PROF. RAJENDRA SINGH (RAJJU BHAIYA) UNIVERSITY, PRAYAGRAJ

Structure of Syllabus for the

Program: M.Sc. Subject: ZOOLOGY

Structure of Syllabus Developed by			
Name of BoS Convener/BoS Member	**Designation**	**Department**	**College/ University**
Prof. Archana Sinha (Convenor)	Dean Science		K A P G College, Prayagraj
Dr. Girijesh Shukla (Member)	Assistant Professor	ZOOLOGY	DDU Govt. P.G. College Saidabad Prayagraj
Dr. Neelam Bajpai (Member)	Assistant Professor	ZOOLOGY	Mahamaya Govt. Degree College Kaushambi
Prof. K P Singh (Subject Expert)	Professor	ZOOLOGY	Allahabad University, Allahabad
Dr. Anuradha (Subject Expert)	Assistant Professor	ZOOLOGY	C M P College, Prayagraj
Prof. Shri Prakash (Special Invitee)	Professor	ZOOLOGY	K A P G College, Prayagraj
Dr. A K Verma (Special Invitee)	Assistant Professor	ZOOLOGY	DDU Govt. P.G. College Saidabad, Prayagraj

Course Code		**Course Title**	**Credits**	**T/P**	**Evaluation**	
					CIE	**ETE**
A	**B**	**C**	**D**	**E**	**F**	**G**
SEMESTER I (YEAR I)						
B050701T	**Core**	Non-Chordata	5	T	25	75
B050702T	**Core**	Ecology and Environmental Biology	5	T	25	75
B050703T	**Core**	Cytogenetics	5	T	25	75
B050704T	FIRST` ELECTIVE (Select any one)	Toxicology	5	T	25	75
B050705T		Immunology				
B050706P	SECOND ELECTIVE (Select as per first elective)	Practical /Field Visit/Project Presentation	4	P	50	50
B050707P		Practical /Field Visit/Project Presentation				
SEMESTER II (YEAR I)						
B050801T	**Core**	Chordata and Comparative Anatomy	5	T	25	75
B050802T	**Core**	Biostatistics and Evolutionary Biology	5	T	25	75

B050803T	**Core**	Biodiversity and Wildlife Conservation; Economic Zoology	5	T	25	75
B050804T	THIRD ELECTIVE (Select any one)	Fish and Fisheries: Taxonomy, Anatomy and Physiology	5	T	25	75
B050805T		Entomology: Insect Diversity, Agriculture and Medical Entomology				
B050806T		Cell Biology: Structure and Function of Cell and its Organelles				
B050807P	FOURTH ELECTIVE (Select as per third elective)	Practical /Industrial Training/Project Presentation	4	P	50	50
B050808P		Practical /Industrial Training/Project Presentation				
SEMESTER III (YEAR II)						
B050901T	**Core**	Animal Physiology and Biochemistry	5	T	25	75
B050902T	**Core**	Computational Biology and Bioinformatics	5	T	25	75
B050903T	**Core**	Biological Tools and Techniques; Molecular Taxonomy	5	T	25	75
B050904T	FIFTH ELECTIVE (Select any one)	Fish and Fisheries: Fishery Science and Management	5	T	25	75
B050905T		Entomology: Insect Physiology and Toxicology				
B050906T		Cell Biology: Cell Communication Systems				
B050907P	SIXTH ELECTIVE (Select as per fifth elective)	Practical /Project Presentation	4	P	50	50
B050908P		Practical /Project Presentation				
SEMESTER IV (YEAR II)						
B051001T	**Core**	Developmental Biology and Animal Behaviour	5	T	25	75
B051002T	**Core**	Biotechnology and Molecular Biology	5	T	25	75
B051003T	SEVENTH GENERIC ELECTIVE (Select any one)	Waste Management and Sustainable Development	4	T	25	75
B051004T		Human nutrition and Neutraceuticals				
B051005T		Public health and Hygiene				
B051006T		Natural Resources and Management				
B051007R	RESEARCH PROJECT/ DISSERTATION	Major Research Project/ Dissertation	10	R	50	50

NOTE:

1. **Do not mark any Code/Information in Column-A, it will be indorsed by the University.**
2. **T/P**in Column-E stands for **Theory/Practical**.

3. **CIE** in Column-F stands for **'Continuous Internal Evaluation'** and depicts the maximum internal marks. Respective examination will be conducted by subject teacher.
4. **ETE** in Column-G stands for **'External Evaluation'** and depicts the maximum external marks. Respective Examination will be conducted by the University.
5. Column-B defines the nature of course/paper. The word **CORE** herein stands for **Compulsory Subject Paper**.
6. Column-D depicts the credits assigned for the corresponding course/paper.
7. **First Elective:** It will be a Subject Elective. Students may select one of the two subject papers under this category.
8. **Second Elective:** It will designate a Practical Paper or equivalently a Field Visit or Project Presentation. In case of Field Visit, student is required to submit a detailed report of the visit for the purpose of evaluation. The report should include the observational features and benefits of the visit. In case of Project Presentation, the student may be assigned to go for a survey/practical or theoretical project/assignment or seminar with presentation.
9. **Third Elective:** It will be a Subject Elective. Students may select one of the two subject papers under this category.
10. **Fourth Elective:** It will accommodate a practical paper or Industrial Training or Project Presentation. In case of Industrial Training, student may be allowed for the summer training and is required to submit a detailed training report including training certificate for the evaluation.
11. **Fifth Elective:** It will be a Subject Elective. Students may select one of the two subject papers under this category.
12. **Sixth Elective:** It will be a Practical Paper or equivalently a Project Presentation based on Survey/ Seminar/ Assignment. In case of Project Presentation, student has to submit an exhaustive report on respective topic and to face an open presentation for the evaluation.
13. **Seventh Elective:** It will be a **Generic Elective**. The student may study or receive training of the any subject of his interest (depends on the availability in his institution of enrollment).
14. **Master Research Project:** It will be a Major Research Project or equivalently a research-oriented Dissertation on the allotted topic. The student will have to complete his/her research project under any supervisor. The supervisor and the topic for research project shall be allotted in second semester. The student straight away will be awarded 05 credits if he publishes a research paper on the topic of Research Project or Dissertation.

