गोंय विद्यापीठ
ताळगांव पठार
गोंय - ४०३ २०६
फोन: +९१-८६६९६०९०४८

Goa University
Taleigao Plateau, Goa - 403 206
Tel : +91-8669609048
Email : registrar@unigoa.ac.in
Website: www.unigoa.ac.in

(Accredited by NAAC)

GU/Acad –PG/BoS -NEP/2023/90/2 Date:30.05.2023

Ref: GU/Acad –PG/BoS -NEP/2022/339/22 dated 19.08.2022

CIRCULAR

In supersession to the above referred Circular, the updated approved Syllabus with revised Course Codes of the **Master of Sciences in Zoology** Programme is enclosed.

The Dean/ Vice-Deans of the School of Biological Sciences and Biotechnology is requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

ASHWIN VYAS LAWANDE
Digitally signed by ASHWIN VYAS LAWANDE
Date: 2023.05.30 16:15:38 +05'30'

(Ashwin Lawande)
Assistant Registrar – Academic-PG

To,

1. The Dean, School of Biological Sciences and Biotechnology, Goa University.
2. The Vice-Deans, School of Biological Sciences and Biotechnology, Goa University.

Copy to:

1. The Chairperson, Board of Studies in Zoology.
2. The Programme Director, M.Sc. Zoology, Goa University.
3. The Controller of Examinations, Goa University.
4. The Assistant Registrar, PG Examinations, Goa University.
5. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

Goa University

Syllabus of M.Sc. (Zoology) Programme in SBSB
(To be followed from the Academic year: 2023-24)

Programme Name: M. Sc. Zoology
Programme Code: ZOO
Programme description:

This program is intended to develop learning about Zoology and significance of fauna ranging from single cell to multicellular systems. Keeping in mind the Programme thrust area "Biodiversity, Comparative Animal Physiology, Wildlife, Toxicology and Fisheries'', the current Post graduation curriculum has been totally restructured. A precise balance between the classical courses and modern biological courses has been made to introduce and emphasize the skill based programmes with an Internship experience. Apart from the classical topics on Animal Sciences namely, Taxonomy and Systematics; Biodiversity; Anatomy of Non- chordates and Chordates, Genetics and Ecology this syllabus also covers topics on various aspects of Life Processes such as Animal Physiology, Developmental Biology and Molecular Biology. The restructured M. Sc. programme also focuses on various application based or skilled based courses such as Advanced Aquaculture Techniques and Ornamental Fish Management, Fish Processing, Butterfly Gardening, Environmental Physiology, Neurophysiology, Stem Cell Biology, Herpetology, Ornithology, Wildlife Biology and Ecotourism. Besides, the courses like Immunology, Cell Biology, Vector Biology and Ecotoxicology programs also represent this restructured syllabus. This programme through the dissertation will also help the students to understand the basic principles of nature and will also provide scope for hands-on experience to experiment with nature /animals and thereby enable them to develop aptitude for research in various allied fields of animal sciences. This curriculum will also enable them to overcome several day to day problems faced by our society by providing them with some workable solutions.

Prerequisite for M. Sc. Zoology Programme:
The candidate must pass the Bachelors degree examination in Zoology at T. Y. B.Sc. level or its equivalent credits in Zoology.

Programme Structure:

A learner should earn a minimum of 80 Credit Courses to receive M.Sc. (Zoology) degree. Out of 80 credits, 40 credits shall be of Programme Core Courses to be earned during Semester I and II and 40 credits are Optional Courses (Including Programme skilled-based

optional and general optional / Interdisciplinary / Dissertation) to be earned during Semester III and IV. Active participation in the Field work component as well as short internship program, included in the laboratory courses, is must for every learner. There is also liberty to carry out Dissertation work in any sister departments of Goa University / neighbouring Institute (within Goa) / in the Industry (within Goa) but it should be under the supervision of one of the faculty members of Zoology.

Also, all the Core Courses have to be studied by all learners in the first year (Semester I & II). Dissertation (16 Credits) is compulsory and shall be undertaken in the second year (Semester III and IV).

Timeline for completion of various credits over four Semesters:

Courses	**Codes**	**Sem I**	**Sem II**	**Sem III**	**Sem IV**	**Total**
Discipline Specific Core Courses	DSC	16	16			32
Discipline Specific Elective Course	DSE	4	4			08
Research Specific Elective Courses	RSE			8	4	12
Generic Elective Course	GE			12		12
Discipline Specific Dissertation	DSD				16	16
		20	20	20	20	80

Semester I

DSC	Discipline Specific Core	Credits
ZOO-500	Principles of Animal Systematics	3 credits
ZOO-501	Anatomy of Non-Chordates	3 credits
ZOO-502	Comparative Physiology of Animals	3 credits
ZOO-503	Molecular Biology	3 credits
ZOO-504	Laboratory Course-I	3 credits
ZOO-505	Field work-I	1 credit
DSE	**Discipline Specific Elective**	
ZOO-521	Advances in Genetics (Theory)	3 credits
ZOO-522	Advances in Genetics (Practical)	1 credit
ZOO-523	Animal Behaviour (Theory)	3 credits
ZOO-524	Animal Behaviour (Practical)	1 credit
ZOO-525	Ichthyology (Theory)	3 credits
ZOO-526	Ichthyology (Practical)	1 credit

Semester II

DSC	Discipline Specific Core	Credits
ZOO-506	Anatomy of Vertebrates	3 credits
ZOO-507	Animal Biochemistry	3 credits
ZOO-508	Molecular aspects of Developmental Biology	3 credits
ZOO-509	Ecology and Biodiversity	3 credits
ZOO-510	Laboratory Course-II	3 credits
ZOO-511	Field work-II	1 credit

DSE	Discipline Specific Elective	
ZOO-527	Environmental Physiology (Theory)	3 credits
ZOO-528	Environmental Physiology (Practical)	1 credit
ZOO-529	Animal Cell Biology (Theory)	3 credits
ZOO-530	Animal Cell Biology (Practical)	1 credit
ZOO-531	Wildlife Conservation & Management (Theory)	3 credits
ZOO-532	Wildlife Conservation & Management (Practical)	1 credit
ZOO-533	Restoration Ecology	4 credits

Semester III

RSE	Research Specific Elective	Credits
ZOO-600	Neurophysiology (Theory)	3 credits
ZOO-601	Neurophysiology (Practical)	1 credit
ZOO-602	Animal Cell Culture (Theory)	1 credit
ZOO-603	Animal Cell Culture (Practical)	3 credits
ZOO-604	Toxicology (Theory)	3 credits
ZOO-605	Toxicology (Practical)	1 credit
ZOO-606	Herpetology (Theory)	3 credits
ZOO-607	Herpetology (Practical)	1 credit
ZOO-608	Ornithology (Theory)	3 credits
ZOO-609	Ornithology (Practical)	1 credit
ZOO-610	Mammalogy (Theory)	3 credits
ZOO-611	Mammalogy (Practical)	1 credit
ZOO-612	Developments in Aquaculture (Theory)	3 credits
ZOO-613	Techniques in Aquaculture (Practical)	1 credit

GE	**Generic Elective**	
ZOO-621	Immunology	2 credits
ZOO-622	Biological Applications of Nanoparticles and Nanotoxicology	2 credits
ZOO-623	Ecotoxicology	2 credits
ZOO-624	Butterfly Gardening	2 credits
ZOO-625	Ecotourism (Theory)	1 credit
ZOO-626	Ecotourism (Practical)	1 credit
ZOO-627	Introduction to Animal Biomimetics	2 credits
ZOO-628	Evolutionary Biology	2 credits
ZOO-629	Ornamental Fish Management (Theory)	1 credit
ZOO-630	Ornamental Fish Management (Practical)	1 credit
ZOO-631	Biology of Animal Reproduction	2 credits
ZOO-632	Fish Processing	2 credits
ZOO-633	Nutritional Biochemistry	2 credits
ZOO-634	Animal Architecture	4 Credits

Semester IV

RSE	**Research Specific Elective**	Credits
ZOO-614	Research Methodology	4 credits
ZOO-615	Stem Cell Biology	2 credits
ZOO-616	Ethics in Experiments with Laboratory Animals	2 credits
ZOO-617	Vector Biology	2 credits

DSD	**Discipline Specific**	Credits
ZOO-651	Dissertation	16 credits

Semester I

Name of the Programme: M.Sc. Zoology

Course Code: ZOO–500 **Title of the Course:** Principles of Animal Systematics

Number of Credits: 3

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic working knowledge of classical and animal taxonomy and systematics.	
Course Objectives:	1. To introduce concepts in animal taxonomy and systematics and their applications. 2. To provide knowledge and means for characterizing and classifying animals based traditional and molecular techniques 3. To assess the ecology and biogeographic distribution of organisms based on evolutionary patterns 4. To establish the importance of traditional and modern trends in taxonomy and research	
Content:	**Module 1** Introduction, stages, importance of taxonomy, advances in taxonomy. Principles, rules and new trends in taxonomy; zoological nomenclature, ICZN regulations, zoological classification, problems faced by taxonomists. Taxonomic collections, identification and description, taxonomical hierarchy (Linnaean hierarchy), concepts of taxon, holotype, paratype, topotype etc. Concept of speciation: biological, phylogenetic and evolutionary.	15 Hours
	Module 2 Morphology based taxonomy, Numerical and Immuno-taxonomy, Paleotaxonomy, Cyto-taxonomy and Chemotaxonomy. Molecular basis of animal taxonomy, genetic polymorphism, electrophoretic variations, amino acid sequencing of proteins, DNA-DNA hybridization. Systematics - definition and role in biology, biological classification, molecular systematics, DNA fingerprinting and molecular markers for detection/evaluation of polymorphism, RFLP, RAPD, etc.	15 Hours

	Module 3 Phylogenetics: introduction; basic terminology, homology and analogy: divergence, convergence, parallelisms and reversals; vicariance. Phylogenetic groups: monophyly, polyphyly, paraphyly. Construction of phylogenetic trees, by using cladistic and phenetic methods. Cladistics and cladogram: Parsimony and finding the shortest trees, rooting trees. Molecular divergence, molecular clock, molecular drive.	15 Hours
Pedagogy:	Lectures/ tutorials/online teaching mode/self-study and discussions	
References/ Readings:	1. J.C. Avise, Molecular Markers, Natural History and Evolution, New York: Chapman & Hall, 2004. 2. A.M. Huston, Biological Diversity, Cambridge: Cambridge University Press, 1994. 3. V.C. Kapoor, Theory and Practice of Animal Taxonomy, Oxford & IBH Publishing Co. 1983. 4. M. Kato, The Biology of Biodiversity, Springer, 2000. 5. E. Mayer, Elements of Taxonomy, Oxford IBH Publishing company, 1971. 6. G.G. Simpson, Principles of animal taxonomy, Scientific Publishers, 2012. 7. B.K. Tikader, Threatened Animals of India, Calcutta: ZSI publication, 1983. 8. E.O. Wilson, Biodiversity, Washington: Academic Press, 1988. 9. E.O. Wilson, The diversity of Life, The College edition W.W. Northem & Co., 1992.	
Course Outcomes:	The learner will 1. Discuss the historical and modern methods of animal classification and systematics. 2. Classify organisms by using keys and field techniques. 3. Compare traditional and molecular techniques in animal taxonomy. 4. Validate the use of traditional and modern techniques in animal taxonomy and biogeography.	

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Name of the Programme: M.Sc. Zoology

Course Code: ZOO–501 **Title of the Course:** Anatomy of Non-Chordates

Number of Credits: 3

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge on non-chordate anatomy, taxonomy and systematics is a prerequisite for this course.	
Course Objectives:	1. To Provide knowledge about fundamental anatomical principles among non- chordates. 2. To identify the adaptive changes in anatomical structures through the course of evolution. 3. To explain the invertebrate anatomy from an evolutionary perspective 4. To study the anatomical structures and their interactions in various environments.	
Content:	**Module 1** Skeletal system types: Endoskeleton-like (Poriferans), Exoskeleton (Arthropods) and Hydrostatic skeleton (Cnidarians, Molluscs and Echinoderms). Annelid locomotory organs involved in simple propulsion, burrowing, peristaltic waves, sinusoidal and inchworm type of locomotion. Primitive and advanced flight muscles of insects. Diffused, simple ganglionic, cycloneuralian, heteroganglionic types of non-chordate nervous systems. Tetraneury plan of molluscan nervous system, streptoneury, euthyneury and centralization in molluscs. **Module 2** Digestive system types: Channel-network systems, Coelenteronic, Saccular and Tubular systems. Radula of Molluscs and various types of mouthparts in Arthropods. Coelomoduct derived, gut derived and other excretory organs of non-chordates. Calciferous gland of earthworms. Reproductive system in arthropods with Gonad-Gonoduct-Gonopore (G-G-G) concept with addition of adjunctive organs **Module 3**	4 hours 5 hours 6 hours 5 hours 5 hours 5 hours 7 hours

	Respiratory organs and specialized respiratory structures of Annelids, Molluscs and Arthropods. Open and closed circulatory system concept of Invertebrates. Circulatory system in Annelids, Arthropods and Molluscs. Hearts of Oligochaetes and bivalves.	8 hours
Pedagogy:	Lectures/ tutorials/online teaching mode/self-study and discussions	
References/ Readings:	1. L.H. Hymen, The invertebrates (all volumes), USA: McGraw Hill, 1951. 2. R.D. Barnes, E.E. Ruppert, Invertebrate Zoology, Saunders College Publishing, 1994. 3. E. J. W. Barrington, Invertebrate Structure and Function, Thomas Nelson and Sons, 1972. 4. A.J. Marshall, and W.D. Williams, Textbook of Zoology (Vol. 1). CBS Publishers & Distributors, 2004. 5. R. D. Jurd, Animal Biology, BIOS Scientific Publishers, 2004. 6. P. Cleveland, C. P. Hickman, L.S. Roberts, and A. Larson, Integrated Principles of Zoology, NY: McGraw-Hill, 2001. 7. R. S. K. Barnes, P. Calow, P. J. W. Olive, D. W. Golding and J. I. Spicer, The Invertebrates: A Synthesis. Blackwell Science, 2001. 8. A. Schmidt-Rhaesa, The Evolution of Organ Systems, Oxford and New York: Oxford University Press, 2007. 9. B. B. Gangully, A. K. Shina, and S. Adhikary, Biology of Animals (Vol. 1), Kolkata: New Central Agency, 2011.	
Course Outcomes:	The learner will 1. Articulate the basic concepts associated with each system of the body. 2. Identify structures in the body systems which perform the functions according to the habits or habitats of the animals. 3. Compare the anatomy of different taxa based on evolutionary patterns. 4. Defend the role of evolution in anatomy of non-chordates.	

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO–502 **Title of the Course:** Comparative Physiology of Animals

Number of Credits: 03

Effective from AY: 2023-24

Pre-requisites for the Course:	Elementary knowledge on animal anatomy and basic physiology	
Course Objectives:	1. To reveal animal body system having physiological homologies and patterns of physiological adaptation to various environments 2. To analyze aspects related to nutrition, excretion, circulation, respiration and reproductive physiology 3. To introduce various principles that underlies higher level integrative bodily functions. 4. To provide a comprehensive knowledge of functional physiological pathways comparing different animals.	
Content:	**Module 1** Nutrition (Feeding and digestion) in Non-chordates and chordates. Metagenome of mammalian gut, concept of gut-brain axis, rumen fermentation. Movements of gastrointestinal tract, control and reflexes. General view of excretion and osmoregulation in non-chordates and chordates in freshwater, marine water and terrestrial environment. Contributions of Crustacean antennal glands and Molluscan mantle to acid-base regulation. Urine formation in Metanephros kidney, Nephrolithiasis-mechanism of renal stone formation. **Module 2** General composition of coelomic fluid and hemolymph of Non- chordates, formation of lymph in humans. Physiological difference between pulmonary and systemic circulation of higher vertebrates and changes during pregnancy. Lung volumes and their physiological interpretations and changes in lung volumes during pregnancy. Ventilation perfusion physiology. Conducting system of heart, regulation of heart beat, cardiac	15 hours 15 hours

	output and blood pressure, comparison of action potentials of Pacemaker cell and cardiomyocyte, effect of exercise on cardiovascular physiology: A human perspective. **Module 3** Various types of reproductive modes in non-chordates and chordates. Uterine physiology, implantation, delayed implantation/embryonic diapause and its regulation, estrous cycles and types of anestrous periods. Gestation, prenatal development and placentation in humans.	15 hours
Pedagogy:	Lectures/tutorials/self-study/videos/presentations/mini projects/Group activities	
References/ Readings:	1. R. S. K. Barnes, P. Calow, P. J. W. Olive, D. W. Golding and J. I. Spicer, The Invertebrates: A Synthesis, (Third edition), Blackwell Science, 2001. 2. C. Moyces and P. Schulte, Principles of Animal Physiology, Second Edition, Pearson International Edition, USA, 2013. 3. C. L. Prosser, Comparative Animal Physiology, Part A, Environmental and Metabolic Animal Physiology (Fourth Edition), Oxford, John Wiley & Sons Publication, 1991. 4. D. Randall, W. Burggren and K. E. French, Animal Physiology, (Fifth edition), New York, WH Freeman and Co, 2001. 5. K. Schmidt-Nielsen, Animal Physiology: Adaptation and Environment, (Fifth Edition), Cambridge University Press, 2001. 6. P. C. Withers, Comparative Animal Physiology, (First Edition), Fort Worth, Saunders College Publication, 1992.	
Course Outcomes:	The learner will 1. Explain the basic concepts and processes of physiological regulation, from cell to organ to organism level. 2. Appraise the functions of important physiological systems 3. Value how separate systems interact to yield interacted physiological responses to challenges such as exercise, kidney stones and pregnancy. 4. Report different physiological parameters with respect to any alterations and diseases.	

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO-503 **Title of the Course:** Molecular Biology

Number of Credits: 03

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge of nuclear and cellular components and the functioning of the cell.	
Course Objectives:	1. To summarize the experiments that led to the discovery of DNA. 2. To explain and analyze the molecular structure and function of Nucleic acids. 3. To categorize the types of DNA damage and repair systems. 4. To explain the molecular techniques associated with Nucleic acids.	
Content:	**Module 1**	
	Journey to the discovery of DNA structure (Review of research work of Rosalind Franklin, Maurice Wilkins, Linus Pauling, Erwin Chargaff, Watson, and Crick to derive a double helix DNA model).	2 hours
	Different types of bonds found in DNA double helix and their associated applications, different types of DNA (B-DNA, A-DNA & Z-DNA).	2 hours
	DNA packaging in bacteria (Looped and supercoiled structures, enzymes, and protein involved in DNA compactization),	2 hours
	Eukaryotic DNA Packaging (Polynucleotides-DNAHelix-Nucleosome-Chromatosomes-solenoid-Chromatin-Chromosome, Cohesins, and condensins), histone structure,	3 hours
	Types of DNA sequences, the structure of Telomere, Centromere,	2 hours
	Types of DNA damages (Single base alterations, Doble base alterations, Chain Breaks, and Cross linking), Types of Mutagens, DNA repair mechanisms (Direct reversal, MMR, BER, NER, HR, MMEJ, NHEJ, SOS)	4 hours
	Module 2	

	Understanding central dogma and flow of information. Replication: Prokaryotic (also rolling circle model and Theta model) and eukaryotic DNA replication in Prokaryotes and Eukaryotes,	4 hours
	Transcription in prokaryotes (also emphasize Promoter clearance and Promoter escape), Types of RNA Pol Proofreading (Pyro-phosphorolytic editing and Hydrolyting editing), RNA Pol inhibitors/Blockers examples.	3 hours
	Transcription in Eukaryotes, Eukaryotic promoter sequence, domains of Transcription factors (Trans-activating domain and DNA binding domains various types)	3 hours
	RNA structures (Primary, Secondary, and Tertiary), RNA types (Coding and non-coding), Splicing (Types and classes), Trans splicing, and alternate splicing.	5 hours
	Module 3 Translation in Prokaryotes and Eukaryotes, Codon and associated concepts, Protein structure and Post-translational modifications (folding, Protein splicing, Phosphorylation-dephosphorylation, N-glycosylation, Methylation, etc.).	5 hours
	Inhibitors of protein synthesis, Ramachandran plot for protein structure, The triple helical structure of the collagen protein.	
	Prokaryotic Gene regulation (Lac Trp operons.), Sum-up of various levels of gene regulation in Eukaryotes.	3 hours
	PCR techniques, CISPR/Cas 9 techniques, and their applications.	5 hours 2 hours
Pedagogy:	Lectures/Tutorials /Presentations/ Group discussion/Self-study.	
References/ Readings:	1. D. Clark, N. Pazdernik and M. McGehee, Molecular Biology. Academic Cell. 2018 2. L. G. Davis, M. D. Dibner and J. F. Battey, Basic Methods in Molecular	

	Biology. Elsevier, 1986. 3. E. J. Gardner, M. J. Simmons and D. P. Snustad, (1991), Principles of Genetics. John Wiley & Sons, 1991 4. G. Karp, J. Iwasa and W. Marshall W, Karp's Cell and Molecular Biology. 9th Edition, John Wiley, 2019. 5. J. E. Krebs, E. S. Goldstein, S. T. Kilpatrick, Lewin's GENES XII. Jones and Bartlett Learning, 2018. 6. G.M. Malacinski, Freifelder's Essentials of Molecular Biology, Narosa Book Distributors Private Limited, 2015.
Course Outcomes:	The learner will 1. Distinguish between DNA, RNA, and Protein and the various processes involved in the flow of information through these molecules. 2. Relate DNA structure and manipulation to the function and control of genes. 3. Critically evaluate the literature related to molecular biology and modify them. 4. Formulate techniques associated with molecular biology.

