Goa University
Goa University, Taleigao Plateau, Goa 403 206

Syllabus of M.Sc. (Zoology) Programme

(To be followed from the Academic year: 2018-19)

Programme Name: M.Sc. Zoology

Programme Code: ZO

Programme description:

This program is intended to develop aptitude for learning about the biology and significance of fauna ranging from single cell to multi-cellular systems. Apart from the classical topics in of animal sciences such as Faunal diversity, Animal physiology and Evolutionary Biology, this syllabus covers various topics in life-sciences including Biochemistry, Physiology, Developmental Biology and Molecular Biology. This M.Sc. programme also focuses on various application based courses such as Animal Tissue culture, Fishery biology, Entomology, Immunology, Human Genetics and Biochemical techniques. This program through the dissertation work helps the students in understanding the basic principles of nature and also gives hands-on experience to the students on experimenting with nature /animals and thereby enables the students to develop aptitude for research in various allied fields of animal sciences. This will help to overcome several of the day to day problems faced by our society and come out with 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 student should earn a minimum of 64 Credit Courses to receive M.Sc. (Zoology) degree.

- Out of 64 credits, 32 credits shall be of Departmental Core Courses and 32 credits are Optional Courses (Including Departmental /Interdisciplinary/Field Work/ Dissertation). These 32 credits shall include 16 Departmental Optional Courses, may be including Field work. The remaining 16 credits may be earned by opting for Optional Courses, including dissertation, from within the Department or outside the Department /University.

- All the Core Courses have to be studied by all students in the first year (Semester I & II).

- Field work (2 Credit course) is mandatory and shall be undertaken by all students in the first year (Semester I & II).

- Dissertation (8 Credits) is optional in lieu of equivalent number of credits of courses from any of the Optional Courses and shall be undertaken in the second year (Semester III & IV).

Timeline for completion of various credits over four Semesters:

SEMESTER	SEM I	SEM II	SEM III	SEM IV
CORE COURSES				
FIELD WORK				
DEPARTMENTAL OPTIONAL COURSES				
INTERDISCIPLINARY COURSES				
DISSERTATION				

COURSE STRUCTURE

SEMESTER I

CORE COURSES (16 CREDITS)

Sr. No.	Course Code	Title of the Course	L-P / week	Credits	Page No.
1	ZOC 101	Animal Taxonomy and Systematics	3-0	3	5
2	ZOC 102	Comparative Anatomy of Animals	3-0	3	7
3	ZOC 103	Animal Biochemistry	3-0	3	9
4	ZOC 104	Cell and Molecular Biology	3-0	3	10
5	ZOC 105	Laboratory Course I (Based on ZOC 101, 102, 103 & 104)	0-4	4	12

SEMESTER II

CORE COURSES (16 CREDITS)

Sr. No.	Course Code	Title of the Course	L-P / week	Credits	Page No.
1	ZOC 201	Animal Genetics	3-0	3	13
2	ZOC 202	Comparative Physiology of Animals	3-0	3	15
3	ZOC 203	Advanced Developmental Biology	3-0	3	17
4	ZOC 204	Agricultural Entomology	3-0	3	18
5	ZOC 205	Laboratory Course II (Based on ZOC 201, 202, 203 & 204)	0-4	4	20

SEMESTER III

DEPARTMENTAL OPTIONAL COURSES (16 CREDITS)
(Any Seven courses to be opted besides the mandatory Field Work Course)

Sr. No.	Course Code	Title of the Course	L-P / week	Credits	Page No.
1	ZOO 301	Animal Cell culture	2-0	2	21
2	ZOO 302	Biodiversity	2-0	2	22
3	ZOO 303	Biology of Reproduction	2-0	2	23
4	ZOO 304	Environmental Physiology	2-0	2	24
5	ZOO 305	Fishery Biology	2-0	2	25
6	ZOO 306	Marine Zoology	2-0	2	26
7	ZOO 307	Molecular Endocrinology	2-0	2	27
8	ZOO 308	Human Parasitology	2-0	2	28
9	ZOO 309	Genetic Toxicology	2-0	2	29
10	ZOO 310	Field Work	0-2	2	30

SEMESTER IV

DEPARTMENTAL INTERDESCIPLINARY COURSES (16 CREDITS)
(Any eight credit courses to be opted besides Dissertation)

Sr. No.	Course Code	Title of the Course	L-P / week	Credits	Page No.
1	ZOO 401	Ethology	2-0	2	31
2	ZOO 402	Avian Biology	2-0	2	32
3	ZOO 403	Biochemical Techniques	2-0	2	33
4	ZOO 404	Evolutionary Biology	2-0	2	34
5	ZOO 405	Human Genetics	2-0	2	36
6	ZOO 406	Immunology	2-0	2	37
7	ZOO 407	Wildlife and Conservation	2-0	2	38
8	ZOO 408	Medical Entomology	2-0	2	39
9	ZOO 409	Nutritional Biochemistry	2-0	2	40
10	ZOO 410	Radiation Biology	2-0	2	41
11	ZOO 411	Dissertation*	0-8	8	42

NOTE:* Dissertation of 8 credits in lieu of 8 credits of Optional Courses besides regular 8 credits of Interdisciplinary Optional Courses. Total 16 credits to be earned during Semester IV

Programme: M. Sc. (Zoology)
Course Code: ZOC-101 **Title of the Course:** Animal Taxonomy and Systematics
Number of Credits: 3
Effective from AY: 2018-19

Prerequisites for the course:	Basic working knowledge of classical and animal taxonomy and systematics.	
Objective:	This course develops concepts in animal taxonomy and systematic, modern methods of taxonomy and systematics and their application, General Organization, affinities and systematic position of minor phyla and molecular basis of animal taxonomy.	
Content:	**Module 1:** Introduction to taxonomy, stages of taxonomy, importance of taxonomy, Rise of taxonomy, Principles and rules of Taxonomy, Zoological nomenclature, ICZN regulations, new trends in taxonomy Zoological classification, problems of taxonomists concept of speciation, Taxonomic collections, identification and description, Taxonomical hierarchy (Linnean hierarchy), Concepts of Taxon, holotype, paratype, topotype etc. **Module 2:** General Organization, affinities and systematic position of minor phyla Lopophorates, Phoronida, Ectoprocta, Brachiopoda, Pogonophora, Chaetognatha, Acanthocephala, Entoprocota and Sipunculida. **Module 3:** Molecular basis of animal taxonomy: Genetic polymorphism, electrophoretic variations, amino acid sequencing for variety of proteins, DNA-DNA and DNA- RNA hybridization.	12 hours 12 hours 12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study.	
References/Readings	1. Barnes RD, Invertebrate Zoology, Halt Saunders Intl. Edition. 2. Hymen LH, The invertebrates (all volumes), McGraw Hill, Philadelphia, USA. 3. Huston A M, Biological Diversity, Cambridge University Press, Cambridge. 4. Kapoor VC, Theory and Practice of Animal Taxonomy, Oxford and IBH Publ., Delhi. 5. McNeely JA, Economics and Biological Diversity, IUCN, Gland, Switzerland. 6. Prasad SN, Life of Invertebrates, Vikas Publ. New Delhi. 7. Sinha AK, Adhikari S and Ganguly BB, Biology of Animals (vol. I & II), Central Book Agency, Kolkata. 8. Young JZ, Life of Vertebrates, Clarendon Press, Oxford**.**	

Learning Outcomes	1. Understand historical and modern methods of animal classification and systematics. 2. Get acquainted with general organization, affinities and systamatic position of minor Phyla. 3. Familiarise with Molecular basis of animal taxonomy: Genetic polymorphism, electrophoretic variations, amino acid sequencing for variety of proteins, DNA-DNA and DNA- RNA hybridization.	

