UNIVERSITY OFKERALA
Thiruvananthapuram

M.Sc. ZOOLOGY Programme with Specialization in Biosystematics and Biodiversity

(Innovative Programme)

Semester System

(for 2020 admissions onwards)

October 2020

UNIVERSITY OF KERALA

M.Sc. Zoology (New Course) – Semester System
Syllabus, Course Structure & Mark Distribution

Semester	Paper Code	Title	Distribution of hours semester	Instructional hrs. per week		Duration of ESA (Hrs)	Maximum Marks		
							CA	ESA	Tot
1	ZO 211	Evolution and Zoogeography	100	5	-	3	25	75	100
	ZO 212	Biochemistry	100	5	-	3	25	75	100
	Z0 213	Biophysics, Instrumentation & Nanoscience	100	5	-	3	25	75	100
	Z0 214	Practical	120	-	10	4	25	75	100
	Total for S 1		**450***	**15**	**10**	**-**	**100**	**300**	**400**
2	ZO 221	Advanced Physiology &Functional Anatomy	100	5	-	3	25	75	100
	ZO 222	Genetics, Quantitative Analysis & Research Methodology	100	5	-	3	25	75	100
	Z0 223	Cell Biology, Molecular Biology& Bioinformatics	100	5	-	3	25	75	100
	Z0 224	Practical	120	-	10	4	25	75	100
	Total for S 2		**450***	**15**	**10**	**-**	**100**	**300**	**400**
3	ZO 231	Microbiology Biotechnology	100	5	-	3	25	75	100
	ZO 232	Ecology and Ethology	100	5	-	3	25	75	100
	Z0 233	Immunology & Developmental Biology	100	5	-	3	25	75	100
	Z0 234	Practical	120	-	10	4	25	75	100
	Total for S 3		**450***	**15**	**10**	**-**	**100**	**300**	**400**
4	ZO 241	Special Paper 1 Bio Systematics &Animal Diversity	100	8	-	3	25	75	100
	ZO 242	Special Paper 2 Biodiversity Management	100	7	-	3	25	75	100
	Z0 243	Special Paper Practical 1 Animal Systematics and Diversity	100	-	5	3	25	75	100
	Z0 244	Special Paper Practical 2 Biodiversity Management	120	-	5	4	25	75	100
	Total for S 4		**450***	**15**	**10**	-	**100**	**300**	**400**
	ZO201	Project	-	-	-	-	25 marks	75 marks	100
	ZO202	Comprehensive Viva Voce					-	100	100
Grand Total			**-**	**-**	**-**	**-**	**400**	**1400**	**1800**

L – Lecture, P – Practical; T – Tutorial; CA Continuous Assessment; ESA – End SemesterAssessment;
*** Tutorial 30 hours per week**

UNIVERSITY OF KERALA
M.Sc. Zoology – Semester System
Revised syllabus (2019)

Semester I
ZO 211 Evolution and Zoogeography
Total 100 hours (70+30 hrs)

AIM: To introduce the nature and scope of various aspects of Evolutionary biology and Zoogeography practiced in biological science with special reference to AnimalScience.

COURSE OBJECTIVES: To impart knowledge on the basic aspects of evolution and zoogeography. To study the fundamentals of origin of species and role of variation in evolution. To understand the basics of the phylogeny, zoogeography and animal distribution.

Evolution(70 hrs)

Module 1. Introduction to Evolution (10hrs)
Lamarckism; Darwin concepts of variation, Contribution of A.R. Wallace in Evolutionary Biology, adaptation, struggle, fitness and natural selection, Mendelism, the evolutionary synthesis, Evolution as the development of Individual, different species and relation, similarity and pattern of evolution. Earth Changing Atmosphere, structure, movement of continents, Possible site for the origin of early molecules, Origin of basic biological molecules, abiotic synthesis of organic monomers and polymers; Concepts of Oparin and Haldane; experiment of Miller; the first cell; the evolution of prokaryotes; the origin of eukaryotic cells; the evolution of unicellular eukaryotes; anaerobic metabolism; photosynthesis and aerobic metabolism

Module 2. Cosmic evolution and the Origin of life (8 hrs)
Cosmic evolution: Origin of the Universe, matter-time-space continuum. Theory of oscillating universe. Origin of galaxies, stellar systems, planets –earth. Origin of Life- Physical basis of life, extra-terrestrial life.

Module 3. Palaeontology and evolutionary history (8 hrs)
The evolutionary time scale, Eras, Periods and Epoch, Major events in evolutionary time scale, Mass Extinction and adaptive radiation, Origin of unicellular and multicellular organisms, Major groups of plants and animals, Human Influences of Evolution, Cultural and Religion Evolution.

Module 4. Natural Selection (8 hrs)
Evolution by natural selection, Artificial and Natural selection, Selection on small continuous variation, Types of Natural selection, Stabilizing selection, Sexual Selection, Group Selection, Directional Selection, Disruptive Selection, Natural Selection, Phenotype and Genotypes. Concepts of neutral evolution

Module 5. Molecular Evolution (12hrs)
Gene evolution, Evolution of gene families, molecular drive, Amino acid sequence divergence in proteins. Nucleotide sequence divergence in DNA, Molecular clocks, Ancient DNA

Module 6. Biochemical and genomic evolution (12hrs)

The evolutionary history of proteins and concept of molecular clock. Outline of origin of prokaryotic and eukaryotic genomes, The "C-Value paradox". Evolutionary history of neural integration Evolution of the endocrine systems, Hormones and evolution.

Module 7. Origin of Higher Categories (12hrs)

Origin of Metazoa, Origin& Evolution and extinction of Trilobites, Origin and evolution of vertebrate groups- Pisces, Amphibia, Reptilia, Aves and mammals, Phylogenetic gradualism and punctuated equilibrium; Micro and Macroevolution, Stages in Primate Evolution- Prosimii, Anthropoidea and Hominids. Factors in human origin-Hominid fossils. Cytogenetic and Molecular basis of origin of man-African origin of modernman- Mitochondrial Eve, Y chromosomal Adam - early migration, hunter-gatherer societies. Evolution of human brain-communication, speech and language. Evolution of culture.

Zoogeography (30 hrs)

Module 8. Introduction (4 hrs)

Introduction to Biogeography, Origin and development of the Earth, Geological time scale and development of life. Origin of continents- Plate tectonicsand continental drift.

Module 9. Distribution (12 hrs)

Geographical distribution of animals – Oriental, Palaearctic, Nearctic, Neotropical, Ethiopian and Australian Regions. Zoogeographical realms; Biogeography of India fauna. Island Biogeography: Continental Island, British Isles, Madagascar, Oceanic Islands, Galapagos. Mr. Sclater's regions, Mr. Huxley's regions, other suggested regions, Wallace. Patterns and types of distributions, theories of distribution, affinities of organisms, Application of biogeography – Remote Sensing & Geographical Information System (GIS).

Module 11. Dispersal and Migration (8 hrs)

Centres of dispersals and pattern of dispersal, Mobility and migration, Geographical checks or barriers to dispersal / movement. Routes of dispersal, Vicariance, Adaptation and competition, Species range, territoriality.

Module 12. Speciation, Island Biogeography (6 hrs)

Meaning and scope, types of speciation. Variety of Island habitats, Problems of isolation, Hazards of island life, effects of inbreeding, dispersal, Opportunities for adaptive radiation. Case studies – Real Island, functional island, Island biodiversity models.

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32. West-Eberhard M.J. 2003. Developmental Plasticity and Evolution. OxfordUniversity Press, oxford, UK.

Web Resources

33. http://www.talkorigins.org
34. http://www.ucmp.berkely.edu
35. http://www.academicearth.org

ZO212 BIOCHEMISTRY (100 hrs)

AIM: To introduce the nature and scope of various aspects of Biochemistry and Synthetic Biology.

COURSE OBJECTIVES: To impart knowledge on various biochemical molecules and path ways in life processes. Also demonstrate knowledge and understanding of the molecular machinery of living cells, the principles that govern the structures of macromolecules and their participation in molecular recognition and understanding of the principles and basic mechanismsof metabolic control and molecular signaling.

Module 1. Introduction (6hrs)

Atoms and molecules, intermolecular and intramolecular interactions. Bonds- covalent and electrovalent bonds, ionic bond, hydrogen bond. Water: Biological importance, pH and Acid – base balance. Buffers: Biological importance. Unique solvent properties; electrolytic dissociation into cations and anions, Henderson– Hasselbalch equation.

Module 2. Carbohydrates (12hrs)

Classification and nomenclature, Monosaccharides: Biological importance, Glucose, fructose, galactose, mannose and ribose. Isomerism – Structural isomerism and stereoisomerism, optical isomerism, Epimerism and Anomerism. Reactions of monosaccharidees: Oxidation, reduction, esterformation, Osazone formation. Glycosidic bond. Disaccharides: Sucrose, Lactose, Maltose, Isomaltose, Cellobiose and Trehalose. Polysacchacides– Homopolysaccharides – Starch, glycogen, cellulose, Chitin, Dextrans, Inulin, Pectin. Heteropolysaccharides- Hyaluronic acid, Heparin, Chondroitin sulphate, Keratansulphate, Dermatan sulphate and Agar-agar. Glycoproteins and Mucoproteins.