M.Sc. Zoology Semester I

Core Paper I: Non-Chordata

Unit I

General characters and Classification of major Invertebrate phyla. Protozoa: Locomotion, nutrition and reproduction, protozoans and human diseases; Porifera: Affinities of Porifera, Skeleton and canal system; Coelenterata (Cnidarians): Polymorphism, Coral and coral reefs, Alternation of generation.

Unit II

Platyhelminthes: Evolution of Parasitism, Host-parasite relationship, Parasitic adaptations. Annelida: Adaptive radiation in Polychaeta, Segmental organ in Annelida, Metameric segmentation.

Unit III

Arthropoda: Mouth parts of insect and mode of feeding habits, Larval forms in Crustaceans, Insect metamorphosis and its hormonal control, Basic concepts of Insect Pest Management, Mollusca: Archimollusca (Ancestral Mollusca), Torsion and detorsion in Gastropods.

Unit IV

Echinodermata: Affinities of Echinodermata, Water vascular system, Larval form and its significance, Hemichordata: Affinities of Hemichordata, Larva of *Balanoglossus*.

Suggested Books:

1. Text book of Invertebrates: R.L. Hyman.
2. Text book of Invertebrates: R.L. Kotpal.
3. Biology of the Invertebrates: Pechenik, Jan A.
4. Non Chordata: Meglitsch Paul A.
5. Text book of Zoology Vol.- I: Parker T.J. and Haswell, W.A.
6. Moore: An Introduction to the Invertebrates.
7. Invertebrate: Protozoa to Echinodermata: Ashok Verma
8. A Handbook of Zoology: A.K. Verma
9. Invertebrate Zoology: R.D. Barnes.
10. Minor Phyla : R.L. Kotpal.

M.Sc. Zoology Semester I

Core Paper II: Ecology and Environmental Biology

Unit I

Concepts of Ecosystem and their types, Marine shores and eschuaries, fresh water, terrestrial, grassland, forest, desert and parasitic habitat, Ecological adaptations, Concept of homeostasis, Environmental stress and strain, acclimation and acclimatization.

Unit II

Conservation of natural resources, Demography, life table , generation time, net reproductive rate and reproductive volume, Life history strategies, evolutions of sex and mating systems, optimal size, r and k selection, population dynamics and its regulation.

Unit III

Pollution monitoring schemes with special reference to bioindicators and prediction of ecological effects, Environmental diseases with special reference to carcinogenesis and radiation injuries, Management of industrial and biomedical wastes, Socio economic aspects of environmental policies and practices.

Unit IV

Ozone depletion, Global warming, Summits for control of green house gases, Challenges of climate change, Nuclear winter, Environmental laws with special reference to air, water and sound.

Suggested Books:

1. Clark: Elements of Ecology
2. Odum: Ecology
3. Verma and Agrawal: Environmental Biology
4. C.J.Krebs: Ecology
5. Allan Frewin Jones: Environmental Biology

M.Sc. Zoology Semester I

Core Paper III: Cytogenetics

Unit I

Basic Principles of Heridity, Penetrance and Expressivity, Various types of Sex determination, Lethal genes, Sex-linked inheritance, Sex-limited and Sex-influenced characteristics, Sex chromosome, Multiple alleles.

Unit II

Transposable elements in prokaryotes and eukaryotes, Role of transposable elements in genetic regulation, Cytoplasmic inheritance, Genetic maternal effects, Interaction between genes and environment: Environmental effects on gene expression.

Unit III

Microbial genetics: Bacterial transformation, transduction, conjugation, bacterial chromosome, bacteriophages, Chromosome mapping, Molecular cytogenetic techniques (FISH, GISH, chromosome painting), flow cytometry.

Unit IV

Elements of Eugenics, Imprinting of genes, Human karyotype, Structural and numerical aberrations of chromosomes, Patterns of inheritance (Autosomal dominant and recessive, X-linked dominant and recessive).

Suggested Books:

1. Lodish et al: Molecular Cell Biology
2. Alberts et al: Molecular Biology of cell
3. Karp: Cell and Molecular Biology
4. Lewin B Genes VIII
5. Primrose. Molecular Biotechnology
6. Frederick Hecht: Textbook of Cytogenetics
7. Snusted: Principles of Genetics
8. Klug and Cummings: Concepts of Genetics

M.Sc. Zoology Semester I

Elective Paper I: Toxicology

Unit I

Definition, nature and scope of toxicology, History and sub-divisions of toxicology, Sources of toxic substances in the environment, Classification of toxic agents, natural toxins, animal and plant toxins, food toxins.

Unit II

Genetic poisons and chemical poisons, Dose effect and dose-response relationship, acute toxicity, chronic toxicity-reversible and irreversible effects, Factors affecting toxicity- species and strains, age, sex, nutritional status, hormones, environmental factors. Toxicity tests: Acute toxicity tests for terrestrial and aquatic animals. Chronic toxicity test, Concept of maximum acceptable toxicants concentration (MATC) and safe concentration.

Unit III

Study of different types of insecticides including organophosphates, carbamates, botanical insecticides, Methods of application of insecticides, Hazards of insecticides, Precautions and antidotes, fumigants, Principles and concepts of Integrated Pest Management (IPM), Chemosterilants, Autocides including 3rd and 4th generation pesticides.

Unit IV

Radiation and chemical toxicology, chemical toxicants and their effects on industrial and agricultural wastes. Ecotoxicology; Ecological changes and disease, Principals of biological control- parasites, predators and pathogens affecting insect pests and the efficacy in controlling the insect pests.

Suggested Books:

1. Odum, E.P. Basic Ecology
2. Stiling, P. Ecology: Theories and Applications
3. Begon,M. Harper,J.L. & Townshend, C.R. Ecology
4. Kormondy, E.J. Concepts of Ecology
5. Grant, W.E. and Swannack: Ecological Modelling
6. Derelanko& Auletta: Handbook of Toxicology
7. Casarett & Doull`s: Toxicology: The Science of Poisons
8. P.D.Sharma: Toxicology
9. A.K. DE : Environmental Chemistry.