Programme: M. Sc. (Zoology)
Course Code: ZOC-102 **Title of the Course:** Comparative Anatomy of Animals
Number of Credits: 3
Effective from AY: 2018-19

Prerequisites for the course:	Basic knowledge on animal anatomy, taxonomy and systematics is prerequisite for this course.	
Objective:	This course develops knowledge about fundamental anatomical principles in a wide variety of animal species through comparison of the major body systems in order to understand the adaptive changes they have undergone in the course of evolution from common ancestors, and provides first line of reasoning in determining the relatedness of species.	
Content:	**Module 1:** Skeletal system: Skeletal system of Arthropods and Echinoderms. Tetrapod limbs and their modification. Muscular system**:** Locomotory organs in Annelids and Molluscs; Types of Vertebrate musculature, Flight muscles of Insects and Birds. **Module 2:** Vascular system: Vascular system in Annelida and Arthropoda. Afferent and efferent branchial system of fishes. Evolution of Portal system in Vertebrates. Respiratory system: Respiratory organs of Annelids and Molluscs, Pharyngeal basket in Lower Chordates, Tertrapod lungs. **Module 3:** Nervous system: Nervous system in Arthropods and Molluscs; Central and autonomous nervous system in Tetrapodes. Urino-genital system: Excretory organs in Helminthes and Annelids, Reproductive organs in Arthropods. Testes, vasa deferentia, ovary and oviduct of Vertebrates.	12 hours 12 hours 12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study.	
References/Readings	1. Barrington EJ, Invertebrate Structure and Function, Thomas Nelson and Sons, USA. 2. Kardong K, Vertebrates: Comparative Anatomy, Function and Evolution, McGraw-Hill Companies, USA. 3. Kent CG and Carr R, Comparative Anatomy of Vertebrates, McGraw-Hill Companies, USA. 4. Liem KF and Franklin W, Functional Anatomy of the Vertebrates: an Evolutionary Perspective, Harcourt College Publishers, California. 5. Wolff RG, Functional Chordate Anatomy**,** Amazon Publication, UK. 6. Withers PC, Comparative Animal Physiology By, Saunders College Publishers., - Fisiologie, Vergelykend	
Learning Outcomes	1. Conceptualization of evolutionary changes in animal	

	anatomy with respect to various systems under study. 2. Ability to value evolutionary adaptations, benefits and mistakes in anatomical structures of animal body. 3. Critical analysis, synthesis, and evaluation of diverse sets of information concerning animal anatomy through theory and practical learning modules.	

Programme: M. Sc. (Zoology)
Course Code: ZOC-103 **Title of the Course:** Animal Biochemistry
Number of Credits: 3
Effective from AY: 2018-19

Prerequisites for the course:	Elementary knowledge on structural biochemistry.	
Objective:	To understand the biochemical integrity of various life processes and the metabolic pathways.	
Content:	**Module 1:** Concept of metabolism; Concept of free energy; Coupled reaction; Electron transport system; TCA cycle; Oxidative phosphorylation; Catalytic and Regulatory strategies of enzymes **Module 2:** Glycolysis and Gluconeogenesis; Pentose phosphate pathway; Glycogenolysis and Glycogenesis; Biosynthesis of fatty acid, Oxidation of fatty acid ; Biosynthesis of Phospholipid, Tri- acylglycerol and Cholesterol**.** **Module 3:** Protein turn-over and amino acid catabolism; Nitrogen excretion pathways; Oxidation of amino acids; Bio-synthesis of amino acids in animal. Biosynthesis of Pyrimidine and Purine	12 hours 12 hours 12 hours
Pedagogy:	Lectures/ Tutorials/Assignments/Self-study.	
References/Readings	1. Albert Lehninger, Principles of Biochemistry, CBS Publisher, New Delhi. 2. Berg J, Tymoczko J and Stryer L, Biochemistry**,** W H Freeman and Company, New York Devlin TM, Text book of Biochemistry with Clinical Correlations, Willey, Oxford. 3. Murray RK, Granner D, Mayes P and Rodwell VW. Harper's Illustrated Biochemistry, McGraw-Hill Companies, USA. 4. Nelson DL and Cox MM, Lehninger's Principles of Biochemistry**,** Freeman WH and Co, USA.	
Learning Outcomes	1. Understanding the various metabolic pathways 2. Understanding the regulation of various metabolic pathways 3. Understanding the integrative metabolism. 4. Achieving the perfection and learning various analytical techniques.	

Programme: M. Sc. (Zoology)
Course Code: ZOC-104 **Title of the Course:** Cell and Molecular Biology
Number of Credits: 3
Effective from AY: 2018-19

Prerequisites for the course:	Basic understanding of different components and functions of the cell.	
Objective:	This course develops concepts in molecular understanding of structural and functional properties of cells and various processes associated which have potential applications in molecular and biochemical and biomedical research	
Content:	**Module 1.** Introduction to the cell: Prokaryotic and Eukaryotic systems; DNA, chromosomes and genomes: Replication, Transcription, Translation; Regulation of gene expression: Operon concept, *lac* and *trp* operons; regulation at the transcriptional and translational level in eukaryotes, Viruses: Structure and classification of animal viruses - reverse transcription; Bacterial viruses: structure, lysogenic and lytic life cycle. **Module 2.** Internal organization of the cell**:** Plasma membrane structure and function; Cell organelles: Intracellular compartments and protein sorting; nucleus, ribosomes, endoplasmic reticulum, peroxisomes; Intracellular membrane traffic: golgi apparatus, endocytosis, exocytosis, lysosomes; mitochondria and energy conversion. . **Module 3.** Cell communication: Cell signalling and communication, Cell junctions and Extra Cellular Matrix (ECM); Cytoskeletal structure and functions; Cell cycle and cell division: Phases of cell cycle, Cyclins and Cyclin dependant kinases, Apoptosis, Cellular aspects of cancer.	12 hours 12 hours 12 hours
Pedagogy:	Lectures/ Tutorials/Assignments/Self-study.	
References/Readings	1. Alberts B, Johnson A, Lewis J, et al. Molecular Biology of the Cell, Taylor & Francis Group, New York, USA. 2. Lodish H, Berk A, Lawrence S, et al., Molecular Cell Biology, Freeman WH & Co. New York. 3. Watson JD, Beyker, Bell JD, et al., Molecular Biology of the Gene, Pearson Education, Delhi 4. Bray BAD, Lewis J, Raff M, Roberts K and Watson JD, Molecular Biology of the Cell, Garland Publishing Co. Ltd. New York. 5. De Robertis EDP and De Robertis EMF, Cell and Molecular Biology Saunders College, Philadelphia Dowben RM, Cell Biology, Harper and Row Publ. London.	

	6. Hartl DL and Jones EW, Genetics: Analysis of Genes and Genomes, Jones & Bartlett Publishers, Boston.	
Learning Outcomes	1. Understand and apply the principles and techniques of molecular biology which prepares students for further education and/or employment in teaching, basic research, or the health professions. 2. Understand the functions of the cell at the molecular level. 3. Gain insight into the most significant molecular and cell-based methods used today to expand our understanding of biology.	

Programme: M. Sc. (Zoology)
Course Code: ZOC-105
Title of the Course: Laboratory Course I (Based on ZOC 101, 102, 103 & 104)
Number of Credits: 4
Effective from AY: 2018-19

Prerequisites for the course:	Basic working knowledge of classical and animal taxonomy, systematics, animal anatomy, structural biochemistry, different components and functions of the cell.	
Objective:	Laboratory training based on courses ZOC 101, 102, 103 & 104.	
Content:	**Module 1:** Study of taxonomic characters, identification and classification (up to Orders) of members of Protozoa, Porifera, Coelenterate, Helminths, Annelids, Arthropods, Molluscs and Echinodermates, Fishes, Amphibians, Reptiles, Birds, Mammals and minor phyla Study of techniques of collection, preservation and mounting of insects.	24 hours
	Module 2: Comparative study of bones of Tetrapod (limb bones, girdles, vertebrae); Appendicular and flight muscles of bird (bird to be collected from slaughter house); Afferent and efferent branchial system of fishes (dead fishes to be collected from market); Cranial nerves (V- VIIth and IX- Xth) of dead teleosts. Reproductive system of dead fish collected from the market**;** Comparative study of heart and brain of Tetrapod (from the preserved or to be collected from slaughter house).	24 hours
	Module 3: Isolation and quantification of bio-molecules (carbohydrate, fat, and protein) of given tissues; Enzyme kinetics: P^{H} optima, Temperature optima, determination of Km and Vmax and enzyme inhibition; Thin Layer Chromatography of lipid/ amino acid.	24 hours
	Module 4: Study of Mitotic metaphase chromosomes from permanent slides; Study of various stages of meiosis from permanent slides; Extraction/Isolation of genomic DNA from mammalian blood (man); Restriction digestion of lambda DNA with EcoRI and Hind III restriction enzymes; Agarose Gel Electrophoretic analysis of DNA, RNA, Isolation of cell organelles (Plasma Membrane, mitochondria and microsomes) by differential centrifugation / sub cellular fractionation and monitoring of purity; Fluorescence In Situ Hybridization (FISH).	24 hours
Pedagogy:	Practicals, mini project.	
References/Readings	As mentioned under individual course ZOC 101, 102, 103 & 104.	
Learning Outcomes	Practicals will give hands on training based on courses ZOC 101, 102, 103 & 104	