Module 3. Proteins (10hrs)

Amino acids: Structure, classification and properties of amino acids. pK value and iso-electric point of amino acids. Peptide and peptide synthesis. Reactions (due to carboxyl group, amino group and side chains). Colour reactions of amino acids and proteins. Proteins–structure and classification-primary structure of protein (eg. Insulin).Secondary structure- Alpha helix, Collagen helix, Beta pleated sheet, Ramachandran angles and Ramachandran map. Fibrous proteins-examples (Keratin Collagen, Elastin, Resilin, Fibrous muscle proteins). Chaperons. Tertiary structure-Globular protein- eg: Myoglobin. Quaternary structure-eg: Haemoglobin. Tissue protein in health and diseases, collagen-structure and synthesis, abnormal collagens, elastin, keratins, muscle proteins, lens proteins and cataract.

Module 4. Lipids (10 hrs)

Biological importance of lipids. Fatty acids: classification, nomenclature. Simple fats: Triacylglycerol (Triglycerides) – Physical properties. Reactions – Hydrolysis, Saponification, Rancidity. Acid number, Saponification number, Iodine number oxidation, Ketosis, Reichert-Meissl-Wollnyvalue. Compound lipids: Phospholipids- Lecithin, Phosphatidyl inositol, Cephalins, plasmologens,Glycolipids, Sphingolipids Steroids: Biologically important steroids-cholesterol, Vitamin D, Bile acids, Ergosterol, Terpenes. Prostaglandins- Structure, types, synthesis and

functions. Lipoproteins.

Module 5. Nucleic Acids (8hrs)

Structure of nucleic acids and nucleotides: Structural organization of DNA (Watson-Crick model) Characteristic features of A,B,C and Z DNA. Structural organization of tRNA and micro RNA stability of proteins and nucleic acids. Protein-nucleic acid interactions. Electrostatic interaction, hydrogen bonding stacking interactions. DNA binding proteins-DNA regulatory proteins, folding motifs, finger motifs, Zipper motifs, conformation flexibilities. Biological roles of nucleotides and nucleic acids.

Module 6. Enzymes (10hrs)

Classification- (I.U.B.system) co-enzymes, iso-enzymes, ribozyme. Enzyme specificity. Mechanism of action of enzymes. Formation of enzyme substrate complex.Various theories. Enzyme kinetics: Michaelis-Menten equation. Km value and its significance. Enzyme velocity and factors influencing enzyme velocity. Enzyme inhibition- suicide inhibition and feedback inhibition. Enzyme regulation: Types of regulation, Allosteric regulations-Key enzymes, Covalent modification.

Module 7. Carbohydrate Metabolism (8hrs)

Major metabolic pathways: Glycolysis – Fate of pyuvate. Citric acid cycle and its significance. Oxidative & substrate level phosphorylation. Pentose phosphate pathway (selfstudy). Gluconeogenesis, CoricycleGlucogen metabolism: Glycogenesis, Glycogenolysis, adenylate cascade system Ca^{+2} Calmodulin-sensitive phosphorylase kinase. Regulation of glycogen synthesis. Inborn errors associated with carbohydrate metabolism. Glycogen storage disease, Lactose intolerance, Galactosuria. Factors maintaining blood glucose, Normal plasma glucose level, OGTT oral glucose tolerance test.

Module 8. Metabolism of Proteins, Amino acids andnucleicacids (10 hrs)

Amino acid metabolism: Deamination, Transamination and Trans- deamination, decarboxylation. Formation and disposal of ammonia. Urea cycle. Fate of carbon skeltons of aminoacids: glucogenic, ketogenic, partly glucogenic and ketogenic with examples. Synthesis of biologically significant compounds from different amino acids with special reference to glycine, glutamic acid, phenylalanine, tyrosine, andtryptophan. Catabolism of purines and pyrimidines. Haeme synthesis and break down – Structure, biosynthesis, porphyrins, bilirubin metabolism, plasma bilirubin, jaundice.

Module 9. Metabolism of Lipids (6 hrs)

Beta oxidation, alpha oxidation and omega oxidation of fattyacids. Formation of ketone bodies, ketosis and ketoacidosis. De novo synthesis of fatty acids and fatty acid metabolism. Biosynthesis and regulation of cholesterol, Metabolism of cholesterol. Metabolism of Triglycerides.

Module 10. Energy Metabolism (8hrs)

Energy rich compounds and their biological significance. Biological oxidation- Mitochondrial electron transport, oxidative phosphorylation, ATP synthesis, Chemi-osmotic theory

Module 11. Detoxification (3hrs)

Formation of toxic compounds in the body. Detoxification- oxidation, reduction, hydrolysis and conjugation

Module 12. Free radicals and antioxidants (3 hrs)

Free radicals and antioxidants, Generation of free radicals. Reactive oxygen species. Damage produced by free radicals, free radical scavenger systems. Lipid peroxidation. Preventive antioxidants.

Module 13. Biochemistry of aging (3 hrs)

Cellular aging. Diseases associated with aging – e.g. Alzheimer's disease. Prions. Apoptosis

Module 14. Clinical biochemistry (3 hrs)

Introduction to clinical biochemistry. Analysis of diseases (Diabletes etc)

References:

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ZO213Biophysics, Instrumentation and Nanoscience and Nanotechnology

(100 hours)

Biophysics (25hrs)

AIM: To utilize the education imparted during the program for an effectual understanding of the impact of nanotechnology in the fields of Biology biotechnology and medical sciences and food technology and environmental science and extend the fundamental scientific understanding to related disciplines

COURSE OBJECTIVES: To get knowledge and understanding of the fundamental of biophysical aspects of biology and application of instruments in biological laboratory. To understand the fundamentals of nano bioscience and nanotechnology at the application levels.

Module 1. Thermodynamics (5hrs)

Introduction-Concept of energy and laws of Thermodynamics. Matter and energy-Life as an energy system-order, disorder, Entropy, Enthalpy. Photo bioenergetics: Photosynthesis – light and dark reactions, Redox couple and redox potential. Chemo-bioenergetics: electron transport and oxidative phosphorylation, Chemi- osmotic theory and binding change mechanism of ATP synthesis. Life as an autocatalytic system

Module 2. Electromagnetic spectrum (5hrs)

Cosmic radiation – Gamma radiation, X-rays, UV – radiation, visible spectrum, infrared rays, microwaves and radio waves. Biological applications

Module 3. Radiation Biophysics (10hrs)

Radioactivity; Detection and measurement of radiation. Radio-labeling methods, detection and measure ment of different types of radioisotopes and their applications in biology, incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material and safety guidelines. Ionizing radiation and induced mutations. Fluorescence. Nuclear medicine-Internally administered radioisotopes. Radio iodine in thyroid function analysis. Renal, liver and lung function analysis.

Module 4 Centrifugation (3hrs)
Ordinary, high speed centrifuge, Density gradient centrifugation, Ultracentrifugation

Module 5 Electrophoresis (4hrs)
Principle, Gel electrophoresis – SDS PAGE, Agarose Gel Electrophoresis. High voltage electrophoresis, Immuno electrophoresis- principle and application

Module 6 Chromatography (4 hrs)

Principle of chromatography,Columnchromatography,IonexchangechromatographyHPLC, Gaschromatography

Module 7 Biophysical methods& Instrumentation(35hrs)

7.1 Colorimetry&Spectrophotometry (6 hrs):

UV-VIS spectrophotometer, flame photometer, Atomic absorption spectrophotometer, Infrared spectrophotometer NMR and EMR spectrophotometry: Principle and Application

7.2 Mass spectrometry (3 hrs): Principles of mass spectrometer, Different types of mass spectrophotometers, Applications of Mass spectrochemistry in biological research. GC-MS

7.3 X-ray crystallography (3 hrs):X-ray crystallography in Molecular structure determination Principles of X ray diffraction. Application of X-ray crystallography in proteomics and biological research

7.4 Electrophysiological methods (6 hrs): Simple neuron recording, patch clamp recording, Brain activity recording using EEG, ECG, Tread Mill Test, Applications of Deep Brain Stimulator & Pacemaker

7.5 Radio-Ultrasound Imaging Techniques (6 hrs): PET (Positron emission tomography), MRI, FMRI, CAT scanning methods, Ultrasound Scanning methods, Eco cardiogram.

7.6 Nanobio-Analytics (2 hrs): Luminescent Quantum Dots for Biological Labeling – Nanoparticle Molecular Labels.

7.7 Surface Biology (4 hrs): Analysis of Biomolecular Structure by Atomic Force Microscopy and Molecular Pulling – Force Spectroscopy, Surface Plasmon Resonance &Antibody Microarrays Surface Plasmon Resonance Spectroscopy

7.8 **Instruments in Molecular Biology (5 hrs):**(Brief study only): PCR – Thermal cyclers, Real time PCR, DNA sequencers, High throughput screening, Gel documentation systems, Nanodrop, Sonicators, Micro array reader, Pulse field gel electrophoresis system, laminar flow systems.

