Goa University

Goa University, Taleigao Plateau, Goa 403 206

Syllabus of M.Sc. (Zoology) Programme

(To be followed from the Academic year: 2020-21)

Programme Name: M. Sc. Zoology

Programme Code: ZO

Programme description:

This program is intended to develop learning about Zoology and significance of fauna ranging from single cell to multi-cellular systems. Keeping in mind the Departmental thrust area "Biodiversity and Comparative Animal Physiology", the current Post graduation curriculum has been totally restructured. A precise balance between the classical courses and modern biological courses has been made to introduce and emphasize the skill based programmes with an Internship experiences. Apart from the classical topics on Animal Sciences namely, Taxonomy and Systematics; Biodiversity; Anatomy of Non- chordates and Chordates, Genetics and Ecology this syllabus also covers topics on various aspects of Life Processes such as Animal Physiology, Developmental Biology and Molecular Biology. The restructured M. Sc. programme also focuses on various application based or skilled based courses such as Fishery Sciences and Fish Farm Management, Food Processing, Environmental Physiology, Neurophysiology, Stem Cell Biology, Herpetology, Ornithology, and Wild Life Biology. Besides, the courses like Immunology, Cell Biology, Biological Techniques, Biostatistics, Vector Biology, Biological Data Base programs also represent this restructured syllabus. This programme through the dissertation will also help the students to understand the basic principles of nature and will also provide scope for hands-on experience to experiment with nature /animals and thereby enable them to develop aptitude for research in various allied fields of animal sciences.

This curriculum will also enable them to overcome several day to day problems faced by our society by providing them with some workable solutions.

Prerequisite for M. Sc. Zoology Programme:

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

Programme Structure:

A 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 to be earned during Semester I and II and 32 credits are Optional Courses (Including Departmental skilled based optional and general optional / Interdisciplinary / Dissertation) to be earned during Semester III and IV. Active participation in Field work component as well as short internship program, included in the laboratory courses, is must for every student. There is also liberty to carry out Dissertation work in any sister departments of Goa University / neighbouring Institute (within Goa) / in the Industry (within Goa) but it should be under the supervision of one of the faculty members of the Zoology Department.

Also, all the Core Courses have to be studied 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 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 COURSE				
FIELD WORK (included in the lab course)				
SKILLED BASED OPTIONAL COURSE				
INTERNSHIP (included in the lab course)				
SOFT OPTIONAL COURSE				
DISSERTATION				

Note: Empty spaces represent the timeline for the courses indicated

CORE COURSES			
Semester I and II Each Semester 16 credits			
			Page Nos
ZOC 101	Principles of Animal Systematic	3 credits	7
ZOC 102	Anatomy of Non- Chordates	3 credits	9
ZOC 103	Animal Biochemistry	3 credits	11
ZOC 104	Molecular Biology	3 credits	13
ZOC 105	Laboratory Course 1 (Field work included)	4 credits	17
ZOC 201	Comparative Anatomy of Vertebrates	3 credits	19
ZOC 202	Comparative Physiology of Animals	3 credits	21
ZOC 203	Advanced Developmental Biology	3 credits	23
ZOC 204	Ecology	3 credits	25
ZOC 205	Laboratory Course 2 (Field work included)	4 credits	27

OPTIONAL COURSE			
Semester III and IV Each Semester 16 credits			
Cluster A: Aquaculture			**Page Nos**
ZOO 301	Fishery Biology	3 credits	30
ZOO302	Fish Farm Management	3 credits	32
ZOO 303	Fish Processing	3 credits	34
ZOO 304	Laboratory Course on Aquaculture (1-month Internship included)	3 credits	36
Cluster B: Life Processes			
ZOO 305	Environmental Physiology	3 credits	37
ZOO 306	Neurophysiology	3 credits	39
ZOO 307	Stem Cell Biology	3 credits	41
ZOO 308	Laboratory Course on Life Processes (1-month Internship included)	3 credits	43
Cluster C: Filed Biology			
ZOO 309	Ornithology	3 credits	44
ZOO 310	Herpetology	3 credits	46
ZOO 311	Wild Life Conservation & Management	3 credits	48
ZOO 312	Laboratory course on Filed Biology (1-month Internship included)	3 credits	51
NOTE	**STUDENT HAS TO OPT ANY ONE CLUSTER.**		
		12 credits	
ZOO 313	Toxicology (Theory and Practical)	3 + 1 credits	52
ZOO 314	Advanced Cell Biology (Theory and Practical)	3 + 1 credits	54
NOTE	**STUDENT HAS TO OPT ANY ONE**	**4 credits**	
ZOO 401	Animal Genetics	3 credits	56
ZOO 402	Biodiversity	3 credits	58

Interdisciplinary Courses			
ZOO 403	Evolutionary Biology	2 credits	60
ZOO 404	Endocrinology	2 credits	62
ZOO 405	Biostatistics	2 credits	64
ZOO 406	Vector Biology	2 credits	65
ZOO 407	Histology and Histochemistry	2 credits	67
ZOO 408	Helminotholgy	2 credits	68
ZOO 409	Ethology	2 credits	70
ZOO 410	Biological Techniques	2 credits	71
ZOO 411	Introduction to Biological database	2 credits	73
ZOO 412	Scientific Communications	2 credits	75
ZOO 413	Immunology	2 credits	77
ZOO 414	Nutritional Biochemistry	2 credits	79
NOTE	**STUDENT HAS TO OPT ANY FIVE**	**10 CREDITS**	
ZOO 415	Dissertation	8 credits	--
NOTE	Dissertation should be for the entire Semester III and Semester IV. It is in lieu of 4 interdisciplinary courses, equivalent to 8 credits.		

Course Code: ZOC 101 **Course Title: Principles of Animal Systematics**
Number of Credits: 3
Effective from AY: 2020 -21

Prerequisite for the Course:	Basic working knowledge of classical and animal taxonomy and systematics.	
Objectives:	This course develops concepts in animal taxonomy and systematic, modern methods of taxonomy and systematics and their application, General Organization and molecular basis of animal taxonomy.	
Content:	**Module 1**	
	Introduction to taxonomy, stages of taxonomy, importance of taxonomy, rise of taxonomy.	**2 hours**
	Principles and rules of taxonomy, Zoological nomenclature, ICZN regulations, new trends in taxonomy, Zoological classification, problems of taxonomists.	**4 hours**
	Taxonomic collections, identification and description, Taxonomical hierarchy (Linnaean hierarchy), Concepts of Taxon, holotype, paratype, topotype etc.	**4 hours**
	Concept of speciation: Biological, Phylogenetic and Evolutionary.	**2 hours**
	Module 2	
	Morphology based taxonomy, Numerical taxonomy, Immuno-taxonomy, Paleotaxonomy, Cyto-taxonomy and Chemotaxonomy.	**4 hours**
	Molecular basis of animal taxonomy, Genetic polymorphism, electrophoretic variations, amino acid sequencing for variety of proteins, DNA-DNA and DNA-RNA hybridization.	**4 hours**
	Systematics - definition and role in biology, Biological classification, Molecular systematics, DNA finger printing and molecular markers for detection/evaluation of polymorphism, RFLP, RAPD etc.	**4 hours**

	Module 3 Phylogenetics: Introduction; Basic terminology, Homology: Convergence, parallelisms and reversals. Phylogentic groups: monophyly, polyphyly, paraphyly. Construction of Phylogenetic trees, by using Cladistics and Phenetic related methods. Cladistics and Cladogram: Parsimony and finding the shortest trees, rooting trees. Molecular divergence, molecular clock, molecular drive.	**3 hours** **1 hour** **6 hours** **2 hours**
Pedagogy:	Lectures/ tutorials/online teaching mode/self-study.	
Learning Outcome:	1. Understand historical and modern methods of animal classification and systematics. 2. Get acquainted with field techniques for taxonomic study and use of literature and identification key. 3. Familiarise with Molecular basis of animal taxonomy.	
References /Reading:	1. Avise JC (2004), Molecular Markers, Natural History and Evolution, Chapman & Hall, New York. 2. Huston AM (1994), Biological Diversity, Cambridge University Press, Cambridge. 3. Kapoor VC (1983), Theory and Practice of Animal Taxonomy, Oxford & IBH Publishing Co. 4. Kato M (2000), The Biology of Biodiversity, Springer. 5. Mayer E (1971), Elements of Taxonomy, Oxford IBH Publishing company. 6. Simpson GG (2012), Principle of animal taxonomy, Scientific Publishers. 7. Tikader BK (1983), Threatened Animal of India, ZSI publication, Calcutta 8. Wilson EO (1988), Biodiversity, Academic Press, Washington. 9. Wilson EO (1992), The diversity of Life, The College edition W.W. Northem & Co.	

Course Code: ZOC 102 **Course Title: Anatomy of Non-Chordates**
Number of Credits: 3
Effective from AY: 2020 -21

Prerequisite for the Course:	Basic knowledge on Non-chordate anatomy, taxonomy and systematics is prerequisite for this course.	
Objectives:	To develop knowledge about fundamental anatomical principles among non-chordates. To understand the adaptive changes anatomical structures have undergone in the course of evolution.	
Content:	**Module 1** Skeletal system types: Endoskeleton-like (Poriferans), Exoskeleton (Arthropods) and Hydrostatic skeleton (Cnidarians, Molluscs and Echinoderms). Annelid Locomotory organs involved in Simple propulsion, Burrowing, Peristaltic waves, Sinusoidal and Inchworm type of locomotion. Primitive and advanced flight muscles of insects. Diffused, Simple ganglionic, Cycloneuralian, Heteroganglionic types of non-chordate Nervous system. Tetraneury plan of molluscan nervous system, Streptoneury, Euthyneury and centralization in molluscs. **Module 2** Digestive system types: Channel-network systems, Coelenteronic, Saccular and Tubular systems. Radula of Molluscs and various types of mouthparts in Arthropods. Coelomoduct derived, Gut derived and other excretory organs of non chordates. Calciferous Gland of Earthworms. Reproductive system in arthropods with Gonad-Gonoduct-Gonopore concept with addition of adjunctive organs. **Module 3** Respiratory organs and specialized respiratory structures of Annelids, Molluscs and Arthropods.	**4 hours** **4 hours** **6 hours** **4 hours** **4 hours** **3 hours** **5 hours**

	Open and Closed circulatory system concept of Invertebrates. Circulatory system in Annelids, Arthropods and Molluscs. Hearts of Oligochaetes and Bivalves.	**6 hours**
Pedagogy:	Lectures/ tutorials/ online teaching mode/self-study.	
Learning Outcome:	1. Understand the basic concepts associated with each system of the body. 2. Identify structures that are in place in the body systems to perform the functions according to the habits or habitats of the animals.	
References /Reading:	1. Hymen LH (1951), The invertebrates (all volumes), McGraw Hill, Philadelphia, USA. 2. Barnes RD and Ruppert EE (1994), Invertebrate Zoology, Saunders College Publishing. 3. Barrington EJW (1972), Invertebrate Structure and Function, Thomas Nelson and Sons, USA. 4. Marshall AJ and Williams WD (2004), Textbook of Zoology (vol 1). CBS Publishers & Distributors. 5. Jurd RD (2004), Animal Biology, BIOS Scientific Publishers, USA. 6. Cleveland P, Hickman CP, Roberts LS and Larson A (2001), Integrated Principles of Zoology, McGraw-Hill, NY. 7. Barnes RSK, Calow P, Olive PJW, Golding DW and Spicer JI (2001), The Invertebrates: A Synthesis. Blackwell Science 8. Schmidt-Rhaesa A (2007), The Evolution of Organ Systems, Oxford University Press. 9. Gangully BB, Shina AK and Adhikary S (2011), Biology of Animals vol. 1, New Central Agency, Kolkata.	

Course Code: ZOC 103 **Course Title: Animal Biochemistry**
Number of Credits: 3
Effective from AY: 2020 -21

Prerequisite for the Course:	Elementary knowledge on structural biochemistry of Protein, Carbohydrate and Fat.	
Objectives:	To understand the biochemical integrity of various metabolic pathways. To understand metabolic pathways, their regulation, and application in diagnostic and maintenance human well being state.	
Content:	**Module 1** Water as biological solvent; Ionization of water and buffering in biological system.	**3 hours**
	Enzyme Kinetics and enzyme inhibition; Catalytic and Regulatory strategies of Enzymes.	**5 hours**
	Concept of metabolism; Concept of free energy; Coupled reaction; TCA cycle; Electron transport system; Oxidative phosphorylation.	**4 hours**
	Module 2 Regulation of Glycolysis & Gluconeogenesis, Glycogenolysis & Glycogenesis.	**4 hours**
	Integration of Fatty acid synthesis & β Oxidation of fatty acid; Importance of Cholesterol and Lipoprotein in health management; Eicosanoids : types, outline of biosynthesis and their physiological importance.	**6 hours**
	Metabolism of Purine and Pyrimidines.	**2 hours**
	Module 3 Protein and peptide chains; Primary-, Secondary-, Tertiary- and Quaternary structures of protein; Purification of proteins.	**4 hours**
	Protein turn-over and amino acid catabolism; Nitrogen	**4 hours**

	excretory pathways; Oxidation of amino acids; Bio-synthesis of amino acids in animal. Integration of metabolism; Caloric homeostasis; Membrane receptors; Role of calcium and calmodulin in metabolism.	**4 hours**
Pedagogy:	Lectures/ tutorials/ online teaching mode/self-study.	
Learning Outcome:	1. Understanding the various metabolic pathways 2. Understanding the regulation of various metabolic pathways. 3. Understanding the integrative metabolism and life processes. 4. Understanding the application of metabolism in maintenance of human well being state.	
References /Reading:	1. Devlin TM (2010), Text book of Biochemistry with Clinical Correlations, Willey, Oxford. 2. Murray RK, Granner D, Mayes P and Rodwell VW (2000), Harper's Illustrated Biochemistry, McGraw-Hill, Companies, USA. 3. Blanco A and Blanco G (2017), Medical Biochemistry, Academic press. 4. Berg J, Tymoczko J and Stryer L (2002), Biochemistry**,** W H Freeman and Company, New York. 5. Nelson DL and Cox MM (2010), Lehninger's Principles of Biochemistry**,** Freeman WH and Co, USA. 6. Pelley J (2012), Elsevier's Integrated Biochemistry, Elsevier Publication, Amsterdam, The Netherlands.	

