Goa University  
P.O. Goa University, Taleigao Plateau, Goa 403 206  
Syllabus of M.Sc. (Zoology) Programme

From the Academic year: 2014 -15 ( Approved by AC April 2014)

A brief description of the course:

**Purpose:**
- To understand the importance of taxonomy and the biodiversity of fauna (non chordate and chordate) and their conservation.
- To study comparative structure and function of the different organ systems and their physiological importance in relation to habit and habitat of the organism.
- To understand the biochemical integrity of various life processes.
- To have advanced knowledge on animal genetics, molecular biology and developmental biology and their applications.
- To prepare the students for pursuing advance studies in various fields of animal sciences by research.

**Prerequisites:**
The Candidate must pass the Bachelor’s degree examination in Zoology at T.Y.B.Sc. level or its equivalent.

**Credits:**
A student has to take minimum 60 credit course form the department out of which 40 credits are core courses and 20 credits are optional courses. Besides, to get Post -graduate degree student has also to take another 20 credits optional courses either from the department and or other department / Institution.

**Dissertation:**
Dissertation is to be treated as equivalent to 12 credits and compulsory for all students and it is in lieu of 12 credit optional courses. Student has to undertake dissertation work during 3rd and 4th Semester and the same will be evaluated at the end of 4th semester.

**Filed Work:**
It is compulsory for all students and they have to do the field work during 1st to 4th Semester and the same will be evaluated at the end of 4th semester. It is equivalent to 2 credit optional courses.
Number of Semester: Four.

In first and second semesters a student has to take courses equivalent to 20 credits. However, in third and fourth semesters, Besides Field work and Dissertation work, a student has to take courses equivalent to 15 credits besides.

Framework of Credit based syllabus (w.e.f. Academic year 2014-2015)

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<tr>
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### SEMESTER III

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### SEMESTER IV

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*Inter disciplinary course (students from other departments can also opt for the said course)
ZOC-101: Animal Taxonomy and Systematics

Contract Hours: 60 Hrs

Credits: 4

ALL MODULES CARRY EQUAL WEITAGE

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, toptype etc.

Module 2:
Affinities, Phylogeny and systematic position of Protozoa, Porifera, Cnidaria, Helminthes, Annelida, Arthropoda, Mollusca and Echinodermata

Module 3:
General Organization, affinities and systematic position of minor phyla Lopophorates, Phoronida, Ectoprocta, Brachiopoda, Pogonophora, Chaetognatha, Acanthocephala, Entoprocta and Sipunculida

Module 4:
Molecular basis of animal taxonomy: Genetic polymorphism, electrophoretic variations, amino acid sequencing for variety of proteins, DNA-DNA and DNA- RNA hybridization.

Reference Books:
Hymen LH, The invertebrates (all volumes), McGraw Hill, Philadelphia, USA
Huston AM, Biological Diversity, Cambridge University Press, Cambridge
Kapoor VC, Theory and Practice of Animal Taxonomy, Oxford and IBH Publ., Delhi
McNeely JA, Economics and Biological Diversity, IUCN, Gland, Switzerland
Prasad SN, Life of Invertebrates, Vikas Publ. New Delhi
Sinha AK, Adhikari S and Ganguly BB, Biology of Animals(vol. I & II), Central Book Agency, Kolkata
ZOC-102: Comparative Anatomy of Non-Chordates and Chordates

Contract Hours: 60 Hrs

Credits: 4

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. Appendicular musculature of Tetrapodes. Flight muscles of Insects and Birds.

Module 2:
Vascular system: Canalicular system in Porifera, Vascular system in Annelida, Arthropoda and Echinodermata; Evolution of Portal system in Vertebrates, Lymphatic system in Land Vertebrates

Module 3:
Nervous system: Nervous system in Arthropods and Molluscs; Sensory organs in Cnidarians and Helminthes; Central and autonomous nervous system in Tetrapodes; Somatic and visceral receptors of the Vertebrates

Module 4:
Urino-genital system: Excretory organs in Helminthes, Annelids and Molluscs; Reproductive organs in Echinoderms and Arthropods. Testes, vasa deferentia, ovary and oviduct of Vertebrates.