Part III Nanoscience and Nanobiology (25 hrs)
Module 8 (7 hrs)
Background to nanoscience Nanobiology and nanotechnology - scientific revolutions -

nanosizedeffects. Natural nanocomposite systems; spider silk, bones, shell, Biomimetics. Definition of a nano system. Quantum dots, Nanowires and Nanotubes, Carbon based nanomaterials – CNT-Organic-Inorganic Hybrids- ZnO- Silicon - DNA- RNA- Nanoproducts

Module 10 (6hrs)
Nanobiotechnology: Application of nanotechnology in food and Agriculture industry: fisheries and livestock sectors. Nanotoxicology:toxicological effect of Nanoparticles. Nano sensors: Enzyme Biosensors and Diagnostics - DNA-Based Biosensors and Diagnostics

Module 11 (7 hrs)
Nanomedicine: Nanocarriers for gene delivery: basic concept of nanotechnology-based systems for gene delivery, Biochips- DNA based biosensors and diagnostics-Nanomaterials in bone substitutes and dentistry, Neuro-electronic Interfaces -Nanorobotics– Photodynamic Therapy - Nanosensors in Diagnosis–Drug delivery – Cancer therapy and other therapeutic applications

Module 12 (5 hrs)
Nanotechnology for environmental safety: Pollution control, gas sensing, waste water treatment. Impact of nanotechnology on the Health, safety and environmental risks/hazards; Social and ethical impacts.
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25. Nanotechnology in agriculture and food production by Jennifer Kuzma and Peter VerHage,, Woodrow Wilson International, 2006.
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27. Nanobiomaterials Handbook by BalajiSitharaman, Taylor & Francis Group, 2011.
28. Handbook of Nanotoxicology, Nanomedicine and Stem Cell Use in Toxicology. Saura C Sahu, Daniel A Casciano.
29. Nanotoxicology - Interactions of Nanomaterials with Biological Systems. Yuliang Zhao and Hari Singh Nalwa
30. Nanotechnology in the Food, Beverage and Nutraceutical Industries, Ed: Qingrong Huang, 2012, Elsevier
31. Applications of Nanoscience in Photomedicine, Eds:Michael R. Hamblin and Pinar Avci, 2015, Elsevier
32. Nanotechnology in Catalysis 3, Eds: Zhou, B., Han, S., Raja, R., Somorjai, G.A., 2007 Springer
33. Nanopharmaceutics-The Potential Application of Nanomaterials, Ed: Xing-Jie Liang, 2012, World Scientific.
34. Application of Nanotechnology in Drug Delivery: Edited by Ali DemirSezer, ISBN 978-953-51-1628-8, 552 pages, Publisher: InTech,
35. Introduction to Novel Drug Delivery Systems By N.K. Jain
36. Understanding Nanomedicine: An Introductory Textbook by Rob Burgess. 2012 CRC Press
37. Nanomedicine for Drug Delivery and Therapeutics, Editor(s): Ajay Kumar Mishra, 2013, Wiley
38. Medical Nanotechnology and Nanomedicine by Harry F. Tibbals. 2010 by CRC Press
Introduction to Nanomedicine and Nanobioengineering, by Paras N. Prasad. 2012, Wiley
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49. Margaret. E, Kosal, "Nanotechnology for Chemical and Biological defence, Springer 2009.

Semester II
ZO22: ADVANCED PHYSIOLOGY and FUNCTIONAL ANATOMY (100 hrs)

AIM: To introduce the nature and scope of various aspects of Anatomy and physiology in general and human Anatomy and physiology in particular**.**

COURSE OBJECTIVES
To impart deep knowledge on the structure and functioning of different systems in organisms from molecular level to organ systems and to the physiological attributes of whole organism.

Module 1Introduction (self study)

Introduction to Physiology and Anatomy, A brief history of Physiology and Anatomy, Cell as a living Module of the body, Fluids in the cell environment, Resistance of the cell to acidity and alkalinity.

Module 2 Support and Movement (10 hrs)

Cellular movements, Cytoskeleton, Hydrostatic skeleton
Terrestrial, aquatic and aerial locomotion Musculo skeletal system – Bones and muscles – structure and its role in locomotion with reference to humans, Theories of molecular basis of muscle contraction. Catch muscle and Fibrillar muscle, Clinical implications

Module 3 Nutrition (10 hrs)

Feeding mechanism in animals (self study), General principles of Gastro-intestinal function.Factors that regulate quantity offood. Secretory function of the alimentary canal-hormones andenzymes. Absorption mechanism of digestednutrients. Obesity-causes andconsequences. Gastro- intestinaldisorders

Module 4 Circulation (12hrs)
Body fluids in invertebrates and vertebrates, types of heart, anatomy of heart (human) and Haemopoiesis. Coronary circulation, Heart valves and Heart sounds. Circulatory Shock, Cardiac failure. Control of blood pressure and blood flow

Module 5 Respiration (10hrs)
Respiratory organs of invertebrates and vertebrates and its functions. Mechanism of Pulmonary ventilation. Respiration of unusual environment – Aviation, High altitude, Deep sea diving, Foetal respiration. Regulation of respiration. Respiratory disturbance: Oxygen therapy,

Artificialrespiration

Module 6 Excretion and Osmoregulation (10 hrs)

Types of Excretion, Structure of kidney, Basic renal process (**self study**). Osmoregulation in fresh water, marine and terrestrial animals. Regulation of sodium and water balance, Primary sodium reabsorption, Urine concentration. Diuretics and kidney diseases. Creatine clearance – Plasmacreatine. Haemodialysis, Peritonial dialysis and transplantation. Regulation of acid-base balance, blood volume and extra cellular volume. Respiratory regulation of acid base balance

Module 7 Nervous Co ordination (10 hrs)

Neurons, Types of Neurons, transmission of Nerve impulse**(self study)**, Giant nerve fibres in invertebrates, Development of neurons and neuronal functionality, Factors leading to neuronal death, Neuro transmitters, neuro modulators and mechanism of neurotransmitter release. Neuronal disorders-strokes, excitotoxicity and NMDA receptors

Module 8 Endocrinology (10hrs)

Invertebrate and Vertebrate endocrine system (selfstudy). Classification of Hormones and nature of hormonalaction. Structure and function of differenthormones. Neuro-endocrine feedback and response to variousstimuli. Measurement of Hormone concentration inblood.

Module 9 Somatic and Special senses (10 hrs)

Structure of Invertebrate and Vertebrate eye. Tactile, Position, Pain, Thermal and taste Senses. Visual pathways organization of visual cortex. Analysis of visual information, detection of colour. Auditory pathways – Functions of cerebral cortex in hearing. Neuronal mechanism of sound detection and direction.

Module 10 Reproduction (10hrs)

Male reproductive system- Anatomy Spermatogenesis and transport of sperm (**self study**). Hormonal control of male reproductive function. Female reproductive system – Anatomy, Ovarian function (**self study**). Control of ovarian function. Uterine changes in menstrual cycle, effects of estrogen and progesterone. Androgen in women. Pregnancy – Ovum transport, sperm activation, implantation and placentation. Hormonal and other changes during pregnancy – Parturition, Lactation. Birth control measures Pre-natal diagnostic tests. Adjustments of the infants to extra uterine life.

Module 11 Physiological adaptation and Stress (5hrs)

Physiological adaptation, acclimation, acclimatization. Concept of stress- definition, stressor, stress response, eustress, distress, acuteand chronic stress, stress acclimation. Concept of ease, recovery response, stress hormones, neuroendocrine control of stress response, role of hypothalamo-pituitary-adrenal axis.

Module 12 Sports Physiology (4 hrs)

Muscles in exercise, cardiac reserve, cardiovascular fitness, fascia training, neurobiological effects of physical exercise, physical fitness and its components. Dope test, drugs and athletes. Fitness test. Bio energetic fuel for muscle work

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10. Professor, C.L.Comparative Animal Physiology,Saunder College,Philadelphia.
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    17. M.C.S. Peter (2013). Understanding the adaptive response in vertebrates: The phenomenon of ease and ease response during post-stress acclimation *Gen.Comp. Endocrinol.* 181, 59-64 IF3.45

Zo222 Genetics, Quantitative Analysis and Research Methodology (100 Hrs)

AIM: To introduce the nature and scope of various aspects of Genetics, Biotechnology and signal transduction processes related with zoological science.

COURSE OBJECTIVE: To introduce students to the science of heredity, from its basic Principles to the most recent advances in the field. To impart knowledge of classical and molecular genetics.

Genetics (70hrs)

Module 1Introduction (5 hrs)

Genetics and modern agriculture, Genetics and medicine. Legal and ethical issues in genetics.