Course Code: ZOC 104 **Course Title: Molecular Biology**
Number of Credits: 3
Effective from AY: 2020 -21

Prerequisite for the Course:	Basic knowledge of nuclear and cellular components and functioning of the cell.	
Objectives:	This course develops concepts in molecular biology enhancing knowledge about the major processes in the cell throwing light upon the details of the central dogma. This knowledge is a prerequisite for biomedical/ biochemical research and shall enable students to have a clear understanding of all the dynamic processes of the nucleus which can be further applied in various fields of research.	
Content:	**Module 1** **Nucleic Acids, bonds, types of DNAs, DNA packaging and model organisms.** Watson and Crick to double helix DNA model. Research work of Rosalind Franklin, Maurice Wilkins, Linus Pauling and Erwin Chargaff on DNA structure. RNA structure. The triple helical structure of the collagen protein by Dr. G.N Ramachandra, and Ramachandran Plot. Different bonding and different types of DNA (B-DNA, A-DNA & Z-DNA). DNA packaging in bacteria (Nucleoid) and Eukaryotes. Chromatin structure, structural features (Telomere, Centromere and Repetitive sequences) of chromosomes and their functions. Lampbrush and polytene chromosomes. Karyotyping (C-banding, G-banding); Chromosomal abrasions and diseases *Drosophila melanogaster* and *Caenorhabditis elegans*as genetic model organisms. Evolution of Genomes: Gene duplication, whole genome duplication, transposable elements, Exon shuffling, Genome reduction and gene loss, mutations, horizontal gene transfer. Paralogous, orthologous, Homeobox genes; and degenerative evolution. **Module 2** **DNA Damage and DNA Repair** Types of DNA damages**:** Double stranded break, single stranded break, Mismatch, deamination, Thymidine dimer, inversion, deletion,	**12 hours**

	insertion, Covalent X-linking, AP site. Different types of Mutagens**:** Base analogues (5-Bromouracil and 2-amino purines), EMS, acridines, NTG, Hydroxylamine; mutagenic radiations- UV, X-rays and gamma rays. Ames test; Auxotrophy; Somatic and germline mutations with examples in Human DNA repair mechanisms in Eukaryotes and Prokaryotes: Nucleotide Excision repair, mismatch repair, recombination repair, homologous end joining, photo reactivation and SOS Repair. Homologous recombinational repair: Role of *RecA/RadA/Rad51* in DNA damage repair. Role of BRCA1 in DNA damage repair. Mutation in BRCA1 as development of breast cancer. Role of p53 protein in DNA repair and tumor suppressor. **Module 3** **How cells read the Genome** DNA to Protein**:** Replication process in prokaryotes and Eukaryotes: Rolling circle/theta model, telomere replication. Transcription in prokaryotes: prokaryotic promotors, Rho dependent and Rho independent transcription termination. Transcription and Post transcriptional modifications in eukaryotes: Eukaryotic promoters, transcription factors and RNA polymerase I, II, III. Transcription Inhibitors. Splicing, 5'-caping, 3'-poly A tail. Various non coding RNAs and their role in different biological processes: rRNA, tRNA, snoRNA, snRNA,exRNAs, scaRNAs, gRNA, Telomerase RNA,long ncRNAs (Xist and HOTAIR). Translation of mRNA in prokaryotes and Eukaryotes: Initiation, elongation and termination. Polycistronic and monocistronic mRNA. Shine-Dalgarno (SD) Sequence, Kozak sequence, IRES sequence, Ribosomes, Genetic code,codon bias, wobble hypothesis, degeneracy of codon. Posttranslational modification of proteins (Protein splicing, phosphorylation,methylation, N-linked glycosylation).Inhibitors of protein synthesis (Aminoglicosides and macrolide antibiotics, Puromycin).	**12 hours** **12 hours**

	RNA world and origin of life: Ribozymes (Ribonuclease P, self-splicing introns I and II, spliceosome, viroids, hair pin ribozyme, hammer head ribozyme).Some viruses contain RNA as genetic material e.g. TMV, HIV; Concept of reverse transcription; Viroid, Virusoid, Prions. Regulation of Gene expression in Prokaryotes and Eukaryotes**:** Heterochromatin and euchromatin – acetylation, phosphorylation, methylation. Epigenetics. Gene dosage effect.Real time PCR technology (qPCR): Absolute quantification and Relative quantification, Cycle threshold (Ct values), SYBR Green Technology and Taq Man probe technology. Various Reporter dyes and quenchers used in Taq Man probe technology. Multiplexing with real-time PCR technology. Regulation of gene expression at transcription level in prokaryotes:*lac* operon and *trp* operon. transcriptional attenuation. Regulation of gene expression at transcription level in eukaryotes: Enhancers, silencers, transcription factors (DNA binding motifs and their role in gene regulatory proteins). Post transcriptional regulation of gene expression: Riboswitches,Alternate splicing, trans splicing, RNA editing, RNA Interference (miRNA, siRNA, piRNA, Fire and Mello Nobel Prize winning experiment). Concept of Transcriptomics and Proteomics. Their application in research and Medical or diagnostics. CRISPR Cas9 Technology: Gene editing. Application of this technology in Medicine.	
Pedagogy:	Lectures/tutorials /online teaching mode/ self-study.	
Learning Outcome:	1. State-of-art knowledge of molecular organisation of chromosomes and genes. 2. 2. Decipher the role of large numbers of molecular events associated with model animal systems and its application in molecular research.	
References /Reading:	1. Clark D, Pazdernik N and McGehee M (2018), Molecular Biology. 3rd Edition, Academic Cell. 2. Davis LG, Dibner MD and Battey JF (1986), Basic Methods in Molecular	

	Biology, Elsevier. 3. Gardner EJ, Simmons MJ and Snustad DP (1991), Principles of Genetics, John Wiley & Sons. 4. Karp G, Iwasa J and Marshall W (2019), Karp's Cell and Molecular Biology, 9th Edition, John Wiley. 5. Krebs JE, Goldstein ES, Kilpatrick ST (2018), Lewin's GENES XII, Jones and Bartlett Learning. 6. Krebs JE, Lewin B, Goldstein ES and Kilpatrick ST (2014), Lewin's Genes XI, Jones and Bartlett Publishers. 7. Malacinski GM (2015), Freifelder's Essentials of Molecular Biology, Narosa Book Distributors Private Limited.

Course Code: ZOC 105 **Course Title: Laboratory Course I**
Number of Credits: 4
Effective from AY: 2020 -21

Prerequisite for the Course:	Basic working knowledge of animal systematics, animal anatomy, biochemistry, molecular biology.	
Objectives:	Laboratory hands on training in certain area of systematics, anatomy, biochemistry and molecular biology. To do a field Survey.	
Content:	**Animal Taxonomy and Systematics** 1. Systematic analysis with proper morphological keys and construction of Phylogenetic keys of the following: - Malacofauna - Lepidoptera - Avifauna - Ichtyofauna - Araneae	**10 lab hours**
	Anatomy of Non Chordates **I. Dissection** 1. Study of Nervous, in Cockroach/Crab (collected from market) 2. Digestive in Prawn (collected from market)/Cockroach and 3. Reproductive system in Cockroach. **II. Mounting** 1. Mounting of Heart in Bivalves 2. Mounting of Visceral and Pedal ganglia in Bivalves. 3. Comparative study of mouth parts in insects.	**10 lab hours**
	Biochemistry 1. Extraction and Estimation of major bio molecules in different tissues of fish. Total Protein & free amino acids / glycogen & glucose/ triglycerides & fatty acid. 2. Determination of Km and Vmax of Na^{+}-K^{+}- ATPase/ Acetylcholinestarease. 3. Separation of serum Proteins through SDS-PAGE. (demo) 4. Fractionation of Lipid moieties through TLC. (demo) 5. Titration of an acid with conjugated base.	**10 lab hours**

	Molecular Biology 1. Isolation of Purine/Pyrimidine bases from Nucleic acids and their analysis through spectrophotometer. 2. Separation of Nucleic acids on Agarose gel and relative quantification. 3. Fluorescent In-situ Hybridization using Fluorescent microscopy. 4. Restriction Endonuclease digestion and mapping. 5. m RNA expression studies through PCR **Field Work** Faunistic survey around 1 km radius of his/ her residence during dawn of every weekend for at least 2 month (8 weeks) using Transect or Quadrangle method of two different fauna. One/ Two day visit to Sanctuary in Goa. * In unavoidable circumstances overnight field work will be replaced by extending the time period (from 8 weeks to 10 weeks of weekend faunistic survey). *Evaluation of the field work component will be based on weekly field note and final compiled field report during SEA.	**10 lab hours**
Pedagogy:	Practicals/ Mini projects/ Group Activities.	
Learning Outcome:	Practicals will give hands on training on certain areas based on courses on systematics, anatomy, biochemistry and molecular biology. To know the fauna surrounding own's house.	
References /Reading:	As mentioned under individual course ZOC 101, 102, 103 & 104.	

Course Code: ZOC 201 **Course Title: Comparative Anatomy of Vertebrates**
Number of Credits: 3
Effective from AY: 2020 -21

Prerequisite for the Course:	Basic knowledge on vertebrate anatomy, taxonomy and systematics is prerequisite for this course.	
Objectives:	To develop knowledge about fundamental anatomical principles among vertebrates. To understand the adaptive changes anatomical structures have undergone in the course of evolution.	
Content:	**Module 1** Detailed comparative analysis of Vertebrate brain, Spinal cord and Sense organs. Basic plan of vertebra construction. Axial and Appendicular skeleton of vertebrates and their modification. Classification of vertebrate musculature. Axial and Appendicular musculature of Vertebrates. **Module 2** Digestive system of Vertebrates with special analysis of Herbivore, Carnivore and Omnivore stomach. Excretory system of Tetrapods, Mammalian kidney in detail, Specialized excretory structures such as Rectal Glands (elasmobranchs) and salt glands (reptiles and Birds). Testes and Vasa deferens in anaminiotes and amniotes. Ovary and Oviduct of anaminiotes and amniotes. **Module 3** Respiratory structure of fishes, Types of Tetrapod lungs (Alveolar, Faveolar, Parabronchial and Broncho-alveolar). Circulatory systems of Vertebrates, Vertebrate portal systems, Lymphatic system in Tetrapods.	**4 hours** **4 hours** **4 hours** **5 hours** **4 hours** **3 hours** **6 hours** **6 hours**

Pedagogy:	Lectures/ tutorials/ online teaching mode/self-study
Learning Outcome:	1. Understand the basic concepts associated with each system of the body. 2. Identify structures that are in place in the body systems to perform the functions according to the habits or habitats of the animals.
References /Reading:	1. Kardong K (2011), Vertebrates: Comparative Anatomy, Function and Evolution, Sixth edition, McGraw-Hill Companies, USA. 2. Kent CG and Carr R (2000), Comparative Anatomy of Vertebrates, Ninth Edition, McGraw-Hill Companies, USA. 3. Liem KF and Franklin W (2001), Functional Anatomy of the Vertebrates: an Evolutionary Perspective, Third Edition, Harcourt College Publishers, California. 4. Moyces C and Schulte P (2013), Principles of Animal Physiology, Second Edition, Pearson International Edition, USA. 5. Prosser CL (1991), Comparative Animal Physiology, Part A, Environmental and Metabolic Animal Physiology, Fourth Edition, John Wiley & Sons Publication, Oxford. 6. Schmidt-Rhaesa A (2007), The Evolution of Organ Systems, First Edition Oxford University Press. 7. Withers PC (1992), Comparative Animal Physiology, First Edition, Fort Worth: Saunders College Publication. 8. Wolff RG (1994), Functional Chordate Anatomy**,** First Edition, Amazon Publication, UK.

Course Code: ZOC 202 **Course Title: Comparative Physiology of Animals**
Number of Credits: 3
Effective from AY: 2020 -21

Prerequisite for the Course:	Elementary knowledge on animal anatomy, Physiology taxonomy and systematics.	
Objectives:	To provide knowledge of animal body system to reveal physiological homologies, patterns of physiological adaptation to various environments. To introduce various principles that underlies higher level integrative bodily functions. To provide a comprehensive knowledge of functional physiological pathways common to all animals.	
Content:	**Module 1** Nutrition (Feeding and digestion) in Non-chordates. Metagenome of mammalian Gut, Rumen fermentation. Movements of GI tract, control and reflexes. Concept of Gut brain Axis. Excretion and Osmoregulation in Non-chordates in fresh water, marine water and terrestrial environment. Contributions of Crustacean Antennal Glands and Molluscan Mantle to Acid-Base Regulation. Urine formation in Metanephros kidney, Nephrolithiasis-mechanism of Renal stone formation. **Module 2** Composition of Coelomic fluid and hemolymph of Non-chordates, Formation lymph. Physiological difference between Pulmonary and Systemic circulation of higher vertebrates and changes during pregnancy. Lung volumes and their physiological interpretations and changes in lung volumes during pregnancy. Ventilation – Perfusion Physiology. Conducting system of heart, Comparison of action potentials of Pacemaker cell and cardiomyocyte.	**6 hours** **6 hours** **4 hours** **5 hours** **3 hours**

	Module 3 Various types of reproductive modes across Non-chordates, Uterine Physiology, Delayed implantation/Embryonic Diapause and its regulation, Estrous cycles and types of anestrous.	**12 hours**
Pedagogy:	Lectures/ tutorials /online teaching mode/self-study.	
Learning Outcome:	1. Understanding of the basic concepts and processes of physiological regulation, from cellular to organ to organismal. 2. Evaluation of physiological possibilities that animals have developed through natural selection.	
References /Reading:	1. Barnes RSK, Calow P, Olive PJW, Golding DW and Spicer JI (2001), The Invertebrates: A Synthesis, Third edition, Blackwell Science. 2. Moyces C and Schulte P (2013), Principles of Animal Physiology, Second Edition, Pearson International Edition, USA. 3. Prosser CL (1991), Comparative Animal Physiology, Part A, Environmental and Metabolic Animal Physiology, Fourth Edition, John Wiley & Sons Publication, Oxford. 4. Randall D, Burggren W and French KE (2001), Animal Physiology, Fifth edition, WH Freeman and Co, New York. 5. Schmidt-Nielsen K (2001), Animal Physiology: Adaptation and Environment, Fifth Edition, Cambridge University Press. 6. Withers PC (1992), Comparative Animal Physiology, First Edition, Fort Worth, Saunders College Publication.	

Course Code: ZOC 203 **Course Title: Advanced Developmental Biology**
Number of Credits: 3
Effective from AY: 2020 -21

Prerequisite for the Course:	Elementary knowledge of embryology.	
Objectives:	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** Mammalian Gametogenesis including the ultra structure of sperm and egg; Molecular events in mammalian fertilization (capacitation, prevention of polyspermy, genetic fusion , activation of egg metabolism). Cleavage in mammals, difference between somatic mitosis and cleavage, regulation of cleavage. Gastrulation (epiboly and emboly). Development of extra embryonic membrane. **Module 2** Mechanism of cell cellular differentiation; Stages of Commitment (differentiation, specification and determination; Cellular communication: Paracrine factors and signal transduction cascades (Jak-Stat pathway, smooth and patched protein pathway, wnt signaling pathway, smad pathway) . Developmental dynamics of cell speciation: Specification of body axes in sea urchin-, insect-, fish-, avian- and mammalian embryo. **Module 3** Induction and Competence; Cascade of induction during the formation of lens; epithelium-mesenchyme interaction during formation of feathers in bird.	**5 hours** **4 hours** **3 hours** **6 hours** **6 hours** **3 hours**

	The central nervous system and the epidermis: Primary and Secondary neurulation; Differentiation of the Neural Tube.	**3 hours**
	Embryonic filed; Pattern formation in Vertebrate Limbs, Generation of the Proximal – Distal, Anterior – Posterior, Dorso - Ventral axis of the Limb.	**3 hours**
	Regeneration ability of animals; Role of Interstitial cells in Regeneration in Hydra. Molecular mechanism of regeneration of limb in Salamander.	**3 hours**
Pedagogy:	Lectures/tutorials/online teaching mode/self-study.	
Learning Outcome:	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 and their interaction.	
References /Reading:	1. Barresi MJF and Gilbert SF (2019), Developmental Biology, 12th edition, Oxford University Press, UK. 2. Carlson BM (2003), Pattern's Foundation of Embryology, Mc Graw Hill Inc., USA. 3. Gilbert SF (2003), Developmental Biology, 5th edition, Sinauer 4.Gilbert SF (2006), Developmental Biology, 8th edition, Sinauer Associates Inc., Sunderland, USA. 5. Gilbert SF (2013), Developmental Biology, 10th edition, Sinauer Associates Inc., Sunderland, USA. 6. Moody SA (2015), Principles of Developmental Genetics, Academic Press., New York. 7. Slack JMW (2012), Essential Developmental Biology, Willey Publication, USA 8. Wolpert L, Tickle C and Arias AM (2019), Principles of Development, Oxford University Press.	

