3, K4, K5
	1.5 FTIR Analysis of Synthesized Nanomaterials (Data Interpretation)	**2**	CO2	K3, K4, K5
	1.6 Antibacterial Activity of Nanomaterials	**4**	CO3	K3, K4, K5
	1.7 Drug Encapsulation using Nanomaterials and Drug Entrapment Efficiency Determination	**4**	CO3	K3, K4, K5
	1.8 Hemolysis Assay (*In vitro* Biocompatibility Test) using nanomaterials	**2**	CO4	K4, K5
	1.9 Evaluation of Nanoparticle Toxicity *in vitro* using MTT Assay	**2**	CO4	K4, K5
	1.10 Assessing Nanomaterial Toxicity *in vivo* using Lysosomal Membrane Stability Assay and TBARS Assay in Bivalve.	**4**	CO4	K4, K5
Pedagogy:	Interactive Lectures, hands-on training, data analysis exercises, Group discussions, debates, Problem-solving tasks and project-based learning.			
Texts:	1. Borisenko, V. E., & Ossicini, S. (2013). *What is what in the Nanoworld: A Handbook on Nanoscience and Nanotechnology* (3rd ed.). John Wiley & Sons. 2. Cao, G. (2004). *Nanostructures & nanomaterials: synthesis, properties & applications* (1st ed.). Imperial college press. 3. Schaefer, H. E. (2010). Nanoscience: The Science of the Small in Physics, Engineering, Chemistry, Biology, and Medicine (1st ed.). Springer. 4. Vo-Dinh, T. (2007). *Nanotechnology in biology and medicine: methods, devices, and applications*. (1st ed.) CRC Press.			

References/ Readings:	1. Ahmed, S., Saifullah, Ahmad, M., Swami, B. L., & Ikram, S. (2016). Synthesis of silver nanoparticles*:* Chemical, physical, and biological methods. *Saudi Pharmaceutical Journal, 24*(5), 562–573. 2. Anish, S., & Mahesh, K. D. (2022). Evaluation of the In Vitro Cytotoxicity of Silver Nanoparticles on PBMC Cells Using MTT Assay. *Ann. Int. Med. Dent. Res. E, 8*, 185-191. 3. Jin, K., Liao, Y. C., Cheng, T. C., Li, X., Lee, W. J., Pi, F., ... & Guo, P. (2024). In vitro and in vivo evaluation of the pathology and safety aspects of three-and four-way junction RNA nanoparticles. *Molecular pharmaceutics*, *21*(2), 718-728. 4. Patra, J. K., Das, G., Fraceto, L. F., Campos, E. V. R., Rodriguez-Torres, M. D. P., Acosta-Torres, L. S., ... & Shin, H. S. (2018). Nano based drug delivery systems: recent developments and future prospects. *Journal of nanobiotechnology*, *16*(1), 71. 5. Reddy, K. M., Feris, K., Bell, J., Wingett, D. G., Hanley, C., & Punnoose, A. (2007). Selective toxicity of zinc oxide nanoparticles to prokaryotic and eukaryotic systems. *Applied Physics Letters*, 90(21), 213902. 6. Vanlalveni, C., Lallianrawna, S., Biswas, A., Selvaraj, M., Changmai, B., & Rokhum, S. L. (2021). Green synthesis of silver nanoparticles using plant extracts and their antimicrobial activities: A review of recent literature. *RSC advances*, *11*(5), 2804-2837.
Web Resources:	1. *Quantification of thiobarbituric acid reactive species (TBARS) optimized for zebrafish brain tissue.* protocols.io. https://www.protocols.io/view/quantification-of-thiobarbituric-acid-reactive-spe-5qpvo5ebxl4o/v1 2. National Cancer Institute. (n.d.). *NCL Method ITA-1*. https://dctd.cancer.gov/research/research-areas/nanotech 3. *Evaluation of oxidative stress in biological samples using the TBARS assay*. *Journal of Visualized Experiments (JoVE).* https://app.jove.com/t/61122/evaluation-oxidative-stress-biological-samples-using-thiobarbituric 4. *Tutorial on powder X-ray diffraction for characterizing nanomaterials. ACS Nano.* American Chemical Society. https://pubs.acs.org/doi/10.1021/acsnano.9b05157?utm_source=chatgpt.com 5. Spectroscopy Online. *How FT-IR spectroscopy advances nanomaterial research.* https://www.spectroscopyonline.com/view/how-ft-ir-spectroscopy-advances-nanomaterial-research

Title of the Course	Marine Ecology
Course Code	ZOO-6011
Number of Credits	03
Theory/Practical	Theory
Level	500
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 marine ecological principles governing structure, function, and dynamics of marine ecosystems. ● To explain and analyze the biogeochemical, biological, and physical processes influencing marine biodiversity, population dynamics and productivity. ● To evaluate the impacts of climate change, anthropogenic stressors, and disturbances on marine ecological resilience and functioning. ● To assess marine conservation frameworks and develop restoration strategies.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Apply principles of marine ecology to explain ecosystem structure and function.	PSO1
	CO 2. Interpret marine biodiversity patterns and population dynamics	PSO2, PSO3
	CO 3. Evaluate climate-driven and biogeochemical impacts on marine ecosystems.	PSO1, PSO2, PSO3