M.Sc. Zoology Semester I

Elective Paper II: Immunology

Unit I

Overview of immune system-Innate and adaptive immune system, Cells of immune system and their production, introduction to infectious disease, innate immunity to infection, adaptive immunity to infection.

Unit II

Humoral Immunity and cellular immunity, Antigen and haptens, Primary and secondary response, Antibody: types, structure, function, production and diversity.

Unit III

Innate immune system:The effector mechanisms of innate immune system, pattern recognition, complement system, antimicrobial peptides, cytokine production in response to viral, bacterial and parasitic pathogens, antigen processing and presentation.

Unit IV

Vaccines & Immuno-techniques, Vaccination: adjuvants, DNA vaccines, recombinant vaccines, bacterial vaccines, viral vaccines, vaccines to other infectious agents, passive & active immunization, Monoclonal antibodies, Introduction to different immunodiagnostic techniques like RIA, double diffusion, Mancini radial immunodiffusion, ELISA, Western blot.

Suggested Books

1. Alberts *et al*: Molecular Biology of cell (4th Edition) Garland Science, 2002
2. Kuby Immunology, 7th ed. 2018 edition, WH Freeman publisher

M.Sc. Zoology Semester I

Practical will be based on Core and Elective papers.

Internal Assessment: 50 marks

External Assessment: 50 marks

M.Sc. Zoology Semester II

Core Paper I: Chordata and Comparative Anatomy

Unit I

Origin and characters of chordates, General characters and affinities of protochordates, Distinctive Characters and Classification of Amphibia, Reptilia, Aves and Mammalia, Origin and evolution of Tetrapoda, Retrogressive metamorphosis in Urochordates, Interrelationship of Ostracoderms and Placoderms, General characters and affinities of Cyclostomata.

Unit II

General organisation and affinities of Holocephali, Crossopterygii and Dipnoi, origin and evolution of paired fins in Teleosts, Origin and evolution of lung fishes (Dipnoans), Migration in fishes, Neoteny and paedogenesis in axolotl larva, Parental care in amphibians.

Unit III

Origin and evolution of reptiles, Adaptive radiation in reptiles, Rhynchocephalia, Bird are glorified reptiles, Aerodynamics in birds, Bird migration, Arial adaptations in birds, Flightless birds, General characters and affinities of Prototherians, Aquatic and volant mammals and their adaptations, Adaptive radiations in mammals.

Unit IV

Comparative anatomy of different systems of Vertebrates: integumentary, digestive, respiratory, skeletal, circulatory, excretory, reproductive and nervous systems.

Suggested Books:

1. The Life of Vertebrates: Z J Young
2. The Phylum Chordata: H.H. Newman
3. Textbook of Zoology Vertebrates: Parkar and Haswell
4. An Introduction to The Vertebrates: L. A. Adams
5. Introduction to Chordates: T.C. Majupuria
6. The Vertebrate Life: Harvey et al
7. A Handbook of Zoology: A.K. Verma
8. Evolution of the Vertebrates: E.H . Colbert
9. A Text Book Zoology Vertebrates: R.L. Kotpal
10. The Vertebrate Body: Romer and Parson

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M.Sc. Zoology Semester II

Core Paper II: Biostatistis and Evolutionary Biology

Unit I

Sampling techniques: methods of sampling, choice of sampling methods, sampling and non-sampling errors, Diagrammatic and graphic representation of data and their significance and limitations, Measures of dispersion: variance and standard deviation.

Probability: Theory and application, Probability distribution: normal, binomial and Poisson; Probit analysis; Correlation, Linear and non-linear regression.

Unit II

Tests of significance:Student's t-test, Analysis of variance: One-way and Two-way analysis of variance (ANOVA), F-test, null hypothesis and chi-square test.

Experimental design: Basic concepts and principles, completely randomized design (SRD) and randomized complete block design (RCD), Latin square design (LSD) and confounding; Interferential biostatistics: statistical estimation, confidence intervals and fiducially limit.

Unit III

Concept of organic evolution, Facts and theories of evolution: during pre- and post-Darwin era. Developments and concept of synthetic theory of evolution, Elemental forces of evolution, Mutation, Selection, Migration, Role of hybridization in evolution, Reproductive Isolation and Isolating mechanisms.

Unit IV

Biological species concepts, Models of speciation (allopatric, peripatric, parapatric, and sympatric), Genetic drift: gene frequency in small population, Population genetics: Gene frequencies in Mendelian population, Hardy-Weinberg Law and Sewall Wright effect, Maintenance of genetic equilibrium, Heredity and evolution, Ecology and evolution.

Suggested Books:

1. George W. Snedecor, William G. Cochran. Statistical Methods.
2. Frederick Emory Croxton, Dudley J. Cowden. Applied General Statistics.
3. Spiegel, M.R.: Theory & Problems of Statistics, Schaum's outline series,
4. Spiegel, M.R.: Probability and Statistics.
5. Marylees Miller, Irwin MillerFreund, John, E.'s Mathematical Statistics with Applications.
6. Strickberger, M.W. Evolution.
7. Futuyama. D.J.Evolution.
8. Lull, R.S. Organic Evolution.

9. Rastogi, Veer Bala, Organic Evolution
10.Bendre and Kumar, Organic Evolution

M.Sc. Zoology Semester II

Core Paper III: Biodiversity and Wildlife Conservation; Economic Zoology

Unit I

Concepts and values of Biodiversity, Levels of Biodiversity: Species diversity, Genetic diversity and Ecosystem diversity, Causes of loss of biodiversity including anthropogenic activities, Biodiversity hot spots with Indian context, Red Data book, Nine categories of IUCN Red List, An introduction to Mega diverse countries, Biodiversity board, authority and conservation act.

Unit II

An introduction to Wild life, Necessity of wild life conservation, Wild life conservation methods: in situ and ex-situ; programmes and strategies, Protected areas: Sanctuaries, National parks and Biosphere Reserves (with Indian context), Threatened animal species, Various Animal Conservation Projects: Project Tiger, Project Crocodile and Project Hangul, Wild life (Protection) Act, Eco-tourism.

