

DEPARTMENT OF ZOOLOGY
SCHOOL OF LIFESCIENCES

M. Sc. Programme in Zoology
(Pure and Applied)

SYLLABUS

(Under Credit and Semester w.e.f 2017 admission)



UNIVERSITY OF KERALA

DEPARTMENT OF ZOOLOGY
SCHOOL OF LIFESCIENCES
UNIVERSITY OF KERALA

MSc. Programme in Zoology (Pure and Applied)

Programme Objectives

- Generating interest to learn about animals in their natural habitats, creating the desire to further extend their understanding.
- To make the students conquer new avenues in biological research by learning in a supportive and challenging environment.
- To mould a generation aware of their eco-system and committed to conserve.
- Make the student capable of taking up duties as educators, conservators and volunteers in the field of biology.

Structure of the Programme

SEM. No.	Course No	Course Title	CREDITS
		CORE COURSES	
I	ZOO-C-411	Functional Anatomy and Physiology	4
	ZOO-C-412	Microbiology, Immunology and Parasitology	4
	ZOO-C-413	Ecology and Environmental Biology	4
	ZOO-C-414	Microbiology, Environmental Biology and Physiology	2
	Internal Electives		
	ZOO-E-415	Bioinformatics and Structural Biology	2
	ZOO-E-416	Wetland Ecology	2
II	ZOO-C-421	Environmental Pollution and Management	3
	ZOO-C-422	Developmental Biology and Stem cell Biology	3
	ZOO-C-423	Bio Systematics and Bio Statistics	3
	ZOO-C-424	Cell and Molecular Biology	3
	ZOO-C-425	Pollution, Developmental and Molecular Biology-Practical	2

	Internal Electives		
	ZOO-E-426	Lab Course	2
	ZOO-E-427	Aquarium Science	2
		Semester III	
III	ZOO-C-431	Genetics, Biotechnology and Signal transduction	4
	ZOO-C-432	Endocrinology and Reproductive Physiology	4
	ZOO-C-433	Biochemistry and Synthetic Biology	3
	ZOO-C-434	Evolution and Animal Behaviour	3
	ZOO-C-435	Endocrinology and Biochemistry - Practical	2
	Internal Electives		
	ZOO-E-436	Cutaneous Disease and Biology	2
	ZOO-E-437	Field Course-Zoology	2
IV	ZOO-C-441	Applied Zoology: Entomology, Aquaculture, Animal Husbandry and Bio-Entrepreneurship	4
	ZOO-C-442	Biodiversity and Conservation Biology	3

	ZOO-C-443	Instrumentation and Research Methodology	3
	ZOO-D-444	Dissertation	6
External ELECTIVE			
I	ZOO-X-411	Stress Physiology	2
II	ZOO-X-421	Biodiversity	2
III	ZOO-X-431	Tropical Cutaneous Biology and Diseases	2

Semester : I

Course Code : ZOO-C-411

Course Title : FUNCTIONAL ANATOMY AND PHYSIOLOGY

Credits: 4

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 functioning of different systems in organisms from molecular level to organ systems and to the whole organism.

COURSE CONTENT:

MODULEI: Orientation, Organization of the body:Body organization, Planes of reference, Body regions and body cavities, Homeostasis and Feedback control, Chemical Composition of the body, Classification of tissues, Genomics, Proteomics and Metabolomics approaches in physiology and anatomy

MODULEII: Integumentary, Skeletal and Muscular System: Integument as an Organ, Layers of Integument, Physiology of Integument (Physical Protection, Hydro regulation, Thermoregulation, Cutaneous Absorption, Communication) Epidermal Derivatives (Hair, Nails, Glands), Physiology of Wound Healing, Inflammatory Conditions, Skin Grafting and Therapies

Organization of Skeletal System, Functions of Skeletal System, Development of Skeletal System, Physiology of Bone tissue, Negative feedback control of calcium and phosphate, Axial Skeleton, Organization of Muscular System, Ultra structure of muscle fiber, molecular mechanism of muscle contraction, muscle metabolism, Role of actin and myosin in eukaryotic

cells, Neuronal Control of skeletal Muscle, Vertebrate smooth and cardiac muscle and their metabolism

MODULE III: Integration and Control: Skeletal and Muscular System

Classification of Neurons, Genesis of membrane potential and action potential, Sodium-potassium pump, Neurotransmitters of central nervous system, Synaptic integration, Peripheral Nervous system, Neuro-pathophysiology: Diseases of nervous system and signaling. Characteristic and categories of Sensory receptors, Somatic sensory systems, olfactory system. Equilibrium, photoreception, mechanoreceptor, echolocation, Chromatophores and bioluminescence

MODULE IV: Cardiovascular System

Anatomy of heart, myogenic heart, specialized tissue, cardiac cycle, heart as a pump, blood pressure, neural and chemical regulation, Cardiac output and the factors that affect cardiac output, micro circulation, blood pressure, chemistry of blood components and their functional significance and molecular regulation, biochemistry of hemoglobin and myoglobin, Lymphatic system, defense mechanism, pathophysiology of cardiovascular and lymphatic system

MODULE V: Respiratory system, Excretory system and Nutrition: Functions and divisions, Concept of respiration, mechanism of breathing; biochemistry of respiratory exchange; Transport of respiratory gases; Regulatory mechanisms (humoral and neural) of respiration, Water and salts in cell environment, resistance of cells to changes in pH, Oxygen availability and temperature, Transport of Oxygen, Cellular response to acidosis and ketosis, hypercapnia, Respiratory control of acid-base balance, Gas transport, Pathophysiology of respiratory system. Comparative physiology of excretion, Concept of excretion and nitrogenous wastes; functional anatomy of renal unit; biophysical and chemical mechanisms of ultrafiltration, reabsorption and secretion, transport mechanisms, urine formation & regulatory control of sugar, urea, Na^+ , K^+ , and H^+ Role of kidneys in regulation of acid-base balance and osmoregulation. Chemistry, metabolic role and sources of vitamins & deficiency diseases. Biological significance and regulation of minerals and deficiency diseases due to them, Structure of digestive system Physiology of digestion, Gastrointestinal Pathophysiology

MODULE VI: Ecophysiology, Environmental Physiology and Stress Physiology

:Physiological homeostasis, Environmental and Biological factors: (Temperature, pH, photoperiodism, hypoxia, and starvation on physiological processes), Adaptive Physiology: Homeothermy and Poikilothermy, salinity adaptation, biochemical basis of physiological adaptation, osmoregulation in fresh water and estuarine and marine and terrestrial animals, hypoxia, sodium pump. Environmental effects on ion regulation, Bioenergetics and energy partitioning, Environmental perturbations of growth and reproduction in fishes, Environmental influence on growth and metabolism, hormonal and biochemical aspects, Concept of stress, stressors, integrated stress response, eustress, distress, stress adaptation and tolerance, mechanism of stress tolerance, stress acclimation, stress proteins, endocrinology of stress, endocrine stress axis, Hormonal regulation of stress adaptation

REFERENCES

- Animal Physiology, Eckart.
- Animal Physiology, Hill, Wyse, Anderson, Sinauer, Associates, Sunderland, 2004
- Biochemistry and physiology of cells, Edward and Hassal, Mc Graw Hill, London, 1980

- Cell Physiology A.G. Giese, W.B. Saunders & Co. New York
- Fish Ecophysiology, J. C. Rankin and F.B. Jensen, Chapman and Hall, London, 1993.
- General and Comparative Physiology, William S Hoar, Printice Hall, New York, 1983
- Human Physiology: From cells to systems, Sherwood, 5 Ed, Thomson, Australia, 2004
- Text Book of Medical Physiology, Arthur C. Guyton W.B. Sanders & Co. 1996
- The Physiology of Fishes, David. H. Evans, CRC press, London, 1993

Semester : I

Course Code : ZOO-C-412

Course Title : **MICROBIOLOGY, IMMUNOLOGY AND PARASITOLOGY**

Credits: 4

AIM: To introduce the nature and scope of various aspects of Microbiology, Immunology and Parasitology in general and human pathogenic microbes in particular

COURSE OBJECTIVES: Integration and consolidation of knowledge in microbiology such as nature of microorganisms, mode of living reproduction/multiplication, various aspects of human microbial pathogens and microbes of economic importance.

COURSE CONTENT

MODULE I: Diversity of Microbes, Their Physiology and Metabolism: Diversity, characteristic features, significance and potential applications and Major Pathological Conditions, Growth and cell division: growth physiology, cell division, growth yields, growth kinetics, steady state growth and continuous growth, Primary and Secondary transport: Drug export systems, amino acid transport, Metabolism of amino acids, lipids and hydrocarbons, nucleotides Heat-Shock responses, pH homeostasis, osmotic homeostasis

MODULE II: Evolutionary Microbiology, Microbial Ecology and genetics: Methods in microbial ecology, Microbial Habitats, Nutrient cycles, Interaction with plants and animals. Microorganism as tools and Industry and Research Methods of genetic transfers

MODULE III: Industrial Microbiology/Biocatalysts, Genetic Engineering and Biotechnology: Environmental Influence and Control of microbial growth, Environmental limits on microbial growth, Microbial response to change in temperature, pressure, PH, water activity and salt concentration, Biological control of microbes

MODULE IV: Virology : Virus evolution and classification, properties of viruses, virus structure, virus replication Strategies, Replication patterns of specific viruses, sub viral pathogens, infections, symptoms, Anti-viral strategies-prevention and control of viral diseases

MODULE V : Immunology: Innate and adaptive immunity, Immune cells, type and production, immune tolerance. Antigen and haptens, Primary and secondary response, Antibody: types, structure, function, production and diversity, T-cell receptors, MHC complexes, Antigen: processing and presentation, T helper cell and lymphocyte activation, Role of cytotoxic T-cell, Tumor Immunology.