	CO 4. Develop marine conservation frameworks with adaptive, participatory strategies for sustainable management.		PSO3, PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Marine Ecosystems: Structure and Function	1.1 Organization of Marine Ecosystems: Structure and function of pelagic and benthic systems, energy flow, trophic dynamics.	**02**	CO1	K3
	1.2 Marine carbon and nitrogen cycles; microbial regeneration of nutrients; brief overview of ocean–atmosphere feedbacks.	**02**	CO1, CO2, CO3	K3, K4
	1.3 Coastal and Transitional Ecosystems: Mangroves, seagrass beds, estuaries, salt marshes, and intertidal zones: zonation, productivity and blue carbon roles.	**02**	CO1, CO2	K3, K4, K5
	1.4 Biodiversity Patterns/ indices in Marine Systems: Alpha, Beta, Gamma Diversity, Functional diversity; Latitudinal Gradients, Depth gradients. Marine biogeographic regions and connectivity.	**02**	CO2,	K3, K4, K5
	1.5 Population and Community Ecology: Population growth, density dependence, species interactions, Succession	**02**	CO2	K3, K4, K5
	1.6 Types of disturbances (pulse vs press), thresholds, recovery dynamics, and resilience, Alternative stable states.	**02**	CO4	K4
	1.7 Ecological Niche Theory and Species Coexistence - Fundamental vs Realized Niche, Limiting Similarity, Coexistence mechanisms.	**02**	CO4	K3, K4
	1.8 Food-web organization, keystone species, and simple network visualization concepts for energy flow and stability.	**01**	CO1, CO2	K3, K4
Module 2: Marine Monitoring	2.1 Indicators of Ecosystem Health: biological, chemical, physical proxies, Baseline vs Long-Term Monitoring, Global observing networks.	**03**	CO1, CO4	K3
	2.2 Remote Sensing and GIS Applications in Marine Ecology - ocean productivity, chlorophyll mapping, coral bleaching detection; habitat mapping.	**03**	CO2, CO3	K3

	2.3 Change Detection, Seascape Ecology: patch dynamics, landscape metrics, spatial heterogeneity; connectivity, larval dispersal, island biogeography in marine contexts	**03**	CO3	K4
	2.4 Environmental DNA (eDNA), Metabarcoding, Genomics for Biodiversity Assessment. Applications of CRISPR and synthetic biology in marine ecology research.	**02**	CO2, CO4	K3
	2.5 Advanced Statistical Methods in Marine Ecology: Multivariate Analysis, Species Distribution Modeling, Network Analysis, Ecological Modeling of Marine Systems - Mechanistic vs Empirical Models, Food Web Modeling, Dynamic Energy Budget Models.	**04**	CO2, CO3	K4
Module 3: Climate Change and conservation	3.1 Ecosystem services provided by marine habitats	**01**	CO1, CO2,	K5
	3.2 Climate Change Impacts – Coral bleaching dynamics, ocean acidification, sea-level rise, range shifts, and invasive species	**02**	CO2, CO3, CO4	K3, K4, K5
	3.3 Climate and anthropogenic threats to mangroves, estuaries, and intertidal habitats; blue-carbon linkages	**02**	CO2, CO3	K3, K4, K5
	3.4 Conservation Frameworks: Ecosystem-based and resilience-based management, Principles of marine protected area (MPA) design: size, spacing, connectivity, Adaptive management.	**03**	CO1, CO3, CO4	K3, K4, K5
	3.5 Restoration: Coral, seagrass, mangrove restoration. Assisted evolution, microbial interventions, gene editing, Geo-engineering prospects.	**02**	CO1, CO4	K4, K5
	3.6 Governance and Policy: UNCLOS, CBD, SDG14, high-seas treaties. Marine spatial planning and fisheries governance models. blue economy goals. Case studies.	**03**	CO4	K3, K4, K5

	3.7 Societal Engagement: Socio-ecological systems theory in marine conservation, Traditional ecological knowledge (TEK). Community-based monitoring and co-management approaches. Case Studies: Coral Triangle, Great Barrier Reef resilience and adaptive governance, Arctic and deep-sea ecosystems under climate stress.	**02**	CO1, CO4	K4, K5
Pedagogy:	Interactive lectures / Project-based learning /case studies/ Seminar-led critical discussions/ Mentored student-led mini-symposia or colloquia/ Reflective assignments/ continuous formative assessments			
Texts:	1. Barnes, R. S. K., & Hughes, R. N. (1999). *An introduction to marine ecology*. John Wiley & Sons. 2. Bertness, M. D., Gaines, S. D., & Hay, M. E. (Eds.). (2001). *Marine community ecology* (p. 550). Sunderland: Sinauer Associates 3. Castro, P., Huber, M. E., Ober, W. C., & Garrison, C. W. (2008). *Marine biology*. New York: McGraw-Hill. 4. Clams, G. (2017). Oceanography and Marine Biology. *Oceanography and marine biology: An annual review*, *55*, 2-303. 5. Dall, W. H. B. J., Hill, J., Rothlisberg, P. C., Sharples, D. J., Blaxter, J. H., & Southward, A. J. (1990). *Advances in marine biology* (Vol. 27). Academic press. 6. Hogarth, P. J. (2015). *The biology of mangroves and seagrasses*. Oxford university press. 7. Lalli, C., & Parsons, T. R. (1997). *Biological oceanography: an introduction*. Elsevier. 8. Miller, C. B. (2009). *Biological oceanography*. John Wiley & Sons. 9. Mittelbach, G. G., & McGill, B. J. (2019). *Community ecology*. Oxford University Press.			
References/ Readings:	1. Álvarez-Noriega, M., Burgess, S. C., Byers, J. E., Pringle, J. M., Wares, J. P., & Marshall, D. J. (2020). Global biogeography of marine dispersal potential. *Nature Ecology & Evolution*, *4*(9), 1196-1203. 2. Jones, G. P., Almany, G. R., Russ, G. R., Sale, P. F., Steneck, R. S., van Oppen, M. J., & Willis, B. L. (2009). Larval retention and connectivity among populations of corals and reef fishes: history, advances and challenges. *Coral reefs*, *28*(2), 307-325. 3. McCoy, E. D., & Heck Jr, K. L. (1976). Biogeography of corals, seagrasses, and mangroves: an alternative to the center of origin concept. *Systematic Zoology*, *25*(3), 201-210. 4. Pinheiro, H. T., Bernardi, G., Simon, T., Joyeux, J. C., Macieira, R. M., Gasparini, J. L., ... & Rocha, L. A. (2017). Island biogeography of marine organisms. *Nature*, *549*(7670), 82-85.			