Reference Books:
Barrington EJ, Invertebrate Structure and Function, Thomas Nelson and Sons, USA.
Kardong K, Vertebrates: Comparative Anatomy, Function and Evolution, McGraw-Hill Companies, USA.
Kent CG and Carr R, Comparative Anatomy of Vertebrates, McGraw-Hill Companies, USA.
Wolff RG, Functional Chordate Anatomy, Amazon Publication, UK.
ZOC 103: Animal Biochemistry

Contract Hours: 60 Hrs
Credits: 4

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 turnover and amino acid catabolism; Nitrogen excretion pathways; Oxidation of amino acids; Biosynthesis of amino acids in animal. Biosynthesis of Pyrimidine and Purine.

Module 4:
Prostaglandins and leukotriene; Biochemical Signals Transduction pathways: G protein, IP3, Tyrosine kinase, Protein kinase; Role of Ca$^{2+}$ and Calmodulin in metabolism.

Reference Books:
Albert Lehninger, Principles of Biochemistry, CBS Publisher, New Delhi.
Murray RK, Granner D, Mayes P and Rodwell VW. Harper’s Illustrated Biochemistry, McGraw-Hill Companies, USA.
Nelson DL and Cox MM, Lehninger’s Principles of Biochemistry, Freeman WH and Co, USA.
ZOC 104: Cell and Molecular Biology

Contract Hours: 60 Hrs Credits: 4

Module 1:
Viruses: Structure and classification of animal viruses - reverse transcription; Bacterial viruses: structure, lysogenic and lytic life cycle, transformation experiment; Regulation of gene expression: Operon concept, \textit{lac} and \textit{trp} operons; regulation at the transcriptional, post-transcriptional, translational and post-translational changes in eukaryotes; activators, enhancers and silencers; Restriction maps and molecular marker maps.

Module 2:
Plasma membrane: Current concepts of Structure and Function; Cell adhesion Molecules; Extra Cellular Matrix (ECM); Cytoskeletal structure and functions; Structure and biogenesis of ribosomes and lysosomes.

Module 3:
Fluorescence, electron (SEM, TEM & STEM) and confocal microscopy: principle, methods and applications; Flow cytometry; Southern, Northern and Western blotting techniques; DNA fingerprinting; Fluorescent in situ hybridization (FISH) and Chromosome painting, DNA sequencing, Autoradiography, PCR, RTPCR, Nested PCR, RAPD, PCR based RAPD.

Module 4:
Mitochondrial genetic system Cell cycle and cell division: Phases of cell cycle, Cyclins and Cyclin dependant kinases, Cellular aspects of cancer, Apoptosis, cellular dynamics.

Reference Books:
De Robertis EDP and De Robertis EMF, \textit{Cell and Molecular Biology} Saunders College, Philadelphia.
ZOC 105 : Laboratory Course 1  
(Based on ZOC 101, 102, 103 and 104)

Contract Hours: 60 x3 hrs  
Credits: 4

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.

Module 2:

Osteological preparation of chick and rat with emphasis on limb bones and girdles; Appendicular and flight muscles of bird;  
Afferent and efferent branchial system of fishes; Hepatic portal system of rat.  
Nervous system of Crab, Pila/Loligo, Cranial nerves (V- VIIth and IX- Xth) of teleosts;  
Nerves and blood vessels in the neck region of rat;  
Reproductive system of cockroach and fish;  
Mounting (Temporary) of Mouth parts of Mosquito, Salivary glands of cockroach,  
Statocyst of Prawn/Loligo, Ctenidium and Osphradium of Pila, Radula of Pila, Trachea and Spiracles of insect.

Module 3:

Isolation and quantification of bio-molecules (carbohydrate, fat, and protein) from given tissues;  
Biochemical extraction of phosphatydylcholine, collagen and their purification;  
Kinetic and characteristic of Enzyme : pH optima, temperature optima, determination of $K_m$ and $V_{max}$ and enzyme inhibition;  
Electrophoresis of serum protein (PAGE);  
Thin Layer Chromatography of lipid.