MODULEVI :Parasitology : Parasite associations, Parasite host, Co-evolution of Parasite and host, Life style of parasite, Useful Parasites. Contaminative transmission, Transmission associated with reproduction, Active parasite transmission, host factors, Vaccines against parasite diseases, Control of Parasite diseases.

REREFENCES

- Biology of Microorganisms Masigan, Matinko and Parker, 10th Ed. Printice hall Publishres.
- Brock Biology of Microorganisms, Michael .T. Martinko and Jack Parker Prentice Hall and
- Microbes and Society- An Introduction to Microbiology, I.E. Alcamo, Jones &Barlett Publishres, London, 2003
- Microbiology - A Laboratory Manual, Cappuccino and Sherman, Pearson Education Inc., 2004.
- Microbiology: An Introduction, 7th edition update Gerard Tortora, BerdellFunke Christian Case Pearson Education 2002.

Semester : I

Course Code : ZOO-C-413

Course Title : ECOLOGY AND ENVIRONMENTAL BIOLOGY

Credits: 4

AIM: To introduce the nature and scope of various aspects of Ecology and Environmental Biology in general and human environment in particular.

COURSE OBJECTIVES:

Imparting basic knowledge about the environment and its allied problems. Developing an attitude of concern for the environment. Make one striving to attain harmony with Nature, Acquiring skills to help the concerned individuals in identifying and solving environmental problems.

COURSE CONTENT:

MODULEI:Introduction to the Environment, Habitat and niche,Population ecology and Species Interactions: Subdivision & scope of ecology, Physical environment, biotic environment; biotic and abiotic interactions, concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement. Characteristics of a population; population growth curves; population regulation; life history strategies (*r* and *K* selection); concept of metapopulation-demes and dispersal, interdemec extinctions, age structured populations. Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis

MODULEII: Community ecology, Eco-succession, Ecosystem and Bio-geological Cycle: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones, Types; mechanisms; changes involved in succession; concept of climax. Classification; Major ecosystems of the world (forests, grasslands, wetlands, oceans, rivers and lakes, deserts). Managed Ecosystems; Agri-Ecosystems, Urban Ecosystem, Energy flow and mineral cycling (CNP); primary production and decomposition

MODULEIII: Environmental Biology, Natural Hazards, Precautions and Management

Atmosphere: structure and composition, Water: quantity and quality, Parameters and standards, Surface and subsurface waters in India, Environmental hotspots related to water in India, Soil and Land use Floods: River flooding, flood plains, drainage basins, flood hazards, urbanisation and flooding, flood plain management and control. Land slides: causes, human use and land slide analysis, determination of stability and safety factor. Volcanoes: nature, extent and causes of volcanism, volcanic materials, geographic distribution of volcanoes. Coastal hazards: tropical cyclone, coastal erosion, sea level changes and its impact on coastal areas and coastal zone management. Earth quakes: causes, intensity and magnitude of earthquakes, geographic distribution of earthquakes zones, seismic waves, , nature of destruction, quake resistant buildings and dams. El Nino, La Nino: Reason, Causes, Disaster Management: risk analysis; Disasters, causes and effects; Factors affecting damage, Type, scale, population density, habitation pattern, physiology and climate

MODULEIV: Resource Ecology and Environmental Biotechnology

Conventional and Non-Conventional energy sources, Forest, Mineral resources with respect to India, Over-exploitation, Water resources and management. Bio-remediation, Phytoremediation, Biodegradation, Biodegradation of petroleum constituent, heavy metal, polycyclic aromatic hydrocarbon, Pesticides and Detergents, Biosorption, Biomass production, Biogas and biofuel production, Vermiculture, Bio-fertilizer

MODULEV: Environment Impact Assessment and Environmental Education, Bio ethics and Bio safety

Environmental Policy, Environmental Laws and their Enforcement, Environmental awareness, Tribal welfare, Environmental Protection Strategies and environmental education Environmental Impact Assessment and Environmental Risk Assessment, Regional and Global Environmental Issues. Bioethics and patenting, Indian subgenera of animal variety and farmer's rights protection act. Requirement, of biosafety and biodiversity, Biosafety for human health and environment, Social and ethical issues, Biosafety in relation to transgenic research and applications.

MODULEVI: Ecology of Space Travel:

Types of life support systems, Exobiology, Remote Sensing as a tool for the study and the management of ecosystems: Physical basis of remote sensing, Process of information extraction

READING LIST:

- Benton, A. H. and Wernaer, W.E.Jr 1974. Field Biology and Ecology, Tata Mc Graq Hill Publishing Co., New Delhi
- Bindu N.L. et. Al., 1997. Environmental impact Assessment, Asian Development Bank.
- Brewer, R 1994. The Science of Ecology, Saunders Collins Publishing, New York.
- Chauhan, T. S and Joshi K.N. 1996. Applied Remote Sensing and Photo-Interpretation. Vigyan prakash, Jodhpur.
- Connel, D. W. and Hawker, D. W. 1992. Pollution in Tropical Aquatic Ecosystem, CRC Press Inc. London.
- Cutter. S. L. 1999. Environmental Risks and Hazards, Prentice hall of India, Pvt. Ltd. New Delhi.
- Ramade, F. 1987. Ecology and Natural Resources. John Wiley and Sons, New York.

Semester : I

Course Code : ZOO-C-414

**Course Title : MICROBIOLOGY, ENVIRONMENTAL BIOLOGY AND PHYSIOLOGY
-PRACTICAL**

CREDITS :2

AIM: To introduce the various aspects of practical microbiology

COURSE OBJECTIVES: The students will be introduced to hands on training of various aspects of microbiology practicals.

COURSE CONTENT

Module I Microbiology

Introduction to Microscope, Introduction to some common microbiological apparatus, Microbial culture, Transfer Techniques, Techniques for isolation of pure cultures, Cultural characterization of Micro-organisms, Microscopic Examination of Stained Organisms, Microscopical examinations of Live Bacterial Preparations, Microscopic Measurements of Microorganisms, Cloning and Plasmid Isolation

Biochemical tests for Identifying Microorganisms.

1. Urease Test.
2. Hydrogen sulphide Production Test.
3. Litmus milk Reactions.

Module II Environmental biology

1. Examination of Physico chemical Parameters of Aquatic Ecosystems.
Temperature, Photoperiodism, Salinity, Alkalinity
2. Sediment analysis, Organic carbon, Soil composition.
3. Study of Bioindicators of Water pollution.
4. Identification of Biomarkers in a fish species
5. Preparation of an Environment Impact Assessment Report of an Industry in the Local area

Module III Physiology

1. Quantification of osmolarity in biological samples
2. Estimation of electrolyte mineral uses flame photometer or/ atomic absorption spectrometer.
3. Quantification of metabolic indices in biological samples
4. Identification of cell type using varied tonicity materials
5. Measurement of luminal pH using microelectrodes
6. Estimation of nitrates from the body fluid

Semester : I

Course Code : ZOO-E-415

Course Title : **BIOINFORMATICS AND STRUCTURAL BIOLOGY**

CREDITS :2

AIM: To introduce the nature and scope of various aspects of bioinformatics and structural biology in zoological studies.

COURSE OBJECTIVES:

Provides with skills and tools to develop new computational methods and models and to apply them to real world biomolecular data.

COURSE CONTENT:

MODULE I :Introduction to Genes and Proteins

Genome Sequences, ORFs, Genes, Introns, Exons, Splice Variants, DNA/RNA, Secondary Structure, Triplet Coding, Protein sequences, Protein Structure, Secondary, Tertiary, Quaternary.

MODULE II : The notion of Homology, Sequence Information Sources, EMBL, GENBANK, Entrez, Unigene, Understanding the structure of each source and using it on the web

MODULE II :Protein Structure and Information Sources

Information Sources, PDB, SWISSPROT, TREMBL, Understanding the structure of each source and using it on the web.4, Blots, PCR, Microarrays, Mass Spectrometry, Structure Analysis, Phylogenetic Analysis

RERERENCES

- Bioinformatics online (Methods in Enzymology V. 266 computer methods for macromolecular sequence), Ed. By Doolittle, Academic Press 711p, 1996
- Bioinformatics: A practical guide to the analysis of genes and proteins, Ed. By Baxvanis, 1998
- Bioinformatics: Sequences, structure and databanks, Des Higgins and Willie Taylor, Oxford University Press, 256p, Oct 2000,
- Bioinformatics: The machine learning approach Pierre Baldi and Soren Brunak, MIT Press, 351p 1998 ISBN 0 262 02442 X
- Molecular Evolution: a phylogenetic approach, 1998, 352p, ROM and Holmas EC, Blackwell Science
- Mount "Bioinformatics" Gold Spring Harbor Laboratory Biochemistry by Voet&Voet. Molecular Modeling Principles and Applications by Andrew Leach

Semester : I

Course Code : ZOO-E-416

Course Title : WETLAND ECOLOGY

Credits :2

AIM: To introduce the nature and scope of various aspects of wetland ecosystems and its conservation and management.