	5. Sanford, E. (2014). The biogeography of marine communities. *Marine community ecology and conservation*, 131-163. 6. Shaver, E. C., & Silliman, B. R. (2017). Time to cash in on positive interactions for coral restoration. *PeerJ*, *5*, e3499.
Web Resources:	1. United Nations https://sdgs.un.org/goals/goal14 2. National Centres for Environmental Information https://www.ncei.noaa.gov/news/field-identification-guides-for-pacific-coral-species 3. Great Barrier Reef Marine Park Authority https://www2.gbrmpa.gov.au/learn/threats/climate-change 4. World Register of Marine Species https://www.marinespecies.org/ 5. International Union for conservation of Nature https://iucn.org/our-work/topic/marine-species

Title of the Course	Practical in Marine Ecology
Course Code	ZOO-6012
Number of Credits	1
Theory/Practical	Practical
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	ZOO-6011	
Course Objectives:	• To understand marine ecological field methods and quantitative analysis techniques. • To assess trophic structures, productivity, biodiversity, and environmental parameters across coastal habitats. • To investigate the influence of physical and chemical parameters on marine community structure and function. • To analyse and relate ecological data with functional and environmental drivers in marine ecosystems.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Demonstrate competence in marine ecological field methods for sampling and data collection across coastal habitats.	PSO1, PSO2, PSO3
	CO 2. Compute and interpret biodiversity indices across environmental gradients.	PSO1, PSO3
	CO 3. Assess key abiotic parameters and their influence on marine community structure.	PSO2, PSO3, PSO4
	CO 4. Apply spatial data and GIS tools toto assess habitat patterns and ecosystem health.	PSO2, PSO4

Content	Topic	No of hours	Mapped to CO	Cognitive Level
Module 1: Practical techniques in Marine Ecology	1.1 Trophic guild classification and food web construction	**4**	CO2	K3, K4
	1.2 Measure ecosystem productivity, structural complexity, and biodiversity supported by mangroves	**4**	CO1, CO2	K3, K4
	1.3 Vertical zonation (species diversity, abundance, distribution patterns) and population density of dominant taxa in rocky shores	**4**	CO2, CO3	K3, K4, K5
	1.4 Test substrate preference, early recruitment and colonization	**6**	CO3	K4, K5
	1.5 Measure key physical parameters affecting marine communities	**4**	CO4	K3, K4
	1.6 Measure key chemical parameters affecting marine ecosystem (pH, Dissolved Oxygen [DO], Nitrate, Phosphate)	**4**	CO4	K4
	1.7 Spatial mapping and analysis using GIS Tools	**4**	CO1	K4
Pedagogy:	Laboratory practical/ Field excursions and biodiversity surveys /Project-based / Inquiry-based and problem-centered learning.			
Texts:	1. Bakus, G. J. (2007). *Quantitative analysis of marine biological communities: field biology and environment*. John Wiley & Sons. 2. Hiscock, K. (2014). *Marine biodiversity conservation: A practical approach*. Routledge. 3. Kennish, M. J. (2019). *Practical handbook of marine science*. crc press. 4. Sims, D. W. (2009). Advances in marine biology (Vol. 56). Academic Press. 5. Sumich, J. L., & Dudley, G. (2004). *Laboratory and field investigations in marine life*. Jones & Bartlett Learning.			
References/ Readings:	1. Braarud, T. (1961). Cultivation of marine organisms as a means of understanding environmental influences on populations. *Oceanography*, *67*, 271-98. 2. Gibson, R., Barnes, M., & Atkinson, R. (2001). Practical measures of marine biodiversity based on relatedness of species. *Oceanography and Marine Biology*, *39*, 207-231.			

	3. Lessios, H. A. (1996, October). Methods for quantifying abundance of marine organisms. In *Methods and techniques of underwater research. Proceedings of the American Academy of Underwater Sciences Scientific Diving Symposium. Washington DC* (pp. 149-157). 4. Schoener, T. W. (1983). Field experiments on interspecific competition. *The american naturalist*, *122*(2), 240-285. 5. Straughan, D. (1974, May). Field sampling methods and techniques for marine organisms and sediments. In *Proc. NBS Symp* (pp. 183-187).
Web Resources:	1. World Register of Marine Species https://www.marinespecies.org/ 2. International Union for conservation of Nature https://iucn.org/our-work/topic/marine-species 3. National oceanic and atmospheric administration https://www.noaa.gov/education/resource-collections/marine-life 4. Tha Marine life information network https://www.marlin.ac.uk/species

Discipline Specific Vocational Elective (DSVE) Courses

Title of the Course	Ecotourism
Course Code	ZOO-6401
Number of Credits	04 (2T+2P)
Theory/ Practical	Theory and practical
Level	500
Effective from AY	2025-26
New Course	YES
Bridge Course/ Value Added Course	NO
Course of Advanced Learners	No

Perquisites of the course	Nil	
Course objectives	• To provide knowledge on ecotourism. • To develop skills in ecotourism management • To design a community based tourism • To use technology for promoting sustainable ecotourism.	
Course outcomes	**Students will be able to:**	**Mapped to PSO**
	CO 1. Identify ecotourism potential sites	PSO1, PSO2
	CO 2. Manage ecotourism site	PSO2
	CO 3. Design eco-friendly ecotourism infrastructure.	PSO3

	CO 4. Promote Sustainable Ecotourism using technology		PSO3, PSO4	
Content	**Topic**	**No. of Hours**	**Mapped to CO**	**Cognitive level**
Module 1 (Theory) Concept of Ecotourism	1.1 Concept: Ecotourism, ecotourist, eco-sensitivity, ecocentrism.	**2**	CO1	K1, K2
	1.2 Principles, Types, importance of ecotourism	**3**	CO1	K1, K2
	1.3 Benefits of Ecotourism	**2**		
	1.4 Ethics of ecotourism	**2**	CO1, CO2	K2, K3
	1.5 Ecotourism impact assessment and management analysis.	**4**	CO1, CO2	K2, K3
	1.6 Challenges in development of community-based ecotourism.	**2**	CO2	K3, K4
Module 2 (Theory) Setting up Ecotourism	2.1 Designing eco-friendly infrastructure	**4**	CO3	K5, K6
	2.2 Set-up and management of community based ecotourism	**4**	CO2	K4
	2.3 Local, National, Global case studies of community-based ecotourism.	**4**	CO1, CO2	K2, K3
	2.4 Strategies for promoting responsible tourism.	**3**		
Module 3 (Practical) Identification and Documentation	3.1 Visit to the community-based ecotourism site.	**6**	CO1	K2
	3.2 Identification of flora	**6**	CO1	K4
	3.3 Identification of fauna	**6**		
	3.4 Nature Photography- using different lenses- macro, telephoto	**4**		
	3.5 Documenting Traditional Knowledge of flora and fauna in a selected site.	**6**		
Module 4 (Practical) Designing	4.1 Design experiential ecotourism incorporating local culture in a selected site.	**6**	CO1, CO2	K6
	4.2 Conducting nature interpretation trail	**6**		K3