Course Code: ZOC 204 **Course Title: Ecology**
Number of Credits: 3
Effective from AY: 2020 -21

Prerequisite for the Course:	Basic knowledge on Taxonomy, Biodiversity, Environment and Ecology.	
Objectives:	This course will help the learner to understand the concept and components of ecology and its importance, population, community structures along with interactions. Overall the course develops an in depth understanding of the whole ecosysytem ecology and the various related concepts. Additionally, this course also deals with emerging field of molecular ecology, conservation genetics and the environmental aspects highlighting the changing environment and global effects.	
Content:	**Module 1** **Introduction to ecology**; **Environment:** Physical environment; biotic environment; biotic and abiotic interactions; **Habitat and Niche:** Concept of habitat and niche, niche width and overlap, fundamental and realized niche, resource partitioning, character displacement; **Environmental concepts** – laws and limiting factors, ecological models. Ecological structure: Review of six levels of ecological organization and their importance and characteristic features.	**6 hours**
	Population Ecology: **Review** of Characteristics of a population; population growth curves; population dynamics, regulation and growth limits, fertility rate and age structure, life history strategies (*r* and *K* selection); concept of metapopulation – demes and dispersal, interdemic extinctions.	**3 hours**
	Community Ecology: **Review** of nature of communities ,community structure and attributes, levels of species diversity and its measurement; edges, ecotones and related concepts.	**3 hours**
	Module 2 **Ecological energetics:** Primary productivity, Gross productivity, Net Productivity. Net ecosystem production and various levels of respiratory losses (Autotrophs, Heterotrophs and decomposer levels), Biomass, Standing crop and Turnover, The Residence Time of Energy, Limiting factors of primary production (Light and Nutrients), Eutrophication, Secondary production, Production efficiency, Earth's Heat budget.	**5 hours**

	Species Interactions <u>Review</u> of Types of interactions, intra-specific and inter-specific interactions, Mutualism, Commensalism, Competition, prey-predator interactions, herbivory, carnivory, pollination, symbiosis.	**2 hours**
	Trophic ecology: Food web (Node, link, basal species, Top predators), Global comparisons of Marine food chains (Coastal regions, Open ocean and High upwelling areas), Types of food webs: connectedness webs, Energy flow webs and Functional webs; Topological webs, Flow webs and Interaction webs, Trophic cascades (Bottom-up and Top-down trophic level controls). Bioaccumulation and Bio-magnification.	**5 hours**
	Module 3 **Ecological Succession: <u>Review</u>** of Trajectory of Succession. Mechanisms/models of ecological succession (Facilitation, Inhibition, Tolerance), Alternative stable states and its model (stability, change & Hysteresis), Regime shifts and its models, Stability and sustainability (inertia/persistence, Constancy, Resilience)	**4 hours**
	Biogeography: Major terrestrial biomes; theory of island biogeography; biogeographical zones of India.	**2 hours**
	Restoration ecology: Ecosystem degradation and restoration model, restoration approaches (Reclamation, Revegetation, Re-creation and Ecological engineering), Structural and Functional restoration type, Active and Passive restoration types, Biomanipulation, Bioremediation and Biological augmentation strategies, restoration in India (Nirmal Ganga Action Plan).	**4 hours**
	Molecular ecology: Genetic analysis of single and multiple population, phylogeography, molecular approach to behavioural ecology, conservation genetics.	**2 hours**
Pedagogy:	Lectures/tutorials/online teaching mode /self-study.	
Learning Outcome:	1. Essential in depth understanding of the concepts and components of ecology. 2. Learner will learn ecosystem structure and function along with the interactions involved at various levels.	

	3. Vision to understand the ecosystem ecology along with sufficient knowledge of energy flow and exchange. 4. Information about molecular ecology and conservation genetics. 5. Sensitization towards the environment with respect to the global scenario and the related problems, impact, along with methods to tackle the problems.
References /Reading:	1. Andel JV and Aronson J (2012), Restoration Ecology: The New Frontier, Second edition, Blackwell Publishing Ltd. 2. Baker AJ (2000), Molecular Ecology, In Molecular Methods in Ecology (ed. AJ Baker), Blackwell Publishing. 3. Chapman JL and Reiss MJ (1999), Ecology: Principles and Applications, Cambridge University Press. 4. Conklin AR (2004), Field Sampling: Principles and Practices in Environmental Analysis, CRC Press. 5. Fahey TJ and Knapp AK (2007), Principles and Standards for Measuring Primary Production, Oxford University Press, UK. 6. Grant WE and Swannack TM (2008), Ecological Modeling, Blackwell. 7. Odum EP and Barrett GW (2004), Basic Ecology: Fundamentals of Ecology, Fifth Edition, Oxford and IBH Publishing Co. Pvt. 8. Perrow MR and Davy AJ (2002), Handbook of Ecological Restoration Vol 2 Restoration in Practice, Cambridge University Press. 9. Sutherland WJ (2006), Ecological Census techniques a handbook, Cambridge University Press. 10. Wilkinson DM (2007), Fundamental Processes in Ecology: An Earth system Approach, Oxford University Press, UK.

Course Code: ZOC-205 **Course Title: Laboratory Course II**
Number of Credits: 4
Effective from AY: 2020 -21

Prerequisite for the Course:	Basic working knowledge of Animal Anatomy, Physiology, Embryology and ecology	
Objectives:	Laboratory hands on training in various aspects of developmental biology, anatomy, physiology and ecology.	
Content:	**Anatomy of Chordates** 1. Preparation of skeleton using a bird (bird to be collected from slaughter house). 2. Exposure of axial muscle of fish (dead fishes to be collected from market). 3. Flight muscles of bird (bird to be collected from slaughter house). 4. Afferent and Efferent branchial system of fishes. 5. Reproductive system of fish (dead fish collected from the market). 6. Cranial nerves (Vth - VIIth and IXth - Xth) of teleosts. (dead fish collected from the market). **Animal Physiology** 1. Study of human lung volumes and capacities during before and after exercise using Respirometer. 2. Determination of metabolic rate using Respirometer. 3. Estimation of heart rate, pulse rate and blood pressure changes during exercise using the Oscillometric technique. 4. Study of ECG and its evaluation in normal and pathological variations. 5. Evaluation of heart rate, blood pressure using ECG strip. 6. Measurement of muscular fatigue using Finger Ergograph. 7. Study of nitrogenous waste products of animals from different habitats. 8. Analysis of coelomic fluid of star fish. **Developmental Biology** 1. Identification of developmental stages of chick embryo using HH classification. 2. In vitro culture of chick embryo. 3. Effect of proline / retinoic acid in early development of chick embryo (In vivo as well as in vitro). 4. Effect pesticides on the ossification process of chick embryo by dual staining method.	**12 lab hours** **12 lab hours** **12 lab hours**

	Ecology 1. Assessment of density, frequency and abundance of animals in a community using various techniques i.e. transect, quadrate etc. 2. Measurement of Productivity in ecosystems. 3. To study frequency of herbaceous species in a landscape and to compare the frequency distribution with Raunkiaer's standard frequency diagram. 4. To determine the biomass of a particular area. 5. Food web analysis and studies along with energy flow. 6. Decomposition of various organic matters and nutrient release mechanisms, quantification / role of arthropods and other micro-, and macrofauna in decomposition. 7. Biomagnification/Bioaccumulation analysis in ecosystems. 8. To study the biotic components of a water body. 9. Principles of GIS, GPS and Remote Sensing technology. 10.Interpretation (visual and automated) of remote sensing information for landscape differentiation. **Field Work** Faunistic survey around 1 km radius of his/ her residence during dawn of every weekends for at least 2 months (8 weeks) using Transect or Quadrangle method of two different fauna. Visit to some National Park / Sanctuary and Some University and Research Institution out side Goa (within 1000 km from Goa) for 5 -6 days including Journey period. *In unavoidable circumstances overnight field work will be replaced by extending the time period (from 8 weeks to 10 weeks of weekend faunistic survey). *Evaluation of the field work component will be based on weekly field note and final compiled field report during SEA.	**12 hours**
Pedagogy:	Practicals/ Mini projects/ Group Activities.	
Learning Outcome:	Practicals will give hands on training based on courses ZOC 201, 202, 203 & 204.	
References /Reading:	As mentioned under individual course ZOC 201, 202, 203 & 204.	

Course Code: ZOO 301 **Course Title: Fishery Biology**
Number of Credits: 3
Effective from AY: 2020 -21

Prerequisite for the Course:	Basic knowledge on animal anatomy, physiology and endocrinology	
Objectives:	To understand the various aspects of fisheries. To understand the potentiality of fisheries in India, more particularly in Goa.	
Content	**Module1**: Fish diversity: Fish Classification and diversity of freshwater and Marine fishes of India. Gas exchange and swimming: Air breathing organs and gas bladder; Swimming modes (fin versus body trunk), swimming muscles and tail beat. Fish Reproduction: Sexual maturity and breeding season of various cultivable species; Development of gametes in male and female; Endocrine control of fish reproduction. Fecundity, Fish egg and embryonic development, Reproductive cycles, reproductive behaviour, parental care and migration. **Module 2**: Different Types of culture practices: Monoculture, Monosex culture, Cage culture, Pen culture, and Integrated culture. Culture of Freshwater Indian major carps and ornamental (lacustrine) fish culture; Shell fish culture (prawns) practice and scope in India. Fish diseases, Immune response to pathogens. Management of fish farm/ ponds; Aquatic weeds and their control. Integrated health management of farm. Fish nutrition: Sources of food, feed compositions, Forms of feeds: wet feeds, moist feeds, dry feeds, mashes, pelleted feeds, floating and sinking pellets, farm made feeds using local ingredients. Feed storage: Methods of storage and degradation. Use of preservatives and antioxidants in feed. Feed evaluation: Feed Conversion Ratio (FCR); Feed Efficiency Ratio (FER); Protein Efficiency Ratio (PER), Net Protein Utilization (NPU) and Biological Value (BV); Digestive enzymes, feed digestibility; Factors affecting digestibility. **Module 3:** Fishery technology and economics**:** Fishing gears and crafts used in Indian coasts. Fish Industry: Fish preservation, transportation, processing Industries in India. Fishery economics: Status of Indian and global scenario. Major	12 hr 12 hr 12 hrs

	pelagic and demersal fisheries of Indian coasts and strategies for its development and conservation. Stock replenishment, Sea ranching and FADs. Fish supply chains and export.	
Pedagogy:	Lectures/ tutorials/assignments/self-study	
Learning Outcome:	1. Understanding the socio-economic development through Fisheries. 2. Acquiring the basic knowledge about the Fisheries as to set entrepreneurship.	
References /Reading	1. Jhingran V, (1982) Fish and Fisheries of India 2nd Ed (Hind Publication Comp 2. Biswas K P,(1996) A Text Book of Fish, Fisheries and Technology, 2nd ed. (Narendra Publishing House) 3. Kumar S and Thembre M (1996)Anatomy and Physiology of Fishes (Vikas Publishing House) 4. Selvamani B.R and Mahadevan R.K (2008) Freshwater fish farming (Campus Books International) 5. Pillay T V S (1990)Aquaculture – Principles and practices (Fishing News Books Oxford 6. Bal D, and Rao K P(1984) Marine Fisheries of India, Tata McGraw Hill Publishers. 7. DuttaMunshi, J (2006) , Fundamentals of Freshwater Biology, Narendra Publishing House, Delhi. 8. Kurian, C and Sebastain VO (2002), Prawn and Prawn Fisheries of India, Hindustan Publishing Corp., Delh.	

Course Code: ZOO 302 **Course Title: Fish Farm Management**
Number of Credits: 3
Effective from AY: 2020 -21

Prerequisite for the Course:	Basic knowledge on animal anatomy, physiology and endocrinology	
Objectives:	To understand the various aspects of fisheries farm management. To understand the potentiality of ornamental fisheries in India, more particularly in Goa	
Content	**Module 1:** Fin Fish hatchery: Freshwater and marine fish seed resources; Natural breeding of fin fishes; Gears and methods used for seed collection in India, Spawn quality and quantity indices. Bundh breeding: Concept; Wet and dry bundhs; Collection and hatching of eggs; Factors involved in bundh breeding; Advantages and disadvantages of bundh breeding. Breeding and hatchery management: Site selection for the hatchery, Brood-stock collection, transportation and management; Induced breeding of fishes, Synthetic hormones used for induced breeding of carps. Different types of fish hatcheries: traditional, Indian, Chinese, glass jar and modern hatcheries. **Module 2:** Shell fish hatchery: Natural seed resources; collection methods and quality of seeds. Life cycle of important shellfishes: *Penaeus monodon*, *Macrobrachium rosenbergii*, *P. vannamei*, *Scylla serrata*, lobster, edible oyster; Sexual maturity, size t maturity, breeding behaviour and breeding seasons of different species; fecundity and quality of eggs. Hatchery management of Shellfish: Brood stock collection, transportation and maintenance of shell fishes. Breeding and hatchery management of *Penaeus monodon*, *Macrobrachium rosenbergii*; Scylla *serrata*, and molluscs. Larval rearing and health management of shellfish: Food and feeding of larval stages of important shellfishes; Health management in hatcheries. **Module 3:** Ornamental fish production: World trade of ornamental fish and export potential; Different varieties of exotic and indigenous ornamental fishes. Culture of marine and brackish water ornamental fishes; Common diseases and their control of ornamental fishes.; Breeding and rearing of ornamental fishes: Brood stock management; Application of genetics and biotechnology for producing quality strains; Management	12 hrs 12 hrs 12 hrs

	practices of ornamental fish farms Setting up of an aquarium: Principles of a balanced aquarium; Fabrication, setting up and maintenance of freshwater and marine aquariums; Water quality management: Water filtration systems: biological, mechanical and chemical. Accessories for the aquarium: Types of filters; Aquarium plants and their propagation methods; Lighting and aeration; Aquarium fish feeds: dry, wet and live feeds. Preparation of aquarium feeds and storage.	
Pedagogy:	Lectures/ tutorials/assignments/self-study	
Learning Outcome:	1. Understanding the scope of ornamental fisheries. 2. Acquiring the basic knowledge about the management of fish farm. 3. To set entrepreneurship in fish farm.	
References /Reading	1. Dick Mills. (1998). Aquarium fishes, Dorling Kindersly Ltd, London. 2. Jameson, J.D. and Santhanan, R. (1996). Manual of ornamental fishes and farming technologies, Fisheries College and Research institute, Tuticorin 3. Stephen Spottee.(1993.) Marine aquarium keeping. John wiley and sons, U.S.A 4. Joshua,K. et al. (1993). Shrimp Hatchery Operation and Management. Marine products Export Development Authority, Kochi, India 5. Thakur,N.K. et al. (1998) Culture of live food organisms for aqua hatcheries. Training manual. CIFE (ICAR), Mumbai. 6. Jhingran, V.G. Pullin, R.S.V. (1997). A hatchery manual for the Common, Chineseand Indian Major Carps. Asian Development Bank, International Center for Living Aquatic Resources Management, Philippines. 7. Ramanathan, N. and Francis, T. (1996.) Manual on breeding and larval rearing of cultivable fishes, Fisheries College and Research Institute, Tuticorin. 8. Ayyappan, S., (2011). Handbook of Fisheries and Aquaculture, ICAR Publications, New Delhi	