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Name of the Programme: M. Sc. Zoology
Course Code: ZOO–504 **Title of the Course:** Laboratory course I
Number of Credits: 03
Effective from AY: 2023-24

Pre-requisites for the Course:	Basic working knowledge of Animal Systematics, Animal Anatomy, Physiology and Molecular Biology.	
Course Objectives:	1. To obtain Laboratory hands on training in areas of systematics and anatomy. 2. To integrate theoretical knowledge with hands-on methods related to animal physiology. 3. To provide hands-on training on extraction and purification of nucleic acid. 4. To demonstrate PCR techniques using animal samples. 5. To explain the in-silico designing of primers for genes.	
Content:	**Animal Taxonomy and Systematics** Systematic analysis with proper morphological keys and construction of Phylogenetic keys of the following: - Malacofauna - Lepidoptera - Avifauna - Ichthyofauna - Araneae **Anatomy of Non Chordates** **Dissection/Mounting** Exoskeleton and appendages of prawns Nervous system in cockroach / crab (collected from market) /visceral and pedal ganglia in bivalves. Digestive system in prawn (collected from market)/cockroach Comparative study of mouth parts in insects. Reproductive system in cockroach Respiratory system in cockroach Mounting of heart in bivalves **Animal Physiology** Study of human lung volumes and capacities during before and after exercise using respirometer.	11 x 2 lab hours 11 x 2 lab hours 11 x 2 lab

	Determination of metabolic rate using respirometer. Estimation of heart rate, pulse rate and blood pressure changes during exercise using the oscillometric technique. Study of ECG and its evaluation in normal and pathological variations. Evaluation of heart rate, blood pressure using ECG strip. Measurement of muscular fatigue using finger ergograph. Study of nitrogenous waste products of animals from different habitats. Analysis of coelomic fluid of bivalve / crab. **Molecular Biology** Extraction of nucleic acid from chicken liver. Isolation of DNA and RNA from nucleic acids. Qualitative analysis of purified DNA and RNA using UV spectrophotometer / Nanodrop. Separation of nucleic acids on agarose gel and relative quantification. Demonstration/ hands-on training of PCR technique using a chicken DNA sample. Demonstration / hands-on training of RT-PCR technique using chicken total RNA sample. Purine/Pyrimidine bases from nucleic acids using paper chromatography. Primer designing of any two housekeeping genes from *Gallus gallus.*	hours 12 x 2 lab hours
Pedagogy:	Practicals/tutorials/self-study/videos/presentations/mini projects/Group activities	
References/ Readings:	1. R. S. K. Barnes, P. Calow, P. J. W. Olive, D. W. Golding and J. I. Spicer, The Invertebrates: A Synthesis, (Third edition), Blackwell Science, 2001. 2. C. Moyces and P. Schulte, Principles of Animal Physiology, Second Edition, Pearson International Edition, USA, 2013. 3. C. L. Prosser, Comparative Animal Physiology, Part A, Environmental and Metabolic Animal Physiology (Fourth Edition), Oxford, John Wiley & Sons Publication, 1991. 4. D. Randall, W. Burggren and K. E. French, Animal Physiology, (Fifth edition), New York, WH Freeman and Co, 2001. 5. K. Schmidt-Nielsen, Animal Physiology: Adaptation and Environment,	

	(Fifth Edition), Cambridge University Press, 2001. 6. P. C. Withers, Comparative Animal Physiology, (First Edition), Fort Worth, Saunders College Publication, 1992. 7. A. S. Gerstein, Molecular Biology Problem Solver: A Laboratory Guide. John Wiley & Sons, 2004. 8. S. Carson, H. B. Miller, D. S. Witherow and M. C. Srougi, Molecular Biology Techniques: A Classroom Laboratory Manual. Academic Press, 2011. 9. T. S. Work and E. Work, (1999). Laboratory Techniques in Biochemistry and Molecular Biology. North-Holland Publishing Company, Amsterdam, Oxford 1999
Course Outcomes:	The Learner will 1. Classify organisms by using keys and field techniques. 2. Draw a correlation between physical activities and its influence of physiological parameters 3. Use medical instruments to check physiological parameters and interpret medical reports. 4. Compose the molecular studies for standardization of extraction and purification of Nucleic acid. 5. Formulate the PCR thermal profile to suit the sample chosen. 6. To design the primers for housekeeping genes

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Name of the Programme: M. Sc. Zoology
Course Code: ZOO–505 **Title of the Course:** Field work -I
Number of Credits: 01
Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge of Zoology	
Course Objectives:	1. To explore/ observe/ collect specimens (subject to permissions from relevant authorities) and prepare an inventory of the faunal diversity of the selected area using systematics. 2. To enable the learner to examine and implement different practical field methodologies. 3. To motivate the learner to experience real biology in a novel learning environment, and develop a sense of appreciation for the environment. 4. To provide opportunities for independent research experience.	
Content:	Field work faunistic survey around 1 km radius of his/ her residence during dawn every weekend for at least 2 months (8 weeks) using Transect or Quadrat method of two different fauna. One/ two-day visit to sanctuary within Goa*. * In unavoidable circumstances overnight field work will be replaced by extending the time period (from 8 weeks to 10 weeks of weekend faunistic survey).	15 x 2 lab hours
Pedagogy:	Field orientation/ field workshop/ tutorials/self-study/videos/presentations/ mini projects/ Group activities	
References/ Readings:	1. D. Apte, Sea shells of India: an illustrated guide to common gastropods. New York: Oxford University Press, 2014. 2. R. Grimmett, C. Inskipp, and T. Inskipp, Birds of the Indian Subcontinent, Helm field guides, 2011 3. P. Smetacek, A Naturalist's Guide to the Butterflies of India. John Beaufoy Publishing Ltd, 2017. 4. I. Das, and A. Das, A Naturalist's Guide to the Reptiles of India. John Beaufoy Publishing Ltd, 2017. 5. R. Whitaker, A. Captain. Snakes of India: The Field Guide, Draco Books, 2004. 6. P. Rangnekar, A Photographic Guide to Butterflies of Goa, Broadway Publishing House, 2007	

	7. A. Narendra, M. Sunil Kumar, On a trail with ants – A handbook of the ants of peninsular India, 2006. 8. J.C. Daniel, The Book of Indian Reptiles and Amphibians, Oxford University Press, 2002. 9. I. Kehimkar, The Book of Indian Butterflies, Bombay Natural History Society, Mumbai (India), Oxford University Press, Oxford (United Kingdom), 2008. 10. H. Bharti, B. Guénard, M. Bharti, E.P. Economo, An updated checklist of the ants of India with their specific distributions in Indian states (Hymenoptera, Formicidae). ZooKeys 551: 1–83. doi: 10.3897/zookeys.551.6767, 2016.
Course Outcomes:	The learner will 1. Identify fauna using taxonomic keys 2. Develop skills on species identification 3. Construct scientific reports on the field work conducted 4. Present the data of the field study in a scientific manner

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Name of the Programme: M. Sc. Zoology
Course Code: ZOO–521 **Title of the Course:** Advances in Genetics (Theory)
Number of Credits: 03
Effective from AY: 2023-24

Pre-requisites for the Course:	Basic working knowledge of classical genetics	
Course Objectives:	1. To develop concepts of genetics pertaining to human beings 2. To classify chromosomes and modes of inheritance 3. To recognize genetic abnormalities and recall their significance in medical genetics	
Content:	**Module 1** Basic principles of genetics, human genetic make-up, genes as submicroscopic factors controlling human traits, packing of DNA/chromatin into chromosomes, nucleosomes and histones. Review on test cross, back cross, Polytene and Lampbrush chromosomes, human chromosome structure, sex determination in man, sex chromatin, Lyon hypothesis, human karyotype, banding techniques, chromosome identification and nomenclature (ISCN). Principles of inheritance in man (autosomal / sex linked / dominant / recessive / mitochondrial inheritance); human pedigree analysis, human genetic disorders, chromosomal (structural and numerical; autosomal or X linked) and biochemical (congenital diseases / inborn errors of metabolism) with examples, Eugenics, euphenics and euthenics; genetic counseling.	15 hours
	Module 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. Dermatoglyphics and its application in the diagnosis of human genetic disorders**,** principles of FISH, RFLP & DNA fingerprinting and their uses in human genetics. Genetic models: mouse as a model mammal for genetic studies, other animal models for human diseases.	15 hours 15 hours
	Module 3	

	Cancer genetics: Introduction and cellular aspects; types of cancers, protooncogenes; oncogenes; viruses and cancer; oncoproteins; tumor suppressor genes; inherited cancer genes (familial cancers); cell cycle dysregulation in cancer, chromosomal instability; roles of p21, p53, ATM, BRCA1/2 in preventing cancer, tests for detection of cancer, treatment of cancer: radiotherapy, chemotherapy, hyperthermia, targeted drug therapy, immunotherapy 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, gene mapping in Drosophila using two point and three point test crosses with an emphasis on interference and coefficient of coincidence.	
Pedagogy:	Lectures/ tutorials/online teaching mode/self-study and discussions/ Assignments/ Group activities/ Presentations	
References/ Readings:	1. P. Turnpenny, S. Ellard, Emery's Elements of Medical Genetics and Genomics, 16th ed. Elsevier, 2020. 2. T. Strachan, A. Read, Human Molecular Genetics, 5th edition. Garland Science, 2018. 3. M.L. Kothari, L.A. Mehta, and S.S. Roychoudhury, Essentials of Human Genetics, India: Oxford University Press, 2009. 4. B.A. Pierce, Genetics: A Conceptual Approach, 7th ed. W. H. Freeman and Company, 2020. 5. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, and P. Walter, Molecular Biology of the Cell, 6th ed. New York, USA: Taylor & Francis Group, 2014.	
Course Outcomes:	The learner will 1. Identify the different modes of inheritance of genetic disorders 2. Categorize the different types of genetic disorders 3. Determine the medical significance of genetic alterations 4. Interpret the results of various techniques for diagnosis of genetic diseases	

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO–522 **Title of the Course:** Advances in Genetics (Practicals)

Number of Credits: 01

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic working knowledge of classical genetics	
Course Objectives:	1. To outline the techniques involved in genetic analysis 2. To identify human genetic disorders based on available data	
Content:	Preparation of metaphase plates and karyotyping Dermatoglyphics analysis of human handprint Pedigree analysis of X-linked and autosomal recessive, dominant characteristics G banding of chromosomes Random amplification of polymorphic DNA Linkage mapping by two point and three point cross	15 x 2 hours
Pedagogy:	Laboratory-based learning	
References/ Readings:	1. P. Turnpenny, S. Ellard, Emery's Elements of Medical Genetics and Genomics, 16th ed. Elsevier, 2020. 2. T. Strachan, A. Read, Human Molecular Genetics, 5th edition. Garland Science, 2018. 3. M.L. Kothari, L.A. Mehta, and S.S. Roychoudhury, Essentials of Human Genetics, India: Oxford University Press, 2009. 4. B.A. Pierce, Genetics: A Conceptual Approach, 7th ed. W. H. Freeman and Company, 2020. 5. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, and P. Walter, Molecular Biology of the Cell, 6th ed. New York, USA: Taylor & Francis Group, 2014.	
Course Outcomes:	The learner will 1. Construct pedigree charts to determine modes of inheritance. 2. Develop techniques for genetic analysis of human traits / disorders. 3. Interpret the results of genetic tests. 4. Determine the medical significance of genetic alterations.	

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Name of the Programme: M. Sc. Zoology
Course Code: ZOO–523 **Title of the Course:** Animal Behaviour (Theory)
Number of Credits: 03
Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge of animal science and behaviour	
Course Objectives:	1. To develop concepts in animal behaviour 2. To analyze the different behaviours of animals 3. To assess the behaviours of human beings	
Content:	**Module 1** Introduction to animal behaviour (ethology): social behaviour: parental care-types, parent offspring conflict, sexual strategies, mating types and courtship, aggression and territory. Communication in animals: auditory, echolocation, infra and ultra sounds, tactile, visual, pheromones- vertebrates and invertebrates, language of honey bees-circle and waggle dance. Feeding strategies: heterotrophs, parasitic, saprophytes, commensalism, mutualism, coprophagy and hematophagy.	15 hours
	Module 2 Learning and imprinting, habituation, conditioning. trial and error, neural mechanism of learning in animals. Socio-biology: Introduction, WO Wilson, Richard Dawkins, WD Hamilton, Units of socio-biology. Hamilton's theory and Altruism, cooperation, reciprocation and Eusociality. Contributions to sociobiology: Jane Goodall and Dian Fossy; Properties, advantages of a social group, social organization in primates.	15 hours
	Module 3 Migration and navigation of animals: Introduction, types and causes of migration in fishes and birds, advantages of migration. Methods of studying migration and navigation.	15 hours

	Human ethology: Introduction, ethological concepts and human behavior, concepts of sign stimulus and imprinting, kinship and human social system, human beings and territorial behavior, human aggressive behavior.	
Pedagogy:	Lectures/ tutorials/assignments/self-study/Field study	
References/ Readings:	1. J. Alcock, Animal Behavior: An Evolutionary Approach. United States: Oxford University Press, Incorporated, 2013. 2. R. Mathur, Animal Behaviour. India: Rastogi publications, 2014. 3. J.T. Bonner, The Evolution of Culture in Animals. United States: Princeton University Press, 2018. 4. L. Ehrman, P.A. Parsons, The Genetics of Behavior. United States: Sinauer Associates, 1976. 5. T. Halliday, Sexual Strategy. United Kingdom: Oxford University Press, 1980.	
Course Outcomes:	The learner will 1. Observe and interpret animal behaviour 2. Classify the different types of animal behaviour 3. Analyze the behavioural patterns of animals 4. Determine the reasons behind different behaviour	

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO–524 **Title of the Course:** Animal Behaviour (Practical)

Number of Credits: 01

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge of animal science and behaviour	
Course Objectives:	1. To study different types of behaviours in animals 2. To analyze the behaviours of animals	
Content:	Territorial behavior in insects / mammals / birds etc. Foraging behavior in birds / butterfly Parasitism in birds / butterfly / frogs Parental behavior in mammals / birds Human aggressive behaviour	15 x 2 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study/Field study	
References/ Readings:	1. J. Alcock, Animal Behavior: An Evolutionary Approach. United States: Oxford University Press, Incorporated, 2013. 2. R. Mathur, Animal Behaviour. India: Rastogi publications, 2014. 3. J.T. Bonner, The Evolution of Culture in Animals. United States: Princeton University Press, 2018. 4. L. Ehrman, P.A. Parsons, The Genetics of Behavior. United States: Sinauer Associates, 1976. 5. T. Halliday, Sexual Strategy. United Kingdom: Oxford University Press, 1980.	
Course Outcomes:	The learner will 1. Identify specific types of animal behaviours 2. Analyze the behavioural patterns of animals 3. Determine the reasons behind different behaviours 4. To interpret the patterns of behaviours and state their importance	

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Name of the Programme: M.Sc. Zoology

Course Code: ZOO-525 **Title of the Course:** Ichthyology (Theory)

Number of Credits: 03

Effective from AY: 2023-24

Pre-requisites for the Course:	Learners are expected to have a reasonable knowledge of fish biology concerning its anatomical and physiological systems.	
Course Objectives:	1. To enhance the comprehensive understanding of fish biology, emphasising anatomical and physiological adaptations to different aquatic habitats. 2. To provide an acquaintance with the life-history and taxonomic diversity of fishes. 3. To create a learning framework about fish species' ecology, behaviour and management.	
Content:	**Module1**	No of hours
	Fish diversity: natural history, evolution, and biogeographical distribution. Fish classification (selected orders) and diversity of freshwater and marine fishes of India concerning the Western coastline. Meristic and morphometric studies; truss morphometry.	7 hours
	Swimming modes and buoyancy in fishes. Functional anatomy of fish muscles: body waves, energetics. Physiological aspects of dynamic and static lift.	4 hours
	Mechanism of gas exchange in air-breathing organs and air bladder. Circulatory system: aquatic and aerial respiration, cardiovascular physiology and osmoregulation.	4 hours
	Module 2	
	Food and feeding biology: natural fish food, Components of food, food evaluation/consumption ratio, feeding mechanism. Types of feeding. Structural modifications to feeding habits. Digestive enzymes and glands. Gut content analysis.	5 hours
	Concept of growth: growth curve, biotic and abiotic factors affecting growth, the role of minerals, vitamins, and hormones in the regulation of growth, influence of nutrients in growth stimulation. Principles and method of age determination.	4 hours
	Reproductive system: sexual maturity, development of	6 hours

	gametes in male and female. Fecundity and embryonic development. Fish diseases, immune response to pathogens. Effect of abiotic, biotic, and xenobiotic stresses on the fish immune system. **Module 3** Behaviour: feeding, schooling, migration, courtship, and parental care. Adaptations and symbiotic associations. Sensory adaptations and coordination: lateral line system, acoustic system, photoreception, electro-receptors. Bioluminescence, chromatophores, and sensory organs in shellfish. Endocrine glands and neuroendocrine coordination. Pelagic and demersal fisheries of Indian coasts. The relevance of the fish and fishery sector in Goa concerning research, society, and economy.	10 hours 5 hours
Pedagogy:	Lectures/ tutorials/assignments/ small projects/self-study/presentations.	
References/ Readings:	1. B.R. Selvamani and R.K. Mahadevan, Freshwater fish farming, Campus Books International, 2008. 2. D. Pauly, P. Tyedmers, R. Froese, and L. Y. Liu, Fishing down and farming up the food web. Conservation Biology, 2001. 3. P. Cury, and D. Pauly, Patterns and propensities in reproduction and growth of fishes. Ecological Research, 2002. 4. K.I. Stergiou, Fish Base: The modern tool of ichthyology, fisheries biology and marine ecology. Proc. 12th Panhellenic Cong.,2005. 5. S. Jennings, M.J. Kaiser, and J.D. Reynolds, Marine fisheries ecology. Blackwell Science, London, 2001. 6. V. Jhingran, Fish and Fisheries of India 2nd Ed, Hind Publication, 1982. 7. S. Kumar and M. Thembre, Anatomy and Physiology of Fishes, Vikas Publishing House,1996 8. D. Bal, and K.P. Rao, Marine Fisheries of India, Tata McGraw Hill Publishers,1982. 9. M.J. Dutta, Fundamentals of Freshwater Biology, Narendra Publishing House, Delhi,2006. 10. C. Kurian, and V.O. Sebastia, Prawn and Prawn Fisheries of India, Hindustan Publishing Corp., Delhi,2002	
Course Outcomes:	At the end of the course, the learner will 1. Assess an in-depth knowledge of taxonomy, anatomy, and physiological function of the organ systems of fish.	

	2. Distinguish between the developing stages of reproductive organs that occur across the maturation period. 3. Interpret the knowledge about the growth, developmental perspective, behavioural strategies and ecological adaptations. 4. Predict the emerging issues surrounding fish research and fish exploitation.

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Name of the Programme: **M.Sc. Zoology**

Course Code: ZOO-526 **Title of the Course:** Ichthyology (Practical)

Number of Credits: 01

Effective from AY: 2023-24

Pre-requisites for the Course:	Comprehensive knowledge of the practical aspect concerning the study of fish anatomy and physiology.	
Course Objectives:	1. To develop scientific and biological skills among learners to become knowledgeable about fish. 2. To provide hands-on practice on zootomy. 3. To illustrate the functional anatomy of teleost 4. To inculcate knowledge of histology and embryonic development in fishes.	
Content:	Study of Goan fish fauna, sampling of finfish and shellfish, quantitative meristic and morphometrics (Using FAO keys) Comparative studies of gills, scales (Determination of age), pharyngeal teeth, and the brain of fishes. Study of feeding habits based on the relative comparison of the gut length of the fishes. Observation of the reproductive system in fish (male and female) and determination of maturity stages in fish. Crude protein analysis of fish muscle by Lowry's method. Histological studies of any two endocrine glands in fish. Study of embryonic developmental stages in fish/crustaceans	15 x 2 hours
Pedagogy:	Mini projects/ tutorials/Group discussions/Field visits.	
References/ Readings:	1. J.B. Paul, Handbook of Fish Biology and Fisheries, Blackwell Publishing, 2002. 2. B.R. Selvamani and R.K. Mahadevan, Freshwater fish farming, Campus Books International, 2009. 3. D. Pauly, P. Tyedmers, R. Froese, and L. Y. Liu, Fishing down and farming up the food web. Conservation Biology,2001. 4. G. Helfman, B.B. Collette, D.E. Douglas and B.W. Bowen, The Diversity of Fishes: Biology, Evolution, and Ecology. Wiley-Blackwell, 2009. 5. M. Barton, Bond's Biology of Fishes, 2008. 6. G. Cailliet, A. Ebeling, Fishes, a field and laboratory manual on their structure, identification and natural history, Waveland Press, Ill.1986.	
Course Outcomes:	The learner will 1. Demonstrate the functional anatomy of the organ systems of fish. 2. Formulate identification keys for species recognition.	