Module 2Mendelian Genetics and its Application (15 hrs)

Gene mapping, Recombination frequency, Chromosome banding, Genetics in animal breeding, General effects of inbreeding and out breeding; hybrid vigour. Expressivity, penetrance. Modern concept of Mendelism

Module 3 Population Genetics (15 hrs)

Genetic variations, Polymorphism Genepool. Gene frequency. Distribution patterns Hardy Weinberg equilibrium. Disequilibrium. Factors disrupting gene equilibrium

Module 4 Human Genetics (15 hrs)

Pedigree analysis – Karyotypeanalysis. X-Chrmosomedosage. Lyon hypothesis andmosaicism. Genetics of ABOsystem. Rh disease and itsinheritance. Sickle haemoglobin and inheritance;thalassemia. Genetic disorders – Patau, Edwards, Cri-du-chat syndromes, Philadelphia chromosome.

Module 5 Microbial Genetics (12hrs)

Retrovirus. Viral genome and multiplication – HIV genome and multiplication. Reproductive cycle of RNA viruses. Plasmids – Vector DNA – Insert DNA. Lambda Phages. Microbes in genetic engineering

Module 6 Genetics in Medicine and Forensics (8hrs)

Human Genome Project: Human gene therapy. DNA fingerprinting: Applications in forensic science. Applications in paternity testing

Quantitative Analysis (15 hrs)

Module1 Introduction (2hrs)

Definition, history, scope of biostatistics and application of statistics in biology (**self study**). Descriptive and inferential statistics. Preliminary concepts – population and sample, statistic and parameter, variables, sampling (self-study). Collection of data – primary and secondary data, methods. Use of software in statistics.

Module 2 Descriptive Statistics (2 hrs)

Processing and classification of data, presentation of data-tabulation and graphical and diagrammatic representation (**self-study**). Measures of Central Tendency, problems (**self-study**).Measures of Dispersion-problems, Skewness and Kurtosis. Correlation and Regression, problems (**self study**)

Module 3 Probability Distribution (3 hrs)

Definition, important terms and concepts. Theorems in probability. Important theoretical distributions- Binomial, Poisson, and Normal probability distributions.

Module 4 Parametric test (4 hrs)

Basic idea – Hypothesis testing, types of errors. Tests of significance for large and small samples- Z-test, Chi-Square Test, Student's 't' test, F-test – problems – and ANOVA

Module 5 Non-parametric test **(2 hrs)**

Characteristics, advantages and disadvantages. Types (Brief account only)

Module 6 Vital statistics **(2 hrs)**

Introduction, uses, methods of collections. Measures of vital Statistics, life tables

Research Methodology **(15 Hrs)**

Module1 Introduction **(2hrs)**

Definition, meaning, objectives, and significance of research, research methods vs Methodology. Types of research – Descriptive. Analytical, Applied vs. Fundamental, Quantitative vs Qualitative, Conceptual vs Empirical. Characteristics of good research, steps of working of research

Module 2 Research Formulation **(2 hrs)**

Formulation and defining a research problem, techniques involved. Literature survey-Journals, conference proceedings, books, government reports etc. Problem selection, formulation of working hypothesis

Module 3 Research design **(2 hrs)**

Meaning need and features a good research design. Different types of research design (exploratory, descriptive, diagnostic and hypothesis-testing research studies) Developing a research plan

Module 4 Execution of research plan **(2 hrs)**

Data collection methods-primary and secondary, sampling design (**self study**), measurements etc. LC 50 & Dose Response. Analysis of data (**self study**) Interpretations-advantages and techniques-and generalizations of the findings

Module 5 Scientific documentation **(3 hrs)**

Significance of report writing, types of reports. Research report writing (thesis, dissertations, research articles, etc) characteristics and format. Writing and preparation of articles for publication and for oral and poster presentation. Project proposal and report writing.

Module 6 Research, extension and ethics **(4 hrs)**

Publications-abstracting and indexing journals, books, conference/seminar proceedings,periodicals,referencesources,reviews,monographs.Extensiontools, impact factor, citation. Online libraries, e-journals, e-books, e-encyclopedia, institutional websites, TED Talk. Intellectual property Rights-copy right, patents, trademarks, geographical indications, industrial design. Research misconduct: fabrication, falsification and plagiarism. Precaution – ESO standards for safety, lab protocols, lab animal uses, IACUC, control of hazards. Ethical norms,

codes and policies for research ethic, laws in India

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3. Eldon. J., Gardner Principles ofGenetics.
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5. John D Hawkins, Gene Structure and Expression. Cambridge University Press– Edinberg Buildings – Cambridge CBZ/ZRUUK
6. PKU Nair and K. PrabhakarAchar, A Text Book of Geneticsand Evolution: Konarkpublishers.
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8. R. World and S.B. Primrose, Principles of Gene Manipulation: Black WellScientific Publishers, Melbourne, Paris.
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2. Biometrical Genetics – Dover Publication, NewYork
3. Ostle B, Statistics inResearch.
4. Agarwal, B.L. (1996) Basis Statistics. New Age International (P) Ltd.Publishers, NewDelhi.
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13. Finney, D.J. 1980. Statistics for Biologists. Chamman and Hall,London
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15. Oliver, P.2005. Writing Your thesis. Vistar Publications. NewDelhi.

Zo223 Cell Biology, Molecular Biology and Bioinformatics (100 hrs)

AIM: To introduce the nature and scope of various aspects of Cell structure and molecular biological aspects in cell biology**.**

COURSE OBJECTIVES: The students will be introduced on the various aspects of Cell structure, function, cell replication, cell communication, protein synthesis, cell dynamics etc.

Module 1 Membrane structure, models and membrane transport (10 hrs)
Diffusion of small molecules across phospholipids bilayer. Uniporter – catalysed transport. Membrane potential. Active transport by ATP poweredpumps. Co-transport by symporters and antiporters

Module 2 Cell-cell signaling (5hrs)
Cell surface receptors. Signal transduction pathways (cyclic AMP, cyclic GMP, Ras, Raf and kinase pathways). Second messenger system, MAP

Module 3 Cell cycle (6 hrs)
Cyclin and cyclin – dependent kinases, Regulation of CDK – cyclin activity, Check points in the cell cycle, Regulation of cell cycle in malignant cells

Module 4 Chromatin structure (6 hrs)
Types of Chromatin, Detailed structure of nucleosome; higher order structure of chromatin and the role of histones HI, scaffold proteins, and radial loop model

Module 5 Topology of Nucleic Acids (5 hrs)
Liking number and writhing number, DNA Super coiling, Super coiling in prokaryotes, Super coiling in eukaryotes, Role of topoisomerases

Module 6 Organization of the eukaryotic genome (12 hrs)

Genomic size and genetic content. Complexity of eukaryotic genome: Intragenic sequences - exons, introns; split gene organization; regulatory sequences ; Intergenic sequences; Unique sequences; Repetitive sequences: Highly repeated sequences–satellite, minisatellite and microsatellite DNAs Moderately repeated sequences (e.g. SINEs and LINEs).DNA denaturation-

renaturation kinetics and genome complexity; in situ hybridization. Organelle genomes-mitochondrial and plastidDNAs

Module 7 DNA Replication, repair and recombination (14 hrs)

Prokaryotic and Eukaryotic DNA replication. DNA replication machinery. Enzymes and accessory proteins involved in replication. DNA damage and repair. Direct reversal: photo reactivation, adaptive response. Excision repair. Mismatch repair. SOS repair and mutagenesis. ERecombination repair; Rec A and other recombinases. Damage signaling and checkpoints. DNA repair-associated disorders

Module 8 Transcription and RNA processing (8 hrs)

Prokaryotic and eukaryotic transcription. Binding the transcription complex-promoters, factors and RNA polymerases. Regulation of transcription. Sigma factor and its role in prokaryotic transcription.Post-transcriptional processing of RNA precursors, spliceosomes.

Module 9 Translation-gene expression (15 hrs)

Prokaryotic and Eukaryotic translation. The translation machinery. Mechanism of initiation, elongation and termination. Co-and post translational modifications of proteins. Hormonal regulation of protein synthesis.

Module 10 Gene Regulation Mechanisms (7 hrs)

Gene regulation in eukaryotes at various levels. Transcription factors and DNA-binding domains (Zinc-finger motif and Helix- loop-helix motif). Transcription signals – TATA Box, CAAT BOX., Enhancers.