Module 4:

Mitotic metaphase chromosomes of Swiss albino mice / rat  
Study of various stages of meiosis (grasshopper testis)  
Extraction/Isolation of genomic DNA from mammalian blood (man/mice/rat)  
Restriction digestion of lambda DNA with EcoRI and Hind III restriction enzymes  
Agarose Gel Electrophoretic analysis of DNA  
Southern blotting  
Isolation of cell organelles (Plasma Membrane, mitochondria and microsomes ) by differential centrifugation / sub cellular fractionation and monitoring of purity.  
Fluorescence In Situ Hybridization (FISH).
ZOC 201: Animal Genetics

Contract Hours: 60 Hrs Credits: 4

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; assigning function to a Gene; tool to study Functional Genomics; Construction of cDNA libraries; methods of cDNA synthesis, cDNA cloning, Isolation, synthesis and sequencing of Genes; Potential Applications of Functional Genomics; Genome research; Proteomics Research; Significance of proteomics research; methods of proteome analysis. Gene transfer methods and transgenic organisms

Module 4:
Bioinformatics: Definition and brief history of bioinformatics; bioinformatics tool for genetic studies; bioinformatics institutes; Protein and Nucleic Acid database; Systems Approach in Biology; Problems addressed by bioinformatics; Sequence analysis; Genetic Algorithm; Expressed sequence tags; Phylogenetic analysis; Gene prediction; Proteomics; Industrial market for bioinformatics

Reference Books:
David AC and Jenuwein T, Epigenetics, Cold Spring Harbor Laboratory Press, New York, USA.
Hartl DL and Jones EW, Genetics: Analysis of Genes and Genomes, Jones & Bartlett Publishers, Boston.
Primrose SB and Twyman RM, Principle of Genome Analysis and Genomics, Blackwell Publishing Co. Malden, USA.
ZOC 202: Comparative Animal Physiology

Contract Hours: 60 Hrs
Credits: 4

Module 1:
Comparative physiology of digestion: Principle of digestion, Digestive juices – composition, phases of secretion, regulations and functions; Absorption of digestive nutrients; egestion of undigested food, role of gut micro flora in digestion. Movements of GI tract – control and functions and reflexes.
Respiratory pigments in different phylogenetic groups; Pulmonary circulation; Transport and exchanges of gases in aquatic and terrestrial organism; Ventilation –perfusion ratio; Acid-base balance; Regulation of pH; Neural and chemical regulation of respiration.

Module 2:
Physical principle of circulation; Pumping activity of heart; Action potential – Pacemaker and Myocardial; Electrical-mechanical relationship; Cardiac cycle – Volume, Pressure, Electrical Changes; Systems of circulation; Peripheral circulation; Regulation of heart beat, cardiac output and blood pressure, Physiology of nitrogenous excretion; Role of gills in excretion; Role of kidney in excretion; Osmoregulation, Volume regulation; Role of Skin in excretion.

Module 3:
Adaptive physiology of muscle for various activities; neuronal control of muscle contraction, Physiology of electric organ.
Nervous tissue: neuron and glia; Regulation of sensory and motor pathways; neurotransmitters and their physiological functions; physiology of learning and memory; posture.

Module 4:
Sensing the environment: Photoreception, Thermo reception, Chemoreception, Mechanoreception; Endogenous and Exogenous biological rhythms; Bioluminescence and Chemoluminescence, Pheromones and other similar chemicals as means of communication among the animals.

Reference Books:
ZOC 203: Developmental Biology

Contract Hours: 60 Hrs  
Credits: 4

Module 1:
Recognition of sperm and egg during fertilization; Prevention of Polyspermy; Activation of egg metabolism; Regulation of Cleavage; Mechanism of cell cellular differentiation; Paracrine factors and signal transduction cascade.

Module 2:
Developmental dynamics of cell speciation; Establishment of fate map in Sea Urchin embryo and nematodes. Localisation of insect germ cell determinants in cytoplasm; Genetics of axes specification in insect.

Module 3:
Morphogenetic determination of tunicate embryo; Axes formation in fish embryos; Determination of amphibian axes; Axes formation in Avian embryos; Axes formation in mammalian embryo.

Module 4:
Induction and Competence, Regional Specificity of Induction(at the molecular level); Pattern formation in Vertebrate Limbs, Formation of Limb Bud; Generation of the Proximal – Distal, Anterior – Posterior, Dorso - Ventral axis of the Limb; Molecular mechanism of Limb Regeneration.

Reference books:
Carlson BM, *Pattern’s Foundation of embryology*, Mc Graw Hill Inc.USA.
ZOC 204: Agricultural entomology

Contract Hours: 60 Hrs  Credits: 4

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.