	3. Compare the structural, and physiological adaptations shown by different fishes in relation to their environment, including the responses to environmental changes resulting from human activities. 4. Analyze the nutritional application of fish. 5. Develop practical knowledge of embryonic development in fish.

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Semester II

Name of the Programme: **M.Sc. Zoology**

Course Code: ZOO-506 **Title of the Course:** Anatomy of Vertebrates

Number of Credits: 03

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge on vertebrate anatomy, taxonomy and systematics is a prerequisite for this course.	
Course Objectives:	1. To provide knowledge about the general principles of vertebrate classification and phylogeny, and characteristics of the major chordate taxa. 2. To study the anatomical and physiological principles by studying form and function relationships from an evolutionary perspective. 3. To incite curiosity among learners about the complex ecological interactions of the organisms 4. To discuss how the environmental conditions modulate these interactions through adaptive mechanisms. 5. To indicate the role of scientific methods in advancing our knowledge of vertebrate anatomy and physiology.	
Content:	**Module 1** Detailed comparative analysis of vertebrate brain, spinal cord and sense organs. Basic plan of vertebra construction. Axial and Appendicular skeleton of vertebrates and their modification. Classification of vertebrate musculature. Axial and appendicular musculature of vertebrates. **Module 2** Digestive system of vertebrates with special analysis of herbivore, carnivore and omnivore stomach. Excretory system of Tetrapods, Mammalian kidney in detail, specialized excretory structures such as rectal glands (elasmobranchs) and salt glands (reptiles and Birds). Testes and Vasadeferens in anaminiotes and amniotes. Ovary and oviduct of anaminiotes and amniotes. **Module 3** Respiratory structure of fishes, Types of Tetrapod lungs	15 hours 5 hours 5 hours 5 hours

	(Alveolar, Faveolar, Parabronchial and Broncho- alveolar). Circulatory systems of Vertebrates, Vertebrate portal systems, Lymphatic system in Tetrapods.	8 hours 7 hours
Pedagogy:	Lectures/ tutorials/ online teaching mode/self-study	
References/ Readings:	1. K. Kardong, Vertebrates: Comparative Anatomy, Function and Evolution, McGraw-Hill Companies, 2011. 2. C.G. Kent, and R. Carr, Comparative Anatomy of Vertebrates, McGraw-Hill Companies, 2000 3. K.F. Liem, and W. Franklin, Functional Anatomy of the Vertebrates: an Evolutionary Perspective, CA: Harcourt College Publishers, 2001. 4. C. Moyces, and P. Schulte, Principles of Animal Physiology, Pearson International Edition, 2013. 5. C.L. Prosser, Comparative Animal Physiology, Part A, Environmental and Metabolic Animal Physiology, Oxford: John Wiley & Sons Publication, 1991. 6. Schmidt-Rhaesa, The Evolution of Organ Systems, Oxford University Press, 2007. 7. P.C. Withers, Comparative Animal Physiology, Fort Worth: Saunders College Publication, 1992. 8. R.G. Wolff, Functional Chordate Anatomy, Amazon Publication, 1994.	
Course Outcomes:	The learner will 1. Articulate the basic concepts associated with each system of the body. 2. Identify structures in the body systems which perform the functions according to the habits or habitats of the animals. 3. Compare the anatomy of different taxa based on evolutionary patterns. 4. Integrate the role of evolution in anatomy of non-chordates.	

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Name of the Programme: **M.Sc. Zoology**
Course Code: ZOO-507 **Title of the Course:** Animal Biochemistry
Number of Credits: 03
Effective from AY: 2023-24

Pre-requisites for the Course:	Elementary knowledge on structural biochemistry of Protein, Carbohydrate and Lipids	
Course Objectives:	1. To perceive enzymes in the context of kinetics, structure, regulation and importance 2. To determine the biochemical integrity of various metabolic pathways 3. To outline metabolic pathways, their regulation, and importance in animals	
Content:	**Module 1** Water as biological solvent; Ionization of water and buffering in biological systems. Enzyme Kinetics and enzyme inhibition; Catalytic and Regulatory strategies of Enzymes, Allosteric proteins and enzymes and its importance Concept of metabolism; Concept of free energy; Coupled reaction; Review of ATP and ATPase. Role and mechanism of action of NAD+/NADP+, FAD, lipoic acid, thiamine pyrophosphate, tetrahydrofolate, biotin, pyridoxal phosphate, B12 coenzymes and metal ions with specific examples, ascorbic acid, thiamine, pantothenic acid and folic acid. **Module 2** Review on Regulation of Glycolysis & Gluconeogenesis, Glycogenolysis & Glycogenesis. TCA cycle; Electron transport system; Oxidative phosphorylation Integration of fatty acid synthesis & β Oxidation of fatty acid; Importance of cholesterol and lipoprotein in health management Synthesis of steroid hormones; Eicosanoids: types, outline of biosynthesis and their physiological importance. Biological Membranes and transport: Lipid bilayer, membrane dynamics, solute transport across membranes. **Module 3**	15 hours 15 hours

	Nomenclature and classification of amino acids; Protein and peptide chains; Primary-, Secondary-, Tertiary and Quaternary structures of protein; Separation and Purification of proteins. Protein turn-over and amino acid catabolism; Nitrogen excretory pathways; Oxidation of amino acids; Biosynthesis of amino acids in animal. Biochemistry of Electrophoretic separation techniques; Structures of Membrane receptors (Lipoproteins and glycoproteins); G Protein coupled receptors, receptor tyrosine kinase, adaptor proteins and gated ion channels.	15 hours
Pedagogy:	Lectures/ tutorials/ online teaching mode/self-study	
References/ Readings:	1. T.M. Devlin, Text book of Biochemistry with Clinical Correlations. Willey, Oxford, 2010. 2. R.K. Murray, D. Granner, P. Mayes, and V.W. Rodwell, Harper's Illustrated Biochemistry. USA: McGraw-Hill, Companies, 2000. 3. A. Blanco, and G. Blanco, Medical Biochemistry. Academic press, 2017. 4. J. Berg, J. Tymoczko, and L. Stryer, Biochemistry. New York: W. H. Freeman and Company, 2002. 5. D.L. Nelson, and M.M. Cox, Lehninger's Principles of Biochemistry, USA: Freeman WH and Co, USA, 2010. 6. J. Pelley, Elsevier's Integrated Biochemistry. Amsterdam: Elsevier, 2012.	
Course Outcomes:	The learner will 1. Explain the importance of enzymes in various metabolic processes 2. Illustrate the key pathways involved in cellular metabolism 3. Determine the medical significance of various metabolic processes 4. Integrate the concepts of biochemistry with animal sciences.	

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Name of the Programme: **M.Sc. Zoology**

Course Code: ZOO-508 **Title of the Course:** Molecular Aspects of Developmental Biology

Number of Credits: 03

Effective from AY: 2023-24

Pre-requisites for the Course:	A basic understanding of cellular and molecular biology is essential.	
Course Objectives:	1. To provide a comprehensive understanding of the concepts of early animal development 2. To compare and contrast various events that occur during gametogenesis, cleavage formation and fertilization. 3. Construct in-depth knowledge of cell signalling pathways that regulate embryonic induction, tissue interactions, pattern formation and expression of regulatory genes. 4. Critically assess the current scientific literature on topics related to developmental biology.	
Content:	**Module 1** Mammalian Gametogenesis: ultra structure of sperm and egg; Molecular events in mammalian fertilization (capacitation, prevention of polyspermy, genetic fusion, activation of egg metabolism). Cleavage in mammals, the difference between somatic mitosis and cleavage, regulation of cleavage. Gastrulation (epiboly and emboly). Development of Extra embryonic membrane. **Module 2** Mechanism of cell cellular differentiation; Stages of Commitment (differentiation, specification and determination; cellular communication: paracrine factors and signal transduction cascades (Jak-Stat pathway, smooth and patched protein pathway, wnt signalling pathway, SMAD pathway). Developmental dynamics of cell speciation: Specification of body axes in sea urchin-, insect-, fish-, avian- and mammalian embryo. **Module 3** Induction and competence; a cascade of induction during the formation of a lens; epithelium-mesenchyme interaction during the formation of feathers in a bird.	7 hours 5 hours 3 hours 8 hours 7 hours 5 hours

	The central nervous system and the epidermis: Primary and Secondary neurulation; Differentiation of the Neural Tube. Embryonic field; Pattern formation in vertebrate limbs, generation of the proximal–distal, anterior–posterior, dorso - ventral axis of the limb. Regeneration ability of animals; Role of Interstitial cells in Regeneration in Hydra. Molecular mechanism of regeneration of limb in Salamander.	4 hours 3 hours 3 hours
Pedagogy:	Lectures/tutorials/online teaching mode/self-study.	
References/ Readings:	1. M.J.F. Barresi and S.F. Gilbert, Developmental Biology (12th edition), Oxford University Press, UK, 2019. 2. B.M. Carlson, Pattern's Foundation of Embryology, Mc Graw Hill Inc., USA,2003. 3. S.F. Gilbert, Developmental Biology (5th edition), Sinauer Associates Inc.,2003. 4. S.F. Gilbert, Developmental Biology (10th edition), Sinauer Associates Inc., Sunderland, USA, 2016. 5. S.F. Gilbert, Developmental Biology (8th edition), Sinauer Associates Inc., Sunderland, USA. 2006. 6. S.A. Moody, Principles of Developmental Genetics, Academic Press., New York, 2015. 7. J.M.W. Slack, Essential Developmental Biology, Willey Publication, USA, 2012. 8. L. Wolpert, C. Tickle and A.M. Arias, Principles of Development, Oxford University Press, 2019.	
Course Outcomes:	The learner will 1. Appraise the morphological process that transforms a fertilized egg into a multicellular organism. 2. Assess the molecular, biochemical and cellular events that regulate the development of specialised cells, tissue and organs during embryonic development. 3. Compare different model organisms which can be used to investigate various developmental processes. 4. Justify how different genes control axis formation in invertebrates and vertebrates. 5. Create comprehensive knowledge of various steps involved in Pre and Post- fertilization process in mammals.	

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Name of the Programme: **M.Sc. Zoology**

Course Code: ZOO-509 **Title of the Course:** Ecology and Biodiversity

Number of Credits: 03

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge on Taxonomy, Biodiversity, Environment and Ecology	
Course Objectives:	1. To develop the concepts of ecology and biodiversity 2. To outline ecosystem functioning 3. To identify the reasons for decline of biodiversity 4. To sensitize the learners of the issues arising from unsustainable development with respect to the global scenario and methods to tackle the problems.	
Content:	**Module 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, Study of behavior and behavioral ecology Ecological energetics: Food chains, Food webs and Trophic levels, Primary production, Nutrient cycles **Module 2** Population ecology: population parameters and demographic techniques, Population growth and regulation, Population studies and applications Community ecology: Community nature and parameters, community changes and ecological succession, Community organization Distribution and abundance: Biogeography: analysis of geographic distributions, reasons of existence and co-existence of organisms in niches Management of threatened species: threat to species, In-situ conservation, Ex-situ conservation **Module 3** 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).	15 hours 15 hours 15 hours

	Applied ecology: optimum yield problem, biological control, ecotoxicology and pollution management, restoration ecology.	
Pedagogy:	Lectures/ tutorials/ online teaching mode/self-study	
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.	
Course Outcomes:	The learner will 1. Outline the importance of ecological interactions and energetics. 2. Prioritize the requirements for biodiversity conservation. 3. Plan for long term conservation of ecosystems. 4. Formulate strategies for pollution management and restoration.	

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Name of the Programme: **M.Sc. Zoology**
Course Code: ZOO-510 **Title of the Course:** Laboratory Course-II
Number of Credits: 03
Effective from AY: 2023-24

Pre-requisites for the Course:	Basic working knowledge of Animal Anatomy, Biochemistry, Embryology and Ecology	
Course Objectives:	1. To examine various anatomical features of chordates 2. To determine the concentrations of biomolecules in different samples 3. To experiment with different life stages of chick embryo 4. To interpret ecological indices of selected areas	
Content:	**Anatomy of Chordates** Preparation of the skeleton using a Chicken*. Exposure of axial muscle of fish*. Digestive system of fish*. Reproductive system of fish*. Afferent and Efferent branchial system of fishes*. Brain of Chicken* *Dead fish collected from the market and chicken from the slaughterhouse	11 x 2 lab hours
	Biochemistry Preparation of biological buffers and standard reagents Calibration of pH meter using standard buffers Extraction and Estimation of major biomolecules in different tissues of fish. Total Protein & free amino acids / glycogen & glucose/ triglycerides & cholesterol. Determination of Km and Vmax of Na+ -K + - ATPase/ Acetylcholinesterase. Fractionation of Lipid moieties through TLC (demo). Titration of an acid with conjugated base.	11 x 2 lab hours
	Developmental Biology Identification of developmental stages of chick embryo using HH classification. In vitro culture of chick embryo. Effect of proline / retinoic acid in early development of chick embryo (In vivo as well as in vitro).	11 x 2 lab hours

	Effect pesticides on the ossification process of chick embryo by dual staining method. **Ecology** Study of Pond, Grassland, and Forest Ecosystem Habitat Preferences of Stream Invertebrates Abundance and Distribution of Birds/Butterflies/Snakes etc Landscape Ecology Communities: Measuring Diversity Basic concepts of cartography	12 x 2 lab hours
Pedagogy:	Practicals/ Mini projects/ Group Activities	
References/ Readings:	1. M.J.F. Barresi and S.F. Gilbert, Developmental Biology (12th edition), Oxford University Press, UK, 2019. 2. B.M. Carlson, Pattern's Foundation of Embryology, Mc Graw Hill Inc., USA,2003. 3. S.F. Gilbert, Developmental Biology (10th edition), Sinauer Associates Inc., Sunderland, USA, 2016. 4. T.J. Fahey, and A.K. Knapp, Principles and Standards for Measuring Primary Production. UK: Oxford University Press, 2007. 5. W.E. Grant, and T.M. Swannack, Ecological Modeling. Blackwell, 2008. 6. E.P. Odum and G.W. Barrett, Basic Ecology: Fundamentals of Ecology, 5th ed. Oxford and IBH Publishing Co. Pvt, 2004. 7. J. Berg, J. Tymoczko, and L. Stryer, Biochemistry. New York: W. H. Freeman and Company, 2002. 8. D.L. Nelson, and M.M. Cox, Lehninger's Principles of Biochemistry, USA: Freeman WH and Co, USA, 2010.	
Course Outcomes:	The learner will 1. Interpret the functions of different systems of chordates. 2. Create observational and technical skills to investigate and communicate concepts in developmental biology. 3. Construct the outcome of teratogenic effects which inhibits organogenesis and the process of ossification in the chick embryo. 4. Test for the presence or absence of various biomolecules in biological samples. 5. Estimate the diversity and assess the abundance and distribution of different populations.	

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO–511 **Title of the Course:** Field work -II

Number of Credits: 01

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge of Animal systematics	
Course Objectives:	1. To explore/ observe/ collect specimens (subject to permissions from relevant authorities) and prepare an inventory of the faunal diversity of the selected area using systematics. 2. To enable the learner to examine and implement different practical field methodologies. 3. To motivate the learner to experience real biology in a novel learning environment, and develop a sense of appreciation for the environment. 4. To provide opportunities for independent research experience.	
Content:	Field Work faunistic survey around 1 km radius of his/ her residence during dawn every weekend for at least 2 months (8 weeks) using Transect or Quadrangle method of two different fauna. Visit to a National Park / Sanctuary, Universities and Research Institutions outside Goa (within 1000 km from Goa) for 5 -6 days including Journey period. *In unavoidable circumstances overnight field work will be replaced by extending the time period (from 8 weeks to 10 weeks of weekend faunistic survey). #Evaluation of the field work component will be based on weekly field notes and final compiled field report as a component of the SEA.	15 x 2 lab hours
Pedagogy:	Lectures/tutorials/self-study/videos/presentations/mini projects/Group activities	
References/ Readings:	1. D. Apte, Sea shells of India: an illustrated guide to common gastropods. New York: Oxford University Press, 2014. 2. R. Grimmett, C. Inskipp, and T. Inskipp, Birds of the Indian Subcontinent, Helm field guides, 2011 3. P. Smetacek, A Naturalist's Guide to the Butterflies of India. John Beaufoy Publishing Ltd, 2017. 4. A. Das, and A. Das, A Naturalist's Guide to the Reptiles of India. John	

	Beaufoy Publishing Ltd, 2017. 5. R. Whitaker, A. Captain. Snakes of India: The Field Guide, Draco Books, 2004. 6. P. Rangnekar, A Photographic Guide to Butterflies of Goa, Broadway Publishing House, 2007 7. A. Narendra, M. Sunil Kumar, On a trail with ants – A handbook of the ants of peninsular India, 2006. 8. J.C. Daniel, The Book of Indian Reptiles and Amphibians, Oxford University Press, 2002. 9. I. Kehimkar, The Book of Indian Butterflies, Bombay Natural History Society, Mumbai (India), Oxford (United Kingdom): Oxford University Press, 2008. 10. H. Bharti, B. Guénard, M. Bharti, E.P. Economo, An updated checklist of the ants of India with their specific distributions in Indian states (Hymenoptera, Formicidae). ZooKeys 551: 1–83. doi: 10.3897/zookeys.551.6767, 2016.
Course Outcomes:	The learner will 1. Identify fauna using taxonomic keys. 2. Develop skills on species identification. 3. Construct scientific reports on the field work conducted. 4. Present the data of the field study in a scientific manner.

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO–527 **Title of the Course:** Environmental Physiology (Theory)

Number of Credits: 03

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge of Animal Physiology, environmental science and biochemistry	
Course Objectives:	1. To reflect on the nature, levels and mechanisms of adaptation 2. To categorize variations in adaptations with respect to various challenges in different environments 3. To elaborate on biological rhythms operating across the animal kingdom	
Content:	**Module 1** Nature and levels of adaptation; mechanism of adaptation; cellular metabolism, regulation and homeostasis; concept of stress and strain in animals. Thermal adaptation: biochemical and physiological effects of temperature; Regulation of heat gain and heat loss, Dubois temperature balance; role of nervous system and endocrine system in thermal biology; homeoviscous adaptation of membrane. **Module 2** Salinity adaptation: biochemical and physiological effects of salinity; regulation and movements of water and solute; osmoregulatory organs and their excretory products; Role of membranes in osmoregulation. Strategies and mechanism in physiological adaptation with reference to marine life, estuarine life, freshwater life and terrestrial life. **Module 3** Physiological and morphological adaptation of the animals living in extreme environments. Circadian rhythm: biological clock; analysis of circadian rhythmicity; ultradian and infradian rhythm; behavioural and autonomous rhythm; endogenous mechanism of rhythm.	15 hours 15 hours 15 hours

Pedagogy:	Lectures/tutorials/self-study/videos/presentations/mini projects/Group activities
References/ Readings:	1. P. W. Hochachka and G. N. Somero, Biochemical Adaptation, UK: Oxford University Press, 2002. 2. P. Wilimer, G. Stone and I. A. Johston, Environmental Physiology. of Animals, USA, Wiley Blackwell Publishing Co, 2004. 3. R. G. Foster and L. Kretzman, Circadian rhythm, A very short Introduction, UK, Oxford University Press, 2017. 4. R. Refinetti, Circadian Physiology, USA, CRC Press, 2016. 5. S. Nielsen, Animal Physiology: Adaptation and Environment, Cambridge, Cambridge University Press,1997.
Course Outcomes:	The learner will 1. Examine the functioning and control of physiological systems in a range of animals with respect to their habitats 2. Use knowledge of the physiological responses of animals to overcome a range of environmental challenges 3. Interpret the physiological data with respect to different stress environments 4. Design experiments and apply a range of practical skills relevant to the environmental physiology studies.