Unit III

Basic concepts and principals of economic importance of different groups of animals Apiculture, Sericulture, Lac culture, Pearl culture, Prawn culture, Poultry, Livestocks and Dairy management.

Unit IV

Vermiculture and Vermicomposting, Edible fresh water fishes, Aquaculture and Pisciculture, By products of fishing industry, Economic importance of fishes.

Suggested Books:

1. Methods and Practice in biodiversity Conservation: David Hawks worth.
2. A Text Book of Biodiversity: K.V. Krishnamurthy.
3. Wildlife of India: V.B. Saharia.
4. Wildlife Management Manual: Robert Giles.
5. Text book of Wild life Management: S.K. Singh.
6. Applied and Economic Zoology: Shukla and Upadhyay.
7. Applied Zoology: Balwan and Verma
8. Poultry Farming: Balwan and Verma.
9. Economic Zoology: Herbert Osborn.
10. Animal Behaviour and wild life: Awasthi, Singh and Srivastava.
11. Applied and Economic Zoology: Deshmukh et al.

M.Sc. Zoology Semester II

Elective Paper I: Fish and Fisheries: Taxonomy, Anatomy and Physiology

Unit-I

Classification: Systematic and classification of Elasmobranches, Holocephalians, Dipnoans and Actinopterygians including the ancestral groups of Acanthodians, Placoderms and Crossopterygians.

Origin and evolution of major groups of fishes. General features, origin and evolution of the skin, scales and fins of teleosts.

Unit II

Adaptation: Major adaptations developed in teleosts with special reference to hill stream and deep sea fishes.

Specialized organs: Important specialized organs developed in fishes; Electric organs, Bioluminescence, Air bladder and Weberian apparatus, Lateral line organs and poison glands.

Endocrine glands: Major endocrine glands found in fishes with special reference to reproduction and migration.

Unit III

Anatomy and Physiology: General features, anatomy and physiology of internal organs of teleosts; Alimentary canal and digestion, Excretion and osmoregulation, Reproductive organs and reproduction, Respiratory organs and mechanism of respiration, Blood circulation and aortric arches, Sensory organs and nervous system, Central and peripheral skeletal system.

Unit IV

Embryonic development: Fertilization, Zygote formation, Stages of embryonic development, Organogenesis, Hatching and larval development; Viviparity in fishes.

Fish Behavior: Migratory behavior of Salmon and Eel and their hormonal regulation; Courtship behavior, Parental care and nest building, Air-gulping behavior in air-breathing fishes.

Suggested Books:

1. Datta Munshi, J.S. and M.P. Srivastava, Natural History of Fishes and Systematic of Fresh Water Fishes of India.
2. Jayaram KC, Fundamentals of Fish Taxonomy.
3. Hoar WS, Randall DJ and Donaldson EM, Fish Physiology
4. Gupta S.K. and Gupta P.C., General Applied Ichthyology.

5. Srivastava, C.B.L. A Text book of Fishery Science and Indian Fisheries.
6. Lagler, Ichthylogy.
7. Norman, J.R., History of Fishes.
8. Kyle, H.M.A., Biology of Fishes.
9. Khanna, S.S., An Introduction to Fishes.
10. C B L Srivastava : Soft anatomy

M.Sc. Zoology Semester II

Elective Paper II: Insect Diversity, Agricultural and Medical Entomology

Unit I

External characteristic features of insects, comparative study of antennae, mouth parts, legs and abdominal appendages in different orders of insects. Classification of insects up to sub families in economical important groups, origin and evolution of insects.

Unit II

Pest, Pest status, economic injury level, economic threshold, secondary pest outbreak, pest resurgence.Host-plant interaction by phytophagous insects. Bionomics and damages caused by insect pests of paddy, sugarcane, cotton, oilseeds, fruits, vegetables and stored grains. IPM, Physical, Chemical, Biological and Genetic (SIT), Biorational methods (Pheromones, JH mimics, MH agonists) in pest management.

Unit III

Organization and behaviour in social insects.Beneficial (honey bee, silkworm and lac insects) and medically important insects (fleas, lice, bugs, mosquitoes and flies), their biology and management.Mode of transmission of pathogens by insects.

Unit IV

Forensically important insects, Role of insects in criminal investigation, by predicting time and cause of death.

Suggested books:

1. A general text book of entomology, Imms , A. D., Chapman & Hall, UK
2. Principles of Insect Morphology, Snodgrass, R. E., Cornell Univ. Press, USA
3. The Insect Societies, Wilson, E. O., Harvard Univ. Press, UK .
4. Agricultural Insects pests of the tropics and their control, Hill, D. S., Cambridge University Press,
5. Medical Entomology for students, Service, M. Cambridge University Press, UK
6. A textbook of insect morphology, physiology and endocrinology, Temphare, D B, New Delhi, S. Chand and Co.
7. Agricultural pest of South Asia and their management by Atwal, A.S., Kalyani publishers.
8. Textbook on Agricultural Entomology. New Delhi, ICAR Publications.
9. Dynamics of insect plant interactions, Ananthkrisnanan, T.N. and Raman, A., Oxford and IBH publishing Co Pvt Ltd, New Delhi.

M.Sc. Zoology Semester II

Elective Paper III: Cell Biology: Structure and function of Cell and its Organelles

Unit I

The nucleus: The nuclear envelope, internal organization of the nucleus, the nucleolus, Plasma membrane: structure and chemical composition, movement of substances across the membrane.

Unit II

Protein shortening and transport: endoplasmic reticulum (the endoplasmic reticulum and protein secretion, export of protein and lipids from the ER), Golgi apparatus (organization of the Golgi complex, protein glycosylation, lipid and polysaccharide metabolism, protein sorting and export), Lysosomes (Ultrastructure, lysosomal acid hydrolases, endocytosis and lysosome formation, phagocytosis and autophagy).

Unit III

Bioenergetics and metabolism (mitochondria-organization and function, mechanism of oxidative phosphorylation), Peroxisomes and its functions, ultrastructure and functions of ribosomes.