COURSE OBJECTIVES:

The students will be introduced on the various aspects of wetland ecology, its dynamics, conservation and management.

COURSE CONTENT:

MODULE I: Wetlands: an overview: Definition and distributions, wetland classification, wetland types, Wetland functions, Zonation and Succession: shorelines as a prism, Shorelines as a model system for the study of wetlands, Mechanisms of zonation, some relevant theory: ecological and physiological response curves, empirical studies of zonation.

MODULE II: Diversity: Dominance and diversity factors controlling the number of species in wetlands, Biomass and diversity: a general model for herbaceous plant communities, Species pools and biodiversity.

MODULE III: Wetland conservation, management and research: Change in wetlands, perspectives on conservation, Priorities for action, Indicators: setting goals and measuring performance, ecosystem management, Goals, tactics and strategies.

MODULE IV: Wetlands in India, Wetland management, Wetland policy and law, Ramsar Wetlands

Future prospects of wetlands, Environmental impact assessment of wetlands,

MODULE V: Wetlands of Kerala, Wetland agriculture –Problems and prospects, Back waters of Kerala, Management of river wetlands, Avian fauna of wetlands of Kerala, Flora and fauna of wetlands.

MODULE VI: Wetland pollution, Constraints, management and conservation of wetlands, Coral reef ecosystem, Mangrove ecosystems of India, Wetland planning and monitoring
Economic assessment of wetland management, People's participation in wetland conservation

REFERENCES

- Production & Ecology of wetlands. DF West Lake et al, Cambridge University press.
- Wetland ecology principles and conservation /Paul Keddy.2000, Cambridge university press, 2000.
- Wet land Indicators –Ralph W. Tirur CRC Press
- Wetland Management Policy & law, 2002 |P.C Sinha & R. Mohanty 436p

Semester : II

Course Code : ZOO-C-421 (Core)

Course Title : **ENVIRONMENTAL POLLUTION AND MANAGEMENT**

Credits: 3

AIM: To introduce the nature and scope of various aspects of Environmental pollution and its management in micro and macro levels.

COURSE OBJECTIVES: To introduced on the various aspects of pollution problems such as water, air and radioactive, thermal etc. The various biological aspects of pollution problems will also be covered.

COURSE CONTENT:

CREDIT I : Water Pollution

Types, sources and consequences of water pollution, Physico-chemical and Water quality Standards- Drinking, Irrigation, Stream, Minimal National Standards bacteriological sampling and analysis of water quality, turbidity, dissolved oxygen, pH, conductivity etc. The Water (Prevention and Control of Pollution) Act of India, Treatment, disposal and recycling of waste waters, Movement pollutants, their monitoring and control in water bodies. Sources of marine pollution and control. Criteria employed for disposal of pollutants in marine system-coastal zone management. Nature, source and degradation of organic matter, effects and measurements of organic pollution. Groups of pesticides, pesticide kinetics, mode of action

and toxicity, Accumulation and toxicity to aquatic organisms. Source and accumulation of heavy metals, toxicity of metals-lead, mercury, cadmium, chromium, arsenic and copper

CREDIT II: Oil Pollution, Thermal Pollution, Radioactive Pollution and Air pollution

Characteristics and composition of oil, sources of oil in environment, effects of oil on organism, control of oil pollution. Effects of thermal pollution, standards and control of thermal pollution, beneficial use of thermal polluted waters, Acid pollution- effects on aquatic fauna, effects of acid pollution, Effluent plant and management. Isotopes and nature of radiations, sources of radio activity, distribution of man-made radioactivity in environment, fate and movement of radio-activity in environment, mechanism and biological effects of radiation, control of radioactive pollution. Classification of air pollutants, source of emission, effects on plants humans and other animals, prevention and control of air pollution, Green house gases and green house effects. Noise pollution and its effects

CREDIT III : Polychlorinated biphenyls and other toxic organics

Detergents, Phenols, Plastics, Dioxines and PAHs. Biocides, Herbicides, Fungicides. Xenobiotic metabolism- uptake, Biotransformation, , cytochrome P450

CREDIT IV: Solid Waste Management and Techniques

Types of solid waste – Municipal waste, urban, rural-and industrial wastes, House hold hazardous wastes, demolition waste, domestic waste, sewage sludge and municipal waste, slaughterhouse waste; agricultural waste; Mining waste, Integrated Solid waste Management

CREDIT V: Risk assessment and bio monitoring

Bio-indication and biomarkers, Impact of pollution on bioindicator species, biomarkers of pollution for risk assessment.

CREDIT VI: Ecotoxicology, Physiological and biochemical measures in pollution biology

Bioassay procedures bioremediation, phytoremediation and probiotics, Molecular mechanism of toxicant action and tolerance, pollution finger printing. Water quality criteria, haematology, immunology and challenge tests

REFERENCES:

- Chemical Principles of Environmental Pollution. B.J.Alloway et al., 1993, Blakie Academic and Professional Publication, Glasgow.
- Environmental Chemistry, Ajay Kumar Bhagi & G. R. Chatwal, Himalaya Publishing House, 2003.
- Marine Pollution. R.B.Clark II Edition, Oxford Science Publication, 1989.
- Oil Pollution Control, S.Z. Prichard, Croom Helm Publishers, London, 1987.
- Pollution Control and Conservation, M.Kovacs, Ellis Horwood Ltd. Publishers, 1985.
- Water Pollution- Causes, effects and Control, P.K.Goel, New Age International Publishers, New Delhi, 2001.

Semester : II

Course Code : ZOO-C-422

Course Title : DEVELOPMENTAL BIOLOGY AND STEM CELL BIOLOGY

Credits: 3

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 reproduction, development, cellular differentiation, systems biology etc.

COURSE CONTENT:

CREDIT I: Introduction to embryology, Early embryonic development

Overview of Animal Development, Asexual and Sexual Reproduction, Types of cell reproduction and molecular reproduction, Gene and differentiation, Gametogenesis, Embryological concept of development, Genetic Labeling. Structure of gametes, Fertilization, Embryo, Epigenesis, General and unique features of cleavage, Blastula, Activation of blastula genome, Developmental anatomy of gastrula, Types of gastrula, Mechanism of germ layer formation, Embryogenesis and Differentiation, The genetics of cell lineage, Homeotic mutants, Homeo boxes, Palingenesis, Cenogenesis in vertebrates, Early vertebrate developments (Amphibians, Birds, Mammals)

CREDIT II: Mechanism of Cellular Differentiation

Genomic equivalence and differential gene expression, Transcriptional Regulation of gene expression, during development, Mechanism of differential gene transcription, Control of development by RNA Processing, Translational and post-translational regulation of Developmental process

CREDIT III: Cell, Cell Interaction in Development

Cell communication during development model of cell interactions, cell nitrate, cell signaling and development, Indeer molecular, role of ECM in development. Early development and axis formation, The spatial ordering of cells-Role of cell surface, Secondary induction, Pattern formation, Cell interaction with hormones as a mediator of development. Patterns of growth and oncogenesis, Sex determination hormonal and environmental

CREDIT IV: Post-embryonic development and Systems biology

Metamorphosis, regulation, biology of ageing. Genetic errors of human development, Teratogenesis: Environmental assaults on human development, biotic, abiotic and symbiotic regulation of development, Medical accepting of developmental therapies, developmental plasticity, mechanism of evolutionary change, Developmental constructions on evolution, selectable epigenetic variation

CREDIT V: Stem cell Biology and Stem cell characterizations: Types and sources of stem cell with characteristics, embryonic, adult, haematopoietic, fetal, cord blood, placenta, bone marrow, primordial germ cells, cancer stem cells, induced pluripotent stem cells. Isolation & characterizations, markers & their identification, growth factor requirements and their maintenance in culture. Feeder and feeder free cultures.

CREDIT VI: Molecular regulation of stem cells :Molecular basis of stem cell renewal and differentiation, Metaplasia and trans- differentiation, Molecular basis of pluripotency and stem cell niche, Nano-scale approaches to stem cell culture and applications of stem cells, neurodegenerative diseases, spinal cord injury, heart disease, diabetes, burns and skin ulcers, muscular dystrophy, orthopaedic applications, stem cells and gene therapy, Cancer stem cells

REFERENCES

- Developmental Biology—Scott.F.Gilbert
- Developmental Biology—Virginia Walvot and Nigel Holder
- Developmental Biology—Browder
- Embryology-An Introduction to Developmental Biology—Stanley Shostak
- Developmental Biology—Patterns, Problems and Principles—John.W.Saunders.

Semester : II

Course Code : ZOO-C-423

Course Title : **BIO SYSTEMATICS AND BIO-STATISTICS**

Credits: 3

AIM: To introduce the nature and scope of various aspects of Animal taxonomy and Classification practiced in biological science and the various Statistical techniques and tools applicable in biological research.

COURSE DESCRIPTION: The students will be introduced on the various aspects of taxonomy, classification, nomenclature, types, collection of specimens, etc.