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Name of the Programme: M. Sc. Zoology
Course Code: ZOO–528 **Title of the Course:** Environmental Physiology (Practical)
Number of Credits: 01
Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge of Animal Physiology, environmental science and biochemistry	
Course Objectives:	1. To validate experimentally the physiological outcomes on exposure to various stressor 2. To provide hands on training to study how animals behave during different stress conditions 3. To analyze and extrapolate the different biochemical and physiological parameters of animals that may get affected during environmental challenges in the natural environment.	
Content:	Effect of thermal stress on the excretory rates in bivalves/fish. Effect of salinity stress on the respiratory rates of bivalves/fish. Effect of salinity acclimation in the osmo-regulatory processes of mud crab / fish / bivalves. Effect of thermal stress on the carbohydrate metabolism of bivalve/fish. Effect of salinity stress on the membrane fluidity of gill epithelial cells of mud crab /bivalve/fish.	15 x 2 hours
Pedagogy:	Practicals /tutorials/self-study/videos/presentations/mini projects/Group activities	
References/ Readings:	1. P. W. Hochachka and G. N. Somero, Biochemical Adaptation, UK, Oxford University Press, 2002. 2. P. Wilimer, G. Stone and I. A. Johston, Environmental Physiology. of Animals, USA, Wiley Blackwell Publishing Co, 2004. 3. S. Nielsen, Animal Physiology: Adaptation and Environment, Cambridge, Cambridge University Press,1997.	
Course Outcomes:	The Learner will 1. Analyze the effect of environmental stressors on physiological response of animals 2. Validate the effect of stress on altered membrane fluidity 3. Apply a range of practical skills to study environmental physiology 4. Design experiments to study physiology of animals during environmental stress	

Name of the Programme: M. Sc. Zoology

Course Code: ZOO-529 **Title of the Course:** Animal Cell Biology (Theory)

Number of Credits: 03

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic understanding of different components and functions of the cell. Parallel enrolment for the courses ZOO-530, Animal cell biology Practical	
Course Objectives:	1. To evaluate the dynamics of Plasma membrane and its importance. 2. To summarize the experiments used for proving the dynamic nature of the Plasma membrane. 3. To explain the structure and function of the endomembrane system. 4. To appraise cell death and cell signaling.	
Content:	**Module 1** Cell membrane: Plasma membrane dynamics involved in membrane fluidity (Paracrystalline state, liquid-disordered state and liquid-ordered state), trans bilayer movements, lateral movements, membrane rafts, caveolins, cell-cell interaction, membrane fusions. Importance of freeze-fracture microscopy and fluorophore photobleaching experiments to decipher membrane structure and dynamism. Nuclear transport: passive transport and selective energy dependent transport, Karyopherins (importins and exportins), NLS and NES **Module 2** Structural component of Endomembrane system, main vesicular transport pathways (inward transport: Endocytotic pathway and outward transport: Secretory pathway) of endomembrane systems and transport proteins involved. Structural and functional polarization of Golgi apparatus, two models for cis to trans-Golgi progression (Cisternal Maturation Model and Vesicular transport model, three pathways of protein sorting at trans-Golgi network. Lysosomes, signal-mediated diversion to regulated secretion,	7 hours 4 hours 4 hours 4 hours 6 hours

	constitutive secretory pathways. LAMP and LIMP of lysosomes and their significance.	2 hours
	Synthesis, structure, and functions of the ribosome and its subunits in Prokaryotes and Eukaryotes. Concept of LUCA in relation to ribosomes. (Additional: mention of Mitochondrial Eve and Y-chromosome Adam concept).	2 hours
	Comparison of organelle composition of protein-secreting and steroid-secreting cells.	1 hour
	Module 3 Comparison of the constitution of Cytoplasm, Cytosol and Nucleoplasm. Comparison of Cytoskeletal elements of Prokaryotes and Eukaryotes.	3 hours
	Programmed and non-programmed cell death and its types, Autophagy, Pyroptosis, Necroptosis, Parthonatos, Ferroptosis, Apoptosis, and Necrosis. Extrinsic versus Intrinsic pathway of Apoptosis in Mammals.	6 hours
	Cell signaling: General principles, specific responses to cell signaling (survive, grow+divide, differentiate, death) with example each, feedback loops of signaling networks, adaptation to sensitivity to signaling. Overview of receptors, signaling transducers and second messengers.	6 hours
Pedagogy:	Mini Projects, Group activities, Demonstrations	
References/ Readings:	1. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, and P. Walter, (2014) Molecular Biology of the Cell. Taylor & Francis, New York, USA, 2014. 2. H. Lodish, A. Berk,C. A. Kaiser, M. Krieger, A. Bretscher, H. Ploegh, A. Amon, and M. P. Scott, *Molecular Cell Biology*. W. H. Freeman, New York, 2016. 3. J. D. Watson, T. A. Baker, and S. P.Bell, Molecular Biology of the Gene. Benjamin-Cummings Publishing Company, 2014. 4. E. D. P. De Robertis, and E. M. F. De Robertis, Cell and Molecular Biology Saunders College, Philadelphia Dowben RM, Cell Biology, Harper and Row Publ. London, 2021. 5. D. L. Nelson, and M. M. Cox, Lehninger Principles of Biochemistry. Seventh Edition (2017). Freeman WH and Co, USA, 2008.	

Course Outcomes:	The learner will 1. Manipulate the construction of the Plasma membrane with respect to the changing environment. 2. Interpret the results of experiments that are conducted to demonstrate Plasma membrane dynamics. 3. Defend the various cell death events encountered in the tissues during the normal and pathological conditions. 4. Infer the complexities of cell signaling associated with nuclear transport, endomembrane trafficking.

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO-530 **Title of the Course:** Animal Cell Biology (Practical)

Number of Credits: 01

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic understanding of different components and functions of the cell. Parallel enrolment for the courses ZOO-529, Animal cell biology Theory	
Course Objectives:	1. To provide hands-on training on organelle separation technique. 2. To determine viable cell count and toxicity assay for isolated cells. 3. To demonstrate the histological and cytological techniques.	
Content:	Isolation of lysosomes/ mitochondria from chicken liver using differential centrifugation. Cell isolation and enumeration using the trypan blue method. Cell toxicity study using MTT/XTT assay. Study of histology technique using HE staining. Study of Cytokinesis-block assay using lymphocytes culture.	15 x 2 hours
Pedagogy:	Mini Projects, Group activities, Demonstrations	
References/ Readings:	1. C. L. Ghai, A text book of Practical physiology. Jaypee Brothers Medical Publishers, 2013. 2. M. Clynes, Animal Cell Culture Techniques. Springer, New York, 1998. 3. R. I. Freshney, Culture of Animal Cells: A Manual of Basic Techniques. Willey Publishers, 2005.	
Course Outcomes:	The learner will 1. Skilled to isolate cells from tissue and perform the cell count and toxicity studies. 2. Design and interpret the cytokinesis experiments. 3. Independently prepare the histological slides of given animal tissue. 4. Design the cell toxicity experiment to evaluate various compounds.	

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO-531 **Title of the Course:** Wildlife Conservation & Management (Theory)

Number of Credits: 03

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge in wildlife conservation and management	
Course Objectives:	1. To provide knowledge on the status of Indian wildlife and the importance of conservation. 2. To create opportunities for learners to explore different approaches to wildlife conservation and management 3. To develop skilled learners to undertake research in the field of wildlife biology 4. To inculcate a deeper understanding of scientific principles and policies/ legislations and their enforcement in wildlife conservation	
Content:	**Module 1** Wildlife conservation and management: Introduction to Indian Wildlife, History and Diversity, Biogeographic zones, Value of Wildlife, Important Indian fauna and their distribution, Protected Areas, Endemic species; IUCN red list: Extinct species of India, Endangered, Threatened, Least concern and Critically Endangered. Climate change and its impact on wildlife. Impacts of pesticides on fauna. **Module 2** Environmental Ethics and Management: Conservation and Management of Wildlife: Conservation and management: In-situ conservation and Ex-situ conservation; Reintroduction, Ecological Restoration. Innovative Methods in Wildlife: Camera Trap, Conservation Drones, Remote Sensing, Radio Telemetry, GIS, GPS Mobile App, Capturing and marking techniques, trapping, darting, tagging and banding, scat analysis, sign surveys. Wildlife Census and Indices: Methods of animal census,	7 hours 8 hours 4 hours 6 hours 5 hours

	counting methods. Animals in Indian Mythology. Major Projects. Ecotourism and Environment Impact Assessment	4 hours
	Module 3 Human Wildlife Conflict: Types of conflict, Prevention or precautions, Human Elephant Conflict, Conflict between human, Tiger and Leopard, Conflict with Sloth Bear.	3 hours
	Wildlife Trade and Crime: Wildlife products CITES, TRAFFIC, Wildlife Crime Control Bureau in India, Wildlife Forensics.	
	Law, Ministry and Organizations: Wildlife Protection Act of (1972), National Board of Wildlife, Environment Protection Act (1986), Biological Diversity Act (2002), The First National Wildlife Action Plan (NWAP) (1983), National Wildlife Action Plan (2017-2031), MoEFCC	5 hours
	International organizations; UNESCO, IUCN, PETA. National Institutes/Organizations; NTCA, ZSI, BSI, CZA, WII, SACONH, ENVIS. Non-Government Organizations.	3 hours
Pedagogy:	Practicals/ Mini projects/ Group Activities	
References/ Readings:	1. A.J. Urfi, Birds beyond Watching, India: University Press Pvt. Ltd., 2004. 2. R.F. Dasmann, Wildlife biology, New York: John Wiley and Sons, 1964. 3. M.J. Groom, K.G. Meffe, and C.R. Carroll, Principles of Conservation Biology – 2nd ed. Massachusetts: Sinauer Associates, Inc Sunderland, 2005. 4. R.H. Giles Jr.,Wildlife management techniques - 3rd ed, The wildlife society, Washington D.C, 1984. 5. R. Grimmet, C. Inskipp, and T. Inskipp, Pocket Guide to the birds of Indian Subcontinent. New Delhi: Oxford University Press, 1999. 6. B.B. Hosetti, Wetlands Conservation and management. Jaipur: Pointer Publishers, 2003. 7. K. Kazmerezak, and V.P. Ber, A field Guide to the birds of India. New Delhi: OM Book Series, 2000. 8. W.L. Robinson, and E.G. Bolen, Wildlife Ecology and Management. New York: Millen Publishing Co., 1984 9. S. Ali, The book of Indian Birds, revised edition. New Delhi: BNHS &	

	Oxford University press, 2002. 10. B.K. Sharma, and H. Kaur, Environmental Chemistry. Goel Publishing House, Meerut, 1986. 11. R.D. Teague, ed., A Manual of wildlife conservation. The Wildlife Society Washington D.C., 1980. 12. R.B. Primack, Essentials of Conservation Biology, 6th ed. Sinauer Associates, 2014. 13. R. Mathur, Wildlife Conservation and Wildlife Management. Rastogi Publications, 2018.
Course Outcomes:	The learner will 1. Outline the reasons behind the decline of wildlife 2. Gain insight on the different methods and techniques in wildlife conservation 3. Formulate strategies for wildlife conservation and management 4. Plan for long term conservation of wildlife

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO-532 **Title of the Course:** Wildlife Conservation & Management (Practical)

Number of Credits: 01

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge in wildlife conservation and management	
Course Objectives:	1. To recall the distribution of different wildlife in Goa 2. To list the various methods used to document wildlife 3. To gain experience on wildlife documentation by field visits	
Content:	Mammal distribution of Goa Primates: Rhesus macaque Carnivores: Tiger, Panther, Sloth bear Ungulates: Sambar, Chital, Wild boar. Horn/ Antler identification. Pugmark analysis and Camera trap methods. Animal Scat, pellet, dung, droppings analysis (Indirect evidences) Case study of Man-Animal conflict and Ethnozoology. Visit to Zoo/Wildlife Sanctuary/National Park/Turtle nesting site	15 x 2 hours
Pedagogy:	Practicals/ Mini projects/ Group Activities	
References/ Readings:	1. A.J. Urfi, Birds beyond Watching, India: University Press Pvt. Ltd., 2004. 2. R.F. Dasmann, Wildlife biology, New York: John Wiley and Sons, 1964. 3. M.J. Groom, K.G. Meffe, and C.R. Carroll, Principles of Conservation Biology – 2nd ed. Massachusetts: Sinauer Associates, Inc Sunderland, 2005. 4. R.H. Giles Jr.,Wildlife management techniques - 3rd ed, The wildlife society, Washington D.C, 1984. 5. R. Grimmet, C. Inskipp, and T. Inskipp, Pocket Guide to the birds of Indian Subcontinent. New Delhi: Oxford University Press, 1999. 6. B.B. Hosetti, Wetlands Conservation and management. Jaipur: Pointer Publishers, 2003.	
Course Outcomes:	The learner will 1. Demonstrate the different methods of wildlife identification. 2. Estimate the range of distribution of wildlife. 3. Formulate strategies for wildlife conservation and management. 4. Devise plans for mitigation of man-wildlife conflicts.	

Name of the Programme: M. Sc. Zoology

Course Code: ZOO-533 **Title of the Course:** Restoration Ecology

Number of Credits: 04

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge on Zoology, Botany, Ecology.	
Course Objectives:	1. To provide knowledge regarding the fundamental concepts and theoretical development relating to ecological restoration in natural ecosystems. 2. To discuss the relationship of ecological restoration with conservation biology 3. To explore alternative objectives/ problems and restoration strategies by examining case studies.	
Content:	**Module 1** Introduction to ecosystem restoration, definition, importance, types and services. Difference between ecosystems and landscapes, Causes of ecosystem degradation, Concepts in Ecological Biodiversity and Eco-restoration.	15 hours
	Module 2 Ecological principles, ecosystem degradation, tools for spatial analysis, Attributes for reference models. Types of restoration, Challenges and opportunities, The Conceptual Community/Ecosystem Model, -Ecological Theory within restoration ecology, Nature of Communities: Concepts and Explanations from Community Ecology, Approaches and principles to restoration.	15 hours
	Module 3 Restoration planning, site inventory and analysis, design and planning - Assessing Institutional, Policy and Legal Frameworks, Environment Planning and Impact Assessment, cross boundary influences. Restoration opportunities assessment methodology (ROAM).	15 hours
	Module 4 Impacts of invasive alien species in ecological restoration (India specific with reference to invasive species)–	15 hours

	challenges in eradication of alien species in ecosystem restoration efforts; ecological and socioeconomic needs met by native and alien species; assessment of the risks involved in using alien species in restoration; incorporating indigenous knowledge in understanding the invasive alien species in ecological restoration.	
Pedagogy:	Lectures/ tutorials/ online teaching mode/self-study/Quizes/ Field Trips/ Case studies/ Assignments/ Mini-Projects	
References/ Readings:	1. J. van Andel, and J. Aronson, Eds., Restoration Ecology: The New Frontier, Oxford: Blackwell Publishing, 2012. 2. M. A. Palmer, J. B. Zedler, and D. A. Falk, Eds., Foundations of Restoration Ecology, WA: Island Press, 2016. 3. E. A. Howell, J. A. Harrington, S. B. Glass, Introduction to Restoration Ecology, WA: Island Press, 2011. 4. A. F. Clewell, J. Aronson, Ecological Restoration, Principles, Values, and Structure of an Emerging Profession, WA: Island Press, 2013. 5. S. Greipsson, Restoration ecology, Jones & Bartlett Learning, 2011. 6. S. A. Ballari, C. Roulier, E. A. Nielsen, C. Pizarro, and C. B. Anderson, A Review of Ecological Restoration Research in the Global South and North to Promote Knowledge Dialogue, Conservation & Society, vol. 18, no. 3, 2020.	
Course Outcomes:	The learner will 1. Analyze the basic concepts of ecological restoration. 2. Identify the major ecological principles underlying the successful restoration of ecosystems including the legal frameworks 3. Select and apply appropriate methods and tools for designing and conducting restoration projects taking the stakeholders into consideration 4. Design a restoration plan for a degraded ecosystem.	

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Semester III
Name of the Programme: M. Sc. Zoology
Course Code: ZOO-600 **Title of the Course:** Neurophysiology (Theory)
Number of Credits: 03
Effective from AY: 2023-24

Pre-requisites for the Course:	Basic working knowledge of the Nervous system. Parallel enrolment for the courses ZOO-602 Neurophysiology (Practicals)	
Course Objectives:	1. To review the gross and microanatomy of the nervous system to examine the blood-brain barrier, neuro circuits, and types of synaptic transmission. 2. To examine electrophysiological techniques for the acquisition of data and to compare the electrophysiology of impulse conduction in various nerve fibers. 3. To inspect the neurophysiological aspect of learning, memory formation, sensation, sleep, posture, and balance.	
Content:	**Module 1**	
	Review of classification of neurons and their functions. Blood-brain barrier and its physiological importance, CSF composition, formation, and drainage.	4 hours
	Physiological characteristics of neuronal cell membrane components for impulse conduction.	2 hours
	Myelin ultrastructure and Nodes of Ranvier, nerve impulse conduction in myelinated and unmyelinated neurons.	4 hours
	Electrophysiology of neurons. Comparison of action potentials of giant axon of Squid and mammalian neuron.	3 hours
	Voltage and Cell-Patch Clamp Techniques.	2 hours
	Module 2	
	Types of synaptic connections (axosomatic, axodendritic, dendro-dendritic, and axo-axonal synapses). Properties of Synapse. The basic concept of Neural integration: Diverging, Converging, and Reverberating circuits.	2 hours
	Chemical and electrical synapses and their transmission	4 hours

	physiology. Axonal impulse conduction-excitatory and inhibitory synaptic transmission.	
	Neurotransmitters, Neuropeptides, and receptors.	2 hours
	Steps involved in synthesizing, transporting, and releasing neurotransmitters and neuropeptides.	2 hours
	Synthesis and release of Acetylcholine, Glutamate, GABA, Dopamine, Norepinephrine, and Epinephrine, Serotonin, Nitric oxide.	5 hours
	Module 3 Learning and Memory types and its Neural and Cellular basis in Aplysia, Drosophila, Honey bee, and Humans.	4 hours
	Neurophysiology of Avian song/ call formation.	4 hours
	Cognition and its major domains. Mechanoreception, Photoreception, Chemoreception.	2 hours
	Neurophysiology of balance and posture.	3 hours
	Neurophysiology of sleep.	2 hours
Pedagogy:	Lectures/ Presentations/ Assignments/ Self-study/ Discussion	
References/ Readings:	1. B. Scott, G. Siegel, R. W. Albers, and D. L. Price, Eds., Basic Neurochemistry: Principles of Molecular, Cellular, and Medical Neurobiology. Academic Press, 2011. 2. C. Hammond, Cellular and Molecular Neurophysiology. Academic Press, 2008. 3. R. Carpenter and B. Reddi, Neurophysiology: A Conceptual Approach, Hodder and Arnold. UK, 2012. 4. D. Purves, G. J. Augustine, D. Fitzpatrick, L. C. Kartz, A. S. LaMantia, J. O. McNamara and S. M. Wiliams, Eds., Neuroscience. Oxford University Press, 2018. 5. R. Menzel and P. Benjamin, Eds., Invertebrate Learning and Memory, Academic Press, 2013. 6. D. Poeppel, G. Mangun and M. S. Gazzaniga, Eds., The Cognitive Neurosciences. A Bradford Book the MIT Press Cambridge,	

	Massachusetts London, England, 2009.
Course Outcomes:	The learner will 1. Appraise and justify the importance of the molecular setup of the nervous system cells to bring about neurotransmission. 2. To predict and justify the neurophysiological changes during pathological alterations in neuronal functioning. 3. To elaborate on the understanding of neurophysiological aspects of learning and memory. 4. To elaborate on the functional aspects of sleep, sensation, and balance.

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO-601 **Title of the Course:** Neurophysiology (Practical)

Number of Credits: 01

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic working knowledge of the Nervous system. Parallel enrolment for the courses ZOO-601 Neurophysiology (Theory)	
Course Objectives:	1. To evaluate the biochemical techniques for brain homogenates. 2. To establish the *in vitro* primary cell culture techniques for brain tissue. 3. To perform and evaluate the learning, memory, and sensory-motor function of human subjects.	
Content:	Estimation of Glutamate and GABA from brain tissue (Chicken head) either by Spectrophotometric/ Chromatographic/ Fluro-spectrophotometric methods. Primary culture of neurons from the chicken brain. Primary culture of neurons from Chick embryo brain Numerical and pictorial memory analysis using a memory drum. Learning and short-term memory formation analysis in human subjects. Pressure phosphene, Balancing analysis using human subject. Visual test analysis for photoreception in human subjects	15 x 2 hours
Pedagogy:	Mini Projects, Group activities, Demonstrations	
References/ Readings:	1. T. R. Raju, B. M. Kutty, T. N. Sathyaprabha, B. S. Shankarnarayana Rao, Eds., Brain and Behaviour. National Institute of Mental Health and neurosciences, Bangalore, 2004. 2. K. D. Pagana, T. J. Pragana and T. N. Pagana, Eds., Mosby's Manual of Diagnostic and Laboratory Tests. Mosby, 2021. 3. F. T. Fischbach and M. A. Fischbach. Fischbach's Manual of Laboratory and Diagnostic Tests. LWW, 2017. 4. F. T. Fischbach and M. B. Dunning, A Manual of Laboratory and Diagnostic Tests. (Lippincott Williams & Wilkins, 2015. 5. C. B. Morrow, Nurse's Manual of Laboratory and Diagnostic Tests. F. A. Davis Company, 1999.	
Course Outcomes:	The learner will 1. Carry out biochemical analysis of nervous tissue. 2. Develop the *in vitro* neuronal culture system to study neurological experimental parameters. 3. Evaluate the learning and memory skills of a human subject.	