Module 11 Bioinformatics (12hrs)

Introduction to bioinformatics, brief history and its role and importance in modern biology, internet, internet, portals, servers and search engines. Biological databases, their purpose, primary, secondary, curated and curated databases types of databases (DNA, protein, RNA, functional and structural databases),Uploading and downloading of data, FASTA format, data retrieval from databases, analyses tools and softwares and their applications, pairwise and multiple sequence analyses. Construction of rooted and un-rooted phylogenetic trees, their interpretation and use in analyzing evolutionary trends, steps in phylogenetic analyses. Brief overview of computational biology, computation, prediction and modulation of biological pathways, (ex. Kegg pathways, E-cell, human Cyc)computational analyses of genomes and proteomes

References

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2. Gerald Karp (2005) Cell and Molecular Biology, John Wiley and Sons, Inc.USA
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7. John Ringo (2004) Fundamental Genetics. Cambridge University Press,UK.
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24. Wilson K and Walker J (2006) Principles and Techniques of Biochemistry andMolecular Biology, Cambridge University Press,N.Y
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ZO214 Practical 1

A. Biochemistry

1. Titration curve of acetic acid. Titration of a measured volume of acetic acid with sodium hydroxide (NaOH) to determine the amount of acid in the given solution and pKa of acetic acid.
2. Determination of the isoelectric pH of the given amino acid by titration method.
3. Estimation of DNA/RNA
4. Quantitative estimation of glycogen of a tissue.
5. Quantitative estimation of blood glucose.
6. Quantitative estimation of serum protein.

7. Determination of acid value of the given fat.
8. Determination of saponification value of the given fat.
9. Estimation of serum cholesterol using a standard protocol
10. Determination of the Michaelis constant (Km value) for the digestion of casein by trypsin.
11. Estimation of serum cholesterol using a standard protocol.
12. Estimation of acetylcholine content in tissue sample.

B. Biophysics and Instrumentation

1. Micrometry: Measurement of microscopic objects using micrometer.
2. Separation of haemolymph of serum protein by gelelectrophoresis.
3. Sketching of biological specimens using a camera Lucida.
4. Quantification estimation of Na, K, Ca of the given sample with the help of flame photometer/ spectrophotometer preparing standard curve.
5. Preparation of tables and bar diagrams using suitable software, from the data provided.
6. Statistical Analysis (Chi-square, t-test, correlation, regression, standard deviation and standard error, One way ANOVA) of the given data using suitable software. E.g. MS Excel and Vassar Stats.

C. Evolution

1. Comparative study of prokaryotic and eukaryotic cells by staining and mounting (evolutionary significance).

References

1. Hardd Varley- Practical clinical Biochemistry
2. Ranjana Chawla – Practical Clinical Biochemistry – Methods and interpretations.
3. Hawk's Practical Physiological Chemistry
4. Jayaraman, Practical Biochemistry.
5. http://vassarstats.net/

Practical 11

ZO 224 Advanced Physiology and Functional Anatomy

Please use software such as **Physio Ex.9.0** where ever applicable

1. Effect of salivary amylase on starch(colorimetric)
   a) Influence of temperature and calculation ofQ10
   b) Influence of pH
2. Transport of glucose through intestinal wall (everted gut sac) of a suitable animal
3. Recording of heart beat and the effect of drugs (acetylcholine and adrenaline) in fowl.
4. Effect pH different concentrations of NaCl (0.1% to 2%) on the diameter of RBCs using micrometry.
5. Estimation of RBCs and WBCs in vertebrate blood
6. Blood histology of earthworm/cockroach/fish and chick.
7. Studies on feeding-Mounting of mouth parts of housefly, honey bee and mosquito in relation to food and feeding.

8. Observation of mitochondria in yeast cells.
9. Observation on ciliary movement in bivalve gills in relation to temperature and pH. Genetics and Quantitative analysis
10. Chromosome study – Squash preparation of Drosophila/Chironomous larvae
11. Calculation of Mean, Standard deviation, Standard Error, and Student's-test.
12. Calculation of correlation coefficient & Test of significance.
13. Preparation of histogram, frequency polygon and pie diagram using appropriate software. Cell and molecular biology
14. Study of meiosis- Squash preparation of grasshopper testis.
15. Histological localization of protein and glycogen in paraffin sections.
16. Estimation of DNA from tissue extract.

Semester III

Paper1-Zo231 Microbiology and Biotechnology (100Hours)

AIM: To introduce the nature and scope of various aspects of Developmental Biology and stem cell biology in general and human development and applications of stem cell biology in particular.

COURSE OBJECTIVE: The students will be introduced on the various aspects of developmental biology such as animal development, cellular differentiation, stem cell biology etc.

PART A. Microbiology (50hours)

Module1 Introduction to Microbiology (7 hrs)

Scope and history of microbiology – mention the contributions of important Scientists who developed Microbiology as a major disciple(e.g. Pasteur, Koch etc).Microbial diversity including Extremophiles – brief account. Characteristic features of microorganisms –Bacteria, Virus, Fungi & Protozoa. Mention Microalgae. Classification of Bacteria, Virus, Fungi & Protozoa. Classification of bacteria, Bergey's Manual, **(self-study**).

Module2 Bacterial Cell structure and function (8hrs)

Ultra structure of bacteria – cell membrane, cytoplasmic inclusions, nucleotide etc
Bacterial Cell Wall- structure; differences between gram positive and negative cells, gram staining. External components & their functions – pili, flagella, fimbriae, capsules, slime layers etc.

Module3 Microbial Nutrition and Growth (10 hrs)

Common nutritional requirements of microorganisms- autotrophy and heterotrophy. Types of culture media. Microbial growth – overview of cell growth, generation time, measurement of growth. Typical growth curve, continuous culture, effect of environmental factors on growth. Stress response.

Module4 Industrial & Environmental Microbiology (10hrs)

Industrial Microbiology

Concept of fermentation. Types of fermentation – submerged, solid state – mention briefly. Basis design and types of fermenters. Products of Industrial Microbiology such as Alcohol, Antibiotics (e.g. Penicillin), Organic acids (e.g. Acetic acid, Lactic acid).Microbiology of mild& foods. Preservation of milk–Pasteurization techniques. Probiotics. Microbial spoilage of different types of foods& Food borne diseases (**self-study**)Beneficial activities of microbes in food (**self-study**)Microbial quality control and safety of food (**self-study**)

Environmental Microbiology

Introduction to terrestrial and aquatic microbiology. Principles of Microbial Ecology. Biogeochemical cycles – nitrogen cycle, sulphur cycle& carbon cycle. Role of microorganisms in the biogeochemical cycles. Microbiology of waste treatment. Brief account of microbial treatment of waste water and solid wastes. Bioremediation – microbial treatment of radioactive wastes and xenobiotics. Microbes in decomposition and recycling process (**self-study**)Symbiotic and asymbiotic N2 –fixation (**self-study**)

Module5 Medical Microbiology (15 hrs)

Host-microbe interaction-process of infection, pathogenecity, virulence & infection, microbial adherence, penetration of epithelial cell layers and events in infection following penetration, Infection of blood, lymphatic system. Exotoxins – classification, mechanism of action of exotoxinse.g. Diphtheria, Botulinum, Tetanus, and Choleratoxins. Control of Microorganisms – various physical & chemical methods. Use of antibiotics and other antimicrobial drugs. Drug resistance and emergence of multiple drug resistance – recent cases of TB (XDR, TDR); NDMetc.A survey of harmful and beneficial microbes (**self-study**)

Topics for Self Study (not for evaluative purposes)

- Classification of Bacteria, Bergy's manual
- Microbes in decomposition and recycling process
- Symbiotic and asymbiotic N2-fixation
- Microorganisms and food
- Microbial spoilage of different types of foods & Food borne diseases
- Beneficial activities of microbes in food
- Microbial quality control and safety of food

PART B. Biotechnology (50hrs)

Module6 Introduction to Biotechnology (10hrs)

History of Biotechnology (self study). Board areas of BT – traditional and modern; types – plant biotechnology, animal biotechnology and microbial biotechnology. Techniques in Biotechnology – brief description of common techniques such as tissue culture, genetic engineering, cloning etc.

Module7 Molecular Cloning (15hrs)

Gene cloning – basic steps in gene cloning. Isolation of donor DNA. Vectors – types and characteristics e.g. plasmids, phages, hybrid vectors, artificial chromosomes. Enzymes used in gene cloning – exonuclease, endonuclease, ligase, reverse transcriptase, polymerase, terminal transferase etc. Techniques of gene transfer – calcium chloride transformation, microinjection, electroporation, shotgun cloning, Agrobacterium mediated transfer etc. Practical application of genetic engineering – useful products. Application in Medicine, Agriculture, Agriculture and Animal Husbandry, Environment etc. Biotechnology Industry.

Module 8 Recent Trends in Biotechnology (15 hrs)

Synthetic Biology – description and developments in the area. Artificial life – concept and achievement. DNA Barcoding – concept and experimental details with examples. GMOs and GM Foods – pros and cons. Microbial warfare – bio-weapons and bioterrorism

Module 9 Bioethics (5hrs)

Ethical, legal and social issues of Biotechnology.