Unit IV

Chromosome morphodynamics and achromatic apparatus in cell division, Physiology of a dividing cell, Apoptosis and natural cell death.

Suggested Books:

1. Cooper : Cell- a Molecular Approach
2. Lodish et al: Molecular Cell Biology
3. Watson et al: Molecular Biology of the gene
4. Alberts et al: Molecular Biology of cell
5. Karp: Cell and Molecular Biology
6. Lewin B Genes VIII
7. Primrose. Molecular Biotechnology
8. Sambrook et al: Molecular Cloning

M.Sc. Zoology Semester II

Practical will be based on Core and Elective papers.

Internal Assessment: 50 marks

External Assessment: 50 marks

M.Sc. Zoology Semester III

Core Paper I: Animal Physiology and Biochemistry

Unit I

Ultrastructure of muscle and its contraction, Nerve conduction and neurotransmitter, Heart function and its electrical conduction system, Transport of oxygen and carbon dioxide in blood and body fluids, Physiological response to oxygen deficient stress.

Unit II

Patterns of nitrogen excretion in different animal groups, Physiology of digestion in mammals, Concept of homeostasis: Thermoregulation in homeotherms, poikilotherms, hibernation and aestivation, Structure and functions of ovary and testis.

Unit III

Protein structure- Primary, secondary, tertiary: domain and motif and quaternary, Ramachandran plot, Enzyme kinetics, activation energy and transition stage,common features of active sites, enzyme specificity,Derivation of Michaelis-Menten equation, regulation of enzyme activity, Enzyme inhibition.

Unit IV

Structure, function and properties of Polysaccharides, Mucopolysaccharides, Glycoproteins and their biological functions, Structure and functions of sphingolipids, glycolipids, Prostaglandins, Cholesterol.

Metabolism: Glycolysis,Kreb's cycle, oxidative phosphorylation, β-oxidation of fatty acid.

Suggested Books:

1. Ganong: Review of Medical Physiology (21st Ed.), Lang Medical Publications, 2003
2. Guyton and Hall: Text Book of Medical Physiology (10th Ed.), W.B. Saunders, 2001
3. Arthur J. Vander, James H. Sherman, Human Physiology: The Mechanisms of Body Function (McGraw-Hill International Editions Series), 7th edition
4. David L. Nelson , Michael Cox, Lehninger Principles of Biochemistry: International Edition,7th Edition
5. Balwan and Verma: Advances in Biochemistry and Biotechnology.
6. Zubay et al: Principles in Biochemistry (2nd Ed.), WCB, 1995
7. Stryer: Biochemistry (5th ed. 2001, Freeman)

M.Sc. Zoology Semester III

Core Paper II: Computational Biology and Bioinformatics

Unit I

Computer networking, Internet and E-mail, Concept of home pages and web-sites, World Wide Web, Uniform Resource Locators, Introduction and scope of Bioinformatics, Genomics, Transcriptomics, Systems Biology, Functional Genomics, Metabolomics, Molecular Phylogeny.

Unit II

Applications and Limitations of Bioinformatics, Bioinformatics and its relation with molecular biology, Examples of related Tools (FASTA, BLAST, BLAT, RASMOL), Biological databases (GENBANK, Pubmed, PDB) Nucleic acid sequences, Genomes, Protein sequence and structures and software (RASMOL, Ligand Explorer).

Unit III

Scoring Matrices (PAM, BLOSUM), Methods of Alignment (Dot matrix, Dynamic, Programming, BLAST and FASTA), Local and global alignment, pair wise and multiple sequence alignments, Similarity, identity and homology of sequences.

Unit IV

Trees: Rooted and unrooted trees, Species tree and Gene tree: Homology, Homoplasy, Orthology, Paralogy and Xenology Trees Construction Methods: Maximum Parsimony, Maximum Likelihood, Branch and Bound.

Suggested Books:

1. Barnes & Gray (ed): Bioinformatics for geneticists, Wiley (2003)
2. Lesk: Bioinformatics, Oxford (2003, Indian ed)
3. Dan E. Krane and Michael L. Raymer, Pearson Education inc.
4. Jaspreet Kaur and Jasvinder Kaur, Bioinformatics Practical, Manual :An easy guide to In-silico analysis
5. Westhead et al: Bioinformatics Instant Notes, Viva Books (2003, Indian ed)
6. Campbell A. M. and Heyer, L. J. 2007. Discovering Genomics, Proteomics and Bioinformatics,2nd Edition. Benjamin Cummings.
7. Mount W. 2004. Bioinformatics and sequence genome analysis 2nd Editon CBS Pub

M.Sc. Zoology Semester III

Core Paper III: Biological Tools and Techniques; Molecular Taxonomy

Unit I

Principles and uses of Spectrophotometer, spectroflurophotometer, atomic adsorption spectrophotometry.

Elementary principle of fluorescence and electron microscopy (transmission electron, scanning electron and atomic force microscope).

Unit II

Chromatography: paper and thin layer chromatography, Gas liquid chromatography, column chromatography, gel exclusion chromatography, high performance liquid chromatography, affinity chromatography.

Unit III

Separation of biomolecules by electrophoresis (purification and fractionation of nucleic acids), Principles of differential and density centrifugation.

Unit IV

Nucleic acid hybridization, PCR, DNA finger printing, Methods of determining genetic diversities- isozymes, RFLP, RAPD, gene sequencing, generating molecular data bases.

Suggested Books:

1. Wilson and Walker: Principles and techniques of Biochemistry and Molecular Biology
2. Primrose. Molecular Biotechnology
3. Boyer: Modern experimental Biochemistry and Molecular Biology
4. David Freifelder: Physical Biochemistry
5. Wilson and Walker: Practical Biochemistry
6. Ruthman: Methods in Cell Research

M.Sc. Zoology Semester III

Elective Paper I: Fish and Fisheries: Fishery Science and Management

Unit I

Aquaculture: Definition, types of resources, cultivable fishes and non-fin fish organisms including sea weeds; Current and future prospects of aquaculture in India, Basic principles of aquaculture.