COURSE CONTENT:

MODULE I: Principles and methods of taxonomy,Levels of structural organization:Concepts of species and hierarchical taxa, Biological Nomenclature, Classical and quantitative methods of taxonomy of animals, Importance of taxonomy in biodiversity conservation, Research studies, Medicine, Agriculture and Pest Management, Unicellular, colonial and multicellular forms, Levels of organization of tissues, organ and system. Comparative anatomy, adaptive radiation, adaptive modifications

MODULE II: Outline classification of animals ,Taxonomic collections and classification:Important criteria used for classification in each taxon, Classification of animals, Evolutionary relationship among taxa, Higher taxa and Linnean hierarchy.Collecting methods, identification, classification and zoological nomenclature and Taxonomic characters

MODULE III: Molecular Systematics

DNA markers and their applications in taxonomy: Introduction, Molecular Investigations, Mitochondrial DNA and Ancestral Polymorphisms, RFLP, RAPD, AFLP, VNTR, etc.Alternate Molecular Approaches, Allozyme polymorphism, Microsatellite Loci, Test of the Phylogenetic Potential of Microsatellites

MODULE IV : Species concepts :Polytypic species, race, variety, cline, subspecies, semispecies, super species. Typological species concept, Nominalistic species concept,

biological species concept, evolutionary species concept Difficulties in applying biological species concept

MODULE V: Measures of dispersion: Population, sample, variable, parameter, primary and secondary data, screening and representation of data, frequency distribution, Concepts and applications-measures of dispersion, range, mean deviation, Skewness and Kurtosis, coefficient of variation, variance, Standard deviation, Quartile deviation and standard error.

MODULE VI: Testing of hypotheses : Concepts of Normal, Binomial and Poisson distribution; Student's -t distribution, G-tests; Concepts of Null hypothesis and alternative hypothesis, degrees of freedom Level of significance, errors of inference; one-way ANOVA-applications in biology Concepts and applications of correlation and regression, Chi-square test for independence

REFERENCE:

- Bailey, N. T. J. (1995). *Statistical Methods in Biology*. 1st ELBS ed. Boyer, R. (2000). *Modern Experimental E*
- Gerge Gaylord Simpson(1969) Principles of Animal Taxonomy, Oxford &IBH, India
- Bailey, N. T. J. (1995). *Statistical Methods in Biology*. 1st ELBS ed. Boyer, R. (2000). *Modern Experimental E*
- Cambridge Low-price Ed. Cantor, C.R. & Schimmel, P.R. (2003). *Biophysical chemistry* (3 vol. set). W. H. Fr 1999).
- Cambridge Low-price Ed. Cantor, C.R. & Schimmel, P.R. (2003). *Biophysical chemistry* (3 vol. set). W. H. Fr 1999)
- Dellala and Sharma (1975) Animal Taxonomy and Museology, Jai Prakash Nath Co, Meerud
- Ernst Mayr and Peter D Ash Lock (1991) Principles of systematic zoology. Mc graw Hill, Singapore
- Kapoor V. C. (1998) Theory and Practice of Animal Taxonomy, Oxford &IBH, India
- Narendran T. C. An Introduction to Taxonomy. Zoological survey of India
- Selvin, S. (2004). *Biostatistics: How it works?* Pearson Education
- Selvin, S. (2004). *Biostatistics: How it works?* Pearson Education

Semester : II

Course Code : ZOO-C-424

Course Title : CELL AND MOLECULAR BIOLOGY

Credits: 3

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.

COURSE CONTENT:

MODULE I :Introduction to cell biology,Biological Molecule Structure and Function:Basic properties of the cells, characteristics that distinguish prokaryotic and eukaryotic cells, Types of Prokaryotic and eukaryotic cells, Size of cell and their components, The origin of eukaryotic cells. Covalent and Non-Covalent Bonds, Nature of Biological

Molecule, Biological compounds, macromolecular structure and bonding, abiotic origin of biological molecules, Enzyme activity, receptor binding and regulation

MODULE II: Cellular Membrane and Trafficking: Membrane structure and function, Membrane dynamics and cell surface transport, Endocytosis and Exocytosis, Mechanism of cell recognition, Cell junctions and Plasmodesmata, Cell wall and extracellular matrix, Microfilaments, Intermediate Filaments

MODULE III: Cellular Organization and Cellular Movement: Endomembrane system, Approaches to study endomembrane system, Endoplasmic reticulum, Golgi Complex, Types of vesicle transport and function, Lysosomes, Mitochondria structure and Function, Oxidative metabolism in Mitochondria, Mitochondria and ATP Formation, Peroxisomes, The Extracellular matrix and Interaction. Structure, Function and Targeting, Cytoskeleton, Microfilament and actin, Dynamics of actin Filament, Mechanisms of actin filament assembly, Organization of actin-based cellular structure, Myosin: Actin based motor proteins, movements, Cell migration: Mechanisms, Signaling and Chemotaxis, Cell Adhesion.

MODULE IV: Cell Cycle and Signaling: Cell Cycle, Division, Early Metazoan development and Embryonic Stem cells, Stem Cell Niche, Basic elements of Cell Signaling, G-Protein Coupled Receptors and their Second Messengers, Protein-Tyrosine Phosphorylation as a signal for Signal transduction.

MODULE V: Cell death and its regulation, Cancer: Apoptosis, Mitochondria and Cell Death, Apoptosome and Caspase Activation, Tumor Cell and the Onset of Cancer, Cancer Checkpoint Regulators, Cancer and Mutation. Major metabolic pathways and regulation, Respiration and fermentation, synthesis and degradation of macromolecules, hormonal control and intracellular messengers.

MODULE VI: Historical development of molecular biology Central dogma concept, The Path to Gene Expression: Introduction to nucleic acids- chemistry and structure and DNA and RNA, metabolism of purine and pyrimidine nucleotides, Molecular aspects of mutation Replication, DNA damage and repair mechanisms, Transcription and translation, genetic code- prokaryotic and eukaryotic gene organization, exons, intron splicing- repetitive DNA and non-repetitive DNA- interrupted genes- nonsense sequences and tandem gene cluster –satellite DNA. Leucine Zipper family, Transcription control in prokaryotes and eukaryotes, Cytological mapping- construction of linkage map or genetic mapping- determination of linkage group, Determination of map distance, DNA damage and Repair.

REFERENCE:

- Cell Biology, Gerald Karp.
- Cell and Molecular Biology: Concepts and Experiments, Karp .
- Essential Cell Biology, Bruce Alberts, Dennis Bray, Alexander D Johnson, Julian Lewis, Martin Raff, Keith Roberts, & 1 More.
- Molecular Biology of the Cell, Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter.
- Molecular Cell Biology, Harvey Lodish , Arnold Berk , Chris A. Kaiser , Monty Krieger , Matthew P. Scott , Anthony Bretscher , & 2More.
- The Cell: A Molecular Approach, Geoffrey M. Cooper and Robert E. Hausman

Semester : III

Course Code : ZOO-C-425

Course Title : POLLUTION, DEVELOPMENTAL AND MOLECULAR BIOLOGY- PRACTICAL

Credits: 2

AIM: To impart training on various aspects of pollution tests and assessment and practicals involved in developmental and molecular biology

COURSE OBJECTIVE: The students will be introduced on the various aspects of practical skills in the assessment and testing of pollutants.

COURSE CONTENT:

MODULE I Pollution Biology

1. Determination of salinity
 2. Estimation of dissolved oxygen.
 3. Determination of primary productivity
 4. Estimation of dissolved carbon dioxide.
 5. Determination of hardness
 6. Determination of soils
 7. Colorimetric estimation of nutrients, Phosphate phosphorous, Nitrate-Nitrogen, Nitrite-Nitrogen
 8. Analysis of Sediments and Pollutants, Total organic carbon, Hydrogen sulphide
 9. Effect of Pollution on the oxygen consumption of fishes.
- Study of histopathological changes in selected tissues (blood, gill, liver, kidney) of fish exposed to a given concentration of a pollutant over a period of time-submit two slides at the time of examination

MODULE II Developmental Biology

1. Vital staining of chick embryo (24-72 hours)
2. Morphogenetic movement of chick blastoderm
3. Preparation of permanent slides of embryos and larva
4. Study of different types of placenta in mammals
5. Thyroxine effects on amphibian metamorphosis.
6. Thyroxine on amphibian metamorphosis.

MODULE III Molecular Biology

1. Electrophoresis and Western Blotting
2. Immunohistochemistry
3. Elisa
4. Extractive of RNA and DNA
5. Qualification of mRNA expression by PCR assay

Course Code : ZOO-E-426

Course Title :LAB COURSE

Credits: 2

AIM: To introduce hand son training on one or two lab techniques to the students.

COURSE OBJECTIVES: The students will be given hands on training on the various aspects of one or two laboratory techniques such as microtechniques/microscopy/electrophoresis etc.

COURSE CONTENT

This course requires submission of a report based on the experiences gathered from a selected laboratory in the Department.

Semester : II

Course Code : ZOO-E-427

Course Title :AQUARIUM SCIENCE

Credits: 2

AIM: To introduce the nature and scope of various aspects of aquarium keeping and and their maintenance.

COURSE OBJECTIVES: To introduced into the details such as principles and procedures of making and maintaining aquariums in home /gardens etc.

COURSE CONTENT:

MODULE I : Introduction to common exotic ornamental fishes, their maintenance and breeding techniques.