Programme: M. Sc. (Zoology)
Course Code: ZOC-201 **Title of the Course:** Animal Genetics
Number of Credits: 3
Effective from AY: 2018-19

Prerequisites for the course:	Basic working knowledge of classical genetics.	
Objective:	This course develops concepts in classical animal genetics and their application. Use of various animals for understanding the basic principles and the working of genetic principles in producing better breeds of animals with better vigour.	
Content:	**Module 1**: Drosophila Genetics: Biology and life cycle of Drosophila; Drosophila as "Cinderella of genetics"; Chromosome constitution; Polytene chromosomes; puffs as regions of gene transcription; Lozenge in Drosophila. Epigenetics and Epigenomes : Definition, brief history; Epigenetic patterns; Genomic imprinting; Histone Code; DNA Methylation (DM); Mutations and Epimutations; Cellular transformation; chromosome imprinting; Epigenetic defects and ageing. **Module 2:** Cancer Genetics: Introduction; Origin of Oncogenes; Identification of an Oncogene; Viral Oncogene; Transfection Assay for Oncogene; Activation of Proto- oncogenes; retroviruses contain Oncogenes; Proto- oncogenes; A model of Carcinogenesis; Evidences supporting Pall's model; Tumor suppressor genes or Anti-oncogenes; Inherited Cancer genes (Familial Cancers); Cellular function of Oncoproteins. **Module 3:** Genomics and Proteomics: Introduction, tools to study functional genomics; assigning function to a gene; cDNA: synthesis, cloning, construction of cDNA libraries and sequencing; Application of functional genomics; Gene transfer methods and transgenic organisms; Genome research; Proteomics: tools, application and research; Bioinformatics: tools and application in genetic studies; Databases: nucleic acid and protein; Phylogenetic analysis; Expressed sequence tags; Genetic algorithm; Gene prediction.	12 hours 12 hours 12 hours
Pedagogy:	Lectures/ Tutorials/Assignments/Self-study.	
References/Readings	1. Alberts B, Johnson A, Lewis J, et al., Molecular Biology of the Cell, Taylor & Francis Group, New York, USA. 2. David AC and Jenuwein T, Epigenetics, Cold Spring Harbor Laboratory Press, New York, USA. 3. Griffiths AJF, Gelbart WM, Lewontin RC and Miller JH, Modern Genetic Analysis: Integrating Genes & Genomes, WH Freeman & Co. New York.	

	4. Hartl DL and Jones EW, Genetics: Analysis of Genes and Genomes, Jones & Bartlett Publishers, Boston. 5. Lewin B, Genes IX, Oxford University Press, Oxford, New York. 6. Lodish H, Berk A, Lawrence S, et al.,Molecular Cell Biology, Freeman WH & Co. New York. 7. Primrose SB and Twyman RM, Principle of Genome Analysis and Genomics, Blackwell Publishing Co. Malden, USA. 8. Watson JD, Beyker, Bell JD, et al., Molecular Biology of the Gene, Pearson Education, Delhi.	
Learning Outcomes	1. Understand genetic analysis at the gene, genome and population levels. 2. Understanding of the latest developments in Drosophila genetics. 3. Evaluation of the various techniques used in advanced genetic analysis 4. Distinguish between structural, functional and comparative genomics and how they differ from proteomics. 5. Designing and development of experiments using Drosophila and their evaluation through genetic analysis using genetic techniques and interpretations. 6. Knowledge on cancer genetics.	

Programme: M. Sc. (Zoology)
Course Code: ZOC-202 **Title of the Course:** Comparative Physiology of Animals
Number of Credits: 3
Effective from AY: 2018-19

Prerequisites for the course:	Elementary knowledge on animal anatomy, Physiology taxonomy and systematics.	
Objective:	This course provides knowledge of animal body system functions across levels of organization, from sub cellular through organismal, in order to reveal physiological homologies, patters of physiological adaptation to various environments and general physiological principles in a wide range of organisms to understand how organisms evolved their functional characteristics and how they stay alive in the face of constantly changing internal and external environments.	
Content:	**Module 1:** Digestion: Principle of digestion, Gastric phases of digestion and its regulation Absorption of digestive nutrients; egestion of undigested food, Metagenome of gut. Excretion and Osmoregulation: Role of gills in excretion; Role of kidney in excretion, Osmoregulation, Volume regulation. **Module2:** Circulation: Physical principle of circulation, systems of circulation; Ventilation –perfusion ratio; Pumping activity of heart; Action potential – Pace maker and Myocardiac; Electrical-mechanical relationship; Cardiac cycle, sure, Electrical Changes; Regulation of heart beat, cardiac output and blood pressure. **Module 3:** Muscle physiology: Muscle contraction, Neuro-muscular Junction, Physiology of electric organ. Neurophysiology: neuron and glia; neurotransmitters and their physiological functions; learning and memory; posture; Photoreception, Thermo reception, Chemoreception; Pheromones and other similar chemicals as means of communication among the animals.	12 hours 12 hours 12 hours
Pedagogy	Lectures/ tutorials/assignments/self-study	
References/Readings	1. Kenney WL, Wilmore J and Costill D, Physiology of Sport and Exercise, Amazon, UK. 2. Moyces C and Schulte P, Principles of Animal Physiology, Pearson International Edition, USA. 3. Prosser CL, Comparative Animal Physiology (vol 1 and 2), Willey Publication, Oxford. 4. Randall D, Burggren W and French K, Eckert Animal Physiology, WH Freeman and Co, New York. 5. Withers P, Comparative Animal Physiology, Saunders College Publications,	
Learning Outcomes	1. Understanding of the basic concepts and processes of physiological regulation, from cellular to organ to	

	organismal. 2. Understanding of how different groups of animals have different physiological adaptations appropriate to carry out the required function to the fullest. 3. Appreciation of the gorgeous diversity of physiological possibilities that animals have developed through natural selection.	

Programme: M. Sc. (Zoology)
Course Code: ZOC-203 **Title of the Course:** Advanced Developmental Biology
Number of Credits: 3
Effective from AY: 2018-19

Prerequisites for the course:	Elementary knowledge of embryology, molecular biology, signal transduction.	
Objective:	To understand the overall chronology of the development and the role of various morphogens (protein/mRNA) in specification and determination of various organs and body axis formation.	
Content:	**Module 1:** Recognition of sperm and egg during fertilization; Prevention of Polyspermy; Activation of egg metabolism; Types of cleavage, Regulation of Cleavage; Gastrulation. Mechanism of cell cellular differentiation; Cellular communication: Paracrine factors and signal transduction cascade. **Module 2**: Developmental dynamics of cell speciation: Specification of body axes in sea urchin-, nematode-, insect-, amphibian-, avian- and mammalian embryo. **Module 3:** Induction and Competence; Cascade of induction during the formation of lens; epithelium-mesenchyme interaction. Pattern formation in Vertebrate Limbs, Formation of Limb Bud; Generation of the Proximal – Distal, Anterior – Posterior, Dorso - Ventral axis of the Limb	12 hours 12 hours 12 hours
Pedagogy:	Lectures/Tutorials/Assignments/Self-study.	
References/Readings	1. Carlson BM, Pattern's Foundation of embryology, Mc Graw Hill Inc.USA. 2. Gilbert SF, Developmental Biology, 5th ed Sinauer Associates Inc., Sunderland, USA. 3. Gilbert SF, Developmental Biology, 8th ed. onwards , Sinauer Associates Inc., Sunderland, USA. 4. Moody SA, Principles of Developmental Genetics, Academic Press. New York. 5. Waddington CH, Principles of Development and Differentiation, The MacMillan Co. New York.	
Learning Outcomes	1. Understanding the basic concept of the development. 2. Understanding the cyto-differentiation and cellular communication during the process of development. 3. Boosting their concepts and knowledge regulation of gene expression. 4. Learning the different stages of development of chick embryo 5. Gaining the knowledge to do experimental embryology through mini project work.	