	4. Design an experimental setup to carry out neurophysiological experiments.

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Name of the Programme: M. Sc. Zoology
Course Code: ZOO–602 **Title of the Course:** Animal Cell Culture (Theory)
Number of Credits: 01
Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge of anatomy, organization of cells, structures and functions of cell in animal body	
Course Objectives:	1. To provide theoretical knowledge on the basics of animal cell culture 2. T analyze the laboratory layout, sterile handling and requisites for animal cell culture 3. To assess the techniques involved in cell culture, maintenance and characterization 4. To analyze advantages of animal cells and specifically stem cells in various applications	
Content:	**Module 1** Basics of animal cell culture, Laboratory layout and sterile handling, Equipments, Chemicals and other requisites for animal cell culture, safety during Animal cell culture. Primary cell culture (Explant and free cell culture), subculture and cell line. Maintenance of cell culture, characterization of cultured cells, Advantages of Animal cell culture, Stem cells (Embryonic and Adult) and their applications.	15 hours
Pedagogy:	Lectures/tutorials/self-study/videos/presentations/mini projects/Group activities	
References/ Readings:	1. R. I. Freshney, Culture of animal cells: a manual of basic technique and specialized applications. John Wiley & Sons, 2015. 2. R. Lanza, J. Gearhart, B. Hogan, D. Melton, R. Pedersen, E. D. Thomas, and J.A. Thomson, Essentials of stem cell biology, Elsevier, 2005. 3. J. Masters Animal cell culture: a practical approach (Vol. 232). OUP Oxford, 2000. 4. A. A. Boulton, G. B. Baker, and W. Walz, Practical cell culture techniques (Vol. 23). Totowa, New Jersey: Humana Press, 1992.	
Course Outcomes:	The learner will 1. Explain the basis of animal cell culture 2. Defend the laboratory layout 3. Design the sterile handling techniques 4. Prioritize the cell culture isolation and maintenance technique as per requisition. 5. Value the advantages of cell culture in therapeutic applications	

Name of the Programme: M. Sc. Zoology

Course Code: ZOO–603 **Title of the Course:** Animal Cell culture (Practical)

Number of Credits: 03

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge of anatomy, cell biology and laboratory setup	
Course Objectives:	1. To provide aseptic environment for cell culture 2. To defend the sterilization techniques 3. To design the isolation techniques based on cell types to attain successful cell culture 4. To improvise the isolation and characterization techniques based on the hands on experience gained during the course	
Content:	**Module 1** Sterilization of Animal cell culture/Tissue culture Room Preparation of Laminar Flow hood for cell culture Sterilization techniques: Steam & Hot Air Preparation and sterilization of medias and buffers **Module 2** Isolation and inoculation of gill cells from bivalves by mechanical (trituration) dissociation Isolation of mantle cells from bivalves by explant culture method Isolation of siphon cells from bivalves by enzymatic (Trypsinization) dissociation Isolation and culture of cells from hepatopancreas of prawns/crabs Isolation and primary culture of hepatocytes from fish **Module 3** Primary cultures of fibroblast from chick embryo. Isolation and maintenance of chicken embryonic stem cell from blastoderm. Isolation and culture of chicken cartilage Stem/Progenitor cells. Isolation and inoculation of mesenchymal stem cells from chicken compact bones.	15 x 2 hours 15 x 2 hours 15 x 2 hours

	Isolation and culture of dermis-derived mesenchymal Stem/Progenitor cells from chick embryo.	
Pedagogy:	Practicals/tutorials/self-study/videos//mini projects/Group activities	
References/ Readings:	1. A. A. Boulton, G. B. Baker and W. Walz Practical cell culture techniques (Vol. 23). Totowa, New Jersey: Humana Press, 1992. 2. R. I. Freshney, Culture of animal cells: a manual of basic technique and specialized applications. John Wiley & Sons, 2015. 3. R. Lanza, J. Gearhart, B. Hogan D. Melton, R. Pedersen, E. D. Thomas, and J. A. Thomson, Essentials of stem cell biology, Elsevier, 2005. 4. J. Masters, Animal cell culture: a practical approach (Vol. 232). OUP Oxford, 2000. 5. J. Mitsuhashi, Invertebrate tissue culture methods. Springer science & business media, 2002.	
Course Outcomes:	The Learner will 1. Use sterile techniques and sterile environment for cell culture 2. Choose the isolation techniques best suited for any particular cell culture 3. Compare the isolation techniques 4. Modify the isolation and maintenance as per the need of the cells for better growth and proliferation of cell culture	

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO–604 **Title of the Course:** Toxicology (Theory)

Number of Credits: 03

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge on Chemistry, Anatomy, Physiology and Ecology.	
Course Objectives:	1. To determine the toxicity of substances, their routes of exposure and fate in the body and the environment 2. To classify the different types of toxicants based on their modes of action 3. To outline the significance of toxicological studies in forensic sciences	
Content:	**Module 1** Introduction to toxicology: Definition and Scope, History of Toxicology, Branches of Toxicology. Classification of Toxicants (based on 1] Source, 2] Use, 3] Target organ 4] Reactivity). Toxicokinetics: Definitions and concepts of Exposure, Dose and response. Metabolism of toxicants (Phase I and Phase II reactions), Absorption, Distribution, Biotransformation and Elimination of Toxicants (Renal Elimination, Hepatic Elimination, Respiratory Elimination), Toxic actions /mechanism (Acute, Sub-chronic & Chronic). Toxicokinetic models (Descriptive and Physiological Models). **Module 2** Environmental Toxicity: Environmental contaminants, Dilution paradigm and Boomerang paradigm, Ways of poisoning food chain, Environmental persistence. Pollution: Air pollution, Noise pollution, water pollution and thermal pollution: types and sources, effects of pollutants on human health. Solid waste pollution: sources and effects of solid waste toxicity on human health. Pesticide and Heavy metal toxicity: effects of pesticides and heavy metals on ecosystem, mechanism of pesticides toxicity, heavy metal toxicity and their effects on human health. Zootoxins, phytotoxins and bacteriotoxins **Module 3**	15 hours 15 hours 15 hours

	Forensic toxicology: Disciplines of Forensic toxicology (Definition of poisons, Forensic classification of poison, factors affecting the mode of action of poisons, extraction and isolation of poisons from biological samples. Drugs included in routine post-mortem toxicology, Forensic DNA typing system. Applications of forensic toxicology Alkaloid toxicity: definition, classification and isolation of alkaloids from biological samples, general properties of toxic alkaloids. Food poisoning- definition and common sources. Analysis of food products for adulterants by physical, chemical and instrumental techniques.	
Pedagogy:	Lectures/Tutorials/Videos/Assignments/Group discussion/Self-study.	
References/ Readings:	1. J. Timbrell, Introduction to Toxicology, 3rd ed. Taylor and Francis Inc., 2002. 2. C. Klaassen, J. Watkins, Casarett & Doull's Essentials of Toxicology, 3rd ed. McGraw-Hill Education publication, 2015. 3. K. Stine, T.M. Brown, Principles of Toxicology. 3rd ed. CRC Press, 2015. 4. A.H. Wallace, Principles and Methods of Toxicology. 5th ed. USA: Informa Healthcare Publication, 2007. 5. T. Kwong, B. Magnani, T. Rosano, L. Shaw. The Clinical Toxicology Laboratory: Contemporary Practice of Poisoning Evaluation, 2nd ed. AACC Press, 2013. 6. G. Pandey, Y.P. Sahani. Toxicological Laboratory Manual. India: International E-Publication, 2013. 7. B. Levine, Principles of Forensic Toxicology, 2nd ed. Amer Assn for Clinical Chemistry Press, 2007. 8. E. Hodgson, A Textbook of Modern Toxicology, 4th ed. Wiley Publication, 2010. 9. M. Durrant, Handbook of Clinical Toxicology. Hayle Medical Publishers, 2019.	
Course Outcomes:	The learner will 1. List the routes of exposure and fates of toxic substances in the body and environment 2. Categorize the sources and effects of various toxicants 3. Assess the risk of toxicants in the environment 4. Establish the importance of medico-legal aspects of toxicology	

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO–605 **Title of the Course:** Toxicology (Practical)

Number of Credits: 01

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge on Chemistry, Anatomy, Physiology and Ecology.	
Course Objectives:	To identify different toxic substances from samples To determine the toxicity of various toxic substances	
Content:	Detection of heavy metals in water samples Detection of additives in food items Detection of microplastics in water samples Determination of LD50 from given data using Probit analysis. Effect of heavy metal pollution physiological process in crabs/fishes Estimation of oxidative damage in organisms exposed to pollutants Understanding the classes of drugs and their modes of action	15x2 hours
Pedagogy:	Lectures/Tutorials/Videos/Assignments/Group discussion/Self-study.	
References/ Readings:	1. J. Timbrell, Introduction to Toxicology, 3rd ed. Taylor and Francis Inc., 2002. 2. C. Klaassen, J. Watkins, Casarett & Doull's Essentials of Toxicology, 3rd ed. McGraw-Hill Education publication, 2015. 3. K. Stine, T.M. Brown, Principles of Toxicology. 3rd ed. CRC Press, 2015. 4. A.H. Wallace, Principles and Methods of Toxicology. 5th ed. USA: Informa Healthcare Publication, 2007. 5. T. Kwong, B. Magnani, T. Rosano, L. Shaw. The Clinical Toxicology Laboratory: Contemporary Practice of Poisoning Evaluation, 2nd ed. AACC Press, 2013. 6. G. Pandey, Y.P. Sahani. Toxicological Laboratory Manual. India: International E-Publication, 2013. 7. B. Levine, Principles of Forensic Toxicology, 2nd ed. Amer Assn for Clinical Chemistry Press, 2007. 8. E. Hodgson, A Textbook of Modern Toxicology, 4th ed. Wiley Publication, 2010. 9. M. Durrant, Handbook of Clinical Toxicology. Hayle Medical Publishers, 2019.	
Course	The learner will	

Outcomes:	Assess the risk of toxicants in the environment Develop protocols for analysing toxic substances in the environment Predict the toxicity of substances by experimentation Interpret the results of toxicity tests

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO–606 **Title of the Course:** Herpetology (Theory)

Number of Credits: 03

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge on herpetofauna its identification at taxonomic level and the systematics Parallel enrollment for ZOO-608 Herpetology (Practicals)	
Course Objectives:	1. To appraise the diversity and biology of reptiles and amphibians 2. To identify the distinguishing characters of representative herpetofauna 3. To explain the ecology and distribution of herpetofauna	
Content:	**Module 1** Introduction to herpetology: shared characteristics of Amphibians and Reptiles, significance of studying Amphibians and Reptiles, the diversity of Amphibians and Reptiles. Thermal Ecology: Heat Exchange in the environment (Absorption of radiant energy, radiative loss, conduction, convention, evaporative cooling, role of body size and shape in heat exchange), Response to environmental temperatures (Basking, Perching, Breezing, Postural changes, Shade seeking and shuttling, Burrowing, Dial patterns of response to temperature), Costs and benefits of Ectothermy and Endothermy. Water relations in amphibians and reptiles, Aestivation, Hibernation and other Eco physiological adaptations in reptiles and amphibians **Module 2** Factors affecting distribution and abundance of amphibians and reptiles, Biogeography of Amphibians and reptiles, Communication in Amphibians and reptiles, Diet and foraging behaviour, Parental care in Amphibians and Reptiles, The Ecology and Behaviour of Amphibian Larvae, the niche (niche theory, interspecific competition, niche overlap and resource partitioning, factors influencing resource partitioning). **Module 3**	15 hours 15 hours 15 hours

	Systematics and diversity of extant Amphibian & Reptiles: life history, skin, reproduction, sensory systems. Taxonomy, morphology, reproduction, life history & fossil Records (Caudata, Anura & Gymnophiona), Taxonomy, Morphology, Reproduction, Life History & Fossil Records (Squamata, Testudines, Crocodilia, Sphenodontia)	
Pedagogy:	Lectures/Tutorials/Videos/Assignments/Group discussion/Self-study/ Presentations	
References/ Readings:	1. K.R. Porter, Herpetology. Philadelphia: W. B. Saunders Co., 1972. 2. K. Adler, ed., Contributions to the History of Herpetology. Society for the Study of Amphibians and Reptiles, 2007. 3. D.R. Khanna, and P.R. Yadav, Biology of Reptiles. India: Discovery Publishing Pvt. Ltd, 2004. 4. H.S. Bhamrah, and Kavita Juneja, An Introduction to Reptiles. Anmol Publications Pvt. Ltd, 2002. 5. T.S.N. Murthy, The Reptile Fauna of India. B.R. Publishing Corporation, 2010. 6. T.S.N. Murthy, A Pocket Book on Indian Reptiles Crocodiles, Testudines, Lizards and Snakes. Nature Books India, 2009. 7. J. C. Daniel, The book of Indian Reptiles and Amphibians (BNHS). Oxford, 2002. 8. R. Whitaker, and A. Captain, Snakes of India, The Field Guide. Draco Books, 2008. 9. M.A. Smith, The Fauna of British India, Ceylon and Burma, Reptilia and Amphibia, VOL III – Serpentes. Today & Tomorrow's Printers & Publishers, 1981. 10. M.A. Smith, The Fauna of British India, Ceylon and Burma, Reptilia and Amphibia, VOL II – Sauria. Ralph Curtis Books, 1973.	
Course Outcomes:	The learner will 1. Identify and classify different species of amphibians and reptiles 2. Outline the structures and functions of different amphibian and reptilian systems 3. Deduce the evolutionary history of herpetofauna based on phylogenetic analysis 4. Formulate strategies for conservation of threated herpetofauna	

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO–607 **Title of the Course:** Herpetology (Practical)

Number of Credits: 01

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge on herpetofauna its identification at taxonomic level and the systematics Parallel enrollment for ZOO-607 Herpetology (Theory)	
Course Objectives:	1. To appraise the diversity and biology of reptiles and amphibians 2. To know the distinguishing characters of representative herpetofauna 3. To learn the handling techniques of herpetofauna	
Content:	The identification of the amphibian families through basic external anatomy The identification of the reptile families through basic external anatomy Identification of reptiles through scale count Learning handling techniques of Amphibians and Reptiles Beta diversity of herpetofauna in the Goa University campus Identification of venomous and non-venomous snakes	15 x 2 hours
Pedagogy:	Practical/Tutorials/Videos/Assignments/Group discussion/Self-study/ Presentations	
References/ Readings:	1. K.R. Porter, Herpetology. Philadelphia: W. B. Saunders Co., 1972. 2. K. Adler, ed., Contributions to the History of Herpetology. Society for the Study of Amphibians and Reptiles, 2007. 3. D.R. Khanna, and P.R. Yadav, Biology of Reptiles. India: Discovery Publishing Pvt. Ltd, 2004. 4. H.S. Bhamrah, and Kavita Juneja, An Introduction to Reptiles. Anmol Publications Pvt. Ltd, 2002. 5. T.S.N. Murthy, The Reptile Fauna of India. B.R. Publishing Corporation, 2010. 6. T.S.N. Murthy, A Pocket Book on Indian Reptiles Crocodiles, Testudines, Lizards and Snakes. Nature Books India, 2009. 7. J. C. Daniel, The book of Indian Reptiles and Amphibians (BNHS). Oxford, 2002. 8. R. Whitaker, and A. Captain, Snakes of India, The Field Guide. Draco Books, 2008. 9. M.A. Smith, The Fauna of British India, Ceylon and Burma, Reptilia and Amphibia, VOL III – Serpentes. Today & Tomorrow's Printers & Publishers, 1981.	

	10. M.A. Smith, The Fauna of British India, Ceylon and Burma, Reptilia and Amphibia, VOL II – Sauria. Ralph Curtis Books, 1973.
Course Outcomes:	The learner will 1. Efficiently handle amphibians and reptiles 2. Identify and classify different species of amphibians and reptiles 3. Calculate the diversity indices of herpetofauna in any given area 4. Outline the structures and functions of different amphibian and reptilian systems

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO-608 **Title of the Course**: Ornithology (Theory)

Number of Credits: 03

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge on birds and their identification at taxonomic level and the systematics Parallel enrollment for ZOO-610 Ornithology (Practicals)	
Course Objectives:	1. To develop major concepts in ornithology, including avian origin, evolution, systematics, distribution, flight adaptations, and physiology. 2. To review ecology of birds with respect to their feeding, breeding, roosting and migration. 3. To explain methodology in ornithology 4. To provide knowledge on advances in applied ornithology 5. To review the recent research work in the field of ornithology	
Content:	**Module 1** Avian origin, evolution, systematics, distribution, flight adaptations and physiology: Evolution- Diversification of modern birds – Adaptive radiation & speciation in birds. Flightless birds and adaptations Topography of bird, types of beaks, types of feet, types of feathers, types of pigments, visual functions of plumage, flight: forms, mechanisms & energetics Avian systematics - avian classification, diversity and distribution of birds of India. Endemism in Indian avifauna – Endemic Bird Areas of India. Flight Adaptations - morphological, anatomical and physiological. Physiology- vocal organ and vocalization, Neurophysiology of song control system, Analysis of bird song using Acoustic spectroscopy, colour physiology of iridescent and non- iridescent feathers and gloss production; Thermoregulatory mechanisms; avian eye and its adaptations Biology of moulting in birds (periodic and forced moulting). **Module 2** Avian Ecology: Avian food and foraging - diversity of foods	15 hours 15 hours

	and foraging behaviors, feeding specialization and generalization, resource partitioning, colonial behaviour, cooperation, competition and conflicts. Breeding- nesting territories, communal nesting, bird songs, courtship, mating systems, types of nests, clutch size, parental care, nest parasitism. Migration - types of migration, flyways of migrations, physiological aspects of migration, orientation & navigation in migratory birds, threats to migratory bird populations. Roosting behaviour **Module 3** Applied ornithology: Importance of bird population monitoring; census techniques - applications, assumptions & limitations; methods: Line transects, point counts, fixed and variable width and call counts. Bird Banding- Principles of mist-netting; types of marking birds: rings/bands, flags, tags, dyes, and natural markers – Radio-tracking of birds & satellite telemetry. - Conservation of threatened avifauna - Captive breeding & ex-situ conservation of critically endangered birds - Birds as indicators of environmental health – Merits and limitations of birds as ecological indicators, Birds as model systems in applied genetic studies. -Birds as pests in agriculture, pisciculture, apiculture, sericulture, and free-ranging poultry farms – Role of birds in the dispersal of weeds, parasitic, and invasive plants – Birds as vectors of pathogens and parasites – Zoonoses. – Bird strike hazards to aircraft & their management, - Birdwatching as an emerging eco-tourism venture - Biomimicry & birds – Aerodynamic studies, bionic bird, bullet train inspired by Kingfisher. -Recent research in the field of ornithology.	15 hours
Pedagogy:	Use of conventional, online and ICT Methods. Field visit/project/self-study/Lecture/Tutorials/Assignments	
References/	1. S. Ali, The Book of Indian Birds. India, Bombay Natural History Society	

Readings:	and 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. J. Faborg and S. B. Chaplin, Ornithology: an Ecological Approach. New Jersey, Prentice Hall Inc. 1988. 5. F. B. Gill, Ornithology. (3rd ed.) New York, NY. W. H. Freeman and Company, 2007 6. P. Goodfellow, Birds as Builders. New York, Arco Publishing Co., 1977 7. J. Lovette and J. W. Fitzpatrick, Handbook of Bird biology (3rd Ed) Wiley publishers. 2016 8. C Inskipp, R Grimmett and T Inskipp, Birds of the Indian Subcontinent, Princeton University Press2011. 9. D.B. Meyer, The Avian Eye and its Adaptations. In: Crescitelli F. (eds) The Visual System in Vertebrates. Handbook of Sensory Physiology, (vol 7 / 5). Berlin, Heidelberg Springer,. 1977 10. P. D. Sturkie, Sturkie's Avian Physiology. 5th Edition. San Diego, Academic Press, 1998.
Course Outcomes:	The learner will 1. Identify the birds on the field and be familiar with the methods for bird studies. 2. Analyze various aspects of avian biology such as evolution, taxonomy, anatomy, and physiology. 3. Review ecology of birds with respect to their feeding, breeding, roosting and migration. 4. Comment on applied ornithology 5. Reflect on recent research in the field

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO-609 **Title of the Course**: Ornithology (Practical)

Number of Credits: 01

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge on birds and their identification at taxonomic level and the systematics Parallel enrollment for ZOO-609 Ornithology (Theory)	
Course Objectives:	1. To develop on-field bird identification skills 2. To provide knowledge on statistical analysis of data using software	
Content:	Identification of birds on the field, based on colour, size, flight, and call. Comparative study of resident and migratory birds with respect to habitats (Plateau, Forest and Wetland). Analysis of ornithological data using statistical software. Study of nesting behaviour of Baya Weaver. Acoustic analysis of bird calls and songs. Structural and functional analysis of avian feathers. Anatomy of bird (poultry chicken): flight muscles, digestive system, respiratory system, urinogenital system, skeletal system, and brain.	15 x 2 hours
Pedagogy:	Use of conventional, online and ICT Methods. Field visit/project/self-study/Lecture/Tutorials/Assignments	
References/ Readings:	1. S. Ali, The Book of Indian Birds. India, Bombay Natural History Society and 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. J. Faborg and S. B. Chaplin, Ornithology: an Ecological Approach. New Jersey, Prentice Hall Inc. 1988. 5. F. B. Gill, Ornithology. (3rd ed.) New York, NY. W. H. Freeman and Company, 2007 6. P. Goodfellow, Birds as Builders. New York, Arco Publishing Co., 1977 7. A. J. Lovette and J. W. Fitzpatrick, Handbook of Bird biology (3rd Ed) Wiley publishers. 2016 8. C Inskipp, R Grimmett and T Inskipp, Birds of the Indian Subcontinent, Princeton University Press2011.	