MODULE II : Introduction to Common Marine Aquarium Fishes, Their Maintenance, Management and Breeding.

MODULE III : Water quality Management in Aquarium, Aquarium Accessories and health management(disease control) and feeds and feeding.

MODULE IV : Aquarium tank fabrication, Setting of aquarium, Maintenance and management.

MODULE VI: Aquarium Plants, their familiarization and methods of propagation.

REFERENCE

- Brymer, J.M.P., A Guide to Tropical Fish Keeping.
- Dick Mills and Gwynne Vevere. Tropical Aquarium Fishes. Published by Salamander Books Limited.London.

- Dick Mills, 1987. Illustrated Guide to Aquarium Fishes. Published by Galley and Price, an imprint of W.H. Smith and Sons Limited, England.
- Janze, A.O. Aquarium techniques II Fishes and plants.
- Ratjak, K. and Zukal, R., Aquarium Fishes and Plants.

Semester : III

Course Code : ZOO-C-431

Course Title : GENETICS AND BIOTECHNOLOGY AND SIGNAL TRANSDUCTION

Credits: 4

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.

COURSE CONTENT

MODULE I: Mendelian Genetics and its application and Population Genetics, Gene Regulations and Gene Activity: Gene mapping, Chromosome mapping, recombination frequency, genetics in animal breeding, Non Mendelian pattern of inheritance, Modern Mendelism. Genetic variation, Polymorphism, polyploidy, gene pool, gene frequency, distribution pattern, Hardy –Weinberg equilibrium, disequilibrium, patterns disrupting gene equilibrium. Induction and repression, Sigma factor, signals for gene control, transcriptional signals, TATA Box, CAAT Box, enhancers

MODULE II: Human Genetics and Immunogenetics: Pedigree analysis, Karyotype analysis, Lyon Hypothesis, Genetics of ABO system, Rh disease and inheritance, Sickle haemoglobin and inheritance, Thalassemias, Human Genome Project, Gene therapy, Human Proteome Research, Human Protein Atlas, DNA finger printing and foot printing. Genetic disorders- Patan, Edward's, Chriduchat syndrome, Philadelphia Chromosome. MHC system, Life Cycle of HIV, HIV Genome, Tssue transplantation and Tissue rejection, Cancer Genetics

MODULE III: Tools and Techniques in Genetic Engineering: History and concept of biotechnology, Vectors, Plasmids, Bacteriophage, Cosmids, Shuttle vectors, Yeast vectors, Minichromosomes, Artificial chromosomes, Probes and molecular markers, Properties and type of Isozymes, RFLP, RAPD, AFLP, VNTR, Minisatellites, Microsatellites. Selection and isolation of desired genes, Gene splicing, Introduction of rDNA into host, Selection of clone containing DNA insert, PCR, DNA Finger printing, DNA sequencing, Chromosome jumping, Genomic library, cDNA library,

MODULE IV: Gene cloning: Cloning techniques in animals, gene cloning, cloning bacteria and eukaryotes, Amplification of DNA by PCR, gene transfer technology, and expression of induced genes

MODULE V: Applications and Problems related of Biotechnology:Medicine, Diagnosis of diseases, Detection of genetic disorders, Metabolites production, Bio controls agents, Biofuel, biogas, Bioethanol, Use of transgenic animals, Production of transgenic animals, Ethics of transgenic animals. Social, cultural, economic and legal problems, safety in biotechnology, Bioethics, Intellectual Property Rights, and Patenting.

MODULE VI: Signal transduction:Function and structure of inter and intra-cellular communication, G-proteins, Ras proteins, Adenylate cyclase, Receptor tyrosine kinases (MAP kinases), Protein phosphatases, Phosphoinositide Pathway, Jak-Stat pathway, Wnt pathway, SHH pathway, Diseases and Signal Transduction Pathways

READING LIST:

- Animal Biotechnology M.M. Ranga, Agrobios Publishers, India, 2003
- Identification of antigen –antibody reaction using an enzyme labeled antibody
- A Text book of Biotechnology, Dubaey, R. C. 1993, S. Chand & Co. New Delhi
- Biotechnology, Kalyani Publishrs, New Delhi
- Gene Structure and Expression- J.D.Hawkin, Cambridge University Press
- Genes V – Benjamin Lewin, Oxford University Press, New York.
- Genetics- Eldon J Gardner
- Genetics- Strick Berger
- Heredity- A.F.Shull, 4th Edition, McGraw hill Book Company, London
- Molecular Genetics Part I and II – H. Herbert Taylor
- Principles of Gene Manipulations: An Introduction to Genetic Engineering, Blackwell Sci. Publ.
- Principles of Genetics- 3rd Edition, E.J. Gardner

Semester : III

Course Code : ZOO-C-432

Course Title :ENDOCRINOLOGY AND REPRODUCTIVE PHYSIOLOGY

Credits: 4

AIM: To introduce the nature and scope of various aspects of vertebrate and invertebrate endocrinology and Human Reproductive Physiology.

COURSE DESCRIPTION: The students will be introduced on the various aspects of both invertebrate and vertebrate endocrinology with a view to its applications in various fields of medicine and agriculture.

COURSE CONTENT:

MODULE I: Introduction to endocrinology and vertebrate endocrine systems:

Concept of Endocrinology, Historical perspective, classes of chemical messengers, peptide hormones, steroid hormones, bioamines, eicosanoids chalcones, neurotransmitters, neuropeptides, neurosteroids, neurohormones, phytohormones, synthetic hormones, prohormones, paracrine, merocrine, cytotogenic secretion. Vertebrate endocrine glands, Morphology and anatomy of endocrine glands, evolution of endocrine glands, Biosynthesis of hormones, hypothalamus and hypophyseal, secretion, hypothalamo hypophyseal interaction,

endocrine axes, function, of hormones, disorders of hormonal imbalance, Regulation of hormone, secretion, synthesis and metabolism of hormones, half-life of hormones, metabolic clearance rate, miscellaneous hormones, eicosanoids, prostaglandins, prostacyclins, thromboxanes, leukotrienes

MODULEII: Mechanism of hormone action:General and molecular mechanism of action of amines, polypeptide and steroid hormones, Mechanism of signal transduction in vertebrates, hormone receptors-as mediation of endocrine signals, classes of endocrine receptors, receptor-ligand interaction, cell surface receptors-structure and regulation of receptor units. Second messengers of hormonal action, cyclic nucleotides, inositol triphosphate, cAMP as second messengers, genomic action of cAMP, G protein and its dual control on adenylate cyclase, receptor crosstalk, ligand-gated ion channels, non-genomic actions of steroid hormones

MODULEIII: Hormones and Cancer and Functional Endocrinology

Hormonal control of development of cancer, hormone therapy in cancer Treatment, Oncogenes and hormonal function, Breast cancer and Hormone receptor status, Etopic production of hormones by tumour cells. Hormones as signal transducers, hormones in developmental process, Role of hormones in behavior of animals, Hormonal control of reproduction, Hormone therapy in reproductive impairments, Hormonal involvement in evolution

MODULEIV: Insect and Crustacean Endocrine organs

Endocrine organs- Structure, Chemistry, Mechanisms of actions in Insects, Growth, Moulting, Differentiation, Juvenile Hormone, Ecdysone, Neuro hormones, Neuro peptides. Endocrine control of vitellogenesis, Spermatogenesis, Diapause-Eclosion, Cuticular tanning, Excretion.Sinus gland, X-organ-Androgenic glands-Maxillary glands-Mandibular glands-Hormonal principles-Chemistry-Action Hormonal control of sex Differentiation, Gonadal activity, Colour change, Retinal pigment Movement control, Heart beat

MODULEV :Reproductive Physiology, Male and Female reproduction:Development of Gonads, Differentiation of testes, and ovary, morphological ,biochemical and hormonal aspects, Development and morphogenesis of male and female sex organs. Male reproductive tract, testes, structure, spermatogenesis, Endocrine, paracrine and autocrine regulation, Accessory sex organs, prostate, seminal vesicles, bulbourethral gland, structure function and regulation, Female reproductive tract, ovary structure, folliculogenesis. Ovulation, Steroidgenesis endocrine, Paracrine, Autocrine regulations. Fallopian tube structure, Function, hormonal regulation, Sex cycles. Hypothalamo-Hypophysial regulation of reproductive function, Neuroendocrine perspectives of mammalian reproduction, Reproductive pheromones

MODULE VI: Pregnancy, Fetal Development and Sexual Physiology: Process of Fertilization, Mechanism of fertilization, Cell division and Implantation of blastocyst, Placenta-its role, Hormonal and physical changes during pregnancy, Developmental stages of foetus, Parturition, Lactation-its hormonal control. Sex determination and differentiation, Abnormalities of sexual Differentiation, Human sexual response, Sexual dysfunction– Infertility, Anatomical, Hormonal, chromosomal, immunological and Physiological factors

REFERENCES:

- An introduction to General and Comparative Endocrinology, E.J.W Barrington, (2ndedn) Oxford University Press, London (1975).
- An Introduction to Invertebrate Endocrinology by A.S. Tombes ,Academic Press.
- Applied Animal Endocrinology 2nd Ed., E.JamesSquires, CAB International, 2010.
- Comparative Vertebrate Endocrinology, 3rdedn, - P.J Bentley, Cambridge University Press (1998).
- Insect Endocrinology KK Nayar
- Insect Hormones VJA Novak
- Introduction to Endocrinology, Chandra S. Neji, PHI learning Pvt Ltd, New Delhi, 2009.
- Metamorphosis by L.I.Gilbert and E.Frieden .Plenum Press
- Morphogenetic Hormones of arthropods(Ed by) A.P.Gupta Vol 2&3. Rutgers University Press
- The Comparative Endocrinology of the Invertebrates by K.C.Highnam&L.Hill, Edward Arnold Publishers
- Vertebrate Endocrinology, 4thedn, - David).Norris, Elsevier Academic Press, (2007).
- Williams Text book of Endocrinology, 11thEdn (1009)-Herry M. Kronenberg, ShlomoMelmed, et al, Elsevier.