Course Code: ZOO 303 **Course Title: Fish Processing**
Number of Credits: 3
Effective from AY: 2020 -21

Prerequisite for the Course:	Basic knowledge on Fish biology, Fishery sciences is prerequisite for this course.	
Objectives:	1. To develop knowledge about post harvest management of fishes. 2. To understand the various aspects of fish preservation and processing	
Content	**Module 1:** Post Harvest Technology: Principles and importance of fish preservation. Fish spoilage-post mortem changes and rigor mortis, post rigor spoilage. Methods of fish preservation-Icing, Freezing, Cold storage, Drying, Salting, Smoking, Canning and Fish Pickling. Fish product and Byproduct: Fish Oil, Fish liver oil, Fish meal, Fish manure, Fish flour, fish glue and isinglass, chitin **Module 2:** Fish and fishery microbiology: Microflora of aquatic environment. Autotrophic and heterotrophic microorganisms in aquatic environment. Prokaryotic growth – characteristic features of bacterial growth curve – Effect of environmental factors on growth. Nutrition and growth of bacteria – different types of media for isolation of bacteria and fungi. Isolation and cultivation of bacteria and fungi from water and sediment. Health significant bacteria in culture ponds. Culture characteristics and epidemiology of *E. coli*, pathogenic *Vibrio*, *Salmonella*, *Aeromonashydrophila*, and *Pseudomonas*. Perishability of seafood – Microbial spoilage of fish and shell fish. Spoilage microflora. Intrinsic and extrinsic factors affecting spoilage. Microflora associated with body parts. Food borne pathogens. Sources of contamination. **Module 3:** Quality Assurance of Fishery Products: Quality control: basic concepts, quality and quality control. Sanitation procedures in seafood processing plants. Waste management in fish processing industries. Risk factors in seafood bio toxins, seafood pathogens, endogenous parasites. Methods of evaluating fish freshness and quality – organoleptic, physical, chemical, microbiological and instrumental methods. Quality standards in India and major importing countries like USA, Japan and EU. Export of fishery products from India – major countries, important products, export documents and procedures. Traceability, Quality certifications, Eco-labeling.	6 hrs 6 hrs 6 hrs 3 hrs 3 hrs 4 hrs 4 hrs 4 hrs

Pedagogy:	Lectures/ tutorials/Group discussions/PBL/self-study
Learning Outcome:	1. Understand the basic concepts fish preservation. 2. Identify main microbes concerned with fish processing 3. To Understand the importance of quality control in fish farm
References/ Reading	1. Biswas K.P. (2004). Fish Processing and Preservation. Daya Pub. House. 2. Govindan T.K (1985). Fish Processing Technology. Oxford & IBH Pub. Co. 3. Badapanda K.C (2013). Fish processing and preservation technology. Narendra Publishing House 4. Fernandes R. (2009) Microbiology Handbook: Fish and Seafood. Leatherhead Food Research Association; 2nd New edition edition. 5. Harry W. Seeley, Paul J. Vandemark, and John J. Lee (1990)- Microbes in Action: A Laboratory Manual of Microbiology 6. Pawar and Diganawala (2010)- General Microbiology – Vol. I and Vol. II. Himalaya Publishing House.

Course Code: ZO0 304 **Course Title: Laboratory course on Aquaculture**
Number of Credits: 3
Effective from AY: 2020 -21

Prerequisite for the Course:	Knowledge on Fishery biology and its application or Environmental Physiology	
Objectives:	Laboratory training based on skilled based courses on Fish biology.	
Content	**Module 1:** 1. Collection of fish pituitary gland and histological studies of pituitary gland. 2. Histological studies of developmental stages of ovary and testes. 3. Study of fish eggs and embryonic developmental stages. 4. Observations on gonadal maturation of prawns. 5. Identification of larval stages of important crustaceans. 6. Identification of common ornamental fishes. 7.Identification of live food organisms **Module 2:** 1. Culture and maintenance of live feeds such as Artemia and algae 2. Measurement of DO, total hardness and salinity of the water bodies. 3. Preparation of fish feed in laboratory 4.Quality control of fishes: Crude protein analysis of fish muscle by lowry method. 5. Detection of organoleptic changes in fish. 6. Isolation and maintenance of bacteria from fishes. . 7.Gram staining of bacteria. **Module 3:** Every student must go for the Internship programme for **1 month**. DC will select the Institution / Industry with in Goa for the Internship programme at State fishery farm, Private fish farm, Fish processing Industries.	12 x 2 hrs 12 x 2 hrs

Course Code: ZOO 305 **Course Title: Environmental Physiology**
Number of Credits: 3 credits
Effective from AY: 2020 -21

Prerequisite for the Course:	Basic knowledge of Animal Physiology and biochemistry	
Objectives:	1. To learn the meaning of adaptation. 2. 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; Cellular metabolism, regulation and homeostasis; Concept of stress and strain in animal. Thermal adaptation: structural and functional effects of temperature; Biochemical and physiological effects of temperature; Regulation of heat gain and heat loss, Dubois temperature balance; Role of nervous system and endocrine system in thermal biology; Homeoviscous adaptation of membrane. **Module 2**: Salinity adaptation: biochemical and physiological effects of salinity; Regulation and movements of water and solute; Osmoregulatory organs and their excretory products; Cost and energy of regulation of water and ions. Role of membrane in osmoregulation. **Module 3:** Strategies and mechanism in physiological adaptation with reference to marine life, estuarine life, freshwater life and terrestrial life. Physiological and morphological adaptation of the animals living at extreme environment. Circadian rhythm: Biological clock; Analysis of circadian rhythmicity; Ultradian and infradian rhythm; Behavioural and autonomous rhythm; Endogenous mechanism of rhythm; Homeostasis and circadian rhythmicity	6 hrs 8 hrs 10 hrs 6 hrs 6hrs
Pedagogy:	Lectures/ tutorials/self-study	
Learning Outcome:	1. Understanding the concept of adaptation. 2. Understanding the life processes at various environmental condition. 3. Understanding the concept of biological rhythm.	

References /Reading	1. Russel G Foster and Leon Kretzman, (2017) ; Circadian rhythm, A very short Introduction, Oxford University Press, UK 2. Roberto Refinetti , (2016) ; Circadian Physiology , CRC Press, USA. 3. Hochachka PW and Somero GN, ( ); Biochemical Adaptation, Oxford University Press, UK. 4. Nielsen S, (1997); Animal Physiology: Adaptation and Environment, Cambridge University Press, Cambridge. 5. Wilimer P, Stone G and Johston IA, (2004); Environmental Physiology. of Animals, Wiley Blackwell Publishing Co, USA

Course Code: ZOO 306 **Course Title: Neurophysiology**
Number of Credits: 3
Effective from AY: 2020 -21

Prerequisite for the Course:	Basic knowledge on Non-chordate and Chordate anatomy and Physiology is prerequisite for this course.	
Objectives:	1. To develop knowledge about fundamental Neurophysiological concepts in animal models and in humans. 2. To be aware of electrophysiology techniques involved in recording neurological parameters.	
Content	**Module 1:**	
	Review of classification of neurons and their functions. Blood-brain barrier and its physiological importance, CSF composition, formation and drainage.	03Hrs
	Physiological characteristics of neuronal cell membrane components for impulse conduction.	03 Hrs
	Electrophysiology of neuron. Comparison of action potentials of Giant axon of Squid and mammalian neuron, Voltage and Cell-Patch Clamp Techniques.	04Hrs
	Myelin ultrastructure and Nodes of Ranvier, Nerve impulse conduction in Myelinated and Unmyelinated neurons.	02Hrs
	Module 2	
	Types of synaptic connection and their conduction physiology: Axosomatic, axodendritic, Dendrodendritic and Axoaxonal synapses. Chemical and electrical sysnapse.	03 Hrs
	Axonal impulse conduction-excitatory and inhibitory synaptic transmission. Properties of Synapse.	03 Hrs
	Effect of Acidosis & Alkalosis, Effect of Hypoxia on Synaptic Transmission, Effect of Narcotic drugs on Synaptic Transmission.	04 Hrs
	Basic concept of Neural integration: Diverging, Converging and Reverberating circuits.	02Hrs

	Module 3 Learning and Memory types and its Neural and Cellular basis in Aplysia, Drosophila, Honey bee and Humans. Cognition and its major domains. Mechanoreception, Photoreception, Chemoreception. Neurophysiology of Balance and Posture.	 06 Hrs 04 Hrs 02 Hrs
Pedagogy:	Lectures/ tutorials/Group discussions/PBL/self-study	
Learning Outcome:	1. Understanding of Neurophysiological concepts. 2. Understanding of learning, memory formation and cognition.	
References /Reading	1. Siegel, G. J.; Agranoff, B. W.; Albers, R. W., et al., (2011). Basic Neurochemistry: Molecular, Cellular and Medical Aspects. Academic Press. 2. Hammond, C. (2008). Cellular and Molecular Neurophysiology. Academic Press. 3. Carpenter, R; Reddi, B. (2012). Neurophysiology: A Conceptual Approach,. Hodder and Arnold. UK. 4. Purves, D.; Augustine, G. J.; Fitzpatrick, D.; et al. (2018). Neuroscience. Oxford University Press. 5. Menzel, R.; Benjamin, P. (2013). Invertebrate Learning and Memory, Volume 22. Academic Press. 6. Gazzaniga, M. S. (2009). The Cognitive Neurosciences. A Bradford Book the MIT Press Cambridge , Massachusetts London, England.	

Course Code: ZOO 307 **Course Title: Stem Cell Biology**
Number of Credits: 3
Effective from AY: 2020 -21

Prerequisite for the Course:	Basic understanding of cytology, histology and cellular types of embryo and adult.	
Objectives:	1. Broad awareness of current issues and approaches in stem cell biology, 2. Appreciation of the many ways in which stem cell science is utilized in therapeutic contexts. 3. A thorough understanding of stem cell science and the molecular nature of pleuripotency and differentiation. 4. Hands-on experience in several stem cell-related technologies and laboratory practices, including the theory and practice of stem cell propagation and differentiation,	
Content:	**Module 1:** Basic Biology of stem cells: Introduction to stem cells and basis of stemness; Embryonic stem cells, embryonal carcinoma cells, embryonic germ cells, adult stem cells, hematopoietic stem cells, mesenchymal stem cells, cancer stem cells, induced pluripotent stem cells. Cellular Mechanisms of Stem Cells: Molecular basis of pluripotency, stem cell niche, cell cycle regulators in stem cells, mechanisms of stem cell self-renewal. **Module 2:** Stem cells isolation and culture: Isolation, characterization and maintenance of embryonic stem cell isolated from: Mouse and Human. Serum and feeder free culture of human embryonic stem cells, evolution of Xeno-free culture systems. **Module 3:** Applications of stem cells: Neurodegenerative diseases, spinal cord injury, heart disease, diabetes, burns and skin ulcers, muscular dystrophy, orthopedic applications, eye diseases, stem cells and gene therapy. Ethical and regulatory issues in the use of stem cells.	4 hrs 8 hrs 12 hrs 12 hrs
Pedagogy:	Lectures/Tutorials/ PBL/Videos/Assignments/Group Activities/Self-study.	
Learning Outcome:	After successful completion of this course, students will be able to: 1. Describe the characteristics of stem cells and the different types of stem cells. 2. Understand the isolation process and cultivation of embryonic stem cells.	

	3. Understand basic biology/mechanisms of pluripotency, self-renewal of stem cells, stem cell niche in regulating stem cell fate, role cell cycle regulators in stem cells. 4. Describe the applications of stem cells in diseases, injury and gene therapy. 5. Appreciate the ethical and regulatory issues associated with use of stem cells.
References /Reading:	1. Atala A & Lanza R, (2012). Handbook of Stem Cells, 2nd Edition, Academic Press, 2012. 2. Lanza R, et al, (2013). Essential of Stem Cell Biology, Elsevier Academic Press. 3. Mao JJ, et al, (2007). Translational Approaches in Tissue Engineering & Regenerative Medicine, Artech House. 4. Habib NA, Levièar NY, Gordon M, Jiao L & Fisk N, (2007).Stem Cell Repair and Regeneration, Volume-2, Imperial College Press, 2007.

Course Code: ZO0 308 **Course Title: Laboratory course on Life processes**
Number of Credits: 3
Effective from AY: 2020 -21

Prerequisite for the Course:	Knowledge on Neuro-physiology and Stem cell biology.	
Objectives:	Laboratory training based on skilled based courses on Physiology.	
Content	**Module 1:** 1. Effect of thermal stress on the excretory rates in bivalves. 2. Effect of salinity stress on the respiratory rates of bivalves. 3. Effect of salinity acclimation in the osmo-regulatory processes of mud crab / tilapia fish. 4. Rates of Na^+, K^+ ion transport, K_m V_{max} of Na^+-K^+ ATPase, rates of excretion and rates of respiration). 5. Effect of salinity stress on the membrane fluidity of gill epithelial cells of mud crab / tilapia fish. 6. Isolation of different parts of brain membrane by sucrose gradient centrifugation and characterization of those isolated membranes 7. Estimation of neurotransmitters from fish brain regions (any two neurotransmitters using any two techniques). **Module 2:** 1. Evaluation of learning and memory experiments using Freshwater Snail or Bivalves or crabs. 2. Primary cultures of neurons from chick embryo brains. 3. Isolation and Culture of Chicken Cartilage Stem/Progenitor Cells. 4.Isolation and Differentiation of Mesenchymal Stem Cells from Broiler Chicken Compact Bones. 5. Isolation and maintenance of chicken embryonic stem cell from blastodem. 6. Isolation and culture of Dermis-Derived Mesenchymal Stem/Progenitor Cells from chick embryo. **Module 3:** Every student must go for the Internship programme for **1 month**. DC will select the Institution / Industry with in Goa for the Internship programme at Pharma Industries, National as well state laboratories at Various Institute etc.	12 x 2 hrs 12 x 2 hrs

Course Code: ZOO 309 **Course Title: Ornithology**
Number of Credits: 3
Effective from AY: 2020 -21