Programme: M. Sc. (Zoology)
Course Code: ZOC-204 **Title of the Course:** Agricultural Entomology
Number of Credits: 3
Effective from AY: 2018-19

Prerequisites for the course:	Basic working knowledge of insects, their classification, beneficial and harmful insects in agriculture	
Objective:	This course deals about the insects encountered in agricultural fields. To provide insight on pests of various foods, fibre, oil household and veterinary importance. Understand principles of pest control methods including pest control appliances	
Content:	**Module 1:** Role of insects in agriculture, insect population and crop losses, organs of support and movement in insects, segmentation and body regions, segmental appendages, musculature, ingestion and digestion of food, control and coordination, reproduction, development and growth in insects, insect-responses to the environment. **Module2:** Insect pests of cereals, vegetables, fibre crops, oil seeds, species, household pests, insects of veterinary importance. Pests of stored products, storage structures, insect pest types, stored products pest control. **Module 3:** Principles of pest control, selection methods for pest control, cultural, mechanical, legislative, chemical control, pesticide residues and their monitoring, bio-ecological practices, Biological control, Microbial pesticides, Integrated pest management, Pesticide application equipments.	12 hours 12 hours 12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study.	
References/Readings	1. Atwal A S, Agricultural pests of South East Asia, Kalyani Publishers, New Delhi. 2. Apple JL and Smith RF, Integrated Pest Management. Plenum Press, New York. 3. Evans JW, Insect Pests and Their Control. Sameer Book Centre, Delhi. 4. Hill DS, Agricultural Insect Pests of the tropics and Their Control. Cambridge University Press, Cambridge. 5. Kumar A and Nigam M, Economic and Applied Entomology, Emkay Publications, New Delhi. 6. Mani MS, General Entomology, Oxford and IBH Publishing Co., New Delhi. 7. Nair MRGK, Insects and Mites of Crops in India. ICAR, New Delhi.	
Learning Outcomes	1. Understands role of insects in agriculture. 2. Studies insect structure and function. 3. Realising various insect pests of various food, fibre,	

	oil and other crops. 4. Learns to apply various agricultural equipments. 5. Understands insect pest management. 6. Practicals will give hand on training to the learner.	

Programme: M. Sc. (Zoology)
Course Code: ZOC-205
Title of the Course: Laboratory Course II based on (ZOC 201, 202, 203 & 204)
Number of Credits: 4
Effective from AY: 2018-19

Prerequisites for the course:	Basic working knowledge of classical genetics, animal anatomy, Physiology, Taxonomy, Systematics, embryology, Molecular biology, Signal transduction, insects, their classification, beneficial and harmful insects in agriculture.	
Objective:	Laboratory training based on courses ZOC 201, 202, 203 & 204.	
Content:	**Module 1**: Demonstration of Green and Red Fluorescence proteins for monitoring gene expression; Observation of DNA fragmentation in apoptotic cells; Culture and maintenance of Drosophila; Study of Life cycle of Drosophila; Mutant Phenotypes of Drosophila; Paper chromatographic separation of proteins (Drosophila eye pigments); Study of transcriptional activity in Polytene chromosomes; Induction of phenocopies in Drosophila; Mounting of the eggs and sex combs of Drosophila. **Module 2:** Transport of glucose and amino acids across the intestine of Poultry birds (tissues to be collected from slaughter house); Study of human lung volume during exercise; Estimation of heart rate, pulse rate and blood pressure changes during exercise, Study of ECG and its evaluation in normal and pathological variations, Study the effect of load on muscle contraction on man; To evaluate the memory of provided subject using memory drum. **Module 3:** Identification of developmental stages of chick embryo; Chick embryo culture, in vitro; Changes in biochemical profiles of developing chick embryo; Effect of thyroxin/ retinoic acid/ proline/ pesticide in developing chick embryo; Organogenesis, preparation of slides and studies of 96 hrs chick embryo. **Module 4:** Collection, preservation and identification of agriculturally important insects. Study of insect body parts (antennae, wings, appendages etc.,) Study of insect pests of Paddy. Study of insect pests of cereals, Study of insect pests of sugarcane/ coconut, Detection of insect pest infestation in agriculture, Appliances of insect pest control. Study of pests of household. Study of insect pests of storage. Study of pests of Live stock.	24 hours 24 hours 24 hours 24 hours
Pedagogy:	Practical/ mini project.	
References/Readings	As mentioned under individual course ZOC 201, 202, 203 & 204.	
Learning Outcomes	Laboratory training based on courses ZOC 201, 202, 203 & 204.	

Programme: M. Sc. (Zoology)
Course Code: ZOO-301 **Title of the Course:** Animal Cell Culture
Number of Credits: 2
Effective from AY: 2018-19

Prerequisites for the course:	Basic knowledge on organization of cells, their structure and function in animal body.	
Objective:	This course is designed to understand structure, growth and function of animal cells and technology involved in cell and tissue culture establishment, characterization and its maintenance in vitro condition.	
Content:	**Module 1:** Introduction, Equipments and materials requisite for animal cell culture and their roles, establishment of explants and free cell culture and its maintenance. Concept of cell line, Continuous cell line. **Module 2:** Scaling up of animal cell culture. Application of various methods for characterization of cultured cells and cell line, Stem cells (Embryonic and adult) and their applications	12 hours 12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/Readings	1. Boulton A, Glenbaker, Wolfgong W, Practical Cell Culture Techniques. Human Press. Lowa. New Jersy. Conn PM, Cell Culture. Academic Press. Sandeigo. USA 2. Freshney RI. Culture of Animal Cells, Wiley Liss New York. 3. Freshney RI, Pragnell IB and Freshney MG, Culture of Epithelial Cells, Wiley Liss, New York 4. Shahar A, De Vellis J, Vernadakis A and Haber BA(1990), Dissection and Tissue Culture Manual of Nervous system. 5. Allan Liss. New York Robert Lanza, Anthony Atala, Essentials of Stem Cell Biology, 140464th Edition, Academic Press	
Learning Outcomes	1. Ability to describe the basic components of culture media and the conditions required to grow and maintain cells in culture for its immediate application. 2. Ability to explain sterile techniques used for growing cells in culture, the sources of bacterial and fungal contamination and be able to identify contamination. 3. Theoretical idea to perform all common cell culture techniques to grow and maintain cells without contamination and further evaluation of cell health, viability, and functional properties	

Programme: M. Sc. (Zoology)
Course Code: ZOO-302 **Title of the Course:** Biodiversity
Number of Credits: 2
Effective from AY: 2018-19

Prerequisites for the course:	Should have studied B. Sc. Zoology with assumption that the student has a basic working knowledge of classical faunal biological diversity.	
Objective:	This course will help the learner to understand the concept and components of biodiversity, its importance, human population Vs biodiversity, wild life and its conservation, national and international efforts to protect and propagate biodiversity, Bioprospecting, IPR, biopiracy etc.,	
Content:	**Module 1**: Concepts and components of biodiversity, genetic, species and ecosystem diversity; Biodiversity as an important resource, human population growth and its implications on biodiversity, biodiversity indices, value of biodiversity. In-situ and ex-situ Conservation of biodiversity. **Module 2**: Wildlife reserves in India, Earth summit and follow up action, Convention on biodiversity. Biodiversity hotspots in the world, national and global red data lists, Bioprospecting and conservation, IPR of biodiversity and its products, patent protection and biopiracy, biodiversity informatics, databases in biological materials. International efforts and issues of sustainability	12 hours 12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/Readings	1. Belsare DK, Introduction to Biodiversity, A. P. H. Publishing Corp. New Delhi. 2. Groombridge B. Global Biodiversity: Status of Earth's Living Resources. Chapman and Hall Publ. London 3. Huston AM (1994), Biological diversity, Cambridge University Press, Cambridge Wilson, E O (1998), Biodiversity, National Academy Press, New York	
Learning Outcomes	1. Learner will understand the concept and components of biodiversity, its importance. 2. Realise the role of human population Vs biodiversity. 3. Will have sufficient knowledge on wild life and its conservation. 4. Will realise the national and international efforts to protect and propagate biodiversity, Bioprospecting, IPR, biopiracy etc.	