ecotourism site and promotional tools			CO1, CO2	
	4.3 Designing signage, leaflets, QR coded information boards, digital brochures for ecotourism promotion, Design ecotourism website	**4**	CO1, CO3	K6
	4.4 Create a documentary on an ecotourism site.	**6**	CO3	K6
	4.5 Preparation of business model for ecotourism sites (Home stay, birding trail, mangrove trail)	**6**	CO3	K6
Pedagogy	Use of conventional, online and ICT Methods. Field visit/Case study/ ecotourism project proposal/ project/ self-study/ Lecture/ Tutorials/ Assignments.			
Texts	1. A.J.S. Raju, A Textbook of Ecotourism Ecorestoration and Sustainable Development by Kolkata, New Central Book Agency (P) Ltd, 2007 2. D. A. Fennell, Ecotourism policy and planning. Wallingford, Oxon, UK, CABI Publishing, 2007 3. J. Hill, T. Gale, Ecotourism and Environmental sustainability Principles and practice, Aghgate ebook. 2009 4. S. Wearing, J. Neil , Ecotourism, impacts, potentials and possibilities 2nd edition Elsevier 2009.			
References /Readings	1. A.K. Bhatia, Tourism development: principles and practices, New Delhi: Sterling Publishers Pvt. Ltd. 2014 2. C. Cooper, Tourism Principles and Practice. Great Britain Pitman publishing, 1994. 3. D. S. Fennell, Ecotourism 4th edition Routledge Taylor & Francis group, 2004 4. Fiorello, A., & Bo, D. (2012). Community-based ecotourism to meet the new tourist's expectations: An exploratory study. Journal of Hospitality marketing & management, 21(7), 758-778. 5. J. Singh, Ecotourism, Wiley 2020 6. Kiss, A. (2004). Is community-based ecotourism a good use of biodiversity conservation funds ? Trends in ecology & evolution, 19(5), 232-237. 7. P.R. Trivedi, Encyclopaedia of Ecotourism (Vol. 5): Future of Ecotourism, New Delhi Jnanada Prakashan, 2006. 8. R. Singh, Indian Ecotourism: Environmental Rules and Regulations, New Delhi, Kaniskha Publishers, 2003 9. Tesfaye, S. (2017). Challenges and opportunities for community based ecotourism development in Ethiopia. African Journal of Hospitality, Tourism and Leisure, 6(3), 1-10.			

	10. Wang, C. C., Cater, C., & Low, T. (2016). Political challenges in community-based ecotourism. Journal of Sustainable Tourism, 24(11), 1555-1568.
Web resources	1. https://forest.goa.gov.in/eco-tourism-sites-in-goa 2. https://gfdcgoa.com/eco-tourism/ 3. https://goa-tourism.com/regenerative-tourism.html 4. https://sanctuarynaturefoundation.org/article/goa%3A-a-potential-for-safe-tourism 5. https://tourism.gov.in/sites/default/files/2022-09/National%20Strategy%20for%20Ecotourism%202022.pdf 6. https://www.cgibali.gov.in/page/eco/

Title of the Course	Ornamental Fish Management and Entrepreneurship
Course Code	ZOO-6402
Number of Credits	4 (2T+2P)
Theory/Practical	Theory and Practical
Level	500
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 provide advanced theoretical and applied understanding of ornamental fish biology, aquaculture systems, and aesthetics. • To develop practical proficiency in aquarium fabrication, breeding, water quality, and health management. • To integrate innovation, sustainability, and entrepreneurship in ornamental fish culture. • To train students to conceptualize and plan viable startups, eco-tourism ventures, and market-based enterprises in ornamental aquaculture.	
Course Outcomes		**Mapped to PSO**
	CO1 Analyze the biological, aesthetic, and environmental principles governing the design and maintenance of ornamental aquaria.	PSO1, PSO2
	CO2 Apply scientific knowledge in breeding, rearing of ornamental fishes and live feed culture.	PSO1, PSO3

	CO3 Evaluate water quality dynamics, disease management, and system design for sustainable ornamental aquaculture operations.	PSO1, PSO2, PSO3		
	CO4 Develop innovative entrepreneurial models, business plans, and eco-tourism-based ventures in the ornamental fish sector.	PSO3, PSO4		
Content		**No. of hours**	**Mapped to CO**	**Cognitive Level**
Module I: Ornamental Aquarium Biology, System Design and Health Management (Theory)	1.1 **Aquarium Fabrication and System Design** : Scientific principles in glass/acrylic fabrication; integration of filtration, aeration, and lighting systems for biological balance and aesthetic appeal.	**3**	CO1	K4
	1.2 **Aquascaping, Species Selection, and Display Dynamics** : Principles of aquascaping and visual design; selection and handling of freshwater and marine ornamental species; behavior-based habitat structuring and species compatibility.	**5**	CO1, CO2	K4, K5
	1.3**Water Quality and Health Management in Closed Display Systems:** Nitrogen cycle in aquaria; management of pH, ammonia, nitrite, nitrate in ornamental tanks; common ornamental fish diseases (Ich, fin rot, fungal infections); quarantine tank setup; preventive health care; safe chemical treatments; biosecurity in aquarium trade.	**5**	CO2	K3, K4
	1.4 Ornamental Fish Breeding and Reproductive Management : Advanced breeding techniques for livebearers and egg layers; hormonal induction; larval rearing; broodstock conditioning; live feed formulation (Artemia, micro worms, etc.).	**4**	CO3	K4, K5
Module II: Ornamental Fish Enterprise Development and Innovation (Theory)	2.1 Ornamental Fish Production Units: Design of small-scale breeding units; space optimization; rack systems; broodstock maintenance for continuous supply; colour morph development and selective breeding in ornamental species.	**3**	CO2, CO4	K3, K4, K5
	2.2 Live Feed and Specialty Feed Production: On-site culture of *Artemia*, Daphnia, Moina, microworms; feed enrichment for pigmentation; spirulina-based colour enhancement diets; ornamental feed formulation basics.	**2**	CO2	K3, K4
	2.3 Handling, Packaging and Transport: Pre-transport conditioning; oxygen packing methods; water additives for transport stress reduction; export quality standards; mortality minimization techniques.	**2**	CO3, CO4	K4, K5