Module 2:
Insect pests of cereals, sub tropical and tropical fruits, vegetables, fiber crops, oil seeds, plantation crops, spices, house hold pests, insects of veterinary importance.

Module 3:
Pests of stored products and their control: Introduction, types of produce and pests, types of damage, storage structures insect pest types, pest spectra for stored products, stored products pest control.

Module 4:
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.

Reference Books:
Atwal A S, Agricultural pests of South East Asia, Kalyani Publishers, New Delhi.
Evans JW, Insect Pests and Their Control. Sameer Book Centre, Delhi.
Nair MRGK, Insects and Mites of Crops in India. ICAR, New Delhi.
ZOC 205 : Laboratory course II
(Based on ZOC 201, 202, 203 and 204)

Contract Hours: 180hrs
Credits: 4

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: Assessing physical and chemical modifier of heart rate in rat/mice.
   To study the effect of load on muscle contraction on man.
   Effect of ions and channel blocker on the transportation of ions across the membrane.
   Transport of glucose and amino acids across the intestine of rat.
   Study of human lung volume during exercise.
   To examine the relative activity of enzyme in different region of gut of fish.
   Electro physiology of membrane excitable cells of bivalve.

Module 3: Identification of developmental stages of chick embryo/ amphibian embryo
   Chick embryo culture, in vitro.
   Changes in biochemical profiles of developing chick embryo.
   Effect of thyroxin in developing chick embryo.
   Organogenesis, preparation of slides and studies of 96 hrs. chick embryo.
   Effect of retinoic acid and essential amino acids in the development of chick embryo.
   Effect of colchicines in the somite proliferation in 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
ZOO 301: Environmental Physiology

Contract Hours: 45 + 45 hrs
Credits: 3(Theory) + 1 (Practical)

Module 1:
Nature and levels of adaptation; Mechanism of adaptation; Cellular metabolism, regulation and homeostasis; physiological regulation of gene expression. 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.

Module 2:
Regulation and movements of water and solute; Osmoregulatory organs and their excretory products; cost and energy of regulation of water and ions; Atmosphere, Solubility of gases in water and air; Respiration in water and air; Hypoxia and anoxia; problems of diving, high altitude adaptation.

Module 3:
Strategies and mechanism in physiological adaptation with reference to marine, estuarine, freshwater, terrestrial, cold, dessert & parasitic life.

Module 4 (Practical):
Effect of low temperature in the rates of nitrogenous excretion and respiration of aquatic animals; Determination of Q10; Pattern of thermal acclimation; Effect of temperature on the kinetics of Acetylcholine esterase; Effect of salinity in the transportation of Na+/K+ ions; Role of transporter proteins in salinity adaptation.

Reference Books:
Hochachka PW and Somero GN, Biochemical Adaptation, Oxford University Press, Oxford.
Wilmer P, Stone G and Johnston IA, Environmental Physiology of Animals, Wiley Blackwell Publishing Co, USA.
ZOO 302: Animal Tissue Culture

Contract Hours: 45 + 45 hrs
Credits: 3(Theory) + 1 (Practical)

MODULE 1:
Introduction, Advantages and disadvantages of tissue culture, Definitions.
Equipments and materials for animal cell culture technology. Various systems of tissue culture, their distinguishing features, advantages and limitations.
Culture medium: natural media, synthetic media, sera. Introduction to balanced salt solutions and simple growth medium. Brief discussion on the chemical, physical and metabolic functions of different constituents of culture medium, role of carbon di oxide, serum and supplements.

MODULE 2:
Primary Culture: Behavior of cells, properties, utility. Explant culture; suspension culture. Established cell line cultures: Definition of cell lines, maintenance and management; cell adaptation. Measurement of viability and cyto-toxicity. Cell cloning, cell synchronization and cell manipulation. Various methods of separation of cell types, advantages and limitations; flow cytometry.

MODULE 3:

Module 4: (Practical):
Epithelial cell culture of mantle and gills of bivalve.
Culture of hepatopancreatic cells of crab.
Neuronal culture using chick embryo.
Fibroblast cell culture using chick embryo.
Organ culture from chick embryo- kidney, muscle.
Culture of bone marrow cells of rat/mice.
Stem cell culture from bone marrow of rat/mouse.