Semester : III

Course Code : ZOO-C-433

Course Title : BIOCHEMISTRY AND SYNTHETIC BIOLOGY

Credits: 3

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

COURSE OBJECTIVES: To 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 mechanisms of metabolic control and molecular signaling.

COURSE CONTENT

MODULE I: Proteins, Carbohydrate, Enzymes and Lipids: The molecular logic of Living Organism, The chemical unity of diverse living organism, Composition of living organisms. Proteins: General structural design. Amino acids and peptides, Amino acid metabolism, Protein structure and folding, primary, secondary, tertiary structure, unfolding, refolding, quaternary structure-hemoglobin, domains and motifs, ramachandran plot. Carbohydrates – structure and biological function, Regulation of carbohydrate metabolism, glycogenesis, gluconeogenesis. Enzymes : classification of enzymes. Specificity of enzyme action. Allosteric enzymes, enzyme inhibition and regulation of enzyme activity. Enzyme kinetics. Factors affecting enzyme activity. Vitamins as Coenzymes. Isoenzymes (LDH) and multienzymes. Lipids : Saturated and unsaturated fatty acids. biosynthesis of fatty acids , Triglycerides, phospholipids, glycolipids. Sterols prostaglandins ,. Cholesterol metabolism.

MODULE II: Nucleic acids: Purine and pyrimidine derivatives. Nucleosides, nucleotides and internucleotide linkages, Chemical nature of DNA and RNA. Biosynthesis and degradation of purine and pyrimidine nucleotides Biological functions of nucleic acids.

MODULE III: Cellular Metabolisms: Thermodynamics of cellular reactions. Redox potential. Energy rich compounds and their biological significance. Biological oxidation, Mitochondrial Electron transport, Oxidative phosphorylation and ATP synthesis. Chemiosmotic theory.

MODULE IV: Metabolic Cycles and Energy Production Glycolysis – A central pathway of glucose catabolism, TCA cycle and its significance. Hexose – Mono-phosphate shunt. Fatty acid oxidation, ketone bodies, ketosis and metabolism of ketone bodies. Glycogenolysis, Glycerol metabolism.

MODULE V: Synthetic Biology, Microarrays, Proteomics and the Proteome: Gradual maturation of Genomics and Proteomics into Biology, Convergence of Genomics, Proteomics, Transcriptomics and Metabolomics into Phenomics. Concept of gene expression, Comparative Genomics; Making, Microarrays-Spotted Microarrays, Insitu synthesized oligonucleotide arrays, RNA synthesis and splicing, Protein synthesis, Protein Engineering, Protein traffic in cells, Protein sorting and signal sequences

MODULE VI: Human Molecular genetics : Genetic mapping of human chromosomes, detection of mutations in human genes, determining gene function, pro-drug activation therapy

REFERENCES

- Anatomy and Physiology-Guyton
- Biochemistry by Voet and voet
- Biochemistry by Zubay Ralston. Int. Ed., McGraw-Hill Book Co
- Biochemistry, L. Stryer, W.H. Freeman, San Francisco.
- Enzymes by Palmer
- Enzymology by Dixon and Webb
- Essentials of Human Anatomy and Physiology- Elaine N.Marieb
- Fundamentals of Anatomy and Physiology- Martini
- Fundamentals of Enzymology by Price and Stevens
- Harper's Biochemistry by Murray, R.K., Granner, D.K., Mayes, P.A. & Rodwell, V.W.
- Human anatomy and physiology-Van Wynsberghe, Noback, Carola
- Human physiology- Rhoades and P flanzer.
- Principles of Biochemistry Vol. I & II (7thEdn.) by E.L.Smith, R.L.Hill et al
- Principles of Biochemistry, Lehninger C Rs. Publ. (1982).
- Problem Approaches in Biochemistry. Wood and Hood.
- Ralston. Int. Ed., McGraw-Hill Book Co.
- Schaum's Outline Series of Theory and Problems of Biochemistry, Philip W. Kuchel and G.B.

Semester : III

Course Code : ZOO-C-434 (Core)

Course Title : EVOLUTION AND ANIMAL BEHAVIOUR

Credits: 3

AIM: To introduce the nature and scope of various aspects of Evolution and Animal Behaviour.

COURSE OBJECTIVES: To demonstrate how the evolutionary principles can be applied to understand human behavior.

COURSE CONTENT:

MODULE I. Emergence of evolutionary thoughts and species, Earth and Origin of molecules of life: Lamarckism; Darwin concepts of variation, adaptation, struggle, fitness and natural selection, Mendelism, spontaneity of mutation, the evolutionary synthesis, Evolution as development of individual, different species and relation, similarity and pattern of evolution. Earth Changing Atmosphere, structure, movement of continents, Possible site for 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; evolution of prokaryotes; origin of eukaryotic cells; evolution of unicellular eukaryotes; anaerobic metabolism; photosynthesis and aerobic metabolism

MODULE II: Eukaryotic Organelles, Genes and Organisms: Organelles, Evolution of Eukaryotic Organelles, Gene Structure, Horizontal gene Transfer and trees of life, Evolution of Eukaryotes, Construction trees of life

MODULE III: Paleontology and evolutionary history: 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, Stages in primate evolution including Homo sapiens, Human Influences of Evolution, Cultural and Religion Evolution

MODULE IV: Natural Selection, Evolution and Molecular Evolution: Introduction, evolution by natural selection, Charles Darwin and Alfred Wallace, Voyages, Theories, 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, Molecular divergence and molecular clocks, Molecular tools in phylogeny, Classification and identification; Protein and nucleotide sequence analysis, Origin of new genes and protein, Gene duplication and divergence, Molecular phylogenetics, Methods and examples, Concerted evolution of multigene families, DNA polymorphism, Factors influencing molecular evolution, Role of mutation and selection in molecular evolution, Genome organization and evolution, Evolution of prokaryotes and eukaryotic genomes, C value Paradox, Tandem Repetitive Sequences

MODULE V: Demes, Gene Flow and Genetic Drift and Speciation

Population genetics, Gene pool, Gene frequency; Hardy-Weinberg law; Concepts and rate of change in gene frequency through natural selection, Migration and random genetic drift; adaptive radiation and modification; isolating mechanism, Phylogeography, Allopatricity and Sympatricity, Convergent Evolution, Sexual selection, Co-evolution, Variations. Variation and

selection for increased fitness, Ring Species, Hybrids and Hybridization, Speciation and Hybridization Zone, Frequency and Impact of Hybridization in Nature

MODULE VI: Animal Behaviour :Foundations: Natural Selection, Learning, Cultural Transmission, Conceptual, Theoretical and Empirical Approaches, Proximate and ultimate Perspectives, Social Learning, Altruism, Reciprocal altruism

Mating systems, Kinship, Cooperation, Foraging, Anti-predator behavior, Communication, Aggression, Play, Social dominance, Domestication and behavioural changes, Parental care. Memory, Cognition, Sleep and Arousal, Biological clocks, Migration, Orientation and Navigation, Latency, Summation, Fatigue, Inhibition, Mammalian Brain and coordination, Homing, Biological Rhythms

REFERENCES

- Evolution: From molecular to ecosystems.-Moya, Adres, etal; Oxford and IBH publishing, Calcutta (2006).
- Evolution: From molecular to ecosystems.-Moya, Adres, etal; Oxford and IBH publishing, Calcutta (2006).
- Principles of Animal Behaviour, Lee Alan, Dugatkin, W.W. Norton and Company, New York (2004)
- Ridley, Mark et al, 2ndedn Oxford University Press, Delhi (2007)
- Ridley, Mark et al, 2ndedn Oxford University Press, Delhi (2007).
- Strickberger's evolution-Hall, Brain and Hallgrimsson, Benedikt (4thedn). Jones and Bartlett publishers, London (2008)
- Strickberger's evolution-Hall, Brain and Hallgrimsson, Benedikt (4thedn). Jones and Bartlett publishers, London (2008).
- Structural approaches to sequence evolution: Molecules, networks, populations-Bastolla, go, et al. Springer vex lay (2007)
- Structural approaches to sequence evolution: Molecules, networks, populations-Bastolla, go, et al. Springer vex lay (2007).

Semester : III

Course Code : ZOO-C-435

Course Title : ENDOCRINOLOGY AND BIOCHEMISTRY-PRACTICAL

Credits: 2

AIM: To introduce the nature and scope of various laboratory practicals related with the theoretical aspects.

COURSE OBJECTIVES: To give hands on training on various laboratory methods in Biochemistry.