Marine Fishery: Important marine water fishery recourses and fish landing in relation to different maritime states of India. Productivity of west coast and east coast of India, Offshore and deep sea fishery, Problems of coastal/inshore fishery, Sardine and Mackerel fishery, Present and future prospects of marine culture in India.

Unit II

Inland fishery: Inland capture fishery recourses of India, Important riverine systems and their fishery, Cold water fishery, Riverine pollution and fish landing.

Inland fish culture: Ecology of natural and artificial ponds, Planning and construction of fish farms (brooder, nursery, rearing and stocking ponds), Principal methods used in fish culture, composite fish culture, air-breathing fish culture, integrated fish farming, cage, pen, raceways and tank culture, Prawn and Pearl culture.

Management of fish ponds: Physical, chemical and biological factors affecting the productivity of ponds, Use of fertilizers, Aquatic vegetation and their control, Eradication of weed and predatory fishers as well as aquatic insect, Control of algal blooms and swarms, Supplementary feeding.

Unit III

Carp seed raising: Natural spawning and seed collection of fish seeds. Techniques of induced breeding, natural and synthetic drugs used for fish breading. Natural and artificial hatcheries and their management.

Fishing Methods: Important traditional crafts and gears used for fish catch in inland and marine water, Modern and commercial fishing crafts and gears used in inland and marine sectors including electric fishing, light fishing, ecosounders and satellite fishing.

Unit IV

Freshness of fish and preservation: Characteristic features of a fresh fish, decomposition of fishes, states of rigor mortis, Principles and methods used for fish preservation.

Fish bye-products: Development of fish by- products and their marketing, Aquarium fishes and their maintenance, Age and growth determination.

Fish diseases: Important fish diseases and their prophylactic management.

Suggested books:

1. An introduction to Ichthylogy by Moyle PB.
2. Jhingran V.G., Fish and Fisheries of India.
3. Reld GR, Ecology and Inland waters and Estuaries.
4. S.K. Gupta, and P.C. Gupta: General and Applied Ichthyology.
5. G.S. Sandhu : Applied Ichthyology.
6. Patrick Safran, Fisheries and Aquaculture- Volume III
7. C.B.L. Srivastava, A text book of fishery science and Indian fisheries
8. Ayyappan, S, Handbook of Fisheries and Aquaculture.
9. Gopakumar, K, A textbook of fish processing technology.
10. Chattopadhyay, N.R., Induced Fish Breeding .
11. Harvey, B J: The theory and practice of induced breeding in fishes.
12. Srivastava C. B. L.: Aquarium Fish

M.Sc. Zoology Semester III

Elective Paper II: Entomology- Insect Physiology and Toxicology

Unit I

Structure and physiology of integument, digestive, excretory and circulatory system.

Unit II

Structure and physiology of respiration, endocrine, nervous and reproductive system.

Unit III

Definition of pesticides, different types; Organochlorines, Organophosphate, Carbamates, Pyrethroids, bio-insecticides, fumigants; IGRs, attractants, repellents and anti-feedants, their toxicity and mode of action.

Unit IV

Next generation pesticides for insect pest management, Nano-pesticides, delivery, mode of action.Impact of pesticides, Heavy metals, pharmaceuticals and other pollutants on insect physiology and their survival.

Suggested Books:

1. The Principles of Insect Physiology, Wigglesworth, Vincent B, Chapman & Hall Ltd.USA.
2. Toxicology and Risk Assessment: A Comprehensive Introduction, Greim H., and Snyder, R. (ed), John Wiley and Sons, UK
3. Safer Insecticides, Hodgson, E., and Kuhr, R. J., (ed), Marcel Dekker Inc., New York, USA
4. Chemical Ecology of Insects, Carde, R. T., and Bell, W. J., Chapman & Hall, New York,USA
5. Elements of Entomology, Singh, R., Rastogi Publications, Meerut.

M.Sc. Zoology Semester III

Elective Paper III: Cell Biology- Cell Communication System

Unit I

Cell signaling: general principles of cell signaling, Classes of cell surface receptors protein, Signaling of steroid and thyroid hormones through intracellular receptors, Signaling via G- protein linked cell surface receptors, interferon.

The cell division cycle: regulation of the cell cycle by cell growth and extracellular signals, cell cycle checkpoints, regulation of cell cycle progression.

Unit II

Cellular mechanism of development: mechanism of cell diversification in the early animal embryo, cell memory.

Differentiated cells and their maintenance, Maintenance of the differentiated states, Tissues with permanent cells, renewal by simple duplication, renewal by stem cells, renewal by pluripotent stem cells.

Unit III

The immune system: cellular basis of immunity, antigen and antibody interactions, functional properties of antibodies, fine structure of antibody, production and synthesis of polyclonal and monoclonal antibodies, T-cell receptors and subclasses, antigen presentation on T-cell, different types of T cells, AIDS, MHC.

Unit IV

Cancer: cancer as a micro-evolutionary process, Causes and types of cancer, Properties of cancer cells, Molecular diagnosis, Prevention and treatment, Molecular genetics of cancer, Controlling gene expression- an overview of gene control, promoter and operator gene, post-translational controls.

Suggested Books:

1. Cooper : Cell- a Molecular Approach
2. Lodish et al: Molecular Cell Biology
3. Watson et al: Molecular Biology of the gene
4. Alberts et al: Molecular Biology of cell
5. Karp: Cell and Molecular Biology
6. Lewin B Genes VIII
7. Primrose. Molecular Biotechnology
8. Sambrook et al: Molecular Cloning

M.Sc. Zoology Semester III

Practical will be based on Core and Elective papers.

Internal Assessment: 50 marks

External Assessment: 50 marks

M.Sc. Zoology Semester IV

Core Paper I: Developmental Biology and Animal Behaviour

Unit I

Gametes: structure and formation, fertilization, nature of eggs and their cleavage, gastrulation, organogenesis of vertebrate brain, eye and heart, Cellular and biochemical events in metamorphosis of insects and amphibians, causes of fetal deformities, Regeneration and gradients in developing systems, ageing and cellular death, transgenic and knock outs animals.