Module 10 Biotechnology in India (5 hrs)

History of biotechnology research in India. India's Biotechnology Policy. Biotechnology Regulatory Agencies in India. Comparison with developed countries

References

Microbiology

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5. Introductory Food Microbiology. H. A. Modi 2007. ISBN8179102213.
6. Food Microbiology An Introduction by Thomas J Montville, Karl R.Mathews
7. Microbiology by Edward Alcamo Wiley publishing inc ISBN0-8220-5333-0
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1. Bejamin Lewin – Genes X(2011).
2. James D Watson - Molecular Biology of the Gene (6thEdition)
3. George W Burns, the Science of Genetics, Mae Millan C0 NewYork.

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Semester III
ZO232 Ecology and Ethology

AIM: To introduce and investigate nature and scope of various aspects of Ecology and Ethology with methods used in natural science.

COURSE OBJECTIVES
Imparting basic knowledge on ecology, ethology and its allied problems. Developing an attitude of concern for the ecological components and animal behaviour.

Part1:Ecology (50hrs)
Topics for self study
Biotic and abiotic factors and their interactions. Structure, basic components, their interactions and inter-relations. Fundamental concepts relating to energy – first and second laws of thermodynamics, entropy. Gaseous and sedimentary cycles. Characteristics of population: density, natality, mortality, biotic potential, environmental resistance, growth forms, immigration, emigration and migration. Characteristic: Species diversity, stratification, dominance, boundaries, ecotone and edge effect, ecological indicators.

Module1 Ecological Energetics (12hrs)
Solar energy and photosynthetic production, efficiency of energy capturing, chemosynthesis, Energy flow – features of energy flow (unidirectional flow and loss of energy as heat) and pathways of energyflow. Productivity – primary production and production efficiency, secondary production, standing crop, Food chain (grazing, detritus and auxiliary food chains), food, webs, trophic levels and ecological pyramids (pyramid of numbers, pyramid of biomass and pyramid of energy (self-study)Classification of ecosystems based on energy input (natural unsubsidized, and subsidized solar powered ecosystems, human subsidized solar powered ecosystem and fuel powered urban and industrial systems).

Module2 Transition and Stability in Communities (8hrs)
Succession- Basic types (Primary succession, Secondary succession, Auogenic succession, allogeneic succession, Autotrophic succession, Heterotrophic succession).Trends in succession Stages of succession – (Nudation, Invasion, Competition and co-action, Reaction, Climax), pulse stability. Examples of succession – (Succession in aquatic and terrestrial ecosystems). Relevance of ecosystem development theory to human ecology, prospects for detritus agriculture, the

compartment model.

Module3 Concepts of Habitant, Niche and Guild (8hrs)

Habitat, microhabitat and niche. different types of niches: spatial niche, trophic niche, species niche, multidimensional niche, fundamental and realized niche. Niche overlap, gause's principle, resource partitioning, compression hypothesis, concept of Guild, character displacement, ecological equivalents.

Module 4 Population Ecology (8 hrs)

Characteristics of a population; population growth curves; population dynamics, life history pattern, fertility rate and age structure. Population regulation; life history strategies (r and K selection); concept of meta population-demes and dispersal, extinctions, age structured populations. Competition and coexistence and other ecological interactions.

Module 5 Species Interactions (8hrs)

Intra and inter specific interactions, Types of Interspecific interactions– (Positive Negative and Neutral), Positive interactions (commensalism, proto-cooperation, mutualism and pollination), Negative interactions (competition, parasitism, commensalism, predation, herbivory, carnivory), Co-evolution

Module 6 Natural calamities (6 hrs)

Natural hazards, flood, volcanoes, coastal hazards, earth quakes, cyclones, landslides, El Nino, La Nina, Avalanche, Tsunami, and Tornado. Epidemics, pandemics and their management. Remote Sensing as a tool for the study and the management of environment and calamities.

Part 2: Ethology (50hrs)

Topics for self-study

History, development and applications; motivation and models of motivation, reflexes imprinting, habituation; neural mechanisms in behavior, hormones and behavior.

Module 5. Introduction. (6 hrs)

Historical background, Stimulus-Response, Causal factors, Quantitative aspects – Duration, interval frequency. Behaviour bouts. Darwinian Perspective on Animal behaviour, Scope of ethology.

Module 6 Learning (6hrs)

Classification of learning: Imprinting, habituation, imitation (self-study), classical conditioning, instrumental/operant conditioning, cognitive learning, latent learning, insightful learning.

Module 7 Communication (8 hrs)

Evolution of communication, Sensory mechanisms: Electrical, Chemical, Olfactory, Auditory and Visual. Dance language of honey bees, Pheromonal communication (Ants and mammals).

Module 8 Nervous System and Behaviour (8 hrs)

Stimulus filtering, sign stimulus, innate release mechanism and fixed action plans (FAPs).Brain centres and learning, neural mechanism of learning and memory.

Module 9 Complex Behaviour patterns (6hrs)

Orientation, Navigation and homing, Migration (Fishes and birds), Biological rhythms – biological clock, circadian, circannual, lunar, tidal and seasonal periodicities, sleep and arousal, genetics of biological rhythms.

Module10 Environment, genetics and Evolution of behaviour (6hrs)

Habitat selection and territoriality. The Evolution of communication; Development of birdsong.The evolution of reproductive behavior and mating systems.

Module 11 Social Behaviour (6 hrs)

Sociobiology (Brief account only) Aggregations – schooling in fishes, herding in mammals, Group selection, Kin selection, altruism, reciprocal altruism, inclusive fitness, co-operation, territoriality, alarm call, social organization in insects and primates.

Module12 Stress and Behaviour. **(4 hrs)**

Adaptations to stress- basic concept of environmental stress, acclimation, acclimatization, avoidance and tolerance.

References

Ecology

1. Beck, W.S., Liem, K.F. & Simpson, G.G. (1991). *Life: An Introduction toBiology*(3rd Ed.). Harper Collins Publishers, New York, pp 1361. ISBN: 0 06 500009 9.
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Cole, India, pp 598. ISBN: 81 7648 552 7.
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18. Manuel C. &Molles Jr. (2009) *Ecology: Concepts andApplications* (5 th Ed). McGraw-Hill International Education. pp 604. ISBN-13:9780070171688

Ethology

1. Alcock, J. (2001): *Animal Behaviour- An Evolutionary Approach*(7th Ed.) Sinaur Associates, Inc. ISBN-10:0878930116
2. Bear, F.M., Connors, B.W. & Paradiso, M.A. (2001). *Neuroscience, exploring thebrain* (2nd Ed). Lippincott Williams & Wilkins, Baltimore, pp 855. ISBN: 0 683 30596 4
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15. Slater, P. & Halliday, T. (Eds.). (1994): *Behaviour andEvolution*(1st Ed.) Cambridge University. Press. Pp348.

ZO233 Immunology and Developmental Biology (100 Hrs)

Immunology(40hrs)

AIM: To introduce the nature and scope of various aspects of Immunology and Developmental biology.

COURSE OBJECTIVES: Integration and consolidation of knowledge in immunology such as nature of resistance, mode of development and growth, various aspects of development.

Module1 Introduction to Immune System (4 hrs)
Types of immunity, innate and acquired immunity; passive and active immunity; humoral and cell-mediated immunity. Organs of immune system: Primary and Secondary lymphoid organs. Brief account on immune cells: types and production.

Module2 Immunogens (Antigens) (7 hrs)
General properties, Structure and function, variability and diversity. Factors affecting antigenicity. Epitopes and Haptens. Adjuvants and their role in enhancing immunogenicity.

Module3 Immunoglobulins (antibodies) (8 hrs)
General Properties-Structure and functions Different classes of immune globulins (1gA, 1gD,1gE,1gG and1gM) Genetic basis of antibody diversity: Immunoglobulin gene organization; Gene rearrangement and expression. Somatic recombination: V (D) J recombination and functional diversity. Somatic hypermutation. Classswitching. Polyclonal and Monoclonal antibodies. Hybridoma technology –technique and applications

Module 4 Antigen-antibody interactions (6 hrs)
Primary and secondary immune responses. Theories of antibody formation (Directive theory, clonal selection theory etc.)

Module 5 Complement System (4hrs)
Complement systems-General features. Classical pathway and alternate pathway complement receptors, biological effect of complements.

Module 6 Transplantation (7hrs)

Classification of grafts. Major Histocompatibility Complex (MHC) and MHC proteins role in tissue transplantation; Mechanism of graft retention and rejection. General immune suppressive therapy.

Module7 Defects in Immune Mechanisms (4 hrs)

Defective innate immune mechanisms. Auto immune diseases

Developmental Biology (60 Hrs)

Module1 Introduction (4hrs)

Definition, history, Scope of embryology and Practical applications **(self-study**)

The evolution of developmental patterns in unicellular protest; origin of sexual reproduction. Developmental patterns among animals-brief survey(asexual means; parthenogenesis; sexual means; gonochorism, hermaphroditism, metamorphosis, uterine development in mammals)

Module 2 Fertilization (8 hrs)

Events in fertilization. Cytoplasmic change. Nuclear changes. Prevention of polyspermy. Significance of fertilization

Module 3 Developmental Model Systems (16 hrs)

Early development of Drosophila-Egg, gastrulation cleavage, mid-blastula transition, Early development of *Caenorhabditis elegans*-Egg, cleavage and gastrulation. Genetic control of development and embryonic axis formation. Gene action in development of Drosophila:- Maternal effect genes; Segmental genes (gap genes, pair-rule gene and segment polarity gene) and Homeotic genes (homeobox and homeodomains). Hox cluster genes in vertebrates

Module4 Embryonic Induction (10hrs)

Types of embryonic induction – Primary, Secondary and Tertiary Induction (Experiments of Spemann and Mangold). Mechanism of axis formation in amphibians; Niewkoop centre. The functions of organizer; the diffusible proteins of the organizer1; the BMP inhibitors.