	2.4 Business Models in Ornamental Fisheries: Aquarium retail outlets; ornamental fish breeding startups; aquascaping studios; online ornamental fish trade; aquarium maintenance services; hobby-based micro-enterprises.	**4**	CO4	K4, K6
	2.5 Marketing, Branding and Wellness-Based Enterprise: Brand development; social media marketing; customer psychology in ornamental fish hobby; ornamental fish keeping for stress relief and emotional well-being; integration with interior design and eco-tourism concepts.	**4**	CO4	K5, K6
Module III: Ornamental Fish Management, Entrepreneurship and Innovation (Practical)	3.1 Fabrication and Setup of Functional Aquarium Systems- Construction, sealing, and installation of aquaria with filtration units.	**8**	CO1, CO2, CO4, CO3	K5
	3.2 Aquascaping and Display Design- Hands-on creation of themed aquascapes integrating live plants, substrates, and lighting principles.	**4**	CO4	K4, K5
	3.3 Identification and handling of popular freshwater and marine ornamental fishes.	**4**	CO1	
	3.4 Water quality analysis (pH, DO, ammonia, hardness) and filtration system operation. and preparation of synthetic seawater.	**4**	CO4	K5, K6
	3.5 Health management: identification of diseases, quarantine, and prophylactic treatments.	**4**	CO4	K5,K6
	3.6 Breeding and rearing of selected ornamental fishes (livebearers and egg layers).	**6**	CO1, CO4	K6
Module IV: Ornamental Fish Management, Entrepreneurship and Innovation (Practical)	4.1 Live feed culture (Grindle worms, micro worms, Vinegar eel, artemia) and feeding strategies.	**8**	CO2	K6
	4.2 Field visit to commercial aquarium units	**8**	CO4	K5
	4.3 Market Survey and Economic Analysis of Ornamental Fish Trade (Shops/Ornamental fish farms)	**6**	CO4	K6
	4.5 Packaging techniques for live ornamental fish.	**4**	CO3	K5

	4.6 Development of a feasible startup proposal with business pitch./ Business plan preparation for a small-scale ornamental fish enterprise.	**6**	CO4	K5, K6
Pedagogy	Demonstrations, Lab work, Field visits, Aquarium fabrication, Aquascaping, Problem-based learning, Entrepreneurship projects and Industry interactions			
Texts	1. Ahilan, B., & Kamalii, A. (2023). *Ornamental Livebearers*. CRC Press. 2. Arumugam, N., Jayashree, K. V., & Tharadevi, C. S. (2023). *Home Aquarium and Ornamental Fish Culture*. Saras Publication. 3. Jain, A. K., Rane, A. J., & Sinha, A. (Eds.). (2025). *Ornamental Fisheries and Aquarium Keeping: Insights from the Indian Aquarium Industry*. CRC Press. 4. Saint-Erne, Nick. (2024). *Handbook of Ornamental Fish Health and Welfare*. CAB International. 5. Sharma, K., et al. (2024). *Ornamental Fish Production and Management*. NPH India.			
References / Readings	1. Chandra, P., & Singh, N. (2024). Aquascaping and Aquarium Aesthetics for Ornamental Fish Display. Journal of Applied Aquatic Design, 8(2), 99–108. MDPI. 2. Lovell, R. T. (2020). Aquarium Fish Nutrition and Water Quality. CRC Press. 3. Murthy, H. S., & Swain, S. K. (2022). Economic Viability of Small-Scale Ornamental Fish Units. Journal of Aquaculture Research & Development, 13(6), 210–218. 4. Satheesh, N., & Kumar, R. (2024). Recirculating Systems and Water Quality Maintenance in Ornamental Aquaculture. Aquaculture Reports, 29, 102165. Elsevier. 5. Sreedhar, U., & Bhat, B. V. (2023). Entrepreneurship Development in Ornamental Fisheries. Indian Journal of Fisheries Extension, 61(4), 115–124.			
Web Resources	1. https://elearning.fao.org/course/view.php?id=1259 2. https://www.oftri.org/ 3. https://nfrdi.da.gov.ph/ 4. https://www.oftri.org/aquarium-keeping-hobby/			

Title of the Course	Processed Fish Products
Course Code	ZOO-6403
Number of Credits	4 (2T +2P)
Theory/Practical	Theory and Practical
Level	500
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 principles and methods of fish preservation and processing. • To study biochemical and microbiological changes in fish during processing. • To learn about value addition, packaging, storage, and quality control. • To familiarize students with HACCP, food safety, and FSSAI regulations. • To promote awareness on sustainability in fish product development.	
Course Outcomes		**Mapped to PSO**
	CO 1. Explain and apply principles of fish preservation, processing, and product preparation.	PSO1, PSO2
	CO 2. Analyze biochemical, microbial, and sensory changes during storage and processing.	PSO1, PSO3