Reference Books:
Conn PM, Cell Culture. Academic Press. Sandeigo. USA
Freshney RI. Culture of Animal Cells, Wiley Liss New York.
Freshney RI, Pragnell IB and Freshney MG, Culture of Epithelial Cells, Wiley Liss, New York
ZOO 303: Fishery Biology

Contract Hours: 45 + 45 hrs Credits: 3(Theory) + 1 (Practical)

Module 1:
INLAND CAPTURE FISHERIES: Fishing gear- Hook and line, Long line; Cast net, Scoop net, Gill net, Trawl net, Rampan net, Purse seine Fishing craft: Catamaran, Dingy, Dugout canoe, Outrigger canoe, Mechanized boat. Sole fish fishery: Mackerel fishery and Sardine fishery; Shell fish fishery: Mussels, Oysters and Clams; North Indian plains with those of Southern peninsula; Dams, Impoundment and their impact on the riverine fishery.

Module 2:
CULTURE FISHERIES: Freshwater Fish Culture: Aquatic weeds and their control; Aquatic pests in the fish farm and their control; Site selection for a fish farm; Types of ponds in a self sustainable fish farm; Bunds, inlets, outlets and monks; Management of fish farm ponds: manuring, liming, stocking, supplementary feeding and harvesting; Composite culture systems of India, China, Israel and Europe. Culture systems- Monoculture, Monosex culture, Cage culture, Pen culture, Integrated culture.

Module 3:
MARINE FISHERIES: Shrimp aquaculture: types of culture practices, critical requirements, site selection and pond preparation, selection of species, hatchery production and management, 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, Export of fishery products. Impact of aquatic pollution on fishes

Module 4 (Practical):
Morphometry including fin formulae of fin fishes. Identification of commercially important fin and shell fishes from the west coast region. Identification of fin fishes belonging to 10 different families up to species level by using identification keys. Working out of the growth curve of fish by length-weight ratio by using suitable fish. Working out the GSI in a suitable fin fish species. Analysis of gut content and feeding habits of fishes.

References Books:
Bal D., Marine Fisheries of India, Tata McGraw Hill Publ., India.
DuttaMunshi J and Srivastava MP, Natural History of Fishes and Systematics of Freshwater Fishes of India, Narendra Publishing House, Delhi.
Jayram K, The Freshwater Fishes of India, Pakistan, Bangladesh, Burma and Sri lanka, A Hand

ZOO 304: Parasitology

Contract Hours: 45 + 45 hrs
Credits: 3(Theory) + 1 (Practical)

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:
Trematodes: General Characters, systematics and pathogenecity of Liverfluke (*Fasciolla hepatica*), Intestinal Fluke (*Fasciolopsis buski*), Lung flukes (*Paragonimus westermani*), Blood flukes (Schistosomes), Cestodes (General characters and classifications. Intestinal Tape worms (*Taenia solium*, *Dipylidium caninum*), Extra- Intestinal Larval Cestodes (*Diphyllobothrium spp.*, *Echinococcus spp*).

Module 3:
Nematodes: General Characters & Classifications, Intestinal Nematodes (*Ascaris lumbricoids*, *Trichinella spiralis*, Hook worms), Blood and tissue nematodes (*Wuchereria bancrofti*, *Dracunculus medinensis*), Partasites of insect origin (Flies & bugs, Fleas and lice) Arachnids (ticks and mites), Crustaceans (Cyclops).

Module 4 (Practical):
Study of life cycle stages of Urogenital protozoa, Ameoba spp.
Study of life cycle of Balantidium / Trypanosoma
Study of life cycle of Leishmania / Malarial parasite
Study of liver fluke/ intestinal fluke / lung fluke
Study of Blood fluke/ tape worm/ Diphyllobothrium / Echinococcus
Study of Intestinal nematodes (eg: Ascaris / Trichinella / Hook worm)
Study of blood tissue nematodes (Eg: Filariasis / Medina worm)
Study of parasites of insect origin (Flea / bug / lice)
Study of arachnid parasites (Ticks / mites)
Study of crustacean parasites (Cyclops)

Reference Books:


**ZOO-305: Biodiversity**

Contract Hours: 45 Hrs Credits: 3

**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.

**Module 2:**

Conservation of biodiversity, in-situ and ex-situ conservation. Wildlife reserves in India, Earth summit and follow up action, Convention on biodiversity.