Module5 Medically assisted human reproductive technologies (12 hrs)

Conventional in vitro fertilization and embryo transfer (IVF-ET) – general protocol (Patientselection, manipulation of menstrualcycle, superovulation, oocyteretrieval, preparation of semen sample, IVF treatment, embryo transfer. Gametic Intra fallopian Transfer(GIFT). Zygotic Intra fallopian Transfer(ZIFT). Tubal Embryo stage Transfer (TET). Intra-cytoplasmic sperm injection(ICSI). Intra Uterine Insemination(IUI)

Module6 Cloning experiments in animals (10 hrs)

Genomic equivalence; differential gene expression. Stem cells, totipotency, pluripotency multiple potencies, unipotency. Amphibian cloning, cloning mammals, human cloning-prospects and demerits.

References

Developmental Biology

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2. V.R. Walvekar, M.J.Jassawalla, P.H.Anjaria and R.J. Wani, Reproductive Endocrinology- A Clinicalapproach.
3. K. Vasudeva Rao, Developmental Biology – a modernsynthesis.
4. R.M. Twyman, DevelopmentalBiology
5. Lewis Wolpert, et al., (2000) Principles of Development,OxfordUniversity Press.
6. Balinsky, B.I, An Introduction to Embryology
7. D.J.Bejley, J.A. Firth, J.R.F.Houtt, Human Reproduction and DevelopmentalBiology

Immunology

1. Roitt, L, Brostoff, J and Male, D.,Immunology
2. Ashim K Chakravarthy,Immunology
3. M.K. Majumdar, Microbiology andimmunology
4. Kudy (2000) Immunology. W.H. Freeman andCompany.
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PRACTICALS

ZO234 Microbiology, Biotechnology, Ecology, Immunology and Developmental Biology

Microbiology and Biotechnology

1. Techniques for Isolation of bacteria-serial dilution, pour plate, spread plate techniques.
2. Enumeration of bacteria from water and soil
3. Motility Testing – hanging drop method.
4. Gram staining of bacteria
5. Determination of quality of milk-methylene blue reductase test.
6. Biochemical tests – catalase test, kovac's oxidase test, gas production etc.
7. Isolation of DNA from plant/animal tissue.
8. Plasmid isolation
9. Detection of coliform bacteria by H2S paper strip method for monitoring water quality.
10. Culturing of paramecium to observe ciliary movement.

Immunology

1. Antigen-antibody interaction in vitro and identification of blood groups.

2. Blood film preparation and identification of cells.
3. Detection of pregnancy using kits.
4. Immunodiffusion and Immuno-electrophoresis
5. Demonstration of phagocytes in insect hemocytes.

Developmental Biology

1. Induced ovulation and artificial fertilization
2. Preparation of temporary whole mounts of chick blastoderm
3. Vital staining of chick blastoderm and tracing the development of stained parts (window method)
4. Effect of drugs on heartbeat of chick embroyo.
5. Study of different types of eggs: insect egg, frog's egg, hen's egg, mammalian egg-models/charts
6. Morphological and histological studies of different placental types of mammals (3 numbers)
7. Identification of cross sections of chick embryo through heart, eye and ear.

Ecology

1. Estimation of pyramid of numbers and biomass in a small ecosystem.
2. Estimation of Primary productivity using dark and light bottles.
3. Description of ecological adaptations of any 10organisms.
4. Habituation in pila/ Alarm response in fishes / Maize learning in rats.
5. Quantitative estimation of planktons.
6. Poster Presentation on a relevant topic (e.g. International conventions and treaties, species interactions, biodiversity loss etc.).
7. Mounting cercaria of flukes in aquatic birds.

Semester IV

ZO241 Bio Systematics &Animal Diversity (100 hrs)

Bio Systematics (60hrs)

Module 1: (12hrs)

Basic concept of Biosystematics and animal taxonomy, Scope and significance of biosystematics, Procedures and methods in Biosystematics. Classical taxonomy to systematics: A historical review; Relationship between experimental, phylogenetical and classical taxonomy taxonomic terms; taxonomy; classification and nomenclature; phenon, taxon and category; α, β and γ taxonomy, experimental category- Turreson categories. Modern concepts and recent trends: chemotaxonomy, cytotaxonomy, serotaxonomy and molecular taxonomy, Importance of application of Systematics in biology, Taxonomy vis-a-vis biodiversity conservation.

Module 2 (12 hrs)

Microtaxonomy: species concepts; typological species concept, nominalistic species concept, biological species concept and evolutionary species concept. Polytypic and monotypic species; species category; subspecies, other infra-specific categories and intra-population variants. Origin of reproductive isolation and mechanism of speciation.

Module 3: **(10 hrs)**

Macrotaxonomy: Theories and practice of biological classification: basic principles of classification: The three schools of macrotaxonomy: Phenetics, cladistics and phylogenetics and their comparison. Variations and their importance in Systematics.

Module 4: **(14hrs)**

Taxonomic characters: Kinds and functions of taxonomic characters; plasmorphic and apomorphic characters. Taxonomic procedures – collection, preservation and process of identification of species.

Taxonomic keys – different kinds of taxonomic keys, their merits and demerits, preparation of taxonomic keys, Systematic publication – different kinds of publication. Process of typification of different zoological types. International Code of Zoological Nomenclature (ICZN), its operative principles; history of rules of Zoological nomenclature. Formation of scientific names of different taxa. Regulations governing this code and code of ethics.

Module 5 **(6hrs)**

Interpretation and application of important rules. Criteria of publication, criteria of availability of names, principles of priority, homonymy, synonymy, type concept. Taxonomy, the present scenario and the global taxonomic initiatives.

Module 6: **(6hrs)**

Molecular techniques as taxonomic tools: DNA Profile making, DNA Finger Printing; Multiple Arbitrary Amplicon Profiling (MAAP), RAPD. Popular Molecular-evolutionary software &tools:- Molecular evolutionary Genetic analysis (MEGA), Phylip, Clustal W, BLAST.

I. Animal Diversity (40hrs)

Animal Diversity: Invertebrates **(20hrs)**

Origin of metazo; Brief accounts of mode of infection and pathogenicity of the following Pathogenic protozoans: Trypanosoma, Leishmania and Plasmodium; Modern concept of Flageller and Ciliary movement in protozoa; Parastic adaptation in helminthes. Polymorphism in cnidarians; Larval forms and their significance, Cnidarians; Polymorphism in Cnidarians, Coral reefs and its formation, Affinities of Ctenophora; Aquiferous and skeleton system in Porifera; Adaptive radiation in polychaetes, Characters and Affinities of Phoronida and Rotifera; Larval forms in Crustacea, Arachnida. Organization and taxonomic importance of Onychophora; Larval forms in molluscans, Torsion and distortion in gastropods; Echinodermata: Water vascular system, Larval forms and affinities.

General topics: Ancestral molluscs and arthropods, and derivation of modern classes; Invertebrate larval forms and their evolutionary significance.

Animal Diversity: Vertebrates **(20hrs)**

Urochordata Cephalochordata and Hemichordata- affinities. Characters and affinities of Cyclostomata. Fish diversity- major classes, Origin and evolution of Amphibia, Parental care in Amphibia; Origin and evolution of Reptilia; Adaptive radiation in Reptilia. Characters and

affinities of Chelonia and Rhynchocephalia; Origin and ancestry of birds, Characters and affinities of Ratitae. Primitive mammals: Characters and affinities of Prototheria, Metatheriaand Eutheria. Adaptive radiation in mammals.

General topic: Geological time scale and fossils. Dentition in mammals, Aquatic and flying adaptations in mammals.