	CO 3. Evaluate value-added products, eco-friendly technologies, and quality standards.	PSO1, PSO3		
	CO 4. Design sustainable and small-scale entrepreneurial models for fish product development.	PSO3, PSO4		
Content		**No. of hours**	**Mapped to CO**	**Cognitive level**
Module I: Principles of Fish Preservation and Post-Harvest Changes (Theory)	1.1 Importance of fish processing: global and Indian fisheries scenario, need for preservation and value addition	**3**	CO1	K2, K3
	1.2 Principles of fish preservation: chilling, freezing, drying, salting, smoking, and canning	**4**	CO1	K4
	1.3 Biochemical and microbiological changes during storage and processing.	**4**	CO2	K4, K5
	1.4 Fish spoilage mechanisms, detection, and prevention techniques.	**4**	CO2	K4, K5
Module II: Value Addition, Packaging, and Food Safety (Theory)	2.1 Value-added fish products and their utilization: fish pickles, sausages, surimi, and ready-to-eat meals, Fish glue, Fish gelatin, Fish oil etc.	**4**	CO3, CO4	K4, K5
	2.3 Packaging technologies in fish products: vacuum packaging, modified atmosphere packaging, active and biodegradable packaging	**4**	CO4	K5
	2.4 Storage, labeling, and transportation standards for fish products	**3**	CO3, CO4	K5, K6
	2.5 Food safety regulations: HACCP (Hazard Analysis and Critical Control Point), FSSAI (The Food Safety and Standards Authority of India), FDA (Food and Drug Administration)	**4**	CO4	K5, K6
Module III: Fish Processing (Practical)	3.1 Preparation of dried, salted, and smoked fish.	**6**	CO1	K4
	3.2 Quality assessment of frozen and thawed fish	**6**	CO2	K5
	3.3 Preparation of fish products (Fish pickle/ fish sauce/ Fish cutlets)	**6**	CO1, CO4	K4, K5

	3.4 Preparation of fish products and by-products (Fish glue/Fish gelatin / Isinglass/ Chitin)	**8**	CO1	K4, K5
	3.5 Sensory evaluation of fish and processed fish products	**4**	CO2	
Module IV: Fish Processing (Practical)	4.1 Biochemical indices to detect fish spoilage.	**8**	CO2	K5, K6
	4.2 Waste valorization: Biodegradable packaging materials, fish meal and fish oil extraction from processing waste.	**8**	CO3	K5, K6
	4.3 Costing, and labelling (using FSSAI guidelines), of small-scale processed fish products.	**6**	CO4	K5, K6
	4.4 Field visit to fish processing/cold storage unit	**8**	CO4	K6
Pedagogy	Case studies, Audio-Visual demos, Discussions, AI tools, Flipped sessions, Value-added design			
Texts	1. Gopakumar, K. (2002). *Textbook of Fish Processing Technology*. Indian Council of Agricultural Research (ICAR), New Delhi. 2. Hall, G. M. (Ed.). (2011). *Fish Processing: Sustainability and New Opportunities*. Wiley-Blackwell. 3. Rathnakumar, K., & Kaavya, R. (2021). *Textbook on Fish Processing Technology*. New Delhi: New India Publishing Agency.			
References / Readings	1. Bremner, H. A. (Ed.). (2002). Safety and Quality Issues in Fish Processing. Woodhead Publishing Limited, Cambridge. 2. FAO. (2024). Fish Processing and Preservation Manual. Fisheries Technical Paper 672. 3. Huss, H. H. (1995). Quality and Quality Changes in Fresh Fish. FAO Fisheries Technical Paper 348. 4. Ninan, G. (2019). Advances in Fish Processing Technology. Indian Journal of Fisheries. Nirmal, N. P., & Benjakul, S. (2020). Retardation of quality changes in refrigerated fish. Food Chemistry. 5. Sikorski, Z. E. (Ed.). (2001). *Chemical and Functional Properties of Food Proteins: Seafood Proteins*. CRC Press. 6. Venugopal, V. (2021). Marine Products for Healthcare: Functional and Bioactive Nutraceutical Compounds. CRC Press.			
Web Resources	1. https://elearning.fao.org 2. https://www.cift.res.in 3. https://nfdb.gov.in			

Title of the Course	Generative AI and Bioinformatics
Course Code	ZOO- 6404
Number of Credits	4 (2T + 2P)
Theory/Practical	Theory + Practicals
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learner	No

Pre-requisites for the Course:	NIL	
Course Objectives:	• To orient students with generative AI tools for literature mining, scientific writing, data visualization, and research communication. • To provide hands-on training in biological databases and bioinformatics tools for molecular, structural, and evolutionary analyses in zoological research. • To integrate AI-assisted and bioinformatics approaches for solving zoological problems using computational and analytical workflows. • To develop ethical awareness and critical evaluation skills in the responsible use of AI and digital tools for biological data interpretation.	
Course Outcomes:	**Student will be able to:**	**Mapped to PSO**
	CO 1. Apply prompt-engineering and generative AI tools for literature mining, evidence extraction, and scientific content creation in zoological research**.**	PSO1, PSO2

	CO 2. Create accurate scientific visuals and schematics using AI-assisted design platforms for effective research communication.		PSO1, PSO3	
	CO 3. Retrieve and analyze gene and protein data using bioinformatics databases and tools to interpret molecular and evolutionary relationships.		PSO1, PSO2, PSO3	
	CO 4. Integrate AI and bioinformatics workflows to produce ethical, data-driven, and reproducible research outputs.		PSO3, PSO4	
Content:	**Topic**	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Generative AI Tools for Scientific Research	1.1. Overview of Artificial Intelligence in Life Sciences: Artificial Intelligence, Machine Learning, and Generative AI; key models and biological applications; role of AI in hypothesis generation, image synthesis, pattern recognition and data interpretation in zoological research.	**3**	CO1	K2
	1.2. Prompt Engineering for Biological Research: Concepts of prompt engineering (context, constraints, clarity); designing prompts for literature summarization, data interpretation, and scientific writing; refinement strategies for generating accurate biological outputs.	**3**	CO1, CO4	K2, K3
	1.3. AI-Assisted Literature Mining and Evidence Synthesis: Literature search using Elicit, Scite.ai, ResearchRabbit and other AI-assisted tools; knowledge graphs, citation reliability, and trend analysis in biological research domains.	**3**	CO1	K2, K3, K4
	1.4. AI Tools for Scientific Writing and Communication: AI platforms for manuscript drafting, editing, summarization, and report generation; responsible use of AI in academic writing.	**3**	CO2	K2, K3
	1.5. Ethical and Responsible Use of AI in Life Sciences: ICMR guidelines for AI in biomedical research; issues of plagiarism, data privacy, authorship transparency, reproducibility, and bias in AI-generated outputs.	**3**	CO4	K3, K4, K5
	1.6. Introduction to Bioinformatics and Computational Biology: scope, importance, and applications in zoological and biomedical research.	**2**	CO3	K2