COURSE CONTENT:

MODULE I Biochemistry Practical

1. Estimation of proteins, Glycogen and Lipids in tissues.
2. Estimation of DNA using DPA method.
3. Estimation of RNA by orcinol method.

4. Quantification of DNA and RNA.
5. Estimation of lipid profiles.
6. Preparation of extract for enzyme assay (alkaline phosphatase)
7. Study of alkaline phosphatase
8. Analysis of urine for normal and Abnormal Constituents

MODULE II Endocrinology

1. Experimental induction of Beta galactosidase synthesis in Escherichia coli.
2. Demonstration of Genetic Recombination in Bacteria by process of Conjugation.
3. The Ames test: A Bacterial test system for Chemical Carcinogenicity.
4. Techniques of etherisation and sexing of Drosophila.
5. Study of chromosomal disorders in man.
6. Chromosome study –squash Preparation of Grasshopper testis.

Semester : III

Course Code : ZOO-E-436

Course Title : CUTANEOUS DISEASE AND BIOLOGY

Credits: 2

AIM: To introduce the nature and scope of various aspects of tropical cutaneous diseases of man.

COURSE OBJECTIVES: The students will be introduced on the details such as principles and procedures of various instruments used in the biological laboratories for the measurements/ estimations/observations etc.

COURSE CONTENT

MODULE I: Cutaneous System:Integument as an Organ, Layers of Integument, Physiology of Integument (Physical Protection, Hydro regulation, Thermoregulation, Cutaneous Absorption, Communication) Epidermal Derivatives (Hair, Nails, Glands), Physiology of Wound Healing, Inflammatory Conditions, Skin Grafting and Therapies

MODULE II: Tropical Cutaneous biology, Diseases, Diagnosis and Treatment:Papular lesions (Insects bits, Onchocerciasis), Subcutaneous Lesions, Bacterial skin infections, Parasite and Ectoparasite infections, Fungal Infections, Diseases Caused by Virus, Non-infectious skin problems in the tropics (Acne vulgaris, Eczema, Psoriasis, Atopic dermatitis, Lichen Planus, Pigmentary Disorders, Melanoma, Urticaria, Leprosy, Lymphedema), Hair disorders (Scarring and Non Scarring Alopecia), Nail Disorders

MODULE III: Role of Omics and Stem cells:Genomics, Proteomics and Metabolomics using biomarker analysis, Stem cell therapy, Environmental, Oxidative stress, Mitochondrial Dysfunction, Comorbidity diseases

REFERENCES

- Chromosome study –squash Preparation of Grasshopper testis
- Demonstration of Genetic Recombination in Bacteria by process of Conjugation.
- Experimental induction of Beta galactosidase synthesis in Escherichia coli.
- Study of chromosomal disorders in man.
- Techniques of etherisation and sexing of Drosophila.
- The Ames test: A Bacterial test system for Chemical Carcinogenicity.

Semester : III

Course Code : ZOO-E-437

*Course Title : **FIELD COURSE-ZOOLOGY***

Credits: 2

AIM: To introduce the nature and scope of various aspects of field visits, collection and preservation of biological specimens.

COURSEOBJECTIVES: The students will be introduced on the details such as principles and procedures of field visits, surveys, collection, preservation, observation etc.

COURSE CONTENT:This course work requires submission of a report based on collection, identification and preservation of selected specimens collected from the field.

Semester : IV

Course Code : ZOO-C-441

*Course Title : **APPLIED ZOOLOGY: ENTOMOLOGY, AQUACULTURE, ANIMAL HUSBANDRY AND BIO-ENTREPRENEURSHIP***

Credits: 4

AIM: To introduce the nature and scope of various aspects of Entomology and pest control and management.

COURSE DESCRIPTION: The students will be introduced on the various aspects of entomology such as insect classification, identification, insect biology, insect collection, pest control measures and pest management.

COURSE CONTENT:

MODULE I :Entomology, Anatomy and Physiology of Insects:Origin of Insects, classification, Phylogeny, Morphology and Anatomy. Structure and Function of Insects, integument, nervous system, muscular system, alimentary canal and nutrition, reproduction & development, sensory mechanisms, locomotion, behavior and

ecology, circulatory system, insect populations and their physical-chemical and biotic environment, insect –host plant reaction ,Growth and metamorphosis, Insects Adaptations.

MODULE II :AppliedEntomology:Beneficial and harmful insects, Insect products, Use of insects in medicine, Insects in biological research, Pollination by insects, Forensic entomology, Agricultural entomology, Aquatic entomology, Harmful insects, Insecticides, Biological control, Genetic control, Ecological control, Physical control, Regulatory control, integrated pest management, Collection, Preservation, Curation and Identification of insects.

MODULE III :AquacultureTechnology:Freshwater, brackish water, marin aquaculture, culture of fish food organisms, Water Quality Requirements for Aquaculture- Role of temperature, pH, salinity, dissolved oxygen, ammonia, nitrite, nitrate, phosphate, Biological oxygen demand and Chemical oxygen demand in aqua farms.

MODULE IV :Application of Aquaculture:Integrated farming, aquaculture engineering, Nutrition of aquatic animals, Genetics in aquaculture, Environmental impact of aquaculture.

.:Commercial Dairy Farming, General problems of sheep, goat, pigs and poultry management, Milk Product Technology, Milk Product Technology, Breeding systems Heritability, Native breeds, Genetically modified breeds.

MODULE VI : Introduction and Importance:The definition of a university spinoff, Examples of university spinoffs, Importance, Historical perspective of spinoffs, Reasons to establish university spinoffs. Factors influencing University spinoffs, Types of technologies initiates University spinoffs, Intellectual Property and Spinoffs, Spinoffs and company creation, Financing and Marketing University Spinoffs.

REFERENCES

- Academic Entrepreneurship, University Spinoffs and Wealth Creation, Shane. S, Edward Elgar Publishing, 2005
- Applied Entomology. D.K.Varma. Mital publications, New Delhi .262 pp.
- Aquaculture and Fisheries Biotechnology Genetic Approaches, Dunham, R. A., CABI Publishing, USA
- Aquaculture Principles and Practices, Pillay, T. V. R., Blackwell Publishing, USA
- Entomology at a Glance. R.C. Saxena & R.C. Srivastava. Agroteh Publishing Academy, Udaipur.
- Fish ponds in Farming Systems, Zijpp, V. D., Verreth, J. A. J., Tri, L. Q., van Mensvoort, M. E. F., Bosma, R. H., and Beveridge, M. C. M., Wageningen Academic Publishers, Netherlands
- Fundamentals of Applied Entomology Robert E.Pfadt (ed). Mac Millan Company, New York 692 pp.
- Fundamentals of Entomology. R.J. Elzinga, 5 th Ed. Prentice Hall College, New Jercey.528 pp.
- General and Applied Entomology .V.A. Little, Oxford & IBH Publishing Co.
- General and Applied Entomology. T.N. Ananthakrishnan and B.V. David. Tata Mc Graw - Hill Publishing Co. New Delhi, 1161 pp. II edn.
- The Insects: Structure & Function. R.F.Chapman. 4 thEd.Cambridge University Press. 800 pp.
- The Science of Entomology. W.S. Romoser& J.G. Stoffolano Jr. 4 th Ed Mac Graw Hill.

Semester : IV

Course Code : ZOO-C-442

Course Title : **BIODIVERSITY AND CONSERVATION BIOLOGY**

Credits: 3

AIM: To introduce the nature and scope of various aspects of Biodiversity and its conservation and management.

COURSE OBJECTIVE: The students will be introduced on the various aspects of global and national biodiversity richness, its measurements, erosion problems and its conservation for the future generations.

COURSE CONTENT:

MODULE I :Biodiversity:Definition, historical and geographical causes for diversity, Genetic diversity, Species diversity and ecosystem diversity. Quantifying biodiversity, Maintenance of biodiversity, Biodiversity hot spots.

MODULE II :Assessing, Analysing and documenting biodiversity, Vulnerability and extinction of bio- diversity, Introduction to biodiversity database: endangered animals, endemism and Red data books, Global biodiversity information system, Intellectual Property Rights (IPR), Sovereignty rights, CBD.

MODULE III : Valuing biodiversity: Economic evaluation, Natural resource loss, Direct, indirect and ethical values of biodiversity. 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, degradation and global climate change. Overexploitation, Invasive species and diseases, Overview and causes of recent extinctions, Western Ghats- origin and biodiversity

MODULE:IV Conservation Biology.Essential concepts for small populations, Method for studying populations, Population variability analysis, Establishing new populations.

MODULE V :Ex-situ conservation strategies, Restoration ecology, Evaluation of priorities for species and habitats: Choosing species to protect: Species quality, Conservation indices, Hotspots for conservation, Major tropical wilderness areas and Eco regions, World heritage sites, Management of Natural Habitats.