Programme: M. Sc. (Zoology)
Course Code: ZOO-303 **Title of the Course:** Biology of Reproduction
Number of Credits: 2
Effective from AY: 2018-19

Prerequisites for the course:	Elementary knowledge on animal anatomy and physiology.	
Objective:	This course provides a fundamental knowledge of animal reproduction at anatomical, physiological and endocrinological level to deal with management of reproduction and fertility in animals and humans.	
Content:	**Module 1**: Male Reproduction: Histo-architecture of testis, Spermatogonia, Stem cells; Biology of spermatozoa ,Seminiferous epithelial cycle, Spermatogenesis, Hormonal control of spermatogenesis, hormonal regulations of accessory male reproductive organs- epididymis , Vas deferens ,prostate glands seminal vesicle , coagulating gland cowper's gland; Biochemistry of semen, semen analysis and its utility in medico legal cases. **Module 2:** Female Reproduction: Reproductive cycles in mammals and their regulations; Ovulation; Implantation , types of implantation , sequence of events during implantation , decidual cell reaction , delayed implantation hormonal regulation; Pregnancy; Corpus Luteum, luteotrophic complex in different mammals; Endocrine control of pregnancy; Parturition; Activation and stimulus of uterus, hormonal mediation; Lactation, morphological and functional development of mammary glands, preparation for lactation, effect of hormones, initiation and maintenance of lactation, milk secretion; Menopause.	12 hours 12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/Readings	1. Knobil E and Neil JD, Physiology of Reproduction (Vol. I and II), Raven Press Ltd., New York. Mandal A, A Handbook of Neuroendocrinology, Emkay Publication, New Delhi 2. Nelson RJ, An Introduction to Behavioral Endocrinology, Sinaeur Associates, Inc., USA. 3. Pablo De, Scanes CG and Weintraub BD, Handbook of Endocrine Research Techniques, Academic Press Inc., USA. 4. Saidapur SK, Reproductive Cycles of Indian Vertebrates, Allied Publishers Ltd. New Delhi. Schatten H and Constantinescu GM, Comparative Reproductive Biology, Willey Blackwell Publications, UK.	
Learning Outcomes	1. Explanation of how to apply reproductive information to strategies for the management of reproduction and fertility in animals. 2. Critically evaluation of the advantages/disadvantages of current and developing reproductive technologies	

Programme: M. Sc. (Zoology)
Course Code: ZOC-304 **Title of the Course:** Environmental Physiology
Number of Credits: 4
Effective from AY: 2018-19

Prerequisites for the course:	Basic knowledge of Animal Physiology and biochemistry	
Objective:	To learn the meaning of adaptation To understand how the various physiological processes adjusted during the fluctuation of the various environmental parameters.	
Content:	**Module 1**: Nature and levels of adaptation; Mechanism of adaptation; Capacity adaptation; Biochemical and physiological effects of temperature; regulation of heat gain and heat loss, Role of nervous system and endocrine system in thermal biology; homeoviscous adaptation Biochemical and physiological effects of salinity; regulation and movements of water and solute; osmoregulatory organs and their excretory products; cost and energy of regulation of water and ions. **Module 2:** Strategies and mechanism in physiological adaptation with reference to Deep sea, high altitude, desert, cave and endo -parasitic organisms.	12 hours 12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/Readings	1. Hochachka PW and Somero GN, Biochemical Adaptation, Oxford University Press, Oxford. 2. Nielsen S, Animal Physiology: Adaptation and Environment, Cambridge University Press, Cambridge. 3. Wilimer P, Stone G and Johston IA, Environmental Physiology. of Animals,Wiley Blackwell Publishing Co, USA	
Learning Outcomes	1. Understanding the concept of adaptation. 2. Understanding the life processes at various environmental condition.	

Programme: M. Sc. (Zoology)
Course Code: ZOO-305 **Title of the Course:** Fishery Biology
Number of Credits: 2
Effective from AY: 2018-19

Prerequisites for the course:	Basic knowledge on animal anatomy, physiology and endocrinology.	
Objective:	To understand the various mode of fisheries. To understand the potentiality of fisheries in India, more particularly in Goa.	
Content:	**Module 1**: Inland capture fisheries: Sole fish fishery; Mackerel fishery and Sardine fishery**;** Shell fish fishery: Mussels, Oysters and Clams. Capture Fisheries: Freshwater Fish Culture with reference to carp and Tilapia; Shrimp aquaculture. **Module 2:**.Types of culture practices: Culture systems- Monoculture, Monosex culture, Cage culture, Pen culture, Integrated culture. Fish farm : site selection and pond preparation, selection of species, hatchery production; Management of fish farm ponds; Aquatic weeds and their control; Fish Nutrition, live feed culture and formulated feed preparation, water quality management in hatchery. Preservation and fish processing, transporting and marketing of fishes, by-product of fish industry.	12 hours 12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/Readings	1. Vertebrate Endocrinology: Academic Press, New York 2. Bal D, Marine Fisheries of India, Tata McGraw Hill Publ., India. 3. DuttaMunshi, J, Fundamentals of Freshwater Biology, Narendra Publishing House, Delhi. 4. DuttaMunshi J and Srivastava MP, Natural History of Fishes and Systematics of Freshwater Fishes of India, Narendra Publishing House, Delhi. 5. Jayram K, The Freshwater Fishes of India, Pakistan, Bangladesh, Burma and Sri lanka, A Hand book. Zoological Survey of India, Kolkata. 6. Jingran VG, Fish and fisheries of India, Hindustan Publishing Corporation, New Delhi. 7. Kurian, C and Sebastain VO, Prawn and Prawn Fisheries of India, Hindustan Publishing Corp., Delhi. 8. Merett NR and Haedrich RL. Deep Sea Demersal Fish and Fisheries, Chapman and Hall, New York.	
Learning Outcomes	1. Understanding the socio-economic development through Fisheries. 2. Acquiring the basic knowledge about the Fisheries as to set entrepreneurship.	

Programme: M. Sc. (Zoology)
Course Code: ZOO: 306 **Title of the Course: Marine Zoology**
Number of Credits: 2
Effective from AY: 2018-19

Prerequisites for the course:	Elementary knowledge about ecology and environmental science.	
Objective:	This course provides thorough grounding about the diversity of marine organisms, their biogeography, interactions with other organisms and adaptations to their environments, covering marine invertebrates and vertebrates from the smallest zooplankton to the largest animals of marine world, so also awareness of the threats to marine life and its conservation besides extraction of marine resources.	
Content:	**Module 1:** Marine Biomes & their characteristics, Natural association of organisms, Nutritional relationship, Ecological subdivisions of marine environment and their faunal inhabitants. **Module 2:** Marine resources (Physical resources, Energy resources, Biological resources and Non-extractive resources), Marine pollution (sources and types, solutions), Bio-fouling & Bio-deterioration.	12hours 12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/Readings	1. Carol Lalli, and Timothy Parsons (2002), Biological Oceanography, Butterworth-Heinemann Publ.,UK. 2. Karleskint G, Turner R, and Small J (2002), Introduction to Marine Biology, Brooks Cole Publ.,USA. 3. Nair NB and DM Thampy (1990), A Text Book of Marine Ecology, Macmillan Company India Ltd., India 4. Southward, Young & Fuiman (2000), Advances in Marine Biology, Elsevier, UK Sumich JL and Marissey JF (2002), Introduction to Biology of Marine Life, Jones & Bartlett Publ., USA. 5. Alan H Linton, Microbes, Man and Animals. John Wiley & Sons, New York.	
Learning Outcomes	1. Understanding of marine animal diversity and various relationships among them. 2. Scientific awareness to understand the marine environmental conditions and human impacts that are affecting marine life. 3. Knowledge about various adaptation strategies to live in various marine habitats. 4. Knowledge of extraction of various marine resources and their applied usage.	

Programme: M. Sc. (Zoology)
Course Code: ZOO-307 **Title of the Course:** Molecular endocrinology
Number of Credits: 2
Effective from AY: 2018-19

Prerequisites for the course:	Basic knowledge on animal anatomy, physiology and endocrinology.	
Objective:	This course provides molecular level insight on endocrinological events in animal body to focus on various approaches to understand hormone action and its related applications in the field of cellular pathologies.	
Content:	**Module 1**: Hypothalamic and Hypophyseal hormones and their functions; Structure and functions of the GI tract hormones. Neuroendocrine feedback and response to varied stimuli. **Module 2:** Mechanisms of hormone action: Receptors and types- membrane receptors, nuclear receptors; receptor regulation and signal transduction, second messengers, permissive actions of hormones and termination of hormone action. Cross talk between steroid and protein hormone pathways.	12 hours 12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/Readings	1. Bolander FF, Molecular Endocrinology, Elsevier, UK 2. Hadley ME and Levine JE, Endocrinology, Adeson-Wesley publication, USA. 3. Melmed S, Polonsky KS, Reed P et al., William's text book of Endocrinology, Willey Blackwell Publication, UK. 4. Franklyn F. Bolander. Molecular Endocrinology: Elsevier- Academic Press. 5. J. Darnell, H. Lodish and D. Baltimore , Molecular Cell Biology: Scientific American Book, Inc. USA 6. Norris, D. O., Vertebrate Endocrinology: Academic Press, New York.	
Learning Outcomes	1. Essential in depth understanding of the molecular synthesis, secretion and action of hormones respectively other regulatory substances of animals. 2. Vision to understand its relatedness to various hormone base disorders and its application to other fields of cell biology.	