Unit II

Determination of polarity and symmetry, pattern regulation in insect imaginable discs, induction and organizer concept, differentiation at the level of chromosomes, Unique properties of stem cells: embryonic stem cells, adult stem cells, umbilical cord stem cells, Similarities and differences between embryonic and adult stem cells, Properties of stem cells, pluripotency and totipotency.

Unit III

Concepts of animal behaviour: Definition and general concepts of ethology and animal behaviour, Fundamental mechanisms of animal behaviour, Major contribution of scientists in classical ethology and modern behavioural biology. Methods used in the study of animal behaviour in their natural habitat, Role of various types of Taxes, Reflexes and Orientation in animal behaviour, Development of innate behaviours,Fixed action patterns (FAPs), Innate releasing mechanisms, Biological rhythms.

Unit IV

Social behaviour: Characteristics of true society, Social organization and social hierarchies; Territorial behaviour: Demarcation and protection of territories, Expression of aggressive behaviour and hormonal control of aggression; Courtship Behaviour: Mating patterns in animals, mechanisms of courtship behaviour; Migratory behaviour: Migratory pattern of fishes and birds and their hormonal control mechanisms, Patterns of communication in animals, Classification or forms of learning and memory, Neural mechanisms of learning and memory, Evolution of behaviour.

Suggested Books:

1. Alfonso Martinez Arias, Alison Stewart: Molecular Principles of Animal Development
2. Gilbert SF.: Developmental Biology.
3. Adam S Wilkins: Genetic Analysis of Animal Development

4. Alfonso M.A.; Molecular Principles of Animal Development
5. Michael J. Barry: Molecular Embryology: How Molecules Give Birth to Animals

6. Janice Moore and Michael D Breed: Animal Behaviour
7. Marian Dawkins: Observing Animal Behaviour
8. Manning, A.: An Introduction to Animal Behaviour
9. P. J. B. Slater: Essentials of Animal Behaviour
10. Russell, E.S.: The Behaviour of Animals
11. David McFarland: Animal Behaviour
12. Alcock, J. Animal Behaviour: An evolutionary approach
13. Dugatkin, Lee: Principles of Animal Behaviour
14. Silverman, P.: Animals Behaviour in the laboratory.
15. Nikolaas Tinbergen: The Study of Instinct
16. Chris Barnard: Animal Behaviour: Mechanism, Development, Function and Evolution

M.Sc. Zoology Semester IV

Core Paper II: Biotechnology and Molecular Biology

Unit I

Recombinant DNA technology: introduction, restriction endonucleases, other useful enzymes for molecular cloning, steps in gene cloning, identification and isolation of desired gene, cloning vectors, screening and selection of recombinant DNA clones, Gene probes as diagnostic tools, Genomic DNA libraries, Biosynthesis of insulin, somatostatin and growth hormone, health care biotechnology, gene therapy.

Unit II

Tissue culture, hybridoma technology and monoclonal antibodies, embryonic stem cell transfer, targeted gene transfer, in vitro fertilization in humans, applications of embryo transfer technology, animal cloning.

Environmental biotechnology: bioconversion, pollution control, microbial enhancement of oil recovery, microbial mining and metal recovery, sewage treatment.

Unit III

An introductory knowledge of biosensors, biochips, immobilized enzymes, bioenergy.

Molecular analysis of Eukaryotic DNA-overall composition, reassociation kinetic, kinetic analysis of Eukaryotic DNA, Organisation of eukaryotic gene-globin gene, IgG, rDNA, histone gene.

DNA replication, nucleotide polymerases, repair and mispair mechanism, the basic transcription apparatus, promoters, enhancers, termination and antitermination.

Unit IV

Protein synthesis, Genetic code, mRNA processing and organisation of interrupted genes, ribonucleoprotein, organelle genome, structure and life cycles of bacteriophase T2 or T4, virulent and temperate phages.

RNA phages, tumor viruses and their life cycles, retroviruses, topoisomerases, gyrases, methylases, nucleases, molecular biology of cancer, oncogenes, chemical carcinogenesis, genetic and metabolic disorders, principles and methods of gene targeting, gene silencing.

Suggested Books:

1. Lodish el al: Molecular Cell Biology
2. Freifelder: Essentials of Molecular Biology
3. Brown: Gene Cloning
4. Sambrook and Russel: Molecular cloning
5. Lewin: Gene
6. Primrose: Principles of Gene Manipulation

M.Sc. Zoology Semester IV

Generic Paper I: Waste Management and Sustainable Development

Unit I

Waste-types and their sources of generation, Traditional methods of waste collection, transport and disposal; Factors influencing waste generation and health hazards, Waste composition, Environmental Policies and Legislation.

Unit II

Municipal and Industrial solid waste: Disposal of solid wastes, Landfill: site selection, site development, site operation, characteristics, generation and control of the movement of gases and leachate in landfill, landfill closure and post closure care.

Unit III

Hazardous waste and Wastewater management, Source, Constituents in waste water inorganic – Organic and metallic constituents, Industrial water treatment, Medical wastes and their disposal, Chemical and Biological treatment methods.

Unit IV

Principles of Sustainable Development: History and emergence of the concept of Sustainable Development, Definitions, Environmental issues and crisis, Natural Resource Management and Sustainability, Resource degradation, greenhouse gases, desertification, Social insecurity, Industrialization, Globalization and Environment.

Suggested Books:

1. M.S. Bhatt and AsherefIlliyan, Solid Waste Management: An Indian Perspective Synergy Books India 2012
2. Techobanoglous Thiesen Ellasen; Solid Waste Engineering Principles and Management McGraw - Hill 1997
3. RajaramVasudevan , Siddiqui Faisal Zia , Agrawal Sanjeev , Khan Mohammad Emran. Solid and Liquid Waste Management
4. Gabriella Marfe, Hazardous Waste Management and Health Risks, Bentham Science Publishers
5. Ram Naresh Bharagava, Pankaj Chowdhary Emerging and Eco-Friendly Approaches for Waste Management, Springer; 1st ed. 2019 edition
6. Manoj Kumar Karnena, Environmental Planning and Sustainable Development, Orange Books Publication; First edition
7. Jonathan W. C. Wong; Rao Y. Surampalli; Tian C. Zhang; Rajeshwar D. Tyagi; and Ammaiyappan Selvam, Sustainable Solid Waste Management, ASCE Press

M.Sc. Zoology Semester IV

Generic Paper II: Human Nutrition and Neutraceuticals

Unit I

Concept of nutrition, malnutrition and health, Scope and importance of nutrition in physical and mental health, Dietary guidelines of RDA for minimum nutritional requirement for different human age groups including pregnant women.