Prerequisite for the Course:	Elementary knowledge about Taxonomy and Animal Systematics, Anatomy, Physiology and Ecology of Birds.	
Objectives:	1. This course develops major concepts in ornithology, including Avian Taxonomy and Systematics, Diversity and Identification, Physiology and Ecological aspects of birds and their applications.	
Content	**Module 1** Avian morphology, anatomy and physiology: Review of bird as glorified reptile, Avian flight (forms, Mechanism and energetics), Bird vocalization-anatomy of vocal organ, Neurophysiology of song control system, Analysis of bird song using Acoustic spectroscopy, Auditory feedback in birdsong learning, Learning through cultural transmission, The cultural trap hypothesis (Evolutionary preservation of bird vocal learning), Colour physiology of iridescent and non- iridescent feathers and gloss production, types of pigments, thermoregulatory mechanisms, avian eye and its adaptations, Biology of moulting in birds (periodic and forced moulting). Module 2 Bird identification, systematics and ecology: Fundamental keys of bird identification and Systematics, parameters for molecular taxonomy, Endemism of Indian avifauna, Bird sanctuaries of India, Importance Types of migration, migratory flyways, orientation and navigation, threats to migratory bird population, Nesting success in birds, Comparison of adaptations of Palaeognathae and Neognathae. Ecosystem services provided by birds, Birds as indicators of environmental health, importance of Important Bird Areas. Module 3 Applied ornithology: Importance of bird population monitoring, Census techniques, Causes of extinction and depletion of bird population of certain species, Conservation of threatened avifauna, Birds as pests in Pisciculture, Apiculture, sericulture and free ranging Poultry farms, Role of birds in dispersal of weeds, parasitic and invasive plants, Birds as vectors of pathogens and parasites, zoonoses, bird strike hazard to aircraft and its management, Bird-watching as an emerging eco-tourism venture, Bio-mimicry and birds in relation to Aerodynamic studies, bionic bird, bullet train inspired by kingfisher, other recent research in ornithology.	**12 hours** **12 hours** **12 hours**

Pedagogy:	Lectures/Tutorials/Videos/Assignments/Group discussion/Self-study.
Learning Outcome:	1. Understand in detail the various aspects of avian biology such asTaxonomy, their specialized Anatomy, Physiology, Migration, Breeding systems and applications. 2. Identification of birds with the help of field guides which will be helpful for field trips or conducting surveys. 3. Knowledge on the crucial Census methods. 4. Learn about Bird diversity, status and Conservation of Birds.
References /Reading	1. Lovette I. J. and Fitzpatrick J. W. Handbook of Bird biology (3rd Ed) Wiley publishers. 2. Meyer D.B. (1977) The Avian Eye and its Adaptations. In: Crescitelli F. (eds) The Visual System in Vertebrates. Handbook of Sensory Physiology, vol 7 / 5. Springer, Berlin, Heidelberg. 3. Gill, F. B. 2007. Ornithology. (3rd ed.) W. H. Freeman and Company, New York, NY. 758 pp 4. Sturkie, P. D. (1998). Sturkie's Avian Physiology. 5th Edition. Academic Press, San Diego. 5. Ziegler, Harris Philip; Bisch of, Hans-Joachim, eds. (1993). Vision, Brain, and Behavior in Birds: A comparative review. MIT Press 6. Brainard, M. S. and Doupe, A. J. (2000). Auditory feedback in learning and maintenance of vocal behavior. Nature Rev. Neurosci. 1, 31-40. 7. Ali S (2016): The Book of Indian Birds. Bombay Natural History Society and Oxford University Press, India. 8. Inskipp C, Grimmett R and Inskipp T (2011): Birds of the Indian Subcontinent, Princeton University Press. 9. Bibby CJ, Burgess ND, Hill A (1992): Bird Census Techniques. Academic Press, UK. 10. Faborg J and Chaplin SB (1988): Ornithology: an Ecological Approach. Prentice Hall Inc. New Jersey. 11. Goodfellow P (1977): Birds as Builders. Arco Publishing Co., New York. 12. Giles RH (1978): Wildlife management Techniques, Wildlife Society, Washington.

Course Code: ZOO 310 **Course Title: Herpetology**
Number of Credits: 3
Effective from AY: 2020-21

Prerequisite for the Course:	Basic knowledge on herpetofauna its identification at taxonomic level and the systematics	
Objectives:	1. Students will be introduced to the diversity and biology of amphibians and "reptiles". 2. The lecture component will have a global and diverse focus, covering topics of phylogenetics, the origin and evolution of amphibians and reptiles, the global diversity of these taxa, and their biogeography, biology, habitat ecology and conservation .	
Contents:	**Module 1:** Introduction to herpetology; Shared Characteristics of Amphibians and Reptiles: Significance of studying Amphibians and Reptiles, The diversity of Amphibians and Reptiles, Shared Characteristics af Amphibians and Reptiles: Ectothermal, Thermoregulation and its role, Aestivation, Hibernation and other Eco physiological adaptations, Costs and benefits of Ectothermy and Endothermy, Body size and shape, Ectothermy and efficiency**;**	08 hrs
	Amphibians and Reptiles in Terrestrial Ecosystems; Factors affecting distribution and abundance of Amphibian and Reptilian fauna of the Indian subcontinent; Communication in Amphibians and reptiles.	04 hrs
	Module 2: Systematics and Diversity of Extant Amphibians: Life History, Skin, Reproduction, Sensory systems.	03 hrs
	Caudata: Salamanders; Morphology, Reproduction and Life History, Fossil Records and Phylogeny of Salamanders.	03 hrs
	Anura: Frogs and Toads; Skeletal Morphology, Reproduction and Life History, Fossil Records and Phylogeny of Frogs.	03 hrs
	Gymnophiona: Caecilian's; Morphology, Reproduction and Life History, Fossil Records and Phylogeny of Caecilian's.	03 hrs
	Module 3: Systematics and Diversity of Extant Reptiles: Characteristics of Reptiles; Reptile skin, Sensory system.	02 hrs
	Lepidosauria: Rhynchocephalia; The Tuatara, Fossil Records. Lepidosauria: General Anatomy of Squamates, Reproduction and Sex determination, Tail Anatomy, Limb reduction, Venom and Venom-delivering structures, Squamate phylogeny, Fossil records.	05 hrs
	Squamata:Lizards-Systematics and Phylogeny of Lizards,	01 hrs

	Squamata: Serpentes, the Snakes- Unique morphological features of snakes, Reproduction, Dentition, Fossil record, Systematics and Phylogeny of Snakes; Crocodylia- Fossil record, Systematics and Phylogeny of Crocodylians; Testudines: Turtles- The turtle skeleton, The turtle shell, Locomotion and reproduction, Fossil record, Systematics and Phylogeny of Turtles.	02 hrs 03 hrs
Pedagogy:	Lectures/ tutorials/assignments/self-study	
Learning Outcome:	1. Students will learn about the Diversity, Habitat-Ecology, Behavior, Adaptation, Taxonomy of the Amphibian and reptiles. 2. Identification of the local herpetofauna through direct field experience. The course assumes that students are familiar with basic evolutionary theory and general biology.	
References /Reading	1. Porter, K.R. 1972. Herpetology. W. B. Saunders Co., Philadelphia. xi, 524 pages. 8o. 2. Adler, K. (Ed.). 1989. Contributions to the History of Herpetology. K. Adler: Herpetologists of the past; J. S. Applegarth: Index of authors in taxonomic 3. Herpetology; R. Altig: Academic lineages of doctoral degrees in herpetology. Contributions to Herpetology, No. 5, Society for the Study of Amphibians and Reptiles, Oxford, Ohio, 202 pages, 1 plate. 4o. 4. Biology of Reptiles: D.R. Khanna and P.R. Yadav, Discovery Pub, 2004, ix, 414 p, figs, ISBN 5. An Introduction to Reptiles: H.S. Bhamrah and Kavita Juneja, Anmol, 2002, Reprint, vi, 193 p, 6. The Reptile Fauna of India : A Source Book by T.S.N. Murthy, B.R. Pub, 2010, xx, 332 p 7. A Pocket Book on Indian Reptiles : Crocodiles, Testudines, Lizards and Snakes, T.S.N. Murthy, Nature Books India, 2009, viii, 88 p 8. The book of Indian Reptiles and Amphibians, By J. C. Daniel, BNHS 9. Snakes of India, The Field Guide, by, R. Whitaker and Ashok Captain. 10. The Fauna of British India, Ceylon and Burma, Reptilia and Amphibia, VOL III – Serpentes, By Malcom A. Smith. 11. The Fauna of British India, Ceylon and Burma, Reptilia and Amphibia, VOL II – Sauria, By Malcom A. Smith.	

Course Code: ZOO 311 **Course Title: Wildlife Conservation & Management**
Number of Credits: 3
Effective from AY: 2020 -21

Prerequisite for the Course:	Basic knowledge in wildlife conservation and management	
Objectives:	1. To provide graduates in Biology a specialization in the field of Wildlife Conservation and Management 2. To generate qualified students who can directly get jobs in the allied fields of Wildlife Conservation and Management; 3. To generate qualified postgraduates who can be part professional/Government organizations working in the field of Wildlife Conservation and Management 4. To generate a team of post graduates who can take up jobs related to Wildlife Conservation in the educational institutions. 5. To generate a skilled post graduates who can undertake research in the field Wildlife biology.	
Contents:	**Module 1:** WILDLIFE CONSERVATION AND MANAGEMENT: Introduction to Indian Wildlife, History and Diversity, Biogeographic zones, Value of Wildlife, Important Indian fauna and their distribution, Protected Areas, Endemic species; IUCN red list: Extinct species of India, Endangered, Threatened, Least concern and Critically Endangered. Climate change and its impact on wildlife. Impacts of pesticides on fauna. **Module 2:** Environmental Ethics and Management: Conservation and Management of Wildlife: Conservation and management: In-situ conservation and Ex-situ conservation; Reintroduction, Ecological Restoration. Innovative Methods in Wildlife: Camera Trap, Conservation Drones, Remote Sensing, Radio Telemetry, GIS, GPS Mobile App, Capturing and marking techniques, trapping, darting, tagging and banding, scat analysis, sign survey's. Wildlife Census and Indices: Methods of animal census, counting methods. Animals in Indian Mythology. Major Projects. Ecotourism and Environment Impact Assessment **Module 3:** Human Wildlife Conflict: Types of conflict, Prevention or	06 hrs 06 hrs 03 hrs 05 hrs 04 hrs 04 hrs

	precautions, Human Elephant Conflict, Conflict between human, Tiger and Leopard, Conflict with Sloth Bear. Wildlife Trade and Crime: Wildlife products CITES, TRAFFIC, Wildlife Crime Control Bureau in India, Wildlife Forensic. Law, Ministry and Organizations: Wildlife Protection Act of (1972), National Board of Wildlife, Environment Protection Act (1986), Biological Diversity Act (2002), The First National Wildlife Action Plan (NWAP) (1983), National Wildlife Action Plan (2017-2031), MoEFCC, International organizations; UNESCO, IUCN, PETA. National Institutes/Organizations; NTCA, ZSI, BSI, CZA, WII, SACONH, ENVIS. Non-Government Organizations.	02 hrs 04 hrs 02 hrs
Pedagogy:	Lectures/ tutorials/assignments/self-study	
Learning Outcome:	1. Understand the distribution and diversity of Indian wildlife including their conservation status. 2. Gain insight on the different methods and techniques in wildlife conservation 3. Will gain practical knwolegde on wildlife management and conservation 4. Understanding towards implementation of different wildlife projects including various laws, acts and regulations for the conservation of wildlife.	
References /Reading	1. Abdul Jamil Urfi (2004): Birds beyond Watching, University Press (India) Pvt. Ltd. 2. Dasmann, R.F. (1964) Wildlife biology, John Wiley and Sons, New York. 3. Gary, K., Meffe, Carroll, C.R. and Contributors (1997): Principles of Conservation Biology - 2nd Edition, Sinauer Associates, Inc Sunderland Massachusetts. 4. Giles, R.H. Jr. (Ed 1984): Wildlife management techniques - 3rd edition, The wildlife society, Washington D.C. 5. Grimmet, R., Inskipp, C. & Inskipp, T. (1999): Pocket Guide to the birds of Indian Subcontinent, Oxford University Press, New Delhi. 6. Hosetti, B.B. (2003): Wetlands Conservation and management, Pointer Publishers, Jaipur, India. 7. Kazmerezak Krys and Van Perlo Ber (2000): A field Guide to the birds of India, OM Book Series, New Delhi. 8. Robinson W.L. and Eric G. Bolen (1984): Wildlife Ecology and Management, Millen Publishing Co. New York. 9. Salim Ali (2002): The book of Indian Birds, revised edn. BNHS & Oxford University press, New Delhi. 10.Sharma B.K and Kaur, H. (1986): Environmental Chemistry. Goel Publishing House, Meerut.	

	11. Teague R.D. (Ed.). 1980. A Manual of wildlife conservation, The Wildlife society Washington D.C. 12. Essentials of Conservation Biology, Fourth Edition, by R.B. Primack. 13. Wildlife Conservation and Wildlife Management, by Reena Mathur	

Course Code: ZOO 312 **Course Title: Laboratory course on Field Biology**
Number of Credits: 3
Effective from AY: 2020 -21

Prerequisite for the Course:	Knowledge on Fishery biology and its application or Environmental Physiology / Neuro-physiology and Stem cell biology or Biodiversity along with Wild life management and Herpetology**.**	
Objectives:	Laboratory training based on skilled based courses on Fish biology, Physiology and Biodiversity.	
Content	**Module 1:** 1. Study of Bird Census techniques in field-Transect, point count and call count methods. 2. Ornithological statistical analysis of field identified birds based on their colour, size, flight, calls and nest building. 3. Comparative study of avian fauna with respect to habitat variation (Plateau, Forest and Wetland) 4. Acoustic analysis of Bird calls and songs. 5. Study of flight muscles of Chicken used in any study area. 6. The identification of the amphibian and reptile families through basic external anatomy 7. Identification through scale count **Module 2:** 1. Learning handling techniques of Amphibians and Reptiles 2. Beta diversity of herpetofauna in the Goa University campus 3. Mammal distribution of Goa (i) Primates: Rhesus macaque (ii) Carnivores: Tiger, Panther, Sloth bear (iii) Ungulates: Sambar, Chital, Wild boar. 4.Horn/ Antler identification. 5.Call Identification of common birds – any five birds 6.Pugmark analysis and Camera trap methods. 7. Animal Scat, pellet, dung, droppings analysis (Indirect evidences) 8.Case study of Man-Animal conflict and Ethnozoology. Visit to Zoo/Wildlife Sanctuary/National Park/Turtle nesting site **Module 3:** Every student must go for the Internship programme for **1 month**. DC will select the Institution / Industry with in Goa for the Internship programme at Biodiversity Board, Forest Department.	12 x 2 hrs

Course Code: ZOO 313 **Course Title: Toxicology**
Number of Credits: 3+ 1
Effective from AY: 2020 -21

Prerequisite for the Course:	Basic knowledge on Anatomy, Physiology and Ecology.	
Objectives:	1. To understand everyday toxic substances and their routes of exposures and its fate in the animal body and in the environment. 2. To understand significance of toxicological studies in forensic science.	
Content:	**Module 1** Introduction to toxicology: Definition and Scope, History of Toxicology, Branches of Toxicology. Classification of Toxicants (based on 1] Source, 2] Use, 3] Target organ 4] Reactivity). Toxicokinetics: Definitions and concepts of Exposure, Dose and response. Metabolism of toxicants (Phase I and Phase II reactions), Absorption, Distribution, Biotransformation and Elimination of Toxicants (Renal Elimination, Hepatic Elimination, Respiratory Elimination), Toxic actions /mechanism (Acute, Sub-chronic & Chronic). Toxicokinetic models (Descriptive and Physiological Models). **Module 2:** Environmental Toxicity: Environmental contaminants, Dilution paradigm and Boomerang paradigm, Ways of poisoning food chain, Environmental persistence. Pollution: Air pollution, Noise pollution, water pollution and thermal pollution: types and sources, effects of pollutants on human health. Solid waste pollution: sources and effects of solid waste toxicity on human health. Pesticide and Heavy metal toxicity: effects of pesticides and heavy metals on ecosystem, mechanism of pesticides toxicity, heavy metal toxicity and their effects on human health **Module 3** Forensic toxicology: Disciplines of Forensic toxicology (Definition of poisons, Forensic classification of poison, factors affecting the mode of action of poisons, extraction and isolation of poisons from biological samples. Drugs included in routine post-mortem toxicology, Forensic DNA typing system. Applications of forensic toxicology Alkaloid toxicity: definition, classification and isolation of alkaloids from biological samples, general properties of toxic alkaloids. Food poisoning- definition and common sources. Analysis of Milk and milk products for adulterants by physical, chemical and instrumental techniques. **Module 4: Practicals** Determination of alcohol in blood and urine sample.	4Hrs 8 Hrs 4 Hrs 4 Hrs 4 Hrs 6Hr 3 Hrs 3 Hrs 12 x 2 Hrs