Programme: M. Sc. (Zoology)
Course Code: ZOO: 308 **Title of the Course:** Human Parasitology
Number of Credits: 2
Effective from AY: 2018-19

Prerequisites for the course:	Basic working knowledge of animal parasites.	
Objective:	This course will help the learner to understand the subject of parasitology, host-parasitic interaction, various protozoan, nematode, and other types of parasites.	
Content:	**Module 1:** Introduction to Parasitology: Host Parasitic interactions in health and diseases, signs and symptoms of parasitic diseases, Intestinal & Urogenital Protozoa (Parasitic Protozoa:General characters & classification of Flagellates (*Giardia intestinalis*, *Trichomonas vaginalis*) Ciliates (*Balantidium coli*, *Isospora belli, Cryptosporidium parvum*), Hemosomatic Protozoa (Free living Amoeba phase, Trypanosomes monomorphic / Polymorphic, Leishmania, Plasmodium, *Toxoplasma gondii).* **Module 2:** Nematodes: General Characters and Classifications, Intestinal Nematodes (*Ascaris lumbricoids, Trichinella spiralis,* Hook worms), Blood and tissue nematodes (*Wuchereria bancrofti, Dracunculus medinensis*), Trematodes: General Characters, systematics and pathogenecity of Liver fluke (*Fasciolla hepatica*), Intestinal Fluke (*Fasciolopsis buski*), Lung flukes (*Paragonimus westermani*), Blood flukes (Schistosomes), Cestodes (*Taenia solium, Dipylidium caninum*), Extra- Intestinal larval Cestodes (*Echinococcus spp).* Partasites of insect origin (Flies and bugs, Fleas and lice) Arachnids (ticks and mites), Crustaceans (Cyclops).	12hours 12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/Readings	1. Alan H Linton, Microbes, Man and Animals. John Wiley & Sons, New York. 2. Burton J. Bogitsh, Human Parasitology, Academic press. New York. 3. Leslie Collier, Albert Balows and Max Sussman, Topley and Wilson's Microbiology and microbial infections: Vol 5: Parasitology, Arnolds publ. New York, 4. Rathnaswamy GK, A Hand book of Medical Entomology and Elementary Parasitology, S.Vishwanath Pvt.Ltd., India 5. Shukla AN and Tyagi R, Protozoan Diseases, Anmolo publication, New Delhi.	
Learning Outcomes	1. Learner will have sufficient knowledge on parasitology, 2. Will understand host-parasitic interaction, 3. Will realise various protozoan, nematode, and other types of parasites	

Programme: M. Sc. (Zoology)
Course Code: ZOO-309 **Title of the Course:** Genetic Toxicology
Number of Credits: 2
Effective from AY: 2018-19

Prerequisites for the course:	Basic working knowledge of Anatomy, Physiology and ecology.	
Objective:	Provides broad theoretical knowledge within toxicology and development of a general working knowledge of the principles and practice of clinical toxicology.	
Content:	**Module 1:** Introduction to toxicology, Branches of toxicology, Dosage and time response relationships. Biotic and abiotic aspects effecting toxicity. Means of exposures (acute, chronic, Impact of toxicants on organism (Direct/ indirect, long term etc.) Toxic risk assessment. Ecotoxicology and bio-monitoring. **Module 2:** Genotoxicity: Introduction to genotoxicity, Neurotoxicity Vs Genotoxicity / hepatotoxicity, Mechanisms, test techniques like bacterial reverse mutation assay, *in vitro* toxicology testing, *In vivo* toxicology testing, comet assay, Chemotherapy, Risk and different treatment like alkylating agents, intercalating agents, enzyme inhibitors.	12 hours 12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/Readings	1. Butler JC, Principle of Toxicology, John Wiley & Sons, NY. 2. Duffers JH, Environmental Toxicology, Edwards Arnold Publ. London 3. De Anil Kumar, Environmental Chemistry, Wiley Eastern Ltd., New Delhi. 4. Hays JW and RR Laws, Handbook of Pesticide Toxicology (vol. I), Academic Press, NY 5. Li A and Heflich RH, Genetic Toxicology, CRC Press, USA.	
Learning Outcomes	1. Identification of different routes of exposure of environmental toxins. 2. Understanding of the physiological and genotoxic effects of drugs and environmental toxins. 3. Knowledge of various techniques for Toxicity evaluation.	

Programme: M. Sc. (Zoology)
Course Code: ZOO-310 **Title of the Course:** Field Work
Number of Credits: 2
Effective from AY: 2018-19

Prerequisites for the course:	Basic working knowledge of classical animal taxonomy, systematics and ecology.	
Objective:	Increased independent skills in activities including Field-based work and its planning and fulfilment by undertaking fieldwork, employing survey and sampling techniques to study biodiversity in a variety of environments, sometimes in remote or indigenous areas.	
Content:	**Module 1: i)** Estimation of Biodiversity on a beach following transact and quadrate method. **ii)** Study of Avian diversity in agricultural area/undisturbed area /monoculture area. **iii)** Study of insect diversity on a plateau/agricultural field/undisturbed area/wild. **iv)** Study of wildlife and birds in a National park/Sanctuary/Zoo /Western Ghats. **v)** Study of Ichthyofauna in local market /along the coastal zone. Study of Molluscan diversity along the coast. **vi)** Study of Crustacean diversity in estuarine ecosystem. **vii)** Study of Nematode diversity in Agricultural Field /Mangroves/Coconut plantation. **viii)** Visit to various National Research Institutes of Zoological importance /Animal Breeding Centers /Fishery Research Institute. **Note: 24 hours in Goa and 24 hours outside Goa and to be completed during 1st & 2nd semester. Out of 7 Field Work mentioned above, any 5 have to be undertaken. Eighth is compulsory. Every student will be evaluated based on attendance, performance in the field, field note book entries and consolidated field report followed by presentation/Viva–voce by Departmental Council at the end of semester II.**	48 hours
Pedagogy:	Field work / self-study	
References/Readings	1. References included under all core courses. 2. Any other relevant reference requirement as suggested by experts.	

Programme: M. Sc. (Zoology)
Course Code: ZOO-401 **Title of the Course:** Ethology
Number of Credits: 2
Effective from AY: 2018-19

Prerequisites for the course:	Basic knowledge of animal science and behaviour.	
Objective:	This course develops concepts in the behaviour of animals such as underlying genetic and molecular mechanisms of behaviour as well as its importance in the animal kingdom	
Content:	**Module 1:** Introduction to Behaviour: Evolution of behaviour: natural selection and behaviour, Behaviour genetics: single gene and behaviour, polygenic inheritance behaviour, Heritability of behaviour, colony and behaviour, adaptational behaviour, social behaviour: sexual selection, altruism, social organization. **Module 2:** Mechanism of Behaviour: Mechanism of behaviour: Natural control of behaviours, sensory process and perception, Homeostasis and behaviour, behaviour in changing environment. Animal learning and decision making, mentality of animals: language and mental representation, Intelligence, tool using, animal awareness and Emotion	12 hours 12 hours
Pedagogy:	lectures/ tutorials/assignments/self-study	
References/Readings	1. Alcock, J, Animal Behavior, Sunderland Sinauer Associates 2. Bonner JT, Evolution of Culture in Animals, Princeton Univ Press. New Jersey 3. Ehrman L and Parsons PA, The Genetics of Behavior, Sinauer Associates, Massachusetts. 4. Halliday T, Sexual Strategies, Oxford University Press, Oxford. Lythgoe, JN, The Ecology of Vision, Clarendon press, Oxford McFarland D, Animal Behavior, ELBS Longman Publ. London	
Learning Outcomes	1. Understand the genetic and molecular mechanisms underlying behaviour. 2. Gain insight on the different types of behaviours used for survival in the animal kingdom	