Books Recommended

1. Boolootian, R. A. and Stiles, K. A., College Zoology, 10th edition, Macmillan Publishing Co., Inc.
2. New York, 1981.
3. Colbert, E. H., Morales, M. and Minkoff, E. C. Colbert's Evolution of the Vertebrates: A history of
4. the backboned animals through time, 5th edition, John Wiley - Liss, Inc., New York, 2002.
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12. Sinha, A. K., Adhikari, S. and Ganguli, B. B.: Biology of Animals, Vol. II, New Central Book
13. Agency, Calcutta, 1988.
14. Young, J. Z. The life of vertebrates, 3rd edition, ELBS with Oxford University Press, 1981
15. Vishwanath, Vertebrate Zoology
16. Alfred J.R.B and Ramakrishna.2004. Collection, Preservation and Identification of Animals. Zoological Survey of India Publications.
17. Benton,M.J.2005 93rdedn.). Vertebrate Paleontology, Blackwell Publishing Com. Oxford, Uk
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22. Margulis, Lynn and M.J. Capman (4thedn.). Kingdoms and Domains: An IllustratedGuide to the Phyla of Life on Earth. W.H. Freeman & Company, USA
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24. Mayr, E.1997. this is Biology: The Science of Living world. Universities PressLtd.
25. Narendran, T.C. 2008. An introduction to Taxonomy. Zoological survey ofIndia.
26. Pat Willmer. 1996. Invertebrate Relationships-patterns in animal evolution.Cambridge UniversityPress

27. Rupert E.Edward., R.S.Fox and R.D.Barnes. 2006. InvertebrateZoology:
28. A Functional Evolutionary Approach. Thomson/Cole, SingaporeSimpon:
29. Waterman, A.J.1971. Chordate Structure and Function. Macmillan Co.London
30. Winston, J.E.2000. Describing species: Practical taxonomic procedure for biologists. Columbia University Press,Columbia
31. Young, J.Z.1950. Life of Vertebrates. Clarendon Press, Oxford,UK

ZO242 - Biodiversity Management (100 hrs)

Module 1: (12 hrs)

Introduction to Biodiversity Definition, History and present status. Biodiversity documentation and species identification. Relevance of Systematics and molecular taxonomy to biodiversity and conservation. Genetic diversity, Species diversity and ecosystem diversity. Distribution of biodiversity, Mega diverse countries, Global hotspots and criteria. Agro-biodiversity and food security.

Module 2 (20 hrs)

Quantifying Biodiversity: Assessing, Inventory, Monitoring, Faunal assessment and sampling techniques. Distribution and gradients of biodiversity, species area relation, Depth gradients, marine realms and freshwater regions. Latitudinal and Altitudinal gradients of biodiversity, Zonation in seas and mountains. Endemism and Biodiversity. Ecological relations, keystone species, flagship species and endangered animals, Red data list, Global biodiversity information system.

Module 3 (14hrs)

Threats to biodiversity: Extinction- past mass extinction, current human caused extinction, extinction rates in islands, local extinctions, vulnerability to extinction, endemic species and extinction, habitat destruction, fragmentation, Overexploitation, Invasive species and diseases, human population growth and its impact. Overview and causes of recent extinctions. Genetic erosion and degradation of aquatic ecosystems and pollution. Species extinction, metapopulation, Genetic consequences of fragmented population and minimum viable population. Effects of global warming to biodiversity.

Values and uses of Biodiversity: Natural capital, Direct and indirect values- economic, ecological, evolutionary, aesthetic, emotional and ethical, Economic evaluation of biodiversity, Ecosystem services and its importance. Intellectual Property Rights (IPR) and Sovereignty rights.

Module 4 (12 hrs)

Conservation of Biodiversity: Ex-situ and in-situ methods of conservation strategies, Captive breeding, zoo and captive breeding, Botanical gardens and gene banks. Evaluation of priorities for species and habitats**:** Choosing species to protect, Hotspots for conservation, Major tropical wilderness areas and Eco regions, UNESCO Man and Biosphere Programme, World heritage sites. Application of genetics in Conservation of biodiversity. Indigenous and Traditional Ecological knowledge (TEK), Biodiversity and sustainable development.

Module 5 **(10 hrs)**

Conservation Organizations and laws: International and national conventions for the conservation of biodiversity: CBD, Ramsar Convention, CITES, UNFCC; IUCN, WWF, Conservation International (CI), TRAFIC, UNEP, WCMC etc. Biological Diversity Act 2002 and Rules 2004, National Action Plan and Strategy for biodiversity conservation, National Biodiversity Authority, State Biodiversity Boards, State Action Plan, Biodiversity Management Committees (BMCs); People's participation in the conservation of biodiversity, Peoples biodiversity register (PBR).

Module 6 **(17hrs)**

Wildlife Management: Principles and practices of wildlife management. Management of special habitats; riparian zones. Grasslands etc. Analysis and need for wildlife management, problems in plantations and exploited forests; Indian and Kerala scenario, Species conservation projects - tiger, lion, rhino, and elephant. Role of Biology in management. Management plan for Protected Areas: Forest working plans and wildlife management plans. Landscape approach and use of modern technology - GIS/GPS/Imagery, camera trapping/Drones etc) in wild life management. Human wildlife conflicts. Principles of planning, objectives, resource surveys, analysis of surrounding region, management zones, theme plans, communications, staff and visitor amenities, monitoring. Financing protected areas.

Module 7 Biodiversity of India with special reference to the Western Ghats **(15hrs)**

Eco regions of India, Distribution of biodiversity, hotspots, endangered species, National parks, biosphere reserves, world natural heritage sites and Wild life sanctuaries. Origin of the Western Ghats**,** Geology and geographical Features, Rivers, Environment, biodiversity, Protected Areas of the Western Ghats. Threats to Bio Diversity of the Western Ghats: The Paradigm Changes -Habitat Fragmentation, Degradation and Loss, Shrinking Genetic Diversity- Declining Natural Resource Base and Overexploitation of Resources, Invasive Alien Species, Climate Change and Desertification, Impact of Development Projects, Madhav Gadgil committee and Kasturirangan committee reports, Biodiversity of Kerala, protected areas, conservation initiatives and challenges. Local issues, sacred groves, mangrove protection and Traditional farming practices. India's Biodiversity Act 2002 and its role in conservation.

References

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3. Odum E P, Ecology-A Bridge Between Science and Society, Sinauer Associates Inc.Publishers, 1996.
4. Chaudhary A B and Sarkar D D, Mega Diversity Conservation,,Daya PublishingHouse,2003.
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ZO243 Animal Systematics and Diversity

(10 practicals to be carried out)

1. Collection, identification and submission of the following:
   A. Insects (10nos)
   B. Prawn (2nos)
   C. Crab (2nos)
   D. Fishes (5nos)
2. Collection of planktons from freshwater, brackish/marine water ecosystems & identification of at least 5 planktons from each ecosystem
3. Collection of specimens of bivalves and identification of any 5 species
4. Collection of Macro-benthos from any aquatic/wetland ecosystem and identification of at least 5 specimens up to order
5. Identification of various parasites of fishes
6. Taxonomy of economically important agricultural pests (at least five specimens)
7. Collection and separation of soil organism using Bearman's and Berlese apparatus and Identification (at least five specimens)
8. Keying out families of organisms of different major orders such as: Odonata, Orthoptera, Blattodea, Mantodea, Isoptera, Hemiptera, Thysanoptera, Phthiraptera, Neuroptera, Coleoptera, Diptera, Lepidoptera , Hymenoptera, Arachnida, Crustacea.
9. Study of Orders of vertebrates and their identification using taxonomic keys.
10. Study of tools &instruments and standard methods used in collection of different organisms from the field.
11. Tools and techniques invlolved in museum preservation of specimens.
12. Demonstration of BLAST for sequence comparison and MEGA for phylogenetic analysis and phylogenic tree construction

Compulsory Field visits (Prepare field study reports and submit for evaluation (10 marks)) at least 3 days

1. Visit to fish market/ fish landing center, specimen collection morphometry data collection identification
2. Visit to forests/wetland ecosystems for studying birds, butterfly, mammalian diversity.
3. Field visits to collect insects of different orders.
4. Field key characters of any amphibians and reptiles reported during field visits

ZO244 Biodiversity Management

(10practicals to be carried out) specimen/ charts/ photos and data and viva for practical examination

1. Study and calculation of the following biodiversity indices based on field data:
   (a) Shannon-Wiener Index
   (b) Richness index
   (c) Evenness index
   (d) Simpson's Diversity Index

Using Excel or other softwares

2. Composition assessment of the taxonomic diversity/biodiversity in a habitat (eg.

Grassland, arid land, wetland)

3. Population studies - Estimation of Abundance, Population Density, Relative density Frequency and Relative frequency
4. Field study and survey methods for various animal groups.
5. Assessment of Invertebrate and Vertebrate diversity in your locality (e.g. campus, ecologically important spots near to the institution).
6. Analysis of species diversity in field such as aquatic/grassland/forest/terrestrial/wetland ecosystem.
7. Study on the micro-habitats
8. Analysis of vegetation types in a specific area/ecosystem.
9. Analysis of habitat characteristics in a specific area/ecosystem.
10. Quantification of flora using vegetation sampling methods (Estimation of species dominance, frequency, density using quadrate / plot methods).
11. Bird watching and identification of resident and migratory birds (minimum30 species) with their salient characteristics and use of different bird census techniques.
12. Visit to museums/repositories and make a report and submit for evaluation. **(5 marks)**
13. Compulsory attendance and production of participatory certificate of a Nature camp conducted by Department of Wildlife and Forests, Govt. of Kerala. **(5marks)**