MODULE VI:ContinentalBiomes, Management of oceanic islands, Management of aquatic habitats, Management of fragmented habitats, zonation and biosphere reserves. Management of species:Metapopulations, Application of genetics in Conservation of biodiversity, Population viability analysis, establishing new populations, *In situ* and *Ex situ* methods, Restoration ecology. Impact of climate change on Biodiversity consideration and application of GIS in conservation of biodiversity and ecosystems

REFERENCE

- Ecology and Tropical biology, Ian Deshmukh, Blackwell Scientific Publication, 1986.
- Ecology-A Bridge Between Wcience and Society, E. P. Odum, Sinauer Associates Inc. Publishers, 1996.
- Global Biodiversity, R.K.Sinha and D. Singh, INA Shree Publishers, India, 1997.
- Indian Wildlife-Threats and Prseervations, B.D.Sharma. Anmol Publications Pvt. Ltd. India, 2002.
- Man and the Ecosystem, J.R.Lloyd, Macmillan Education Ltd. 1984.
- Marine Biodiversity, Ormond et. al. Cambridge

- MegaDiversity Conservation, A. B. Chaudhary and D.D. Sarkar, Daya Publishing House, 2003.

Semester : IV

Course Code : ZOO-C-443

Course Title : **INSTRUMENTATION AND RESEARCH METHODOLOGY**

Credits: 3

AIM: To introduce the nature and scope of various aspects of Research Methodology and the usage and application of various instruments in biological laboratories.

COURSE OBJECTIVES: The students will be introduced on the various aspects of research methods and research reporting and application and use of various instruments in the research labs.

COURSE CONTENT:

Instrumentation

MODULE I: Microscopy, Cell fractionation and Separation methods Principle, structural parts and applications of compound microscope, phase-contrast microscope, fluorescent microscope, Confocal Laser Scanning Microscopy, transmission electron microscope and scanning electron microscope, 2-Photon Excitation Microscopy microscope, Staining techniques. Different mechanical and chemical procedures, Centrifugation and ultracentrifugation methods and applications, structural parts of an analytical ultracentrifuge, Cell Culture, Principles and Applications of Flow cytometry.

MODULE II: Spectrophotometry, Colorimetry and its applications, NMR and ESR spectroscopy, Different types of mass spectrometry, Principles of chromatography, paper chromatography, thin layer chromatography, gas chromatography, gel permeation chromatography, ion exchange chromatography, high-pressure liquid chromatography and affinity chromatography

MODULE III : Principle of electrophoresis, paper electrophoresis, polyacrylamide gel electrophoresis, Disc gel electrophoresis, and SDS-PAGE, gel electrophoresis, 2D gel electrophoresis, Southern transfer, Northern transfer and Western transfer, ELISA. Immunocytochemistry and Immunohistochemistry. Omics Tools. Microarray, Next-generation Sequencing, Protein Array, Genome wide analysis.

MODULE IV: Introduction to Research Methodology: Meaning of Research, Objectives of Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method Criteria of Good Research, Problems Encountered by Researchers in India

MODULE V: Research Problem Defining : What is a Research Problem, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem An Illustration.

MODULE VI: Research Design : Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different

Research Designs, Basic Principles of Experimental Designs

REFERENCE

- Research Methodology in the Medical and Biological Sciences, Petter Laake, Haakon Breien Benestad, Bjorn Reino Olsen, Academic Press Inc; 2015
- Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, John W. Creswell, 2008, SAGE Publications
- Research Methodology: Methods and Techniques, C R Kothari, Gaurav Garg, New Age International Publishers, 2014
- Research Methodology: For Biological Sciences, N Gurumani, 2011, Mjp Publishers
- Encyclopaedia of Research Methodology in Biological Sciences, Richa Arora, 2004
- Research Methodology: A Step - by - Step Guide for Beginners, Ranjit Kumar, 2011, SAGE South Asia edition
- Research Methods: The Essential Knowledge, William Trochim, James P Donnelly, Kanika Arora, 2015

Semester : IV

Course Code : ZOO-D-444

Course Title : DISSERTATION

Credits: 6

AIM: To impart training for each student to formulate and carry out the goals of a small research topic. The students will be benefitted to learn the basics of scientific inventions and understand research methodology for the future and select to practice science as a carrier.

COURSE CONTENT ; Each student has to be allotted to different labs and they have to carry out independent research works and submit the dissertation in time to the Department. The dissertations will be evaluated by the External Examiner selected by the University for the evaluation of the IV semester Examination.

Electives(Externals)

Course Code : ZOO-X-411

Course Title : **STRESS PHYSIOLOGY**

Credits: 2

AIM: To introduce the nature and scope of various aspects of stress physiology.

COURSE OBJECTIVES: The students will be introduced on the various aspects of stress physiology in lower and higher organisms and the physiology of stress adaptation and management

COURSE CONTENT

MODULE-I: Definition and Scope: Concept of stress physiology, implementation on physiological process, the phenomenon of stress, stressor and stress response

MODULE-II: Neuroendocrine control of stress response, Stress hormone, eustress, distress chronic and acute stress, BSC and HPA axes

MODULE-III: Ease response, ease hormone, physiological process that promote ease response

MODULE-IV: Endocrinology of stress and ease, endocrine disruptors, stress adaptation and tolerance, stress proteins, Morphological and Physiological basis of stress adaptation, hormonal control of stress tolerance, molecular mechanism of stress adaptation in aquatic and terrestrial animals, stress resistance, stress avoidance.

MODULE-V: Stress and Ease Physiology - water and mineral balance, acid/base balance, energy metabolism

REFERENCE:

- Animal Physiology, Eckart.
- Cell Physiology, A.G. Giese, W.B. Saunders & Co. New York
- Stress Physiology, D.P. Singh.
- Stress Physiology in Animals, Paul H. M. Balm.

Course Code : ZOO-X-421

Course Title :BIODIVERSITY

Credits: 2

AIM: To introduce the nature and scope of various aspects of Biodiversity and its conservation.

COURSE OBJECTIVE: The students will be introduced on the various aspects of global and regional biodiversity, its richness and erosion and its conservation and management.

COURSE CONTENT:

MODULE I: Biodiversity : An introduction, Biodiversity Convention, objectives Biodiversity of the world, Biodiversity of India, endemic species, biodiversity resource, resource utilization and conservation.

MODULE II : Methodology in biodiversity studies, Ecological monitoring-purpose means ground monitoring population studies, cyclic changes in behavior, Indices of species diversity.

MODULE III : Managing natural areas in tropics, Features of areas to be protected, categories of protected areas, in gene banks, island biogeography theory and protected area management. Economics of biodiversity,

MODULEIV :Threatened categories, red data books, threatened mammals of India, economics of biodiversity conservation.

READING LIST

- 1.Man and the Ecosystem, J.R.Lloyd, Macmillan Education Ltd. 1984.
2. Ecology and Tropical biology, Ian Deshmukh, Blackwell Scientific Publication, 1986.
3. Ecology-A Bridge Between Wcience and Society, E. P. Odum, Sinauer Associates Inc. Publishers, 1996.
4. MegaDiversity Conservation, A. B. Chaudhary and D.D. Sarkar, Daya Publishing House,2003.
5. Global Biodiversity, R.K.Sinha and D. Singh, INA Shree Publishers, India, 1997.
6. Indian Wildlife-Threats and Prseervations, B.D.Sharma. Anmol Publications Pvt. Ltd. India, 2002.
7. Marine Biodiversity, Ormond et. al. Cambridge

Course Code : *ZOO-X-431*

Course Title : *TROPICAL CUTANEOUS BIOLOGY AND DISEASES*

Credits: 2

AIM: To introduce the nature and scope of various aspects of tropical cutaneous diseases and biology.

COURSE OBJECTIVE: The students will be introduced on the various types of cutaneous diseases and causative agents.

COURSE CONTENT

MODULE I: Cutaneous System :Integument as an Organ, Layers of Integument, Physiology of Integument (Physical Protection, Hydro regulation, Thermoregulation, Cutaneous Absorption, Communication) Epidermal Derivatives (Hair, Nails, Glands), Physiology of Wound Healing, Inflammatory Conditions, Skin Grafting and Therapies

MODULE II: Tropical Cutaneous biology, Diseases, Diagnosis and Treatment :Papular lesions (Insects bits, Onchocerciasis), Subcutaneous Lesions, Bacterial skin infections,Parasite and Ectoparasite infections, Fungal Infections, Diseases Caused by Virus, Non-infectious skin problems in the tropics (Acne vulgaris, Ezcema, Psoriasis, Atopic dermatitis, Lichen Planus, Pigmentary Disorders, Melanoma, Urticaria, Leprosy, Lymphedema), Hair disorders (Scarring and Non Scarring Alopecia), Nail Disorders

MODULE III: Role of Omics and Stem cells :Genomics, Proteomics and Metabolomics using biomarker analysis, Stem cell therapy, Role of Environmental Factors, Oxidative stress, Mitochondrial Dysfunction, Comorbidity diseases.

REFERENCES

- Clinical Dermatology: A Color Guide to Diagnosis and Therapy: by Habif
- Guyton and Hall Textbook of Medical Physiology, 13e (Guyton Physiology) 13th Edition by John E. Hall PhD (Author)
- Hair Growth and Disorders: Ulrike Blume-Peytavi (Editor), David A. Whiting (Editor), Ralph M. Trüeb (Editor)

- Hair in Toxicology: An Important Bio-Monitor Editor: Desmond John Tobin
- Medical Physiology, 3e by Walter F. Boron MD PhD (Author), Emile L. Boulpaep MD (Author)
- Textbook of Medical Physiology, 11th Edition With STUDENT CONSULT Online Access Authors: John Hall Arthur Guyton John Hal