	9. D.B. Meyer, The Avian Eye and its Adaptations. In: Crescitelli F. (eds) The Visual System in Vertebrates. Handbook of Sensory Physiology, (vol 7 / 5). Berlin, Heidelberg Springer,. 1977 10. P. D. Sturkie, Sturkie's Avian Physiology. 5th Edition. San Diego, Academic Press, 1998.
Course Outcomes:	The learner will 1. Identify the birds on the field and be familiar with the methods for bird studies. 2. Analyze various aspects of avian biology such as evolution, taxonomy, anatomy, and physiology. 3. Review ecology of birds with respect to their feeding, breeding, roosting and migration. 4. Comment on applied ornithology 5. Reflect on recent research in the field.

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO-610 **Title of the Course:** Mammalogy (Theory)

Number of Credits: 03

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge on mammals and their identification at taxonomic level and the systematics Parallel enrollment for ZOO-612 Mammology (Practicals)	
Course Objectives:	1. To develop major concepts in Mammalogy, including evolution, systematics, and biogeography. 2. To review the ecological perspective and adaptation ecology. 3. To provide knowledge on field techniques to identify and study mammals. 4. To comment on keystone species and mammalian conservation	
Content:	**Module 1** Significance of study on mammals. Mammalian characteristics Evolution, systematics, Molecular technique in mammalian phylogeny Biogeography, morphology, anatomy and physiology of mammals. **Module 2** Foraging behaviour, Activity rhythm, communication Mammalian reproduction: an ecological perspective, mating systems, cooperative breeding, parental care Social organization, territoriality, communities, migration Adaptation: hibernation, torpor, aestivation, locomotion and water regulation of mammals; Adaptations in mammals based on habits and habitat: aquatic, desert, polar, fossorial, cursorial, arboreal, flying and gliding Echolocation in bats, biosonar in cetaceans **Module 3** Field techniques to study mammals, indirect methods of identifying mammals. Mammals as indicators of ecosystem, mammals as indicators of trace elements, mammalian keystone species and their	15 hours 15 hours 15 hours

	significance in different ecosystems Management of mammals in zoological parks, captive breeding of threatened mammals, mammalian conservation ethics	
Pedagogy:	Practical/Tutorials/Videos/Assignments/Group discussion/Self-study/ Presentations	
References/ Readings:	1. T. Clutton-Brock, Structure and function in mammalian societies. 364(1533), 3229–3242. Philosophical transactions of the Royal Society of London. Series B, Biological sciences, 2009. https://doi.org/10.1098/rstb.2009.0120 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2781877/ 2. A. F. George, F. M. Joseph, C D Lee, H. V. Stephen, Mammalogy - Adaptation, Diversity, Ecology. Johns Hopkins University Press, 2007. 3. A. F. George, Mammalogy - Adaptation, Diversity, Ecology. Johns Hopkins University Press. 2020 4. T.A. Vaughan, J.M. Ryan, N. J. Czaplewski Mammology, USA, Jones and Barlett publisher, 2011 5. Mammalian reproduction: an ecological perspective, 1985. https://pubmed.ncbi.nlm.nih.gov/3882162/ - 6. Dieter Lukas, Tim Clutton-Brock, Cooperative breeding and monogamy in mammalian societies. Royal society publishing. 2012.	
Course Outcomes:	The learner will 1. Identify mammals using direct and indirect methods. 2. Explain various aspects of mammalogy such as evolution, systematics, and biogeography. 3. Reflect on adaptations and ecology. 4. Review keystone species and mammalian conservation.	

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO-611 **Title of the Course:** Mammalogy (Practical)

Number of Credits: 01

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge on mammals and their identification at taxonomic level and the systematics Parallel enrollment for ZOO-611 Mammology (Theory)	
Course Objectives:	1. To develop major concepts in Mammalogy, including evolution, systematics, and biogeography. 2. To review the ecological perspective and adaptation ecology. 3. To provide knowledge on field techniques to identify and study mammals. 4. To comment on keystone species and mammalian conservation	
Content:	Study of epidermal derivatives of mammals. Identification of hair of different mammals based on cuticular and medullary patterns. Comparative morphology of dentition. Comparative morphology of skull. Anatomy of rat (preserved specimen). Mapping distribution of primates, carnivores and ungulates in the given area. Field visit to identify mammals using direct/ indirect methods.	15 x 2 hours
Pedagogy:	Practical/Assignments/Group discussion/Presentations/ Field visit/project/self-study/Lecture/Tutorials/Assignments	
References/ Readings:	11. T. Clutton-Brock, Structure and function in mammalian societies. 364(1533), 3229–3242. Philosophical transactions of the Royal Society of London. Series B, Biological sciences, 2009. https://doi.org/10.1098/rstb.2009.0120 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2781877/ 12. A. F. George, F. M. Joseph, C D Lee, H. V. Stephen, Mammalogy - Adaptation, Diversity, Ecology. Johns Hopkins University Press, 2007. 13. A. F. George, Mammalogy - Adaptation, Diversity, Ecology. Johns Hopkins University Press. 2020 14. T.A. Vaughan, J.M. Ryan, N. J. Czaplewski Mammology, USA, Jones and Barlett publisher, 2011 15. Mammalian reproduction: an ecological perspective, 1985. https://pubmed.ncbi.nlm.nih.gov/3882162/ - 16. Dieter Lukas, Tim Clutton-Brock, Cooperative breeding and monogamy	

	in mammalian societies. Royal society publishing. 2012.
Course Outcomes:	The learner will 1. Identify mammals using direct and indirect methods. 2. Explain various aspects of mammalogy such as evolution, systematics, and biogeography. 3. Reflect on adaptations and ecology. 4. Review keystone species and mammalian conservation.

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Name of the Programme: **M.Sc. Zoology**

Course Code: ZOO-612 **Title of the Course:** Developments in Aquaculture (Theory)

Number of Credits: 03

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge of fish biology/aquatic biology and fish culture methods. Parallel enrollment for ZOO-614 Techniques in Aquaculture (Practical)	
Course Objectives:	1. To impart knowledge and scientific skills to understand the field of modern Aquaculture. 2. To provide an in-depth understanding of different forms of fish farming practices and aquaculture farm construction. 3. To inculcate detailed knowledge of fish nutrition, fish feed formulation and organic farming techniques. 4. To develop a comprehensive knowledge of various aquaculture diseases, parasite problems and preventive measures. 5. To empower learners to understand the recent trends and challenges of a fish-farming society and get confidence to work on different kinds of aquaculture practices.	
Content:	**Module 1** Review on the fundamentals of Aquaculture: Scope and principles of aquaculture, History of aquaculture, Importance of aquaculture: worldwide, Nationwide, and state-wide. Different sectors of Aquaculture and Types of culture practices: Monoculture, Mono-sex culture, Cage culture, Pen culture, composite culture and other techniques. Hatchery management: types of hatcheries, design, and construction, Pond management, and fertilization; pre-and post-stocking management. Water-quality criteria for Aquaculture. Aquafeed technology: Sources of food, Aquafeed Technology: Balanced diet, Feed formulation, Linear programming, Feed additives, Feed conversion ratio (FCR), Protein retention, and Calorie retention. Nutritional requirements at various stages of development of fish & crustaceans. **Module 2** Finfish and Shellfish farming: Freshwater and marine fish seed	15 hours

	resources in India. Gears and crafts are used for seed collection and fish collection. Concept of Bundh breeding (Advantages and Disadvantages) Maintenance and criteria for optimum conditions for Hatchery and nursery management (Brood stock collection and transportation, Life cycle, breeding behaviour, breeding season, and sexual maturity) of Indian Major Carps, Freshwater prawns, white-leg shrimp, Mud crab, edible oyster, Green mussels. Induced breeding technique in Carps and Salmonids. Advantages of GIFT (Genetically Improved Farmed Tilapia) in Aquaculture. Fish diseases and Integrated health management of the farm. **Module 3** Organic farming techniques: Integrated farming, Biofloc technology. Green aquaculture, Aquaponic system, Bioremediation, Biofiltration, Eco-labelling. Zero water exchange, and Reuse. Aquaculture Industries: Technology of Fish products and By-products, Environmental considerations: Impact of Climate Change on aquaculture, Mitigation, and adaptive strategies.	15 hours 15 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study/Presentation/classroom activities	
References/ Readings:	1. R. R. Stickney, Aquaculture-An introductory text, Alex Lainsburry, CABI South Asia Edition.2022. 2. FAO, The Stare of World Fisheries and Aquaculture,2020. Available: http://doi.org/10.4060/ca9229en 3. R.L. Naylor, R.W. Hardy, Buschmann, and A.H., Bush, “A 20-year retrospective review of global aquaculture”, Nature, 2021. 4. J.S. Lucas, Aquaculture: Farming aquatic animals and plants, John Wiley & Sons,2019. 5. “The state of world fisheries and aquaculture”, The sustainable development goals. FAO. License: CC BY-NC-SA 3.0 IGO.2020. 6. S. Ayyappan, Handbook of Fisheries and Aquaculture, ICAR Publications,	

	New Delhi, 2011. 7. T.V. Pillay, and M.N. Kutty, Aquaculture: Principles and practices (2nd Edition), Blackwell Publishing,2015. 8. D. Mills, Aquarium fishes, Dorling Kindersley Ltd, London,1998. 9. J.D. Jameson, and R. Santhanan, Manual of ornamental fishes and farming technologies, 1996. 10. N.K. Thakur, Culture of live food organisms for aqua hatcheries. Training manual. CIFE (ICAR), Mumbai,1998.
Course Outcomes:	The learner will 1. Conclude the importance of aquaculture in the country. 2. Assess the basis of technologies of fisheries and aquaculture to understand the principles, their importance, purpose and application. 3. Construct methods and techniques for hatchery/pond construction, their management methods and quality assurance principles. 4. Appraise advanced techniques in aquaculture concerning inducing breeding in fish, fish feed preparation, and fish disease prevention 5. Analyze and evaluate the effects of fisheries and aquaculture on the environment, to provide preventive safety measures. 6. Develop the ability to research in the field of fish biology, fisheries and aquaculture.

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Name of the Programme: **M.Sc. Zoology**

Course Code: ZOO-613 **Title of the Course:** Techniques in Aquaculture (Practical)

Number of Credits: 01

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge of fish biology, fish handling and fish culture methods. Parallel enrollment for ZOO-613 Developments in Aquaculture (Theory)	
Course Objectives:	1. To provide practical knowledge of advanced methods and techniques used in aquaculture and fisheries. 2. To create skills in induce breeding, fish feed formulations and different organic farming techniques. 3. Develop in-depth knowledge of live fish feed culture. 4. To encourage to adapt skills for employment in the field of aquaculture and fisheries.	
Content:	Measurement of DO, total hardness, and Salinity of the water bodies Preparation of fish feed in the laboratory. Study of common fish diseases. Demonstration of Induced breeding of Indian major carps Demonstration of raft technique for mussel culture. Culture and maintenance of live fish feed (Artemia, algae) Demonstration of a small-scale aquaponics system. Observations of gonadal maturation in fish. Detection of organoleptic changes in fish. Visit fish farms/ Fish breeding units/ Fish Processing industry.	15 x 2 hours
Pedagogy:	Mini projects/ tutorials/Group discussions/Field visits/ lab-based activities/Workshops	
References/ Readings:	1. J.B.Paul, Handbook of Fish Biology and Fisheries (Vol.1). Blackwell Publishing,2002 2. B.R. Selvamani and R.K. Mahadevan, Freshwater fish farming Campus Books International, 2008 3. D. Pauly, P. Tyedmers, R. Froese, and L. Y. Liu, ”Fishing down and farming up the food web”, Conservation Biology in Practice, Vol, 2 no.4, 2001. 4. Helfman, B. Bruce, E. Douglas, and B.W. Bowen, The Diversity of Fishes: Biology, Evolution, and Ecology, Wiley-Blackwell,2009. 5. G. Cailliet, and Ebeling, Fishes, a field and laboratory manual on their structure, identification and natural history, Waveland Press, Ill,1986. 6. Pillay, Aquaculture Principles and Practices, John Willey, 2005.	

	7. N. Jain and P. Mishra, Practical Manual on Fish Nutrition and Feed Technology, Daya Publishing House, 2021.
Course Outcomes:	The learner will 1. Design ideas to construct and manage a fish farm/hatchery/fish pond. 2. Be skilled to formulate fish feed with in-depth knowledge of its components. 3. Construct small-scale aquaponics and bio floc unit set-up. 4. Create logical knowledge in fish breeding, rearing, culturing and feeding technologies. 5. Develop the ability to guide layman individual who wishes to carry out various activities related to aquaculture. 6. Compose strategies for aquaculture business management and will be able to research in the field of fish biology for more outcomes in aquaculture.

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO-621 **Title of the Course:** Immunology

Number of Credits: 02

Effective from AY: 2023-24

Pre-requisites for the Course:	Fundamental knowledge of Cell biology	
Course Objectives:	1. To explain advanced mechanisms of immunity. 2. To explicate the scope and importance of clinical immunology. 3. To impart a conceptual understanding of the functional organization of the immune system and its responsiveness to health and disease	
Content:	**Module 1** An overview of immune system, Cells of immune system, Primary and secondary lymphoid organs and their role in immunity. Concept of innate and acquired- types, functional features. Concept of Antigens, Immunogen, antigenicity and immunogenicity**,** Adjuvants (definition, types and applications). Antibody structure and types. Generation of antibody diversity. **Module 2** Cellular Immune System**-**Lymphocytes: Development, types, morphology, clones / sub-populations, distribution, B and T cell receptors, B and T cell epitopes, Toll-like receptors. Antigen-presenting cells: antigen processing and presentation, MHC molecules and their immunologic significance. Complement system Components, three major activation pathways,	5 hours 5 hours 5 hours 5 hours 5 hours 5 hours
Pedagogy:	Mini Projects, Group activities, Demonstrations	
References/ Readings:	1. T. J. Kindt, R.A. Goldbye, B.A. Osborne, Kuby's Immunology. W.H. Freeman Company, 2007. 2. C. A. Janeway, Immunobiology: The Immune System in Health and	

	Diseases. Garland Science, 2005. 3. P. Delves, S. Martin, D. Burton, I. Roitt, Roitt's Essential Immunology. Wiley-Blackwell, 2006. 4. A. K. Abbas, A. H. Lichtman, and S. Pillai, Cellular and Molecular Immunology. Elsevier, USA, 2008. 5. J. M. Willey, C. J. Woolverton, and L. M. Sherwood, Klein's Microbiology Publisher: McGraw-Hill, 2009.
Course Outcomes:	The learner will 1. Distinguish between various types of immune cells. 2. Predict the involvement of various immune mechanisms after infection. 3. Evaluate the progression of immunological processes after infection. 4. Validate and propose the immunological response after infection.

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO–622 **Title of the Course:** Biological Applications of Nanoparticles and Nanotoxicology

Number of Credits: 02

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge of chemistry, physics and biology	
Course Objectives:	1. To provide knowledge of nanoscience in biology. 2. To analyze interaction of nanoparticles with biological systems. 3. To assess the applications of nanoparticles in the various areas of biology 4. To reveal the toxicity of nanoparticles used in different applications. 5. To adopt preventive measures while handling nanoparticles	
Content:	**Module 1** Overview of nanoscience, Nanoparticles. Various types of nanoparticles, chemically and biologically synthesized nanoparticles, Characterization of nanoparticles, Biocompatibility, Importance of nanoparticles in biology: medicine, drug delivery, cancer therapy, tissue regeneration, prosthesis, Recent advances in nanoscience. **Module 2** Nanotoxicology, Sources of nanoparticles, Nanopollution, Routes of exposure in aquatic and terrestrial animals, Human exposure to nanosized materials. Effect of nanoparticles in cells and biological systems. Preventive measures during nanoparticle handling, Toxicity hazards and assessment of risk, mitigating strategies	15 hours 15 hours
Pedagogy:	Lectures/tutorials/self-study/videos/presentations/mini projects/Group activities	
References/ Readings:	1. H. E. Schaefer, Nanoscience: the science of the small in physics, engineering, chemistry, biology and medicine. Springer Science & Business Media, 2010. 2. N. A. Monteiro-Riviere and C. L. Tran, Nanotoxicology: characterization, dosing and health effects. CRC Press, 2007 3. P. Houdy, M. Lahmani and F. Marano, Nanoethics and nanotoxicology. Springer Science & Business Media, 2011. 4. S. C. Sahu and D. A. Casciano, Handbook of nanotoxicology,	

	nanomedicine and stem cell use in toxicology, John Wiley & Sons, 2014. 5. S. Lindsay, Introduction to nanoscience. Oxford University Press, 2010. 6. V. Zucolotto, Nanotoxicology: materials, methodologies, and assessments. Springer Science & Business Media 2013.
Course Outcomes:	The learner will 1. Apply knowledge of nanoscience in biology 2. Assess the nanoparticles interaction with different biological systems 3. Defend the applications of nanoparticles in various fields of biology 4. Elaborate on toxicity of Nanoparticles 5. Plan preventive measures while handling nanoparticles directly or indirectly.

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO-623 **Title of the Course:** Ecotoxicology

Number of Credits: 02

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge of Chemistry, Biology, Physiology and Ecology	
Course Objectives:	1. To outline the toxicity of substances, their routes of exposure and fate in the body and the environment 2. To classify the different types of toxicants based on their modes of action 3. To summarize the various tests involved in ecotoxicity testing	
Content:	**Module 1** Introduction to Ecotoxicology: Important concepts of ecotoxicology, Routes by which pollutants enter ecosystems; Major classes of pollutants (heavy metals, hydrocarbons, microplastics, etc), their sources and ecotoxicological effects. Effects of toxic substances and biomonitoring Acute and chronic toxicity, dose response, bioaccumulation, biomagnification, bioavailability, biodegradation; Toxicokinetics: Absorption, Distribution, Metabolism, Biotransformation and Elimination of Toxicants, Physiological and biochemical effects of toxic substances: Genotoxic, neurotoxic compounds, endocrine disruptors; Effects at the molecular level, cellular level, organism level (physiological, reproduction, behaviour) **Module 2** Ecotoxicity tests (lab-based and field tests) in air, water and soil, Use of model organisms for ecotoxicology: fish, helminthes, molluscs, mice, Environmental Risk Assessment Environmental bioindicators of ecotoxicity with faunistic studies Microbial Ecotoxicology: Interaction between microorganisms and pollutants; Role of microorganisms in detoxification and degradation of	15 hours 15 hours

	environmental pollutants Metagenomic techniques to study microbial diversity in polluted environment Biotechnology for mitigating environmental toxicity: Ameliorating nutrient toxicity (Nitrates and Phosphates), Handling sludge toxicity, Microbial and Phytoremediation (wetlands), Treatment of domestic wastewater using wetlands – a case study.	
Pedagogy:	Lecture/ Group discussion/Presentations/ Field visit/project/self-study/Tutorials/Assignments	
References/ Readings:	1. C.H. Walker, R.M. Sibly, S.P. Hopkin, and D.B. Peakall, Principles of Ecotoxicology, 4th ed. CRC Press, Taylor and Francis, 2012. 2. S.E. Jorgensen, Ecotoxicology: A derivative of encyclopedia of ecology. Academic Press, 2010. 3. F. Moriarty, Ecotoxicology: The study of pollutants in ecosystems. 3rd ed. Academic Press, 1999. 4. D. Peakall, Animal Biomarkers as Pollution Indicators. Chapman and Hall, 2012. 5. W.A. Hayes, Principles and Methods of Toxicology. CRC Press, Taylor and Francis, 2014. 6. M.M. Naik, and S.K. Dubey, Marine pollution and Microbial remediation. Springer, 2017. 7. C. Cravo-Laureau, C. Cagnon, R. Duran, and B. Lauga, Microbial Ecotoxicology. Springer, 2017. 8. A. Scragg, A. Environmental Biotechnology. Oxford University Press, 2005. 9. J.M. Willey, L.M. Sherwood, and C.J. Woolverton, Prescott's Microbiology. 10th ed. McGraw-hill Education, 2017. 10. C. Munn, Marine Microbiology: Ecology and applications. 3rd edition. Garland science, 2020. 11. T. Satyanarayana, B. Johri, and T. Anil, Microorganisms in Environmental Management. Springer, 2012.	
Course Outcomes:	The learner will 1. Outline the routes of exposure and fates of toxic substances in the body and environment. 2. Categorize the sources and effects of various toxicants. 3. Assess the risk of toxicants in the environment. 4. Recommend solutions for mitigating toxicants in the environment.	