	Determination of barbiturate by UV -visible Spectrophotometric method. Extraction of drugs from hair sample. Determination of a drug in urine by visible / UV Spectrophotometry Determination of LD50 from given data using Probit analysis. *In Vitro* Cytotoxicity test using XTT/MTT assays and cell cultures. Effect of heavy metal pollution in the osmoregulatory process in crabs/fishes	
Pedagogy:	Lectures/Tutorials/Videos/Assignments/ Group discussions/Self-study.	
Learning Outcome:	1. Understanding the significance of toxicology and to distinguish the different toxic materials. 2. Understanding application of different routes of exposure for toxicological studies and dose findings. 3. Understanding of the physiological and environmental effects of toxins. 4. Knowledge of various techniques for Toxicity evaluation.	
References /Reading:	1. Timbrell J. Introduction to ToxicologyThird Edition (2002), Taylor and Francis Inc. 2. Klaassen C, John Watkins J. Casarett & Doull's Essentials of Toxicology, Third Edition (2015). McGraw-Hill Education publication. 3. Stine K., Brown TM. Principles of Toxicology. Third Edition (2015). CRC Press. 4. Wallace A H. Principles and Methods of Toxicology. Fifth edition (2007). Informa Healthcare Publication, USA 5. Kwong T, Magnani B, Rosano T,Shaw L. The Clinical Toxicology Laboratory: Contemporary Practice of Poisoning Evaluation, Second Edition (2013). AACC Press. 6. Pandey G, Sahani YP. Toxicological Laboratory Manual. First Edition (2013)International E-Publication, India. 7. Levine B. Principles of Forensic Toxicology. Second Edition (2003)Amer Assn for Clinical Chemistry Press. 8. Hodgson E. A Textbook of Modern Toxicology. Fourth Edition (2010). Willey Publication. 9. Durrant M. Handbook of Clinical Toxicology. First Edition (2019). Hayle Medical Publishers.	

Course Code: ZOO 314 **Course Title: Advanced Cell Biology**
Number of Credits: 3 + 1
Effective from AY: 2020 -21

Prerequisite for the Course:	Basic understanding of different components and functions of the cell.	
Objectives:	3. To develop advanced concepts of structural and functional properties of cell and its components. 4. To understand dynamic functions associated with cell membrane and organelles.	
Content	**Module 1**	
	Cell membrane: Plasmamembrane Dynamics involved in Membrain fluidity (Paracrystalline state, Liquid-disordered state and Liquid-ordered state), Transbilayer movements, lateral movements, Membrane Rafts, Caveolins, cell-cell interaction, membrane fusions.	07 hrs.
	Importance of Freeze-fracture microscopy and Fluorophore Photobleaching experiments to decipher membrane structure and dynamism.	02 Hrs
	Nuclear transport: Passive Transport and selective energy dependant transport, Karyopherins (Importins and exportins), NLS and NES	03 Hrs
	Module 2	
	Endomembrane system: Main Vesicular transport pathways (inward transport: Endocytotic pathway and Outward Transport: Secretory pathway) of endomembrane systems and transport proteins involved.	04 Hrs
	Structural and functional Polarization of Golgi apparatus, Two models for cis to trans-Golgi progression (Cisternal Maturation Model and Vesicular transport model, three pathways of protein sorting at trans Golgi network: Signal mediated diversion to Lysosomes, Signal mediated diversion to regulated secretion, constitutive secretory pathways. LAMP and LIMP of Lysosomes and their significance.	06 hrs
	Synthesis, Structure and Functions of Ribosome and its subunits in Prokaryotes and Eukaryotes. Concept of LUCA in relation to Ribosomes.	02 Hrs
	Module 3	
	Comparison of constitution of Cytoplasm, Cytosol and Nucleoplasm. Comparison of Organelle composition of Protein secreting and Steroid secreting Cells. Comparison of Cytoskeletal elements of Prokaryotes and Eukaryotes.	03 Hrs
	Programmed and non-programmed Cell death and its types, Autophagy, Pyroptosis, Necroptosis, Parthonatos, Ferroptosis, Apoptosis and Necrosis. Extrinsic *versus* Intrinsic pathway of	04Hrs

	Apoptosis in Mammals. Cell signaling: General Principles, Specific responses to cell signaling (Survive, Grow+divide, Differentiate, Die) with example each, Feedback loops of signaling networks, adaptation to sensitivity to signaling. Overview of Receptors, Signaling transducers and second messengers. **Module 4 Practicals:** 1. Isolation of plasmamembrane from blood cells or from hepatocytes. 2. Cytoskeletal element staining using buccal epithelial cells. 3. Temporospatial patterns of apoptosis in chick embryos during the morphogenetic period of development.	05 Hrs 12 x 2 Hrs
Pedagogy:	Lectures/ tutorials/Group discussions/PBL/self-study	
Learning Outcome:	3. Understand the functions of the cell at the molecular level. 4. Gain insight into the most significant functional cellular machinery to expand understanding of biological disturbances.	
References /Reading	13. Alberts B, Johnson A, Lewis J, et al. Molecular Biology of the Cell, Taylor & Francis Group, New York, USA. 14. Lodish H, Berk A, Lawrence S, et al., Molecular Cell Biology, Freeman WH & Co. New York. 15. Watson JD, Beyker, Bell JD, et al., Molecular Biology of the Gene, Pearson Education, Delhi. 16. Bray BAD, Lewis J, Raff M, Roberts K and Watson JD, Molecular Biology of the Cell, Garland Publishing Co. Ltd. New York. 17. De Robertis EDP and De Robertis EMF, Cell and Molecular Biology Saunders College, Philadelphia Dowben RM, Cell Biology, Harper and Row Publ. London. 18. Nelson, D. L. and Cox, M. M. Lehninger Principles of Biochemistry. Seventh Edition (2017). Freeman WH and Co, USA	

Course Code: ZOO 401 **Course Title: Animal Genetics**
Number of Credits: 3
Effective from AY: 2020 -21

Prerequisite for the Course:	Basic knowledge of classical genetics and fundamental aspects of genetics.	
Objectives:	1. To develop concepts in classical animal genetics and their application. It leads to a better understanding of human genetic profile and the related diseases. 2. To relate the genetic concepts and the basic principles to produce better breeds of animals which can benefit economically. This course also aids in gaining better knowledge of novel aspects of Genetics and Bioinformatics.	
Content:	**Module 1:** Chromosomal Genetics: Chromosomal basis of inheritance and Cytological basis of crossing over- Sterns experiments in Drosophila, Inheritance of linked genes -Coupling and Repulsion phase, differential chromosomal staining techniques. Mapping genomes: a) Genetic mapping – DNA markers - RFLPs, SSLPs, SNPs b) Physical mapping - Restriction mapping, Fluorescent in situ hybridization, Radiation hybrid mapping and Sequence tagged site mapping, gene mapping in Drosophila using two point and three point test crosses with an emphasis on interference and coefficient of coincidence. Genetic models: Mouse as a model mammal for genetic studies, other animal models for human diseases. **Module 2:** Review of Pedigree analysis: Autosomal recessive disorders, Autosomal dominant disorders, X-linked recessive disorders, X-linked dominant disorders, Y-linked disorders (two examples each). Bioinformatics: tools and application in genetic studies. Cancer Genetics: Introduction and cellular aspects; Proto-oncogenes; Oncogenes; Viruses and Cancer; Oncoproteins; Tumor suppressor genes; Inherited Cancer genes (Familial Cancers). **Module 3:** Genetic applications in Fishes, Livestock and Wildlife**:** Evaluation and characterization of various indigenous breeds of fishes, livestock and poultry. *Ex-situ* and *In-situ* conservation of animal and poultry genetic resources.	4 hrs 6 hrs 2 hrs 6 hrs 6 hrs 6 hrs 3 hrs

	Role of artificial insemination / frozen semen / embryo transfer / ONBS / MOET technology in animal breeding. Gene editing in livestock: Promise, prospects and policy. Knock-out animals, Conditional knock outs using cre-loxP recombination; tissue specific promoters.	3 hrs
Pedagogy:	Lectures/Tutorials/Videos/Assignments/Group Activities/Self-study.	
Learning Outcome:	1. Understand Classical genetics and learn about microbial genetics and the related use of the concept in laboratories. 2. Learn about Drosophila genetics to study genetic principles using the model of Drosophila 3. Study the lesser known field of epigenetics 4. Knowledge on cancer and inherited genetics. 5. Distinguish between structural, functional and comparative genomics and how they differ from proteomics. 6. Evaluation of the various techniques used in advanced genetic analysis. 7. Learn about the novel field of Bioinformatics.	
References /Reading:	1. Klug WS, Cummings MR, Spencer C and Palladino MA (2008): Concepts of Genetics, 9th edition Publisher-Benjamin Cummings. 2. Snustad and Simmons (2005): Principles of Genetics, 4th Ed., John Wiley & Sons, USA. 3. Russell J (2009): Genetics, Benjamin-Cummings Publishing Company, San Francisco, California, USA 4. Alberts B, Johnson A, Lewis J, Raff M, Roberts K, and Walter P (2002): Molecular Biology of the Cell, 4th edition, Taylor & Francis Group, New York, USA. 5. Griffiths AJF., Gelbart WM, Lewontin RC and Miller JH (1999): Modern Genetic Analysis: Integrating Genes & Genomes, WH Freeman & Co. New York. 6. Hartl DL and Jones EW (2004): Genetics: Analysis of Genes and Genomes, 6th edition Jones & Bartlett Publishers, Boston, USA. 7. Benjamin L (2008): Genes IX, 9th edition, Publisher - Jones and Barlett Publishers Inc. 8. Primrose SB and Twyman RM (2001): Principle of Genome Analysis and Genomics, Blackwell Publishing Co. Malden, USA. 9. Watson JD, Baker TA, Bell SP, Gann A, Levine M, Losick R (2013): Molecular Biology of the Gene, 7th edition, Pearson Education, Delhi, India.	

Course Code: ZOO 402 **Course Title: Biodiversity**
Number of Credits: 3
Effective from AY: 2020 -21

Prerequisite for the Course:	Should have studied B. Sc. Zoology with assumption that the student has a basic working knowledge of classical faunal biological diversity.	
Objectives:	1. To provide graduates in Biology a specialization in the field of Biodiversity and Conservation. 2. To generate qualified postgraduates who can be part professional organizations working in the field of conservation and environment protection. 3. To provide an alternate avenue to Biology graduates to specialize as "environmental entrepreneurs" in areas such as Environmental audits, Environmental education, Ecotourism etc. 4. To create awareness about Biodiversity and Nature Conservation.	
Content:	**Module 1:** Introduction: Measuring Biological Diversity, Measuring global biodiversity and its decline with special reference to Mammals, Avifauna, Herpetofauna, Ichthyofauna, Malacofauna and Insects, Keystone species, Geographic Distribution of Biological Diversity, Gradients of Spatial Distribution, Endemism and biodiversity	12 hrs
	Module 2: Biodiversity and Ecosystem function (a) Theories on relation between biodiversity and ecosystem function i. Species Complementarity ii. Sampling effect iii. Redundancy (b) Decline of global biodiversity and loss of Ecosystem function. (c) Functional diversity and ecosystem functioning. (d) Insurance Hypothesis: The effect of habitat fragmentation and dispersal on ecosystem functioning. (e) Biodiversity and stability in soil ecosystem: pattern processes and the effect of disturbance. (f) Global pollinator loss and their effect on crop production and non-crop plant reproduction. (g) Multi-trophic dynamics and ecosystem processes. (h) The economics of biodiversity and ecosystem function.	04 hrs 08 hrs
	Module 3: **Type of Diversity:** Alfa, Beta and Gama diversity; Indices: Shannon Index, Simpson Index, Lincoln Index, Dominance index, Margalef richness index, Menhinick Index, Equitability Index, Whitaker Index, Sorensen's Index, Jaccard Index, Brillouin Index,	03 hrs
	Legal framework of biodiversity conservation Introduction to laws and policies for biodiversity conservation: Convention on Biological	03 hrs

	Diversity, Kyoto protocol, Nagoya Protocol, Ramsar Convention on conservation of wetlands, Forest Conservation Act of India (1927), Environment Protection Act of India (1986). **Indian Biodiversity law and rules, State Biodiversity rules:** Bio prospecting and conservation, IPR, patent protection and biopiracy. Tradable bio-resources, biodiversity informatics, databases in biological materials. International efforts and issues of sustainability **Organisations involved in biodiversity conservation:** World conservation Union, National Biodiversity Authority, State Biodiversity Boards, Biodiversity Management Committees and Peoples Biodiversity Register.	03 hrs 03 hrs
Pedagogy:	Lectures/Tutorials/Videos/Assignments/Group Activities/Self-study.	
Learning Outcome:	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. 5. Utilizing skills for preparation of PBR and can actively participate in conservation.	
References /Reading:	1. Belsare DK, (2007) Introduction to Biodiversity, A. P. H. Publishing Corp. New Delhi. 2. Groombridge B. (2011)Global Biodiversity: Status of Earth's Living Resources. Chapman and Hall Publ. London 3. Huston AM (1994), Biological diversity, Cambridge University Press, Cambridge 4. Wilson,E O (1998), Biodiversity, National Academy Press, New York 5. M. Kato. (2000) The Biology of Biodiversity, Springer. 6. B.K. Tikadar. (1983) Threatened Animals of India, ZSI Publication, Calcutta. 7. Kothari, A.S. & Chapgar. (2005) Treasure of Indian Wildlife, BNHS, Mumbai. 8. B. B. Hosetti. (2005) Concepts in Wildlife Management. 2nd Revised & Enlarged Edn, 2005. Daya Publishing House, Delhi. 9. Anne E., Magurran. (2004) Measuring Biological Diversity. Blackwell Publishing. 10. Gadgil, M. *et. al.* (2005) A Methodology Manual for Documenting People's Priorities for Biodiversity and Conservation. Shrustiygyaan.	