	2.1. Biological Databases: primary databases (NCBI, EMBL), secondary databases (UniProt), structural databases (PDB); data formats (FASTA, GenBank, PDB) and biological metadata.	**3**	CO3	K2, K3
	2.2. Sequence Analysis and Alignment: concepts of sequence similarity, pairwise alignment and multiple sequence alignment; BLAST and Clustal Omega applications.	**3**	CO3	K2, K3
	2.3. Phylogenetic Analysis and Molecular Evolution: phylogenetic tree construction using MEGA; evolutionary relationship interpretation in zoological datasets.	**3**	CO3	K3, K4
	2.4. Protein Structure Analysis and Prediction: protein visualization using PyMOL and Chimera; structure prediction using AlphaFold and Swiss-Model.	**2**	CO3, CO4	K2, K3
	2.5. Pathway Mapping and Systems Integration: KEGG pathways, molecular interaction networks, and integration of AI with bioinformatics for systems biology applications.	**2**	CO4	K2, K3, K4
Module: Generative AI and Bioinformatics Tools for Zoological Research **(Practical Module)**	3.1. Prompt engineering for generating accurate and relevant outputs in zoological research using open-access generative AI tools.	**4**	CO1, CO4	K3
	3.2. Literature search and evidence extraction using Elicit, Scite.ai, Perplexity and Consensus.	**4**	CO1, CO4	K3
	3.3. Visualizing research connections and citation networks using Research Rabbit.	**4**	CO1	K2, K3, K4
	3.4. Drafting abstracts and discussions using ChatGPT or Jenni.ai; refining content with QuillBot, PERRLA, and Grammarly.	**4s**	CO1, CO4	K3
	3.5. Managing references and citations using Zotero and Mendeley.	**4**	CO1, CO4	K3
	3.6. Designing figures and scientific schematics using BioRender, MindTheGraph, Bioicons, and Servier Medical Art.	**4**	CO2, CO4	K2, K3, K4
	3.7. Generating AI-based biological illustrations using Figurelab.ai, Illustrae and Edraw.AI.	**4**	CO2, CO4	K2, K3, K4

	3.8. Data visualization and tabulation using ChatGPT Code Interpreter / Datawrapper.	**4**	CO2, CO4	K2, K3, K4
	3.9. Plagiarism detection and ethical evaluation of AI-generated content using Turnitin	**4**	CO4	K5
	3.10. Exploring biological databases – NCBI, UniProt, and PDB; retrieving nucleotide and protein data.	**4**	CO3	K3
	3.11. Performing sequence alignment using BLAST and Clustal Omega.	**4**	CO3, CO4	K2, K3, K4
	3.12. Constructing phylogenetic trees using MEGA X and interpreting evolutionary relationships.	**4**	CO3	K2, K3, K4
	3.13. Visualizing protein structures using UCSF Chimera and annotating binding sites using PyMOL.	**4**	CO3	K2, K3, K4
	3.14. Predicting and comparing protein structures using AlphaFold and Swiss-Model; evaluating docking using AutoDock.	**6**	CO3, CO4	K2, K3, K4, K5
	3.15. Mapping metabolic and signaling pathways using KEGG and interpreting molecular functions.	**4**	CO3, CO4	K2, K3, K4, K5
Pedagogy:	Lectures/ videos/Case-based learning, Group discussions/Formative quizzes, Presentations.			
Texts:	1. Anastasiadou, S., Seremeti, L., & Papalexandris, S.(2024). *Bioethics and legal aspects of AI in healthcare and life sciences.* IGI Global. 2. Cannataro, M., Guzzi, P. H., Agapito, G., Zucco, C., & Milano, M. (2022). *Artificial intelligence in bioinformatics: From omics analysis to deep learning and network mining* (1st ed.). Elsevier. https://doi.org/10.1016/C2020-0-01954-0 3. Hamadani, A., Ganai, N. A., Henna, H., & Bashir, J. (2024). *A biologist's guide to artificial intelligence: Building the foundations of artificial intelligence and machine learning for achieving advancements in life sciences* (1st ed.). Academic Press. 4. Hasija, Y. (2023). *All about bioinformatics: From beginner to expert* (1st ed.). Academic Press.			
References/	1. Huang, J., Mao, L., Lei, Q., & Guo, A. Y. (2024). Bioinformatics tools and resources for cancer and			

Readings:	application. *Chinese medical journal*, *137*(17), 2052–2064. https://doi.org/10.1097/CM9.0000000000003254 2. Luo M., Yang W., Bai L., et al., (2024). Artificial intelligence for life sciences: A comprehensive guide and future trends. The Innovation Life **2(4)**: 100105. https://doi.org/10.59717/j.xinn-life.2024.100105 3. Mooney, M. A., & Wilmot, B. (2015). Gene set analysis: A step-by-step guide. *American journal of medical genetics. Part B, Neuropsychiatric genetics : the official publication of the International Society of Psychiatric Genetics*, *168*(7), 517–527. https://doi.org/10.1002/ajmg.b.32328 4. Shrikar, P. M. (2025). *AI and generative AI for biologists: From data to discovery with artificial intelligence* (1st ed.). Independently Published.
Web Resources:	1. Indian Council of Medical Research. (2023). *Ethical guidelines for application of artificial intelligence in biomedical research* (ICMR Guidelines). https://www.icmr.gov.in/icmrobject/uploads/Guidelines/1724842648_ethical_guidelines_application_artificial_intelligence_biomed_rsrch_2023.pdf 2. Vogel, M. (2023, November 20). *5000x generative AI: Intro, overview, models, prompts, technology, tools, comparisons & the best*. *Medium*. https://medium.com/@maximilian.vogel/5000x-generative-ai-intro-overview-models-prompts-technology-tools-comparisons-the-best-a4af95874e94