**Module 3:**

Biodiversity hotspots in the world, national and global red data lists, categories of species and their management, biodiversity prospecting, IPR of biodiversity and its products, patent protection and biopiracy.
Bioprospecting and conservation, importance of biodiversity. biodiversity informatics, databases in biological materials. International efforts and issues of sustainability

Reference Books:

ZOO-306: Avian Biology

Contract Hours: 45 Hrs  
Credits: 3

Module 1:
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, Sampling bias, Estimation of breeding population, mapping.

Module 2:
Bird fossils- Archosaurs, Archeopteryx and Archiornis; Adaptation for flight in birds, types of flight, identification of birds based on flight patterns, flight metabolism, avian energy balance and thermoregulation. Habitat/ niche based adaptations in birds: woodland, grassland, wetland, desert, polar region. Birds as monitors of environmental change. Environmental impact assessment and conservation

Module 3:

Reference Books:
Module 1:
Habitat diversity of Indian wildlife and faunal zonation; Endemic species
Important Indian fauna and their distribution: Asiatic Lion, Indian Tiger, Indian one horned Rhinoceros, Indian Elephant, Golden Langur, Lion-tailed Macaque, Red Panda, Brow Antler Deer, Indian Wild Buffalo, Crocodile, Great Indian Bustard, Dolphin

Module 2:
Capturing and marking techniques – entrapping, darting, tagging and banding
Conservation and management: In-situ conservation and Ex-situ conservation; 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).

Reference Books:
Krishnan M, *India’s Wildlife*, Bombay Natural History Society, India.
ZOO 308: Immunology
(Interdisciplinary course)

Contract Hours: 30 Hrs
Credits: 2

Module 1:
Immunity and immunology, History of immunology, Immunity inflammation, phagocytosis, Kinds of immunity, natural resistance, acquired immunity, grades and measurement of immunity, mechanism of natural immunity. Antibodies: specificity, one antibody many manifestations, specificity, Structure and function of globulin, formation of antibodies.

Module 2:
Antigen: antigenecity, competition, specificity, natural proteins, bovine antigen and heptanes. Antigen-antibody interaction, combination, neutralization, fixation, precipitation, complementary activity, agglutination.

Reference Books:
Boyd C, *Fundamentals of Immunology*, Inter Science Publ. NY.

ZOO 309: Animal Behaviour
(Interdisciplinary course)

Contract Hours: 30 Hrs
Credits: 2

Module 1:
Evolution of behavior: natural selection and behavior, Behavior genetics: single gene and behavior, polygenic inheritance behavior, Heritability of behavior, colony and behavior, adaptational behavior, social behavior: sexual selection, altruism, social organization.

Module 2:
Mechanism of behavior: Natural control of behaviors, sensory process and perception, Homeostasis and behavior, behavior in changing environment. Animal learning and decision making, mentality of animals: language and mental representation, Intelligence, tool using, animal awareness and Emotion.
Reference Books:


**ZOO 310: Radiation Biology**  
(Interdisciplinary course)

Contract Hours: 30 Hrs  
Credits: 2

**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. Molecular radiobiology: 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

Reference Books:

Albert P Li and Heflich RH, *Genetic toxicology*, CRC Press, USA.
Steel GG, *Basic Clinical Radiobiology*. Amazon, UK.
ZOO 401: Toxicology

Contract Hours: 45 + 45 hrs
Credits: 3(Theory) + 1 (Practical)

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.

Module 2:
Biotoxins: Phyto, Zoo and microbial toxins, metabolism of toxic substances by plants / animals/ microbes. Effect of toxicants at various levels such as sub cellular, cellular, individual, population, ecosystem, biosphere etc. Biomagnification of toxicants, Interaction of toxins with other substances such as vitamins, minerals. Food additives as toxicants.

Module 3:
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, Genotoxic Chemotherapy, Risk and different treatment like alkylating agents, intercalating agents, enzyme inhibitors.