Course Code: ZOO- 403 **Course Title: Evolutionary Biology**
Number of Credits: 2
Effective from AY: 2020 -21

Prerequisite for the Course:	Basic working knowledge of diversity, cell biology, genetics and classical evolutionary biology.	
Objectives:	This course develops major concepts in evolutionary biology, including theories, unicellular/multicellular evolution, evolutionary history and evolutionary time scale. This course also provides a better understanding of population genetics, evolutionary forces and speciation. Additionally, this course throws light on aspects of molecular evolution along with evolutionary models.	
Content	**Module 1:** **Emergence of evolutionary thoughts, Evolutionary theories and evidences:** Contributions of Lamarck, Darwin, Darwin-Wallace postulates, concepts of variation, adaptation, struggle, fitness and natural selection; Spontaneity of mutations; The evolutionary synthesis, limitations of Darwinism, Neo Darwinism.	3 hrs
	Origin of cells and unicellular evolution: Origin of basic biological molecules, Abiotic synthesis of organic monomers and polymers, Concept of Oparin and Haldane, Experiment of Miller (1953), The first cell, Evolution of prokaryotes, Origin of eukaryotic cells, Evolution of unicellular eukaryotes.	3 hrs
	Paleontology and Evolutionary History: Overview of evidences - Paleontological, Embryological, Comparative morphological, Anatomical, Genetics and Cytological, Molecular Biological evidences.	2 hrs
	The Evolutionary time scale: Eras, periods and epoch; Major events in the evolutionary time scale; Origins of unicellular and multi cellular organisms; Major groups of plants and animals; Stages in primate evolution including Homo, Human evolution.	4 hrs
	Module 2 **Population genetics**: Populations, Gene pool, Gene frequency; Hardy-Weinberg Law; **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, Nonrandom mating.	4 hrs

	Hybridization and speciation: Concept of species and models of speciation based on distribution sympatric, allopatric, stasipatric, genetic drift, genetic revolution, genetic transilience, Founder-flush theory, phylogenetic gradualism, punctuated equilibrium, hybridization, adaptive radiation, isolating mechanisms. **Molecular Evolution:** Molecular phylogeny, neutral theory, molecular clock. **Creation and evolution models.**	3 hrs 3 hrs
Pedagogy:	Lectures/Tutorials/Videos/Assignments/Group discussion/Self-study.	
Learning Outcome:	1. Understand in detail the various concepts of evolutionary biology such as theories, history and evidences. 2. Study the time scale and understand stages of life formation and evolution. 3. Learn about the intricacies of population genetics in evolution. 4. Understand the various processes related to evolution. 5. Knowledge about molecular evolution, the field that links various aspects in zoology.	
References /Reading	1. Ferguson A (1980): Biochemical Systematics and Evolution, Blackie Publ., London. 2. Futuyma DJ (1979): Evolutionary Biology, 3rd Edition, Sinauer Associates, New York. 3. Futuyma DJ (2005): Evolution, Sinauer associates, New York. 4. Ridley M (1992): Evolution, 3rd edition, Blackwell Publishers, New York. 5. Rose MR and Mueller LD (2006): Evolution and Ecology of the Organism, Prentice Hall, New York. 6. Barton NH, Briggs DEG, Eisen JA, Goldstein AE, Patel NH (2007): Evolution, Cold Spring Harbor Laboratory Press, New York, USA. 7. Hall BK and Hallgrimsson B (2013): Evolution, Jones and Bartlett Publisher, Sudbury, USA . 8. Mayr E (2001): What Evolution Is, Basic Books, New York, USA.	

Course Code: ZOO-404 **Course Title: Endocrinology**
Number of Credits: 2
Effective from AY: 2020 -21

Prerequisite for the Course:	Basic knowledge on animal anatomy, physiology and endocrinology.	
Objectives:	This course develops concepts in molecular level endocrinological events to understand hormones and their crucial role in the animal body. This course also focuses on various approaches to understand hormone action and the receptors involved. Additionally this course reflects on the endocrine glands and the related applications of hormones in the field of cellular pathologies.	
Content:	**Module1:** Classification of hormones, structure-function relationships in different hormones, transcriptional and post-transcriptional mechanisms of hormone biosynthesis and secretion, regulation of biosynthesis and secretion,inhibitors of hormone biosynthesis and their use, purification and storage of hormones.	4 hrs
	Nature of hormone receptors; receptors and types- membrane receptors, nuclear receptors; receptor antagonists and their applications, structural requirements for successful hormone-receptor interactions.	4 hrs
	Nature and mechanism of hormone action, signal discrimination, signal transduction pathways, secondary messengers, signal amplification, molecular mechanisms of regulation, permissive actions of hormones, signal attenuation, termination of hormone action, cross talk between steroid and protein hormone pathways.	4 hrs
	Module 2: Techniques for quantization of hormones, design and development of hormonal assays.	3 hrs
	Hormones and diseases, Genetic analysis and clinical management of hormonal disorders.	3 hrs
	Hormones as therapeutic agents, current developments in design and production of hormonal contraceptives, recombinant protein hormones-production and applications, evolution of chemical communication in animal systems.	4 hrs
Pedagogy:	Lectures/Tutorials/Videos/Assignments/ Group discussions/Self-study.	

Learning Outcome:	1. Essential in depth understanding of the various hormones, molecular synthesis, secretion, receptors and action of hormones along with regulation. 2. Vision to understand the endocrine glands with the crucial functioning in the body and the various hormone base disorders with new age aspects of hormones and applications to other fields of cell biology.
References /Reading:	1. Bolander FF (2004): Molecular Endocrinology, Elsevier, UK. 2. Hadley ME and Levine JE (2006): Endocrinology, Adeson-Wesley publication, USA. 3. Melmed S, Polonsky KS, Reed P et al (1995): William's text book of Endocrinology, Willey Blackwell Publication, UK. 4. Darnell J Lodish Hand Baltimore D (1986): Molecular Cell Biology: Scientific American Book, Inc. USA. 5. NorrisDO (2013): Vertebrate Endocrinology: Academic Press, New York. 6. Freedman LP (1998): Molecular Biology of Steroid and Nuclear Hormone receptors, ed., Birkhauser, Boston, USA. 7. Litwack G (1985): Biochemical actions of hormones, Academic press, New York, USA. 8. Bentley PJ (1998): Comparative Vertebrate Endocrinology, III edition, Publisher – Cambridge University Press, Cambridge UK.

Course Code: ZOO 405 **Course Title: Biostatistics**
Number of Credits: 2
Effective from AY: 2020 -21

Prerequisite for the Course:	Elementary knowledge of statistical approaches	
Objectives:	1. To understand fundamental concepts and techniques of descriptive and inferential statistics with applications in lifesciences. 2. To understand the principles of various study designs, and explain their advantages and limitations.	
Content:	**Module 1:** Introduction to Biostatistics, Population and samples, Sampling Types, Types of Variables, Difference between Primary and Secondary Data, Data representation, Type I and II Errors, Experimental/Study designs and its types, statistical inferences and Hypothesis Testing, Meaning of statistical Significance, Pre and Post-Hoc tests. Differences between descriptive and Inferential statistics. **Module 2:** Data representation and plotting, Mean, Measure of Variability, Standard deviation, Kurtosis, R programming, Correlation, Regression**,** Interpolation and extrapolation, Concept of Probability, Variance and Covariance**,** Probability distributions, Test of Hypothesis (1 tailed and 2 tailed Test of Hypothesis, p-value, (Type -1 and Type -2 error), . T-test, 1 tailed and 2 tailed T-distribution, Chi-square test, ANOVA.	12 hrs 12 hrs
Pedagogy:	Lectures/Tutorials/ PBL/Videos/Assignments/Group Activities/Self-study.	
Learning Outcome:	After successful completion of this course, students will be able to: 1. Understand the role of biostatistics in biological studies. 2. Use descriptive tools to summarize and display data from biological studies. 3. Identify appropriate tests to perform hypothesis testing, and interpret the outputs adequately. 4. Get familiar with statistical software and standard packages for biostatistics.	
References /Reading:	1. Sakal, R. R.; Rohlf, F. J. Introduction To Biostatistics. Second Edition (2009). Dover Publications, Inc, Mineola, New York. 2. Rosner, B. Fundamentals of Biostatistics. Eight Edition (2016). Cengage Learning, Boston, USA. 3. Winner, L. Introduction to Biostatistics. (2004), University of Florida. 4. Forthofer, R.; Eun Lee, E. Introduction to Biostatistics: A Guide to Design, Analysis and Discovery. First Edition (1995), Academic Press 5. Gurumani, N. An Introduction to Biostatistics. First Edition (2009) MJP Publishers. New Delhi.	

Course Code: ZOO-406 **Course Title: Vector Biology**
Number of Credits: 2
Effective from AY: 2020 -21

Prerequisite for the Course:	Basic working knowledge of taxonomy, biodiversity, arthropodology.	
Objectives:	This course will help the learner to understand the all concept and components of arthropods, in depth, involved in causing diseases. Additionally this course also covers the field of modern vector biology, giving an exposure to the emerging subjects like Proteomics. Moreover the course also deals with vector and disease control and focuses on common mosquito linked diseases.	
Content	**Module 1** Introduction to vector biology and its importance in public health management. Arthropod as disease vectors, taxonomy, classification, biology, ecology. Arthropod transmitting bacteria and viruses of medical importance; Major vector borne diseases; Vector-parasite interaction; Host-pathogen interaction; Factor in disease transmission. Special reference to mosquitoes as vectors, Biology, Bio-ecology, Life history of Anopheles, Culex, and Aedes mosquitoes, malaria, filariasis, dengue, Chikungunya and Japanese encephalitis. **Module 2** General Characters and classification, history, distribution, morphology, biology, life cycle, mode of infection, signs and symtoms, diagnosis, molecular biology, drug resistance, treatment, preventive measures and control of: Flies, Bugs, Fleas And Lice. Modern vector biology; Genomics and Proteogeomics of vectors. Chemical and biological and environmental control of vectors; Integrated vector management, vector resistance mechanism.	1 hr 2 hrs 6 hours 3 hrs 6 hrs 6 hrs
Pedagogy:	Lectures/Tutorials/Videos/Assignments/Group discussion/Self-study.	
Learning Outcome:	1. Learner will understand the concept and components of vectors, their behavior, taxonomy, morphology, life cycle and entire biology. 2. Understand insects as parasites and the various linked diseases. 3. Sufficient knowledge of modern vector biology and proteogeomics. 4. Know about vector control and integrated vector management. 5. Create and communicate knowledge on the causes and prevention of vector borne disease in the population, to promote health and health services. 6. Learn about mosquito linked diseases.	
References /Reading	1. Mani MS (1982), General Entomology, Oxford and IBH Publishing Co.,New Delhi.	

	3. Rathnaswamy GK (1986), A Hand book of Medical Entomology and Elementary Parasitology, S.Vishwanath Pvt.Ltd., India. 4. Bruce ED, Eldridge F and Edman JD (2000), Medical Entomology, Kluwer Academic Publishers, UK. 5. Kahn HA (1983), Introduction of Epidemiology Methods, Oxford University Press, New York. 6. Snodgrass RE (1935), Principles of Insect Morphology, Tata McGraw Hill publishing co. India. 7. Mullen G and Durden L (2002), Medical and Veterinary Entomology, Academic Press, USA. 8. Kettle DS (1984), Medical and Veterinary Entomology, Cabi Press, USA. 9. Service MW (2012), Medical Entomology for students, Cambridge University Press, UK. 10. Service MW (1993), Mosquito Ecology, Field sampling methods, Applied Science Publishing Ltd., London. 11. Marquardt WC (1996), Biology of disease vectors (2nd Edition), Doody Enterprises, Inc.USA.

Course Code: ZOO 407 **Course Title: Histology and Histochemistry**
Number of Credits: 2
Effective from AY: 2020 -21

Prerequisite for the Course:	Elementary knowledge of Cell Biology and Physiology.	
Objectives:	3. To study the microscopic organization of cells into tissues. 4. To understand the microscopic structure of tissues; their cellular function and physiological relevance.	
Content:	**Module 1:** Introduction to Histology, types of Epithelia, Histology of Brain, Spinal cord, Heart, Liver, Kidney, Digestive tract, Bones. Histological Techniques, Tissue fixatives, Processing of tissue, Microtomy, Cryotomy, Staining Principles, Mounting media, Types of Microscopy, Image capture tools, analysis and interpretations. **Module 2:** Principles of histochemistry and cytochemistry, detection techniques of carbohydrates, lipid, and nucleic acid, proteins, hydrolytic and oxidative enzymes, inhibitors and calcium. Cytochemical detection techniques and its principles; Principles and techniques of autoradiography, cytophotometry; Principles of Histopathology techniques and its application.	6 hrs 6 hrs 6 hrs 6 hrs
Pedagogy:	Lectures/Tutorials/ PBL/Videos/Assignments/Group Activities/Self-study.	
Learning Outcome:	After successful completion of this course, students will be able to: 1. To examine images of a tissue section and identify the types of tissues present, their roles, and the relationship between structure and function	
References /Reading:	1. Mescher, A. L.Junqueira's Basic Histology: Text and Atlas, Thirteenth Edition (2013) McGraw-Hill Education. 2. Paulsen, D. F. Histology and Cell Biology: Examination and Board Review, Fifth Edition (2010) McGraw-Hill Education. 3. Shyamsundari S and Hanumantha Roa K (2007) Histochemistry in focus. M J publishers, Chennai 4. A. J. Kiernan (2008) Histological and Histochemical methods: Theroy and practice, Scion Publishing Limited, Oxford 5. Gartner L P and Hiat J L (2000) Colour Atlas of Histology, Williams and Wilkins, Balitmore 6. Kierszenbaur AL (2002) Histology and Cell biology: An Introduction to pathology, Mosby Inc. St.Louis.	

Course Code: ZOO- 408 **Course Title: Helminthology**
Number of Credits: 2
Effective from AY: 2020 -21

Prerequisite for the Course:	Basic working knowledge of animal parasites, their morphology and biology.	
Objectives:	This course will help the learner to understand the subject of parasitology, host-parasitic interaction, various Helminthes, i.e Nematodes, Trematodes and Cestodes along with their entire biology and human immune responses. This course also aids in developing knowledge about helminthes of veterinary importance.	
Content	**Module 1** Introduction to Helminthology: General organization and Classification of Platyhelminthes and Aschelminthes; Functional anatomy of Reproductive system of Nematodes, Trematodes, Cestodes Intramolluscan stages and their effect on molluscan hosts, Effect on foot, haepatopancreas, Reproductive system and general metabolism. 2. Various types of Cercaria. 3. Different types of larvae in cestodes and their pathogencity. 4. Holdfast organs with its adaptations in cestodes. Basic concept and overview - Parasite relationship, Parasitic adaptations, interrelationships between host and parasite. Host Parasitic interactions in health and diseases. Signs and symptoms of parasitic diseases. Immune response and self-defense mechanisms, immune evasion and biochemical adaptations of parasites. Helminths of veterinary importance. **Module 2:** Life cycle, mode of infection, signs and symptoms, diagnosis, molecular biology, drug resistance, treatment, preventive measures and control of each of the following: **Nematodes:** Intestinal (*Ascaris lumbricoids, Trichinella spiralis, Ancylostoma duodenale, Necator americanus*), Blood and tissue nematodes (*Wuchereria bancrofti, Dracunculus medinensis*). **Trematodes:** 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)*.	06 hrs 06 hrs 03 hrs 03 hrs 03 hrs
Pedagogy:	Lectures/Tutorials/Videos/Assignments/Group discussion/Self-study.	