Name of the Programme: M. Sc. Zoology

Course Code: ZOO-624 **Title of the Course:** Butterfly Gardening

Number of Credits: 02

Effective from AY: 2023-24

Prerequisite for the Course:	Basic knowledge on Lepidoptera identification	
Objectives:	1. To introduce the learners to the diversity and biology of Lepidopterans 2. To create an importance of conservation of species of butterflies and moths. 3. To Identify host and nectar plant 4. To provide skill to develop butterfly gardens for conserving rear/endemic species.	
Content:	**Module 1** Introduction: Understanding a butterfly (life cycle, the body, Butterfly behaviours, courtship, temperature control, roosting, mud puddling, migration, overwintering, long distance flights, dangers to caterpillars and chrysalides, dangers to adults, methods of protection) Importance of butterfly gardening, conservation perspective of butterfly gardening, procedure for rearing caterpillars. Demonstration and identification of available species in a particular niche. **Module 2** Creating a butterfly garden, site selection (Understanding plant terminology, larval food plants, nectar plants (native, non-native, cultivated), preparing mud puddling, flower visitation, nectar, fragrance, flower shape, other attractants, basking, hibernation), butterfly rearing chamber. Feeding caterpillars. Planting plan (Know your area, decision time, choosing plants, preparing beds, soil, water, mulch, using native plants, planting native seeds, native grass lawn, adopt a weed, seed and plant sources, landscape plans)	15 hours 15 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study/ Mini projects/	

Learning Outcome:	The learner will 1. Gain knowledge about the Diversity, Habitat-Ecology, Behavior, Adaptation of butterfly. 2. Identify local species of butterflies 3. Acquire skills to maintain plants that attract butterflies. 4. Develop and maintain butterfly gardens
References/ Reading	1. J. Hurwitz, Butterfly Gardening. Princeton University Press, 2018. 2. G. Ajilvsgi, Butterfly Gardening for Texas, Texas A & M University Press, 2013 3. M. Bhakare, H. Ogale, A Guide to Butterflies of Western Ghats (India), Milind Bhakare, 2018 4. P. Rangnekar, A Photographic Guide to Butterflies of Goa, Broadway Publishing House, 2007. 5. I. Kehimkar, BNHS Field Guides Butterflies of India, BNHS, 2016 6. I. Kehimkar, The Book of Indian Butterflies, Bombay Natural History Society, Mumbai (India), Oxford, 2008.

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO-625 **Title of the Course:** Ecotourism (Theory)

Number of Credits: 01

Effective from AY: 2023-24

Pre-requisites for the Course:	Graduation in any discipline from a recognized University Parallel enrolment for ZOO-626 Ecotourism (Practical)	
Course Objectives:	1. To provide knowledge on ecotourism potential, resources, and management issues. 2. To develop skill of identification of flora and fauna	
Content:	**Module 1: Introduction of Ecotourism and Resources in India (Goa in particular)-** Definition, history, scope, characteristics and principles of ecotourism. Ecotourist, eco-sensitivity, ecocentrism, ethics of ecotourism, local participation benefits and conservation. Carrying capacity, resource management, Ecotourism impact assessment and management analysis. Safety measures on field and first aid. Flora and fauna of Wildlife Sanctuaries, Bird Sanctuaries, National Park, sacred grooves, mangroves, backwater, waterfalls, springs, beaches, hill stations, deserts, butterfly parks, spice plantations	15 hours
Pedagogy:	Use of conventional, online and ICT Methods. Field visit/Case study/ ecotourism project proposal/project/self-study/Lecture/Tutorials/Assignments	
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. D. A. Fennell, Ecotourism policy and planning. Wallingford, Oxon, UK, CABI Publishing, 2007 5. J. Hill, T. Gale, Ecotourism and Environmental sustainability Principles and practice, Aghgate ebook. 2009 6. A.J.S. Raju, A Textbook of Ecotourism Ecorestoration and Sustainable Development by Kolkata, New Central Book Agency (P) Ltd, 2007 7. R. Singh, Indian Ecotourism: Environmental Rules and Regulations, New Delhi, Kaniskha Publishers, 2003	

	8. J. Singh, Ecotourism, Wiley 2020 9. P.R. Trivedi, Encyclopaedia of the Ecotourism (Vol. 5): Future of Ecotourism, New Delhi Jnanada Prakashan, 2006. 10. S. Wearing, J. Neil , Ecotourism, impacts, potentials and possibilities 2nd edition Elsevier 2009.
Course Outcomes:	The learner will Review on Ecotourism 2. Identify ecotourism potential sites. 3. Assess ecoresources. 4. Identify flora and fauna

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO-626 **Title of the Course:** Ecotourism (Practical)

Number of Credits: 01

Effective from AY: 2023-24

Pre-requisites for the Course:	Graduation in any discipline from a recognized University Parallel enrolment for ZOO-625 Ecotourism (Theory)	
Course Objectives:	3. To provide knowledge on ecotourism potential, resources, and management issues. 4. To develop skill of identification of flora and fauna	
Content:	How to design: ecotourism websites, portals and documentaries. Visit to the ecotourism sites. Identification of the plants. Identification of butterflies and birds Demonstration of preventive and safety measures on the field. Handling of tools and instruments in the field (camera, binocular, spotscope, GPS, etc)	15 x 2 hours
Pedagogy:	Use of conventional, online and ICT Methods. Field visit/Case study/ ecotourism project proposal/project/self-study/Lecture/Tutorials/Assignments	
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. D. A. Fennell, Ecotourism policy and planning. Wallingford, Oxon, UK, CABI Publishing, 2007 5. J. Hill, T. Gale, Ecotourism and Environmental sustainability Principles and practice, Aghgate ebook. 2009 6. A.J.S. Raju, A Textbook of Ecotourism Ecorestoration and Sustainable Development by Kolkata, New Central Book Agency (P) Ltd, 2007 7. R. Singh, Indian Ecotourism: Environmental Rules and Regulations, New Delhi, Kaniskha Publishers, 2003 8. J. Singh, Ecotourism, Wiley 2020 9. P.R. Trivedi, Encyclopaedia of the Ecotourism (Vol. 5): Future of Ecotourism, New Delhi Jnanada Prakashan, 2006.	

	10. S. Wearing, J. Neil , Ecotourism, impacts, potentials and possibilities 2nd edition Elsevier 2009.
Course Outcomes:	The learner will 1. Review on Ecotourism 2. Identify ecotourism potential sites. 3. Assess ecoresources. 4. Identify flora and fauna

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO-627 **Title of the Course:** Introduction to Animal Biomimetics

Number of Credits: 02

Effective from AY: 2023-24

Pre-requisites for the Course:	Graduation in any discipline from a recognized University	
Course Objectives:	1. To introduce learners to Biomimetics 2. To develop a keen interest in observing mechanisms in the nature 3. To evoke their imagination to develop tools through biomimicking	
Content:	**Module 1** Introduction to biomimetics, Mimicking and Inspiration of Nature, Synthetic Life, Artificial Life, Artificial Intelligence. Nature as a Model for Structures and Tools: Constructing Structures from Cells. Biologically Inspired Mechanisms: Digging as the Gopher and the Crab, Inchworm Motors, Pumping Mechanisms, Controlled Adhesion, Biological Clock. Biologically Inspired Structures and Parts: Honeycomb as a Strong, Lightweight Structure, Hand Fan, Fishing Nets and Fins Defense and Attack Mechanisms in Biology: camouflage, body armor, Hooks, Pins, Sting, Syringe, Barb, and the Spear, Decoy Artificial organs Materials and Processes in Biology: Spider Web — Strong Fibers, Honeybee as a Multiple Materials Producer; Swallow as a Clay and Composite Materials Producer, Fluorescence Materials in Fireflies and Road Signs, Impact Sensitive Paint Mimicking Bruised Skin, Mimicking Sea Creatures with Controlled Stiffness Capability, Biology as a Source for Unique Properties and Intelligent Characteristics, Multifunctional Materials, Biomimetic Processes **Module 2** Bio-Sensors: Miniature Sensors in Biomimetic Robots, MEMS-Based Flow Detector Mimicking Hair Cells with Cilium, Collision Avoidance Using whiskers, Emulating Bats' Acoustic Sensor, Acoustic and Elastic Wave sensors, Fire Monitoring, Sense of Smell and Artificial Nose, Sense of Taste and	15 hours 15 hours

	Artificial Tongue. Robotics Emulating Biology: Artificial Muscles, Aerodynamic and Hydrodynamic Mobility, Social and Other Biological Behaviors. Interfacing Biology and Machines: Telepresence and Teleoperation Biomimetics of Muscle Design Mechanized Cognition: Language, sound, visual. Machine bodies and brains	
Pedagogy:	Use of conventional, online and ICT Methods. Field visit/Case study/ ecotourism project proposal/project/self-study/Lecture/Tutorials/Assignments	
References/ Readings:	1. R.M. Alexander, Principles of Animal Locomotion. Princeton University Press., 2003. 2. C.L. Breazeal, Designing Sociable Robots, Cambridge, Massachusetts: MIT Press, 2004. 3. S.B. Primrose, Biomimetics: Nature-Inspired Design and Innovation. Wiley-Blackwell, 2020. 4. J.F.V . Vincent, Chapter 3 ‘‘Stealing ideas from nature’’, Pellegrino S. Ed., in Deployable Structures, Vienna: Springer-Verlag, 2001. 5. Y. Bar-Cohen, Biomimetics: Biologically Inspired Technologies, New York: Taylor & Francis Group, 2005.	
Course Outcomes:	The learner will 1. Review on biomimetics 2. Reflect upon observing nature with keen interest 3. Hypothesize creating biomimicking tools.	

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO-628 **Title of the Course:** Evolutionary Biology

Number of Credits: 02

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic working knowledge of diversity, cell biology, genetics and classical evolutionary biology	
Course Objectives:	1. To develop concepts in evolutionary biology of animals and humans 2. To perceive different theories of evolution and their relevant applications 3. To examine the importance of populational genetics in influencing evolution	
Content:	**Module 1** Emergence of evolutionary thoughts, Creation and evolution, Evolutionary theories and evidences: Contributions of Lamarck, Darwin, Darwin-Wallace postulates, concepts of variation, adaptation, struggle, fitness and natural selection; Spontaneity of mutations; The evolutionary synthesis, limitations of Darwinism, Neo Darwinism. Origin of cells and unicellular evolution: Origin of basic biological molecules, Abiotic synthesis of organic monomers and polymers, Concept of Oparin and Haldane, Experiment of Miller (1953), The first cell, Evolution of prokaryotes, Origin of eukaryotic cells, Evolution of unicellular eukaryotes. Paleontology and Evolutionary History: Overview of evidences - Paleontological, Embryological,Comparative morphological, Anatomical, Genetics and Cytological, Molecular Biological evidences. The Evolutionary time scale: Eras, periods and epoch; Major events in the evolutionary time scale; Origins of unicellular and multi cellular organisms; Major groups of plants and animals; Stages in primate evolution including Homo, Human evolution. **Module 2** Population genetics: Populations, Gene pool, Gene frequency; Hardy- Weinberg Law; Evolutionary forces that affect the allelic frequencies: Mutation, Migration, Selection - Stabilizing	15 hours 15 hours

	selection, Directional selection, disruptive selection, Balancing selection, Frequency dependent selection, Density dependent selection, Group and kin selection, Selection coefficient, Selective value, Selection in natural Populations, Genetic drift, Nonrandom mating. Hybridization and speciation: Concept of species and models of speciation based on distribution sympatric, allopatric, stasipatric, genetic drift, genetic revolution, genetic transilience, Founder-flush theory, phylogenetic gradualism, punctuated equilibrium, hybridization, adaptive radiation, isolating mechanisms. Molecular Evolution: Molecular phylogeny, neutral theory, molecular clock.	
Pedagogy:	Use of conventional, online and ICT Methods. Field visit/Case study/ ecotourism project proposal/project/self-study/Lecture/Tutorials/Assignments	
References/ Readings:	1. D.J. Futuyma, Evolution, 3rd ed., New York: Sinauer Associates, 2006, 2. M. Ridley, Evolution, 3rd ed, New York: Wiley-Blackwell Publishers, 2003. 3. M.R. Rose, and L.D. Mueller, Evolution and Ecology of the Organism, New York: Prentice Hall, 2005. 4. N.H. Barton, D.E.G. Briggs, J.A. Eisen, A.E. Goldstein, N.H. Patel, Evolution, New York: Cold Spring Harbor Laboratory Press, 2007. 5. M.W. Strickberger, Evolution, Jones and Bartlett Publishers, Sudbury, 2013.	
Course Outcomes:	The learner will 1. Explain the logical sequence of events of animal and human evolution 2. Correlate the available evidences of evolutionary patterns 3. Integrate the concepts of populational genetics with evolution 4. Predict evolutionary trends in a population of animals	

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Name of the Programme: **M.Sc. Zoology**
Course Code: ZOO-629 **Title of the Course:** Ornamental Fish Management (Theory)
Number of Credits: 01
Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge of fish biology and diversity. Parallel enrolment for ZOO-630 Ornamental Fish Management (Practical)	
Course Objectives:	1. To explain the principles and importance of the ornamental fish industry in India. 2. To introduce the nature, scope and basic concept of aquarium science. 3. To build skills in understanding the biological features, feed and feeding habits, sexual dimorphism, diseases and transportation of ornamental fishes. 4. To inculcate knowledge of self-employment opportunities in ornamental fish culture and aquarium management.	
Content:	**Module 1** Diversity of ornamental fish. Major hotspots of ornamental fish- global and Indian perspective. Ornamental fish trade- global and Indian perspective. Preferred species in trade. Major ornamental fish species of India. Ornamental plants. Different varieties of exotic and indigenous ornamental fishes. Reproductive biology. Sexual dimorphism, mode of reproduction in ornamental fish. Commercial farming technologies Principles of a balanced aquarium. Indigenous ornamental fishes and their culture, propagation, and trade. Colouration and Pigmentation: category; types; formation; dietary, neuronal, hormonal control. Physiology of colour changes and their significance. Common aquarium diseases and their control. Feeding and nutrition of ornamental fishes: Nutritional requirements of aquarium fish. Live feed culture. Types of aquarium fish feed. Preparation of aquarium fish food. Packaging, transportation, and marketing of aquarium fishes.	15 hours

	Anaesthetics used in the trade. Problems in ornamental fish export. Applications of genetics and biotechnology for producing quality strains; Management practices of ornamental fish farms.	
Pedagogy:	Lectures/Tutorials/Videos/Assignments/Group discussion/Self-study/ Group activities	
References/ Readings:	1. S. Saha, Concept of Aquarium Fish Keeping (2nd Edition), Techno world Publisher,2022. 2. A. David, Encyclopaedia of Aquarium and Pond Fish, DK Publishing, Inc.,2005. 3. Datta, and Subhendu, Aquarium Water Quality Management, 2014. 4. M. Dick, L. Derek, Aquarium Fish Handbook, Quatro In., 2005. 5. S. Glen, M. Brian, Scott, N. Pronek, Encyclopaedia of Exotic Tropical Fishes for Freshwater Aquariums, TFH Publications, 2005. 6. H. Hieronimus, Guppies, Mollies, Platies: A Complete Pet Owner's Manual, Barron's Educational Series, Inc., 2009. 7. S. Spotte, Marine aquarium keeping. John Wiley and Sons, U.S.A.,1993.	
Course Outcomes:	The learner will 1. Acquire the knowledge of Identifying species and variety of ornamental fishes and know about their breeding biology. 2. Assess the fundamentals of the aquarium fish industry. 3. Apply the scope of the subject concerning entrepreneurship. 4. Develop comprehensive knowledge of fabrication and maintenance of both freshwater and marine water aquariums at home or outdoors. 5. Analyze common health problems with ornamental fishes and their treatment.	

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Name of the Programme: **M.Sc. Zoology**

Course Code: ZOO-630 **Title of the Course:** Ornamental Fish Management (Practical)

Number of Credits: 01

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge of fish biology and diversity. Parallel enrolment for ZOO-629 Ornamental Fish Management (Theory)	
Course Objectives:	1. To introduce the nature, scope and basic concept of aquarium science. 2. To impart hands-on training on setting up the aquarium and its maintenance. 3. To promote employment and entrepreneurship in the ornamental fish sector. 4. To build practical skills in management, development, breeding techniques and rearing of ornamental fishes.	
Content:	Sexual dimorphism in ornamental fishes. Propagation methods of ornamental aquarium plants. Identification of formulated fish feeds, preparation and practising feeding schedules. Maintenance of Freshwater and Marine aquariums. (Aquarium accessories, water quality analysis, Lighting and aeration, décor etc) Study of Water filtration systems: biological, mechanical, and chemical. The culture of live organisms used as fish feed. Identification of common fish diseases. Demonstration of fish handling and packaging method. Demonstration of ornamental fish breeding.	15 X 2 hours
Pedagogy:	Lectures/Tutorials/Videos/Assignments/Group discussion/Self-study/ workshops/Training programme.	
References/ Readings:	1. S. Saha, Concept of Aquarium Fish Keeping (2nd Edition), Techno world Publisher,2022. 2. A. David, Encyclopaedia of Aquarium and Pond Fish, DK Publishing, Inc.,2005. 3. Datta, and Subhendu, Aquarium Water Quality Management, 2014. 4. A.D. Hawkins, Aquarium Systems, Academic Press, 1981. 5. M. Dick, L. Derek, Aquarium Fish Handbook, Quatro In., 2005. 6. S. Glen, M. Brian, Scott, N. Pronek, Encyclopaedia of Exotic Tropical Fishes for Freshwater Aquariums, TFH Publications, 2005.	

	7. H. Hieronimus, Guppies, Mollies, Platies: A Complete Pet Owner's Manual, Barron's Educational Series, Inc., 2009. 8. S. Spotte, Marine aquarium keeping. John Wiley and Sons, U.S.A.,1993.
Course Outcomes:	The learner will 1. Identify species and variety of ornamental fishes and know about their breeding biology. 2. Develop skills and practical experience in the fabrication and maintenance of both freshwater and marine water aquariums at home or outdoors. 3. Create the ability to analyze and treat some common ornamental fish diseases. 4. Build knowledge about techniques of ornamental fish breeding, rearing, and marketing to make them self-sustainable. 5. Apply the scope of the subject concerning entrepreneurship.

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Name of the Programme: **M.Sc. Zoology**
Course Code: ZOO-631 **Title of the Course:** Biology of Animal Reproduction
Number of Credits: 02
Effective from AY: 2023-24

Pre-requisites for the Course:	Elementary knowledge of animal anatomy and physiology.	
Course Objectives:	1. To provide fundamental knowledge of animal reproduction at an anatomical, physiological, and endocrinological level. 2. To analyze comparative the structure and function of male and female reproductive systems; endocrine, neuroendocrine and environmental control of reproduction; development of the gametes, embryo, foetus and placenta; and pregnancy and parturition. 3. To elaborate on the management of reproduction and fertility.	
Content:	**Module 1** Anatomy, Development, and Hormones: Introduction to reproduction. Male Reproductive System: Biology of spermatozoa. Seminiferous epithelial cycle, Spermatogenesis, sperm activation, Hormonal control of spermatogenesis, hormonal regulation of accessory male reproductive organs. Biochemistry of semen, semen analysis, and its utility in medico-legal cases Female Reproductive System: Reproductive cycles in mammals and their regulations; Oogenesis and ovarian cycle. Hormonal regulation, sequence, and types of implantation. Menstruation, puberty, reproductive aging, and menopause. **Module 2** Endocrine control of pregnancy, Parturition, and Lactation. Contraception: Types and various methods (Hormonal, barrier, spermicides, IUDs, Periodic abstinence, etc.). Advantages and disadvantages. Male and Female sexual response. Surgical sterilization. Reproductive health concern: Infertility (factors responsible).	**8 hours** **7 hours** **8 hours**

	Assisted Reproductive Techniques (ART). Reproductive Tract Disorders: - Symptoms and treatment – Onco-fertility (Endometriosis, Testicular Cancer, Ovarian Cancer, Ovarian cysts). Myths and facts on reproduction.	**7 hours**
Pedagogy:	Lectures/Tutorials/Videos/Assignments/Group discussion/Self-study.	
References/ Readings:	1. R. R. Stickney, Aquaculture-An introductory text, Alex Lainsburry, CABI South Asia Edition.2022. 2. FAO,The Stare of World Fisheries and Aquaculture,2020. Available: http://doi.org/10.4060/ca9229en 3. R.L. Naylor, R.W. Hardy, Buschmann, and A.H.,Bush, "A 20-year retrospective review of global aquaculture", Nature, 2021. 4. J.S. Lucas,Aquaculture: Farming aquatic animals and plants,John Wiley & Sons,2019. 5. "The state of world fisheries and aquaculture", The sustainable development goals. FAO. License: CC BY-NC-SA 3.0 IGO.2020. 6. S. Ayyappan, Handbook of Fisheries and Aquaculture, ICAR Publications, New Delhi, 2011. 7. T.V. Pillay, and M.N. Kutty, Aquaculture: Principles and practices (2nd Edition),Blackwell Publishing,2015. 8. D. Mills, Aquarium fishes, Dorling Kindersly Ltd, London,1998. 9. J.D. Jameson, and R. Santhanan, Manual of ornamental fishes and farming technologies, 1996. 10. N.K. Thakur, Culture of live food organisms for aqua hatcheries. Training manual. CIFE (ICAR), Mumbai,1998.	
Course Outcomes:	The learner will 1. Assess comprehensive knowledge of male and female reproductive systems. 2. Develop the ability to think comprehensively in the field of reproductive biology. 3. Design, analyze and interpret the effects of reproduction on the organism and the roles of endocrine secretions of reproductive organs on bodily functions. 4. Justify how the understanding of reproductive physiology informs the management of reproduction and fertility in animals and provides the basis for reproductive technologies.	