Module 4 (Practical):
Determination of LC50 of a pesticide in Bivalves.
Acute and chronic toxicity of a pesticide on the acetyl-cholinesterase activity in bivalves
Acute and chronic toxicity of heavy metals on the ion transport through gill of fish.
Genotoxic effect of cyclophosphamide on the mitotic chromosomes of Swiss albino mice.
Single cell gel electrophoresis studies of blood cells of Swiss albino mice treated with cyclophosphamide

Reference:
Butler JC, Principle of Toxicology, John Wiley & Sons, NY
Duffers JH, Environmental Toxicology, Edwards Arnold Publ. London
**ZOO 402: Human Genetics**

Contract Hours: 45 + 45 hrs  
Credits: 3(Theory) + 1 (Practical)

**Module 1:**  
Introduction: Basic principles of genetics, growth of human genetics, human genetic make-up, genes as submicroscopic factors controlling human traits, packing of DNA/chromatin into chromosomes, nucleosomes and histones.  
Human chromosome structure, chromosomal heteromorphism (X & Y chromosomes), Sex determination in man, Sex chromatin, Lyon hypothesis  
Human karyotype, developments since 1956, banding techniques, chromosome identification and nomenclature (ISCN)

**Module 2:**  
An overview of 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 3:**  
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

**Module 4 (Practicals):**  
Sterilization techniques for leukocyte culture  
Inoculation and Culture of human leucocytes  
Preparation of metaphase plates and their staining and analysis  
G- banding of metaphase plates and their analysis  
Human karyotyping  
Barr Body analysis using fluorescent probes.  
Micrometric analysis of chromosomes.  
Camera-lucida drawing of chromosomes.  
Dermatoglyphics  
Working out of Genetic problems
Reference Books:

Cummings ML, *Human Genetics*, CENGAGE Learning, Stamford
Turnpenny P and Ellard S, *Emery’s Elements of Medical Genetics*, Elsevier, UK

**ZOO 403: Marine Zoology**

Contract Hours: 45 + 45 hrs                      Credits: 3(Theory) + 1 (Practical)

**Module 1:**
Types of Marine habitats & their characteristics, Chemical Environmental factors: O2, CO2, C03, H2S, pH, anions/salts, organic matters, Natural association of organisms, Nutritional relationship, Sea Floor, sediments on the sea floor, Ecological subdivisions of marine environment

**Module 2:**
Marine Zones-Littoral, Pelagic & Benthic, Floral, and Faunal distribution and limiting factors, Benthic Zone - flora and fauna, Pelagic Zone - flora and fauna

**Module 3:**

**Module 4 (Practicals):**

Study of physical parameters of sea water/ estuarine water
Analysis of chemical factors- O2, CO2,carbonates, nitrates, sulphates, phosphates, salinity
Assay of marine diversity- floral and faunal studies in the field.
Study of ecological adaptations of inertidal organisms
Collection of marine planktons and their identification.
Study of bio fouling in marine habitat through field experiments
Study of primary production
Reference Books:

**ZOO 404: Biology of Reproduction**

Contract Hours: 45 + 45 hrs  
Credits: 3(Theory) + 1 (Practical)

**Module 1:**
Male Reproduction: Histo-architecture of testis, Spermatogonia, Stem cells; Biology of spermatozoa, Seminiferous epithelial cycle, Lablond and Clermont Concept of wave and 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.

**Module 3:**
Module 4: (Practical)

Dissection of male and female urinogenital systems in fishes, poultry bird and albino rat for comparative analysis.
Preliminary appraisal as to the live animal care and maintenance with respect to laboratory animal the albino rat.
Determination of durations of phases and length of estrous cycle in albino rat by vaginal lavage method.
Training in Surgical procedures to carry out bilateral Orchidectomy and Ovariectomy
Hormonal assay of LH/FSH/ Progesterone / Prolactin.

References:

Schatten H and Constantinescu GM, *Comparative Reproductive Biology*, Willey Blackwell Publications, UK

ZOO 405  Biochemical techniques

NO. OF CREDITS: 2  CONTACT HOURS: 30

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:


References:

Cooper TG (1977), *The Tools of Biochemistry*, John Wiley publication, India

**ZOO 406: Application of Animal Biotechnology**

NO. OF CREDITS: 2  CONTACT HOURS: 30

Module 1:

Biotechnology in improvement of live stock: Fish breeding; Androgenesis and Gynogenesis in fish ; Gene manipulation in aquaculture.
Reproductive biotechnology: Cryopreservation and Cryoprotection and gamete banking Assisted reproductive technology, In vitro fertilization and embryo transfer, ICSI, Sperm sexing.
Medical Biotechnology: Disease diagnostic markers; Drug delivery and targeting; Forensic Biotechnology
Module 2:
Animal Production technology and Food security: Polyculture of fish for high yield; Edible oyster and Pearl oyster production; Vermiculture and Vermi composting for alternative sustainable agriculture; Soil fauna in soil formation and fertility; Organic farming; Fish culture in flow through system and recirculation technology.
Environmental Bio-technology: Bioprocess technology; Bioassay and Biosensors in ecotoxicological screening; Biomarkers in ecotoxicological screening

References:

ZOO 407: Molecular Endocrinology
(Interdisciplinary course)
NO. OF CREDITS: 2 CONTACT HOURS: 30

Module 1:
Classification of hormones; Nature of hormone receptors; Neuroendocrine feedback and response to varied stimuli; Hypothalamic hormones - their structure and functions; Structure and functions of the GI tract hormones; Nature of hormone action; Hormone receptors - identification, quantization, purification and physico-chemical properties; Membrane receptors – structure and signal transduction mechanisms.

Module 2:
Hormonal regulation through differential gene expression; Production of hormones by DNA technologies; Biosynthesis, characteristics, functions and molecular biology of hormones of pineal gland, thyroid gland, adrenal gland; Genetic analysis and clinical management of hormonal disorders.

References:
Bolander FF, Molecular Endocrinology, Elsevier, UK
Hadley ME and Levine JE, Endocrinology, Adeson-Wesley publication, USA
Melmed S, Polonsky KS, Reed P et al., William’s text book of Endocrinology, Willey Blackwell Publication, UK
ZOO 408: Nutritional Biochemistry  
(Interdisciplinary course)  

NO. OF CREDITS: 2  
CONTACT HOURS: 30  

MODULE 1:  
Basic concepts of energy and energy expenditure. basal metabolic rate  
dietary requirements of carbohydrates, proteins and lipids- natural source  
of carbohydrates, protein and lipids; importance of dietary fibers; protein  
requirement at different stages of development; PUFA & lipid per-oxidation.  

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.  

Reference:  
Chattejea MN and Shindea R, *Text Book of Medical Biochemistry*, Jaypee Pub. India  
UK  
Swaminathan MS, *Nutritional Biochemistry*, T R Publication, India  

ZOO 409: Evolutionary Biology  
(Interdisciplinary course)  

NO. OF CREDITS: 2  
CONTACT HOURS: 30  

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,

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.

Reference:
Andrew Ferguson, Biochemical Systematics and Evolution, Blackie Publ., London
Mark Ridley, Evolution (3rd edition), Blackwell Publishers, New York

ZOO 410 Medical entomology
(Interdisciplinary course)

NO. OF CREDITS: 2 CONTACT HOURS: 30

Module 1:
Insect as disease vectors; Innate behavior 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 behavior; modern vector biology; Proteogeomics of vectors; Chemical and biological and environmental control of vectors; Integrated vector management.

Reference Books:
Bruce ED, Eldridge F and Edman JD, Medical Entomology, Kluwer Academic Publishers, UK.
Snodgrass RE, Principles of Insect Morphology Tata Mcgraw Hill publishing co. India
ZOO 411: Field work

Contract Hours: 90 Hrs*  
Credits: 2

1. Estimation of Biodiversity on a beach following transact and quadrate method.  
2. Study of Avian diversity in agricultural area/undisturbed area/monoculture area.  
3. Study of insect diversity on a plateau/agricultural field/undisturbed area/wild.  
4. Study of wildlife and birds in a National park/Sanctuary/Zoo/Western Ghats.  
5. Study of Ichthyofauna in local market/along the coastal zone.  
6. Study of Molluscan diversity along the coast.  
7. Study of Crustacean diversity in estuarine ecosystem.  
8. Study of Nematode diversity in Agricultural Field/Mangroves/Coconut plantation.  
9. Visit to various National Research Institutes of Zoological importance /Animal Breeding Centers/Fishery Research Institute/.

* 60 hours in Goa and 30 hours outside Goa and to be completed during 1st to IVth semester.  
Out of 9 Field Work mentioned above, any 5 have to be compulsorily undertaken.  
Every student will be evaluated based on attendance, performances in the field, field note book entries and consolidated field report followed by Viva – voce by Departmental Council.

ZOO 412: Dissertation

Credits: 12