Programme: M. Sc. (Zoology)
Course Code: ZOO-402 **Title of the Course:** Avian Biology
Number of Credits: 2
Effective from AY: 2018-19

Prerequisites for the course:	Elementary knowledge about ecology, Taxonomy and animal systematics.	
Objective:	This course develops concepts in ornithology such as underlying genetic and molecular mechanisms of behaviour as well as its importance in the animal kingdom	
Content:	**Module 1:** Introduction to Avian Biology: Bird identification, Systematics and Census**:** Avian systematics, Principal orders and families of Class Aves with salient features; Morphology and morphometry; Methods of identification; Bird diversity, Bird identification on field; Field guides. Bird Census: Counting techniques; Sampling techniques, Estimation of breeding population, mapping. Extinct and endangered species, causes of extinction and endangered status. **Module 2:** Avian flight, territoriality and breeding: Adaptation for flight in birds, types of flight, identification of birds based on flight patterns, flight metabolism, avian energy balance and thermoregulation Bird migration and Navigation: Types of migration, Migratory routes, Bird banding. Breeding Biology: Nesting territories, Communal nesting, Bird songs, courtship, mating systems; Type of nests ; Nest building; Nest defense, Clutch size;. Brood parasitism, Incubation and parental care.	12 hours 12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/Readings	1. Ali S, The Book of Indian Birds. Bombay Natural History Society and Oxford University Press, India. 2. Bibby CJ. Burgess ND, Hill A et al., Bird Census Techniques. Academic Press, UK. 3. Faborg J and Chaplin SB, Ornithology: an Ecological Approach. Prentice Hall Inc. New Jersey. 4. Goodfellow P, Birds as Builders. Arco Publishing Co., New York. 5. Giles RH, Wildlife management Techniques, Wildlife Society, Washington	
Learning Outcomes	1. Understand in detail the various aspects of avian biology such as their specialized anatomy, ecology and breeding systems 2. Identification of birds with the help of field guides which will be helpful for field trips or conducting surveys	

Programme: M. Sc. (Zoology)
Course Code: ZOO-403 **Title of the Course:** Biochemical Techniques
Number of Credits: 8
Effective from AY: 2018-19

Prerequisites for the course:	Elementary knowledge of Physics, chemistry besides Lifescience.	
Objective:	To provide general overview of different biochemical experimental approaches to understand the structure and functions of cell and its components.	
Content:	**Module 1:** Radiant energy: nature and properties of electromagnetic radiation; interaction of radiant energy with matter, Mono chromators; sources of radiant energy, spectrophotometry, x-ray diffraction**.** Radioactive transformation: isotopes; radioactivity detection and quantification; Geiger – Muller Detectors; liquid scintillation detectors; Autoradiography. Ultra Centrifugation: Centrifuge component; Theory of Centrifugation, Types of rotor, Density gradient Centrifugation; Isopycnic Centrifugation; Measurement of Centrifugal force. **Module 2:** Electrokinetic Phenomena: concepts of Electrophoresis and Electro-osmosis; Basis of electrophoretic separation; chemistry of Acrylamide Polymerization; Isoelectric focusing; SDS – PAGE electrophoresis, Recovery of materials from Electrophoretic gels. Chromatography: Adsorption Chromatography, Partition Chromatography, Affinity Chromatography; Exclusion Chromatography, Gas Chromatography, Liquid Chromatography, HPLC.	12 hours 12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/Readings	1. Cooper TG (1977),*The Tools of Biochemistry*, John Wiley publication, India 2. Dryer R and G. Lata G (1989), *Experimental Biochemistry*, Oxford University Press, Oxford Ewing GW(2006), *Instrumental Methods for Chemical Analysis*, Mc Graw Hill Book Co., London Freifelder D (1982), *Physical Biochemistry*, W. H. Freeman & Co., New York. 3. Holme D and Peck H (1998), *Analytical Biochemistry*, Longman Scientific & Technical Publication, England.	
Learning Outcomes	1. Understanding the basic knowledge of some advance techniques and their uses and its potential application in animal biology.	

Programme: M. Sc. (Zoology)
Course Code: ZOO-404 **Title of the Course:** Evolutionary Biology
Number of Credits: 2
Effective from AY: 2018-19

Prerequisites for the course:	Should have studied B. Sc. Zoology with assumption that the student has a basic and working knowledge of classical evolutionary biology	
Objective:	This course develops concepts in classical laws of thermodynamics and their application, postulates of statistical mechanics, statistical interpretation of thermodynamics, microcanonical, canonical and grants canonical ensembles; the methods of statistical mechanics are used to develop the statistics for Bose-Einstein, Fermi-Dirac and photon gases.	
Content:	**Module 1:** Evolutionary theories and evidences: Contributions of Lamarckism, Darwin-Wallace postulates, Overview of evidences- -Paleontological, Embryological, - Comparative morphological, Anatomical, Genetics and Cytological, Molecular Biological evidences, limitations of Darwinism, Neo Darwinism Evolutionary forces that affect the allelic frequencies: Mutation, Migration, Selection - Stabilizing 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, Non-random mating. **Module 2:** Concept of species and models of speciation based on distribution-sympatric, allopatric, stasipatric, based on genetic drift-genetic revolution, genetic transilience, Founder-flush theory, hybridization and speciation, phylogenetic gradualism, punctuated equilibrium, chromosomal phylogeny, molecular phylogeny, neutral theory, molecular clock, isolating mechanisms, Creation and evolution models.	12 hours 12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/Readings	1. Andrew Ferguson, Biochemical Systematics and Evolution, Blackie Publ., London 2. 2. Douglas J Futuyma, Evolutionary Biology (3rd Edition), Sinauer Associates, New York. 3. Douglas J Futuyma, Evolution, Sinauer associates, New York 4. Mark Ridley, Evolution (3rd edition), Blackwell Publishers, New York. 5. Michael R Rose and Laurence D Mueller, Evolution and Ecology of the Organism, Prentice Hall, New York	

Learning Outcomes	1. Explain statistical physics and thermodynamics as logical consequences of the postulates of statistical mechanics. 2. Apply the principles of statistical mechanics to selected problems. 3. Apply techniques from statistical mechanics to a range of situations.	

Programme: M. Sc. (Zoology)
Course Code: ZOO-405 **Title of the Course:** Human Genetics
Number of Credits: 2
Effective from AY: 2018-19

Prerequisites for the course:	Basic working knowledge of classical genetics.	
Objective:	This course develops concepts of Human Genetics and its use in the diagnosis of genetic disorders. This will also help in eugenics by genetic counselling.	
Content:	**Module 1:** Basic principles of genetics, human genetic make-up, genes as submicroscopic factors controlling human traits, packing of DNA/chromatin into chromosomes, nuleosomes and histones. 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); human pedigree analysis**,** Human genetic disorders, chromosomal (structural and numerical; autosomal or X linked) and biochemical (inborn errors of metabolism) with examples, Eugenics and genetic counseling **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 finger printing and their uses in human genetics.	12 hours 12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/Readings	1. Cummings ML, Human Genetics, CENGAGE Learning, Stamford. 2. Kothari ML, Mehta LA and Roychoudhury SS, Essentials of Human Genetics, Oxford University Press, India. 3. Hoelzel AR, Molecular Genetic Analysis of Populations ,Oxford University Press, India. 4. Gersen SL and Keagle MB, The Principles of Clinical Cytogenetics, Humana Press, Totowa, New Jersey 5. Turnpenny P and Ellard S, Emery's Elements of Medical Genetics, Elsevier, UK	
Learning Outcomes	1. Knowledge of genetic variability in human population 2. Knowledge of human genetics 3. Knowledge of modern methods for clinical genetic diagnosis 4. Knowledge of the genetic basis of common types of hereditary diseases	

Programme: M. Sc. (Zoology)
Course Code: ZOO-406 **Title of the Course:** Immunology
Number of Credits: 2
Effective from AY: 2018-19