Title of the Course	Butterfly Gardening
Course Code	ZOO-6405
Number of Credits	04 (2T + 2P)
Theory/Practical	Theory + Practical
Level	500
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites For the Course:	Nil	
Course Objectives:	• To develop a conceptual understanding of butterfly ecology, diversity, and plant–insect relationships. • To enable learners to analyze ecological and environmental factors influencing butterfly distribution and habitat use. • To apply ecological principles to create and manage butterfly-friendly gardens. • To evaluate the role of butterfly gardens in biodiversity conservation, education, and citizen science initiatives.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Analyze butterfly morphology, life cycle, and ecological interactions with host and nectar plants.	PSO1, PSO2
	CO 2. Evaluate patterns of butterfly diversity, biogeography, and conservation status in India and globally.	PSO2, PSO3

	CO 3. Apply principles of butterfly garden design, plant selection, and sustainable management.		PSO3, PSO4	
	CO 4. Design and assess butterfly gardens as models for conservation, education, and citizen science participation.		PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1: Butterfly Ecology	1.1. Overview of Lepidoptera: classification, morphology, and diagnostic traits. Life cycle and metamorphosis: egg, larva, pupa, adult stages	**05**	CO1	K3
	1.2. Host specificity and plant–butterfly co-evolution, Roles of butterflies in ecosystems (pollination, food web dynamics)	**05**	CO1	K3
	1.3. Butterfly diversity in India and global hotspots. Biogeography and habitat preferences, Migration and seasonal variations	**05**	CO2	K4
Module 2: Butterfly Gardening, Design, and Conservation Applications	2.1. Conservation status and threats **(**IUCN, habitat loss, climate change**)**	**05**	CO2	K4
	2.2. Concept and importance of butterfly gardening, Garden components**:** host plants, nectar plants, shelter, water, Soil type, microclimate, and habitat structure**.** Native vs exotic plant species**:** implications for biodiversity	**05**	CO3	K3, K4,
	2.3. Butterfly Garden Design, Management, and Conservation Applications: Site selection, garden layout, and planting plan, Organic and pesticide-free management practices, Monitoring Garden biodiversity and success indicators, Butterfly gardens in conservation, education, and citizen science, Case studies: India Biodiversity Portal, iNaturalist, urban biodiversity corridors.	**05**	CO4	K3, K4, K5
Module 3: Field and Applied Techniques in Butterfly Gardening (Practical)	3.1. Identification of local butterfly species using field guides and online resources (India Biodiversity Portal, iNaturalist).	**04**	CO1	K3
	3.2. Identification of larval host and nectar plants in the field.	**06**	CO1	K3, K4
	3.3. Documentation of developmental stages (egg, larva, pupa, adult) in natural/semi-natural/laboratory conditions.	**08**	CO1, CO2	K4
	3.4. Study of flight, mating, basking, puddling, feeding, and territorial behaviors.	**08**	CO2	K4

	3.5. Visit to butterfly garden.	**08**	CO2, CO3	
	3.6. Designing and implementing a small-scale butterfly garden (plant selection, layout, habitat structure)	**08**	CO3, CO4	K4
	3.7. Butterfly photography and documentation techniques (macro photography, behavioral capture, ethical handling).	**06**	CO3	K5
	3.8. Data collection and biodiversity assessment using diversity indices (Shannon, Simpson) and abundance measures.	**04**	CO3	K5
	3.9. Project: Butterfly Garden Development Proposal (site plan, plant list, maintenance strategy, community component).	**08**	CO4	K5, K6
Pedagogy:	Interactive Lecture/ Hands-on taxonomy workshop/ GIS/Map-based activity/ Seminar/ Discussion/ Problem-based learning/Comparative analysis**.**			
Texts:	1. Daniels, R. J. R. (2002). *Butterflies of Peninsular India.* Universities Press. 2. Gay, T., Kehimkar, I., & Punetha, J. C. (1992). *Common Butterflies of India.* WWF–India. 3. Kehimkar, I. (2016). *The Book of Indian Butterflies.* BNHS. 4. Kunte, K. (2000). *Butterflies of Peninsular India*. Universities Press.Singh, A. P., & Pandey, R. (2004). *Butterfly Gardening in India: A Practical Manual.* WWF–India Publication.			
References/ Readings:	1. Arora, G. S., & Gupta, I. J. (1979). *Taxonomic Studies on Some Indian Butterfly Larvae*. 2. Daniels, R. J. R. (2002). *Butterflies of Peninsular India*. 3. Gay, T., Kehimkar, I., & Punetha, J. (1992). *Common Butterflies of India*. World Wide Fund for Nature-India. 4. Kehimkar, I. (2016). *The Book of Indian Butterflies*. BNHS. 5. Kunte, K. (2000). *Butterflies of Peninsular India*. Universities Press. 6. Online Platforms: India Biodiversity Portal, iNaturalist, BNHS Butterfly Watch. 7. Recent journal articles on butterfly gardening and conservation (e.g., *Journal of Insect Conservation*, *Current Science*).			
Web Resources:	1. Butterflies of India – Species identification, host plants, and regional checklists. https://www.ifoundbutterflies.org/ 2. India Biodiversity Portal – Butterfly observation data and citizen science network. https://indiabiodiversity.org/			

	3. iNaturalist – Global biodiversity data and citizen documentation. https://www.inaturalist.org/ 4. Butterfly Conservation Europe – Best practices for butterfly habitat management. https://www.bc-europe.eu/ 5. The Xerces Society – Guides on pollinator-friendly gardening and butterfly conservation. https://xerces.org/ 6. eButterfly – Digital platform for butterfly observations and research. https://www.e-butterfly.org/ 7. Global Biodiversity Information Facility (GBIF) – Species occurrence and distribution data. https://www.gbif.org/