Unit II

Concept of energy requirement in different age groups with special reference to nature of works, Energy balance and assessment of energy requirement during deficiency and excess regimen (energy auditing), Methods for determination of energy in food as per basic metabolic rate (B.M.R.).

Unit III

Concept of balanced diets, Importance of nutrition for ensuring adequate development and growth from embryo (*in utero*) to aged person, Importance of nutrition in brain development and cognition (I.Q. score).

Unit IV

Importance of growth monitoring, Development of growth charts, Management strategies for maintaining the standard growth pattern, Nutritional requirement by a pregnant women during first, second and third trimester of pregnancy for proper development of embryo-fetus development, Dietary supplementation during pregnancy and lactation, Concepts and use of various neutaceuticals and functional foods during early life, adolescent, young/adults and aged person.

Suggested Books :

1. SrilakshmiB(2014): Dietetics, 7th Multicolour Ed. New Age International (P) Ltd.
2. Guthrie AH(1986):Introductory Nutrition, 6th Revised Ed., McGraw-Hill Inc., US.
3. Robinson CH and Lawler M(1990): Normal and Therapeutic Nutrition. 17th Revised Ed. Macmillan USA.
4. SwaminathanM(2007): Essentials of Food and Nutrition(Vol. I & II), 2nd Ed. Bappco
5. GopalanC , Rama Sastri BV and Balasubramanian SC(2016): Nutritive value of Indian Foods, Indian Council of Medical Research.
6. Nutrient Requirements and Recommended Dietary Allowance for Indians, Indian Council of Medical Research: New Delhi.
7. GhoshS(2007):Nutrition and Child Care, 2nd Ed. Jaypee Brothers Medical Publishers.
8. Mann J and TruswellS(2017) : Essentials of Human Nutrition, 5th Ed. Oxford

University Press.
9.Worthington- Roberts B and Williams SR(1999): Nutrition Throughout the Life Cycle , 4th Ed. McGraw-Hill Higher Education.
10.Elizabeth KE(2015); Nutrition and Child Development , 5th Ed. Paras Medical Publishers.
11.Geissler C and Powers H (2005):Human Nutrition, 11th Ed. Churchill Livingston.

M.Sc. Zoology Semester IV
Generic Paper III: Public Health and Hygiene

Unit I

Health Education: Definition, objectives, principals and methods of health education, ill effects of smoking, alcoholism and drug abuse (emphasis should be given to pan masala, amphetamines, hashish, opium, brown sugar).

Life style habits -excessive uses of T.V., Computer, Mobile phone, two wheelers and their impacts on health, lack of physical exercise and its deleterious effects on the body and mind.

Unit II

Health Hazard: Health dynamicity-definition factors influencing health, health as a medium of socio-economic development; Symptoms, modes of transmission and prevention of Common food borne and water borne diseases (gastroenteritis, jaundice, cholera ,traveller's diarrhoea and *Escherichia coli* infection, typhoid), sexually transmitted infections, AIDS, genital herpes, hepatitis B, Dengue, chikungunya, SARS CoV-2.

Unit III

Hygiene: Definition, personal hygiene- body odour, oral hygiene, grooming, feminine hygiene, sleep hygiene, hand washing, toiletry, social hygiene, clean living movements, occupational hygiene, food and cooking hygiene, medical hygiene, excessive hygiene.

Unit IV

Adulteration of Food: Food hygiene- hygiene of milk, meat; fish, eggs. Fruits and vegetables, common food adulterants- harmful effects and their detection, food additives, fortification of food, food adulteration Act and its stringent implementation.

Suggested Books:

1. Jatin V. Modi and Renjiths S. Chawan. Essentials of Public Health and Janitation. Part I-IV
2. Park; J. E. and K. Text Book of community health for Nurses.
3. Swaminathan S. Principles of nutrition and Dietetics.
4. Murray, C.J.L and A.D. Lopez,(1996). The Global Burden of Disease

M.Sc. Zoology Semester IV

Generic Paper IV: Natural Resources and Management

Unit I

Natural resources- Classification, concept and approaches of natural resource conservation, natural resources of India.

Resources and reserves- Origin, distribution and uses of economic minerals-exploration of mineral resources from Oceans, steps in mineral exploitation.

Unit II

Distribution of soil resources-Role of agricultural practices in soil degradation-soil erosion-soil fertility and nutrient management, Role of organic matter and its significance in soil quality-diagnosis of soil nutrient deficiencies-organic farming, principles, benefits and methods of organic farming; Green manuring, animal manures and composting-wasteland development strategies.

Unit III

Integrated water resources management, Watershed management, Rain water harvesting, Interlinking of rivers and river basin management, water land conservation, wasted zone management strategies, Ecological significance of mangroves, Coral reefs and its conservation.

Unit IV

Significance for the conservation of forest resources -distribution of forests, wood production, Forest land use changes in India, Future demand of forest land, carbon sequestration, forest management tools, social forestry-agro forestry and urban forestry/eco development, eco-tourism, climate change reduction, carbon trading and management of grass lands.

Suggested Books:

1. Dutta A (2001) biodiversity and ecosystem conservation.
2. Nautiyal S and Kaul AK (1999) Forest biodiversity and its conservation.
3. Jha LK (1997) Natural Resources management.
4. MaDicken KG and vergora NT (1990) Agroforestry classification and management. John wiley and sons, New York
5. Nalini Ks (1993) environment Resources and management.
6. Kumar HD (1995) Modern concept of ecology.

M.Sc. Zoology Semester IV

Research project/ Dissertation

Internal Assessment: 50 marks

External Assessment: 50 marks