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Name of the Programme: **M.Sc. Zoology**

Course Code: ZOO-632 **Title of the Course:** Fish Processing

Number of Credits: 02

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge of Fish Biology, Fishery sciences.	
Course Objectives:	1. To build skill-based knowledge for the learners on different aspects of fish processing technologies related to the production of value-added quality fish products and their preservation 2. To develop knowledge about post-harvest management of fish. 3. To elaborate on the various aspects of fish preservation and processing	
Content:	**Module 1** Module 1: Post-Harvest Technology: Principles and importance of fish preservation. Fish spoilage-post mortem changes and rigor mortis, post rigor spoilage. Methods of fish preservation-Icing, Freezing, Cold storage, Drying, Salting, Smoking, Canning, and Fish Pickling. Fish products and By-product: Fish Oil, Fish liver oil, Fish meal, Fish manure, Fish flour, fish glue and isinglass, chitin, pearl essence fish silage Perishability of seafood – Microbial spoilage of fish and shellfish. Spoilage microflora. Fish products (frozen food items) Intrinsic and extrinsic factors affecting spoilage. Microflora is associated with body parts. Foodborne pathogens. Sources of contamination. Seafood biotoxins **Module 2** Quality Assurance of Fishery Products: Quality control: basic concepts, quality, and quality control. Sanitation procedures in seafood processing plants. Waste management in fish processing industries. Quality analysis – organoleptic, physical, chemical,	15 hours 15 hours

	microbiological, and instrumental methods. Quality standards in India and major importing countries like the USA, Japan, and the EU. Export of fishery products from India – major countries, important products, export documents, and procedures. Traceability, Quality certifications, Eco-labeling.	
Pedagogy:	Lectures/Tutorials/Videos/Assignments/Group discussion/Self-study.	
References/ Readings:	1. K.P. Biswas, Fish Processing and Preservation, Daya Pub. House, 2004 2. T.K. Govindan, Fish Processing Technology, Oxford & IBH Pub. Co.,1985 3. K.C. Badapanda. Fish processing and preservation technology, Narendra Publishing House, 2013. 4. R. Fernandes, Microbiology Handbook: Fish and Seafood. Food Research Association,2009. 5. W. Harry, S. Paul, and J. J. Lee, Microbes in Action: A Laboratory Manual of Microbiology,1990. 6. Pawar and Diganawala, General Microbiology – Vol. I and Vol. II. Himalaya Publishing House, 2010.	
Course Outcomes:	The learner will 1. Identify the main microbes concerned with fish processing 2. Justify how to preserve and process fishery products and their value additions. 3. Develop the ability to understand the concept and definition of packaging of fish and fishery products. 4. Demonstrate the importance of quality control in fish farm	

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Name of the Programme: **M.Sc. Zoology**

Course Code: ZOO-633 **Title of the Course:** Nutritional Biochemistry

Number of Credits: 02

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge of physiology and biochemistry	
Course Objectives:	1. To develop concepts in nutritional biochemistry 2. To indicate the nutritional requirements of the body 3. To outline the biomedical importance of various macronutrients and micronutrients	
Content:	**Module 1** Basic concepts of energy and energy expenditure; Calorific values of food – Basal metabolic rate, energy requirements of man, women, infants and children. Dietary Carbohydrates: Functions, classification, food sources, storage in body, biomedical importance; Dietary Proteins - Functions, classification, food sources, composition, essential & non-essential amino acids, protein deficiency, biomedical importance; Dietary Fats: Function of fats, classification, food sources, composition, saturated and unsaturated fatty acids, biomedical importance. Vitamins: sources and functions, deficiency status. **Module 2** Water as nutrient; Electrolyte concentrations of body fluids; Minerals: macro & micronutrients functions, sources. Bioavailability and deficiency of Calcium, Iron, Iodine, Sodium & Potassium (very brief account); concept of acidosis and alkalosis. Nutritional requirements during pregnancy and lactation; Nutrition during infancy, Nutrition in children, Nutrition during adolescence, Nutrition during adulthood. Nutrigenomics of omega 3 and omega 6 fatty acids, essential amino acids, vitamin A, C, D, E and B complex.	15 hours 15 hours
Pedagogy:	Lectures/Tutorials/Videos/Assignments/Group discussion/Self-study.	
References/ Readings:	1. Brody T, Nutritional, Biochemistry, 2nd ed. New York: Academic Press, 1998. 2. C. Gopalan, B.V. Rama Sastri, and and S.C. Balasubramanian, Nutritive	

	value of Indian foods. Indian Council of Medical Research (ICMR), 2016. 3. C. Gopalan, and K. Vijaya Raghavan, Nutrition atlas of India, Indian Council of Medical Research: ICMR, 1971. 4. S. Ghosh, The feeding care of infants and young children. Voluntary Health Association of India, 1981. 5. S.R. Mudambi, Fundamentals of food and nutrition. New Age International, 1995. 6. M. Swaminathan, Handbook of food and nutrition. Bangalore: Bappco, 1989 7. M. Swaminathan, Essentials of food and nutrition: Vol I & II. Madras: Ganesh and Co., 1974. 8. M. Elia, O. Ljungqvist, R. Stratton, and S.A. Lanham, Clinical Nutrition, UK: Willey Blackwell Publication, 2012.
Course Outcomes:	The learner will 1. Perceive the importance of nutrition in the well-being of the body. 2. Outline the importance of various biomolecules, vitamins and minerals. 3. Distinguish the nutritional requirements in different age groups and during pregnancy. 4. Formulate appropriate diet plans to meet daily nutritional requirements.

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Name of the Programme: M.Sc. in Zoology

Course Code: ZOO–634 **Title of the Course:** Animal Architecture

Number of Credits: 04

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic knowledge on Zoology, Anatomy, Physiology, Ecology.	
Course Objectives:	1. To provide knowledge on the major definitions and key concepts of animal architecture, functionality, and basic principles of animal engineering 2. To incite curiosity in the learner regarding the interface of behaviour, ecology and evolution 3. To reflect on the collective behaviours/ interactions among communities and whole ecosystems. 4. To instill in the learner and the society an appreciation towards animals and their building behaviour through observation	
Content:	**Module 1** Introduction, innate and learned behaviours Allogenic and autogenic engineers. Why animals build? Function – habitat, feeding – burrowers and nest builders (prey capture architecture, trap builders), Intraspecific communication - Courtship and territoriality.	15 hours
	Module 2 Construction and civil engineering Building materials – materials obtained from nature – Mud, soil and stones (ants), self- created materials (edible nest swiftlet, Honey bees, Silk from Trichoptera and Lepidoptera, silkworm, spiders), processed materials (wasp nests, Psychidae cocoons, Weaverbirds) – Urbanisation in selection of building materials (Carton, Paper, steel wool) Case study of corvidae.	15 hours
	Module 3 Building behaviour – piling up (Yellow head jawfish, herons, pelicans etc,) Interlocking and weaving (tailorbird, spiderhunter, baya weaver), Sticking together (Polychaete), folding and rolling (tent making bats, arthropods- spiders and lepidoptera), spinning and weaving (insect cocoons, spider webs), Burrows (Uca crabs, Alpheid shrimp, Kingfishers, mice	15 hours

	and rats), Bioturbation Patch dynamics and species diversity, Mutualism and associations (Blind shrimp – goby). **Module 4** Habitat modifiers: Ecosystem engineers vs keystone species Animal architecture as evolutionary evidence – habitat range extension, speciation, and social evolution. Animal architecture as behavioural evidence, atavism, niche construction, ecological and cultural inheritance.	15 hours
Pedagogy:	Lectures/ tutorials/ presentations/ Colloquia/ Group discussions /self–study/ field visits/ field reports/ Mini Projects	
References/ Readings:	1. M. Hansell, Animal Architecture, First Edition, Oxford: Oxford University Press, 2005. 2. K. Cuddington, J. E. Byers, W. G. Wilson, A. Hastings, Ecosystem engineers: plants to protists. Academic Press, 2011. 3. M. Hansell, Bird nests and construction behaviour. Cambridge University Press, 2000. 4. M. Hansell, Built by animals: the natural history of animal architecture. Oxford: Oxford University Press, 2007. 5. G. B. Wiggins, Caddisflies: the underwater architects. University of Toronto Press, 2004. 6. J. S. Turner, The extended organism: the physiology of animal-built structures. Harvard University Press, 2009.	
Course Outcomes:	The learner will 1. Demonstrate knowledge concerning the key concepts of animal architecture and ecosystem engineering. 2. Characterise species behaviour and interactions among community and ecosystems 3. Develop skill to compare and contrast between the most important types of materials used and building behaviour observed in animals. 4. Evaluate habitat modifiers and their evolutionary significance.	

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Semester IV
Name of the Programme: M. Sc. Zoology
Course Code: ZOO-614 **Course Title: Research Methodology**
Number of Credits: 4
Effective from AY: 2023 -24

Prerequisite for the Course:	Basic knowledge of biology and mathematics	
Objectives:	1. To explain the need for research methodology in conducting scientific research 2. To demonstrate the use of various statistical analyses 3. To visualize and interpret data in a scientific manner 4. To communicate the data in the form of reports / research articles	
Content:	**Module 1: Introduction to research methodology** Research and Scientific Method, Types of Research, Significance of Research, Selecting a Research Problem, Research Design, Criteria of Good Research, defining and delimiting Research problem, Formulation of Hypothesis, Characteristics of good Hypothesis, Procedure for Hypothesis Testing, Null hypothesis, Literature review, research methods: Scientific method vs Arbitrary Method, Logical Scientific Methods: Deductive, Inductive, Deductive-Inductive, pattern of Deductive – Inductive logical process – Different types of inductive logical methods, Research fellowships and schemes available for post graduate students for higher education (importance of CSIR NET JRF life science and environmental science/ GATE/ ICMR/ DBT etc). **Module 2** Sources of data: primary, secondary and tertiary, Types of data: Nominal and ordinal, Data collection: observation, field investigations, experimental observations, Sampling: Concepts of Statistical Population, Sample, Sampling Frame, Sampling Error, Sample Size, types of sampling designs: Non-probability sampling, Probability sampling; Primary data, Secondary data, tools and methods of data collection, Sampling Distribution, data compilation, tools in data analysis, Biases in data collection, Descriptive	15 hours 15 hours

	Analysis – Inferential Analysis- Correlation analysis **Module 3: Statistical analyses** Descriptive statistics: Measurement Scales, Sources of error in measurement. Measures of central Tendency (Mean, medium, Mode), Measures of dispersion (range, mean deviation, standard deviation) Inferential statistics: Normal Probability Curve- Meaning, characteristics and applications. Standard error, Confidence Intervals, Type I and Type II errors, Pearson's Correlations, Significance of correlation, Concept of Variance, Analysis of Variance (ANOVA), Regression, Testing the Significance of difference between means (z and 't' test), Non-Parametric Statistics: Sign Test, Mann- Whitney U Test, Kruskall-Wallis test, Characteristics and applications, Statistical software (MS-Excel, SPSS, R studio) **Module 4: Scientific writing** Importance of effective communication, Interpretation of results; Graphical representation of Data, Processing of data, Types of Reports, Oral Presentation, Layout of a Research Paper, Writing Format and style, Literature review, Major findings, Discussion, Conclusions and suggestions, Citation and styles of references and Bibliography, Reference Management Software, Authorship responsibilities, Ethics in writing and publishing, Scientific misconduct: Plagiarism, fabrication and falsification in research, Salami slicing, Duplication of publications; Journal publication processes, Predatory vs reputed journals, Indexed journals: Web of Science, PubMed, Scopus; Journal Metrics.	15 hours 15 hours
Pedagogy	Discussions, tutorials, self-study, video lectures and presentations	
Reading / Reference	1. C.R. Kothari, Research Methodology: Methods and Techniques, 2nd ed. New Delhi: New Age International Publishers, 2004. 2. T. Greenfield, and S. Greener, Research Methods for Postgraduates, 3rd ed. John Wiley & Sons, Ltd., 2016 3. N. Gurumani, Research Methodology for Biological	

	Sciences, New Delhi: MJP Publishers, 2008. 4. D.M. Hawkins, Biomeasurement: a student's guide to biological statistics, New York: Oxford University Press, 2009.	
Outcomes	The learner will 1. Perform research work in a scientific and organized manner and produce accurate results 2. Analyze datasets of their research efficiently 3. Interpret the results of statistical analyses 4. Effectively communicate the results in a report / research paper	

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO–615 **Title of the Course: Stem Cell Biology**

Number of Credits: 02

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic understanding of anatomy, cytology and types of cells	
Course Objectives:	1. To provide theoretical knowledge on stem cell science and the molecular nature of pluripotency and differentiation 2. To estimate competency in the technique of isolation, maintenance, and characterization 3. To review the current issues and approaches in the stem cell biology 4. To develop ways in which stem cell science can be utilized in the therapeutic context	
Content:	**Module 1** Basic Biology of stem cells: Introduction to stem cells and basis of stemness; Embryonic stem cells, embryonal carcinoma cells, adult stem cells, hematopoietic stem cells, mesenchymal stem cells, cancer stem cells, induced pluripotent stem cells. Cellular Mechanisms of Stem Cells: Molecular basis of pluripotency, stem cell niche, mechanisms of stem cell self-renewal. **Module 2** Stem cells isolation and culture: Isolation, characterization and maintenance of embryonic stem cells isolated from: Mouse and Human. Applications of stem cells: neurodegenerative diseases, spinal cord injury, heart disease, diabetes, burns and skin ulcers, muscular dystrophy, orthopedic applications, eye diseases, stem cells and gene therapy, Ethical and regulatory issues in the use of stem cells.	15 hours 15 hours
Pedagogy:	Lectures/tutorials/self-study/videos/presentations/mini projects/Group	

	activities
References/ Readings:	1. A. Atala and R. Lanza, Handbook of Stem Cells, 2nd Edition, Academic Press, 2012. 2. A. Atala, J. J. Mao, A. Mikos, G and Vunjak-Novakovic, Translational Approaches in Tissue Engineering & Regenerative Medicine, Artech House, 2007 3. R. Lanza and A. Atala, Essential of Stem Cell Biology, Elsevier Academic Press, 2013. 4. N.A. Habib, N. Y.Levièar, M. Gordon, L Jiao and N Fisk, Stem Cell Repair and Regeneration, Volume-2, Imperial College Press, 2007.
Course Outcomes:	The learner will 1. Analyze molecular mechanisms involved in pluripotency and differentiation 2. Select techniques of isolation, maintenance and characterization best suited for any particular type of cell 3. Assess the ongoing current issues and approaches involved in stem cell science 4. Generate ways of using stem cells in therapeutics 5. Predict the ethical and regulatory issues associated with the use of stem cells

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Name of the Programme: M. Sc. Zoology

Course Code: ZOO-616 **Title of the Course:** Ethics in Experiments with Laboratory Animals

Number of Credits: 02

Effective from AY: 2023-24

Pre-requisites for the Course:	Basic understanding of Zoology	
Course Objectives:	1. To provide hands-on training on organelle separation using centrifugation method. 2. To determine viable cell count and toxicity assay for isolated cells. 3. To demonstrate the histological and cytological techniques.	
Content:	**Module 1** Historical overview, Classification of animal research: Basic research, Applied research, Toxicology testing, Xenotransplantation. Concept of experimental model animal, Types of model animals, Handling of animals for experiments. Introduction to Committee for the Purpose of Control and Supervision of Experiments on Animals (CCSEA), its objectives and functions. Three R's in animal testing, regulatory guidelines on prevention of cruelty to animals, Need for animal testing, Alternatives to animal testing. **Module 2** Constitution of CCSEA and IAEC, Standard Operating Procedures (SOP) for CCSEA/ IAEC, Concepts of Biosafety Guidelines for Anesthesia for laboratory animals Euthanasia of laboratory animals. Website information of CCSEA. Application for animal ethical clearance and maintenance of records: Form A, B, C, D, and E.	03 hours 05hours 07hours 07 hours 03 hours 05 hours
Pedagogy:	Lectures, Discussion, Video lectures, Group activities, Demonstrations	
References/ Readings:	1. CPCSEA, Committee for the purpose of control and supervision of experiments on animals, [online document], 2015. Available: CPCSEA Online, https://cpcsea.nic.in/Auth/index.aspx [accessed: January 5, 2023]. 2. S. Wolfensohn and M. Lloyd, Handbook of Laboratory Animal	

	Management and Welfare. John Wiley & Sons, 2013. 3. K. Kaushik and R. Vaswani, Research on animals and current UGC guidelines on animal dissection and experimentation: A critical analysis. Bioethics Update, 4(2), 119–139, 2018. 4. R. Hubrecht, The welfare of animals used in research: practice and ethics. John Wiley & Sons Inc, 2014. 5. H. Röcklinsberg, M. Gjerris and A. Olsson, Animal ethics in animal research. Cambridge University Press, 2017. 6. J. Hau and S. J. Schapiro, Handbook of Laboratory Animal Science, Volume I : Essential Principles and Practices. CRC Press, 2010. 7. J. Hau and S. J. Schapiro, Handbook of laboratory animal science. Vol. II. Crc Press, 2011. 8. J. Hau and S. J. Schapiro. Handbook of laboratory animal science. Volume III, Animal models. CRC Press, 2014.
Course Outcomes:	The learner will 1. Draft animal experimentation procedures. 2. Proficiently adopt CCSEA protocols and SOPs. 3. Trained to draft Form A, B, C, D and E of CCSEA. 4. Present and defend research proposal for clearance from IAEC.

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Name of the Programme: **M.Sc. Zoology**
Course Code: ZOO-617 **Title of the Course:** Vector Biology
Number of Credits: 02
Effective from AY: 2023-24

Pre-requisites for the Course:	Basic working knowledge of insect taxonomy, vector-host interaction and arthropodology	
Course Objectives:	1. To extend an in-depth understanding of current emerging vector-borne infectious diseases. 2. To analyze how vector biology is integral to our public health interventions. 3. To build a comprehensive knowledge of the modern field of vector biology concerning the genomics and proteogenomic of vectors. 4. To create and communicate knowledge on vector-host interaction, mosquito-linked diseases, their cause and prevention.	
Content:	**Module 1** Introduction to vector biology and its importance in public health management. Arthropods as disease vectors, taxonomy, classification, biology, ecology. Arthropod transmitting bacteria and viruses of medical importance; Major vector-borne diseases; Vector-parasite interaction; Host-pathogen interaction; Factor in disease transmission. Special reference to mosquitoes as vectors, Biology, Bio-ecology, Life history of Anopheles, Culex, and Aedes mosquitoes, Mosquito-borne diseases like malaria, filariasis, dengue, Chikungunya, and Japanese encephalitis (Symptoms, prophylaxis, and treatment) **Module 2** General Characters, classification, history, distribution, morphology, biology, life cycle, mode of infection, signs, and symptoms, diagnosis, molecular biology, drug resistance, treatment, preventive measures, and control of - Flies, Bugs, Fleas, Ticks, And Lice.	2 hours 4 hours 4 hours 5 hours 8 hours

	Modern vector biology; Genomics and Proteogenomic of vectors. Chemical and biological and environmental control of vectors; Integrated vector management, vector resistance mechanism.	7 hours
Pedagogy:	Lectures/Tutorials/Videos/Assignments/Group discussion/Self-study.	
References/ Readings:	1. M.W. Service, Medical Entomology for students, Cambridge University Press, UK,2012. 2. G. Mullen, and L.Durden, Medical and Veterinary Entomology, Academic Press, USA,2002. 3. E.D. Bruce, F. Eldridge, and J.D. Edman, Medical Entomology, Kluwer Academic Publishers, UK,2002. 4. M.S.Mani, General Entomology, Oxford and IBH Publishing Co., New Delhi, 1982. 5. G.K. Rathnaswamy, A Handbook of Medical Entomology and Elementary Parasitology, S. Vishwanath Pvt.Ltd., India, 1986. 6. H.A. Kahn, Introduction of Epidemiology Methods, Oxford University Press, New York,1983. 7. R.E. Snodgrass, Principles of Insect Morphology, Tata McGraw Hill publishing co. India, 1935. 8. D.S.Kettle, Medical and Veterinary Entomology, Cabi Press, USA,1984. 9. M.W. Service, Mosquito Ecology, Field sampling methods, Applied Science Publishing Ltd., London,1993. 10. W.C. Marquardt, Biology of disease vectors (2nd Edition), Doody Enterprises, Inc. USA,1996.	
Course Outcomes:	The learner will 1. Analyze individual components of vector-borne disease transmission using specific examples. 2. Elaborate on ecological, environmental, biological and genetic drivers that play a role in disease transmission. 3. Justify how globalization and human behaviours can have an impact on disease transmission. 4. Construct control measures and prophylaxis emphasising Integrated vector management practices.	

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Name of the Programme: **M.Sc. Zoology**

Course Code: ZOO-651 **Course Title:** Dissertation

Number of Credits: 16

Effective from AY: 2023 -24

Prerequisites for the course:	Enrollment for M.Sc. Zoology Programme.	
Objective:	1. To understand the need for research methodology in conducting scientific research 2. To initialize independent thinking and applications in the research field. 3. To conceptualise research hypothesis 4. To prepare research workplan using Gnat/PERT charts 5. To defend the findings of proposed research hypothesis.	
Content	Research Internship (compatible with the dissertation topic) Research Conceptualization and standardization of methods, data collection, analysis Research Report and Viva	120 hours 120 hours 240 hours
Pedagogy:	Internship/Discussion/ Experimental work/ field study/ /self-study/Presentations/	
References/Readings	1. Scientific Journals 2. Reference Books 3. Any other authentic source	
Learning Outcomes	The learner will 1. Design research work 2. Formulate research methodology 3. Implement methods for gathering research data and application of statistics. 4. Interpret and present research results.	

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