Learning Outcome:	1. Learner will have sufficient knowledge on parasitology. 2. Will understand host-parasitic interaction. 3. Will realize various helminths and their biology. 4. Develop concept in understanding parasites and impact on lives. 5. Highlights the parasites of veterinary importance.
References /Reading	1. Bogitsh BJ (1990), Human Parasitology, Academic press, New York. 2. Rathnaswamy GK (1986), A Hand book of Medical Entomology and Elementary Parasitology, S.Vishwanath Pvt.Ltd., India. 3. Roberts L and Janovy J (1977), Foundations of Parasitology, McGraw-Hill Publishers, New York, USA. 4. Anderson RM and May RM (1985), Helminth infections of humans: mathematical models, population dynamics and control. Adv Parasitol.:1-101. 5. Cox FEG (1993), Modern Parasitology: A Textbook of Parasitology. 6. Chatterjee KD (1967), Parasitology: Protozoology & Helminthology. 7. Garcia LS, Bruckner DA (1997), Diagnostic medical Parasitology.

Course Code: ZOO 409 **Course Title: Ethology**
Number of Credits: 02
Effective from AY: 2020 -21

Prerequisite for the Course:	Basic knowledge of animal science and behaviour.	
Objectives:	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 Ethology :Social Behaviour:Parental care- Types, parent offspring conflict, Sexual strategies, mating types and Courtship, Aggression and territory Communication in animals:Auditory, Echolocation, Infra and ultra sounds, Tactile, Visual, Pheromones- in vertebrates and invertebrates, Language of honey bees-circle and waggle dance Feeding strategies: Heterotrophs, Parasitic, Saprophytes, Commensalism, mutualism, Coprophagy and Hematophagy **Module 2:** Learning and Imprinting: Introduction and definitions, Habituation, conditioning. Trial and error, Imprinting, Neural mechanism of learning. Socio-biology: Introduction- definition, WO Wilson, Richard Dawkins, WD Hamilton, Units of Socio-biology. Hamilton's theory and Altruism, cooperation, reciprocation and Eusociality. Jane Goodall, Dian Fossy; Properties, advantages of a social group, Social organisation in primates.	04 hrs 04 hrs 04 hrs 04 hrs 08 hrs
Pedagogy:	Lectures/ tutorials/assignments/self-study	
Learning Outcome:	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	
References /Reading	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 5. Animal Behaviour by. Reena Mathur, Rastogi Publication, Meerut-New Delhi.	

Course Code: ZOO 410 **Course Title: Biological Techniques**
Number of Credits: 2
Effective from AY: 2020 -21

Prerequisite for the Course:	Elementary knowledge of Physics, Chemistry besides Lifescience.	
Objectives:	1. To provide knowledge on physical and chemical principles involved in the laboratory instruments used for preparative and analytical biological methods. 2. To provide general overview of different biochemical experimental approaches to understand the structure and functions of cell and its components.	
Content	**Module 1** Spectrophotometry techniques: Laws of radiant energy absorption, Radiant energy resources, Wavelength selectors, Sample containers, Detection devices, amplification and readout, Qualitative and quantitative applications. Molecular biology techniques: PCR and RT-PCR, working principles, data analysis, applications. Microscopic techniques: Visualization of cells and subcellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells, scanning and transmission microscopes, Freeze-etch and Freeze-fracture methods for EM, image processing methods in microscopy. Radiolabeling techniques: Detection and measurement of different types of radioisotopes normally used in biology, incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, safety guidelines. **Module 2** Chromatography techniques: Principle of chromatographic separations, Types of chromatographic techniques, Planar, Column, Thin layer, Displacement, Ion-exchange, Size exclusion, Gas and Liquid Chromatography (their working and application). Electrophoresis techniques: Concepts of Electrophoresis and Electro-osmosis; Slab Gel and Vertical gel assemblies, Agarose gel electrophoresis, PAGE, SDS-PAGE, Isoelectric focusing, 2D Gel electrophoresis, Recovery of materials from Electrophoretic gels. Centrifugation techniques: Types by rotor designs, Types by intended use, Centrifugal techniques (Differential, Density gradient, Rate Zonal, Isopycnic centrifugation.	03Hrs 03 Hrs 03 Hrs 03 Hrs 05 Hrs 04Hrs 03Hrs
Pedagogy:	Lectures/ tutorials/Group discussions/PBL/self-study	
Learning Outcome:	1. Understanding the basic knowledge of some advance techniques and their uses and its potential application in animal biology.	
References /Reading	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. 3. 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. 4. Holme D and Peck H (1998), Analytical Biochemistry, Longman Scientific & Technical Publication, England.

Course Code: ZOO-411 Course Title: Bioinformatics: Introduction to Biological Databases
Number of Credits: 2
Effective from AY: 2020 -21

Prerequisite for the Course:	Basic knowledge of Cell and Molecular biology, Genetics.	
Objectives:	1. To expose students to this subject and modern technology. 2. To make students understand fundamental principles of bio informatics for an in depth understanding of the related subjects. 3. Application of this novel field in Zoology and use of this subject with respect to Evolutionary significance.	
Content:	**Module1:** Bioinformatics- Introduction and definition, History and Scope, Applications of Bioinformatics in various fields.	1 hr
	Nucleic Acid Sequence Databases : • Nucleic acid sequence databases (GenBank, EMBL, DDBJ), Keyword-based search at Entrez Search Engine at NCBI. • Sequence Submission tools at NCBI, EMBL etc. **Protein sequence database**: UniProtKB (SwissPort, TrEMBL). Species specific database for mouse and zebra fish Metabolic pathway databases.	8 hrs
	Open Access Bibliographic Resources and Literature Databases: • PubMed, • MEDLINE, • PubMedCentral at NCBI	
	Module 2 **Sequence Analysis: Various File Formats for Biomolecular Sequences**: • GenBank • FASTA	3 hrs
	Basic concepts of sequence analysis: • Global Pair wise Sequence Alignment • Local Pair wise Sequence Alignment • Needleman and Wunsch, Smith and Waterman algorithms for pair wise alignments, gap penalties, use of pair wise alignments for analysis of Nucleic acid and Protein sequences and interpretation of results.	7 hrs 5 hrs
	Databases Searches : • BLAST • FASTA **Multiple Sequence Alignment:**	

	• The need for MSA • Basic concepts of various approaches for MSA (e.g. progressive, hierarchical, iterative etc.). **Concept of Phylogeny**: • Molecular Phylogeny • Various Methods of Phylogenetic Tree Construction **Scoring matrices:** Basic concept of a scoring matrix, Matrices for nucleic acid and proteins sequences, PAM and BLOSSUM series.	
Pedagogy:	Lectures/ tutorials/online teaching mode/self-study.	
Learning Outcome:	The students will acquire the knowledge about: 1. Various bioinformatics tools and techniques and how to use that for the analysis of the biological experimental data. 2. Concepts of various databases and various methods for the data retrieval, data storage, and data mining and use that data for the further analysis. 3. In-Silico approach for the protein modeling and drug discovery process. 4. Sequencing techniques and gene annotation as well as submission of the sequences to the various databases.	
References /Reading:	1. Mount D (2005), Bioinformatics Sequence and Genome Analysis. 2. Xiong J (2006), Essential Bioinformatics: Cambridge University Press. 3. Wood AH, Parry TK and Smith DJ (2001), Introduction to bioinformatics, Pearson education Asia. 4. Baxevanis AD & Ouellette BFF (2001), Bioinformatics: A practical guide to the analysis of genes and proteins, Wiley Interscience – New York. 5. Misener S & Stephen A (2000), Bioinformatics: Methods and Protocols Krawetz, Humana Press, New Jersey. 6. Higgins D & Taylor W (2000), Bioinformatics, Sequence, structure and databanks –- Oxford University Press. 7. Bosu O and Thukral SK (2007), Bioinformatics Databases, Tools and Algorithms.	

Course Code: ZOO 412 **Course Title: Scientific Communication**
Number of Credits: 2
Effective from AY: 2020 -21

Prerequisite for the Course:	Elementary knowledge of Cell Biology and Physiology.	
Objectives:	To develop successful Science Writing in students to demonstrate their ability to understand and use of available knowledge in science.	
Content:	**Module 1** Making Oral presentation: Pronunciation, accent, intonation, clarity, speed, fluency; eye contact; planning and organization. Enrichment of Vocabulary: word forms and derivation, prefixes and suffixes, Scientific and technical vocabulary, spelling. Basic grammar: Tenses; Voices; Proposition and conjunctions; conditional sentences; Punctuations. Softwares for Plagiarism Check and Grammar, Softwares for Reference styles and manuscript organization. Effective writing presentation: Order of sentences in a paragraph, Sentence connection, cohesion and coherence; Contradiction, tautology, semantic anomaly, circumlocution. Introduction to Scientific writing skills; Ethics of scientific write-up, Scientific method : Concept, hypothesis, theory, law; Design of experiment, Inductive and deductive reasoning. **Module 2** Pattern of a literature review; Online search tools and tactics for literature survey Citing a reference in a text body and in the References, Styles of Reference citations, UGC-CARE LIST. Preparing the manuscript: Guidelines for authors; The IMRAD format. Framing the Title, Abstract, Key words; Introduction with defining the problem, Literature survey, Justification of study; Experimental procedure with proper techniques, reproducibility, units of measurements and statistical analysis; Results with proper presentation data and illustration; caption and legends; Discussion with components and sequesnce, comparison and integration of data; conclusions and significance; implication of further study. Research project proposal: Framing summary of Proposal (SOP), Scientific flow of Project proposal building.	3 hrs 3 hrs 3 hrs 3 hrs 3 hrs 6 hrs 3 hrs

Pedagogy:	Lectures/Tutorials/ PBL/Videos/Assignments/Group Activities/ Online teaching mode/Self-study.
Learning Outcome:	After successful completion of this course, students will be able to: 1. Present scientific information in appropriate language for various audiences, including scholarly and general, in print and online.
References /Reading:	1. Day RA and Gastel B (2006), How to Write and Publish a Scientific Paper. Sixth Edition, ISBN: 0-313-33040-9 2. Alley, M. 2003. 2. The Craft of Scientific Presentations: Critical steps to succeed and critical errors to avoid. Springer, NY. 241 pages. ISBN:0-387-95555-0. 3. Day DA, Sakaduski N and Day N (2011), Scientific English: A guide for scientists and other professionals. ABC-CLIO Publ. 4. Alley M (1996), The craft of scientific writing. Springer Publ. 5. Day RA (1988), How to write & publish a scientific paper, Cambridge University Press.

Course Code: ZOO 413: **Course Title: Immunology**
Number of Credits: 2
Effective from AY: 2020 -21

Prerequisite for the Course:	Basic knowledge on cell biology	
Objectives:	1. To enable the student to understand the principles and mechanisms of immunology 2. To update the student on the scope and importance of clinical immunology and create an awareness about the inherent dangers of microbes 3. To impart conceptual understanding of functional organization of immune system and its responsiveness in health and disease	
Content	**Module 1:** An overview: Scope of immunology, recognition of self and non-self as a basic functional feature of immune system; Concepts of external and internal defense systems;Types of immunity: innate and acquired- types, functional features; concept of adaptive immunity; Immune tissues / organs-- types, anatomical location, structure and development; lymphocyte traffic during development. **Antigens and Immunogenicity:** Definition, characteristic features and classification; Adjuvants: definition, types and applications. **Cellular Immune System:** Lymphocytes: types, morphology, clones / sub-populations, distribution, B and T cell receptors, B and T cell epitopes, Toll-like receptors; Antigen presenting cells: antigen processing and presentation, MHC molecules and their immunologic significance **Module 2:** **Antibodies:** Primary structure, classification, variants and antigen-antibody interactions; Structural and functional characteristics of various antibody classes; Generation of diversity; Monoclonal antibodies: definition, production and applications; Antibody engineering and its applications. **Complement system:** Components, three major activation pathways, and immune functions including anaphylaxis and inflammation. **Cytokines and Interferons:** Definition and salient functional features; Interleukins: definition, types (lymphokines and monokines), and functions; Interferons--Origin, types and functions	12 hrs 12 hrs
Pedagogy:	Lectures/ tutorials/self-study	

Learning Outcome:	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
References /Reading	1. Kuby Immunology, 6th edition (2007), T. J. Kindt, R.A. Goldbye, B.A. Osborne, Publisher: W.H. Freeman and Company. 2. Immunobiology: The Immune System in Health and Diseases, 6th Edition (2005), Charles A. Janeway, Publisher: Garland Science. 3. Roitt's Essential Immunology, 11th Edition (2006) Peter Delves, Seamus Martin, Dennis Burton, Ivan Roitt, Publisher: Wiley-Blackwell. 4. Cellular and Molecular Immunology, 6th Edition (2008) Abul K. Abbas, Andrew H. Lichtman, and Shiv Pillai, Publisher: Elsevier, USA. 5. Prescott, Harley, Klein's Microbiology 7th edition (2009), Joanne M Willey, Christopher J Woolverton, Linda M Sherwood, Publisher: McGraw-Hill.

Course Code: ZOO 414 **Course Title: Nutritional Biochemistry**
Number of Credits: 2
Effective from AY: 2020 -21

Prerequisite for the Course:	Basic knowledge of physiology and biochemistry	
Objectives:	1. To make aware the students about the importance of nutrition in maintaining health. 2. To cultivate proper feeding habits. 3. To learn the proper and scientific value of different food items	
Content	**Module 1:** Basic concepts of energy and energy expenditure; Calorific values of food – Basal metabolic rate, energy requirements of man, women, infants and children. Dietary Carbohydrates : Functions, classification, food sources, storage in body, biomedical importance ; Dietary Proteins - Functions, classification, food sources, composition, essential & non-essential amino acids, protein deficiency. biomedical importance; Dietary Fats: Function of fats, classification, food sources, composition, saturated and unsaturated fatty acids, biomedical importance. Vitamins: sources and functions, deficiency status. **Module 2:** Water as nutrient**;** Electrolyte concentrations of body fluids; Minerals: macro & micronutrients functions, sources. Bioavailability and deficiency of Calcium, Iron, Iodine, Sodium & Potassium (very brief account); concept of acidosis and alkalosis. Nutritional requirements during pregnancy and lactation; Nutrition during infancy, Nutrition of school children, Nutrition during adolescence, Nutrition during adulthood. Nutrigenomics of omega 3 and omega 6 fatty acids, essential amino acids, vitamin A, C, D, E and B complex.	12 hrs 12 hrs
Pedagogy:	Lectures/ tutorials/self-study	
Learning Outcome:	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	
References /Reading	1. Gopalan.C, BS. Ramasastri & SC Balasubramanian: 1971, Nutritive value of Indian foods. National Institute of Nutrition, Hyderabad.	

	2. Gopalan.D & K. Vijaya raghavan 1971, Nutrition atlas of India, ICMR, New Delhi. 3. Ghosh.S 1981, The feeding care of infants and young children, UNICEF, New Delhi. 4. Mudambi.SR ,1995. Fudementals of food and nutrition. New age international, New Delhi. 5. Swaminathan.M, 1989. Handbook of food and nutrition. Bappco, Bangalore. 6. Swaminathan.M, 1974 Essentials of food and nutrition. Vol I & II, Ganesh and Co. Madras. 7. Brody T, Nutritional, Biochemistry, Academic Press, New York. 8. Elia M, Ljungqvist O, Stratton R and Lanham SA, Clinical Nutrition, Willey Blackwell Publication, UK. 9. Swaminathan MS, Nutritional Biochemistry, T R Publication, India.