Prerequisites for the course:	Basic knowledge on cell biology.	
Objective:	This course provides broad foundation base for understanding the defence mechanisms of the human body and also cross disciplinary approach to immune mechanisms focusing on cellular and molecular mechanisms in immunology, inflammation and infection.	
Content:	**Module 1**: Cells and molecules involved in innate and adaptive immunity, antigens, antigenicity and immunogenicity. B and T cell epitopes, structure and function of antibody molecules. Generation of antibody diversity, monoclonal antibodies, antibody engineering. **Module 2**: Antigen-antibody interactions, MHC molecules, antigen processing and presentation, activation and differentiation of B and T cells, B and T cell receptors, humoral and cellmediated immune responses, primary and secondary immune modulation, the complement system, Toll-like receptors, cell-mediated effector functions, inflammation, hypersensitivity and autoimmunity, immune response during bacterial (tuberculosis), parasitic (malaria) and viral (HIV) infections, congenital and acquired immunodeficiencies, vaccines.	12 hours 12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/Readings	1. Abbas AK, Litchman AHH and Pillai S, Cellular and Molecular Immunology, W. B. Saundrs Co., Philadelphia. 2. Berrette JT, Textbook of Immunology, C. V. Mosby & Co., USA 3. Boyd C, Fundamentals of Immunology, Inter Science Publ. NY Carpenter PL, Immunology and Serology, W. B. Saunders Corp. Philadelphia 4. Latha PM , Text Book of Immunology, Tata McGraw Hill Publ. New Delhi	
Learning Outcomes	1. Development of knowledge on the cellular ontogeny and organ involvement in immunity and how the immune system can fight infections and diseases. 2. Knowledge on development of body immune mechanisms and their applications. 3. Understanding of current immunology news and issues	

Programme: M. Sc. (Zoology)
Course Code: ZOO-407 **Title of the Course:** Wildlife and Conservation
Number of Credits: 2
Effective from AY: 2018-19

Prerequisites for the course:	Should have studied B. Sc. Zoology or Lifescience.	
Objective:	This course develops concepts in wildlife biology such as their importance in ecosystems along with an approach in key conservation methods	
Content:	**Module 1.** Introduction to Indian Wildlife: Habitat diversity of Indian wildlife, Biogeographic zones: faunal zonation; Endemic species; Important Indian fauna and their biology and distribution; IUCN red list: Extinct, Threatened and Least concern. **Module 2.** Conservation and Management of Wildlife**:** Conservation and management: In-situ conservation and Ex-situ conservation; Capturing and marking techniques – entrapping, darting, tagging and banding, scat analysis, pug marks; Regional, National and global Conservation efforts and legal aspects: National and international conventions – CITES, TRAFFIC; Forest laws and wildlife laws in wildlife conservation; Rio Protocol, Rio 20+, Project Tiger, Project Elephant, Gir Lion Project, Crocodile Breeding Projects, Project Hangul(1972).	12 hours 12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/Readings	1. Dasmann RF, Wildlife Biology, Wiley Publication, New York. 2. Krishnan M, India's Wildlife, Bombay Natural History Society, India. 3. Nair SM, Endangered animals of India, National Book Trust, India. 4. Noen AN, Wildlife Ecology: An Analytical Approach, WM Freeman and Co, New York. 5. Shah JH , Introduction to Wildlife Management, McGraw Hill, New York. 6. Usher MB, Wildlife Conservation and Evaluation Chapman and Hall, London.	
Learning Outcomes	1. Understand the distribution and biology of Indian wildlife including their conservation status 2. Gain insight on the different methods and projects implemented including various laws, acts and regulations for the conservation of wildlife	

Programme: M. Sc. (Zoology)
Course Code: ZOO-408 **Title of the Course:** Medical Entomology
Number of Credits: 2
Effective from AY: 2018-19

Prerequisites for the course:	Should have studied B. Sc. Zoology with assumption that the student has a basic working knowledge of classical faunal biological diversity.	
Objective:	This course will help the learner to understand the concept and components of insects involved in causing diseases. Their life cycles, epidemiology etc.,	
Content:	**Module 1**: Insect as disease vectors; Innate behaviour of insects; taxonomy , morphology of disease vectors and their life cycles; Life cycles of major vector borne diseases; Factor in disease transmission. **Module 2:** Vector ecology; Vector behaviour; modern vector biology; Proteogeomics of vectors; Chemical and biological and environmental control of vectors; Integrated vector management.	12 hours 12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/Readings	1. Bruce ED, Eldridge F and Edman JD, Medical Entomology, Kluwer Academic Publishers, UK. 2. Kahn HA, Introduction of Epidemiology Methods, Oxford University Press, New York. 3. Snodgrass RE , Principles of Insect Morphology Tata McGraw Hill publishing co. India.	
Learning Outcomes	1. Learner will understand the concept and components of vectors, their behaviour, taxonomy, morphology, life cycles etc., 2. Understand vector ecology, proteogeomics and their control.	

Programme: M. Sc. (Zoology)
Course Code: ZOO-409 **Title of the Course:** Nutritional Biochemistry
Number of Credits: 2
Effective from AY: 2018-19

Prerequisites for the course:	Basic knowledge of physiology and biochemistry	
Objective:	To understand the importance of various nutrients to keep in a well- being State.	
Content:	**Module 1:** Basic concepts of energy and energy expenditure; dietary requirements of carbohydrates, proteins and lipids; natural source of carbohydrates, protein and lipids; importance of dietary fibres; protein requirement at different stages of development; Nutrigenomics of Omega 3 PUFA and some amino acids **Module 2:** Electrolyte concentrations of body fluids; concept of acidosis and alkalosis Nutritional significance of Minerals, Biochemical functions of vitamin and specific deficiency diseases Nutritional requirements during pregnancy and lactation.	12 hours 12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/Readings	1. Brody T, Nutritional, Biochemistry, Academic Press, New York. 2. Chattejea MN and Shindea R, Text Book of Medical Biochemistry, Jaypee Pub. India. 3. Elia M, Ljungqvist O, Stratton R and Lanham SA, Clinical Nutrition, Willey Blackwell Publication, UK. 4. Swaminathan MS, Nutritional Biochemistry, T R Publication, India	
Learning Outcomes	1. Gaining the knowledge of importance about the nutrition and keeping ourselves in well- being state. 2. Understanding the importance of some nutrient in controlling the expression of genes.	

Programme: M. Sc. (Zoology)
Course Code: ZOO-410 **Title of the Course:** Radiation Biology
Number of Credits: 2
Effective from AY: 2018-19

Prerequisites for the course:	Basic working knowledge of lifesciences.	
Objective:	This course is designed to introduce basic principles, concepts, and methodology of radiation, protection and radiological hazard evaluation.	
2ontent:	**Module 1:** Introduction: Definition, scope and significance of radiation biology; General classification of radiation. Ionizing radiation: Linear energy transfer; radiation dose and units; principles of radiation dosimetry; direct and indirect effects; Radiation lesions in DNA; major types of DNA repair; damage recognition and signaling; consequence of unrepaired DNA damage (chromosome damage). Cellular radiobiology: Radiobiological definitions of cell death; survival curves and models; cell cycle effects; relative biological effectiveness (RBE); cellular repair exemplified in survival curves; cellular hyper-radiosensitivity (HRS) and induced repair (IRR); Other molecular targets – bystander (epigenetic) effects; radiation sensitizers and protectors **Module 2:** Radiobiological basis of radiation protection: Health consequences after total body irradiation from radiation accidents; long term radiation risks from low radiation doses; radiation-induced cancer in the atomic bomb survivors; epidemiological studies in other radiation exposed populations; mechanisms of radiation induced cancer; radiation effects in the developing embryo and fetus; radiation induced heritable diseases.	12 hours 12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/Readings	1. Anonymous, Radiation Biology: A handbook for teachers and students; International Atomic Energy Agency (IAEA), Training Course Series 42, Vienna. 2. Albert P Li and Heflich RH, *Genetic toxicology*, CRC Press, USA. *3.* Steel GG, *Basic Clinical Radiobiology*, Amazon, UK.	
Learning Outcomes	1. Knowledge of the fundamentals of radiation transport, interactions and detection and with the principles required for the analysis, design and safe operation of radiation producing and using equipment and systems.	

Programme: M. Sc. (Zoology)
Course Code: ZOO-411 **Title of the Course:** Dissertation
Number of Credits: 8
Effective from AY: 2018-19

Prerequisites for the course:	As per the ordinance applicable for Dissertation	
Objective:	This module provide initialization of independent thinking and applications in research field.	
Content	Chosen scientific area.	
Pedagogy:	Discussion/ Experimental work/ field study/ /self-study	
References/Readings	1. Scientific Journals 2. Reference Books 3. Any other authentic source	
Learning Outcomes	1. Designing of research work 2. Formulation of research methodology 3. Methods implementation and gathering of research data and application of statistics. 4. Research result formulation and interpretation.	