Department of Zoology

M.Sc. Zoology

Two-year PG Program

As per NEP

Course Contents & Syllabus

(w.e.f. Academic Session 2025-26)

Hemvati Nandan Bahuguna Garhwal University

(A Central University)

Srinagar Garhwal-246174 (Uttarakhand)

M.Sc. Zoology Two-Year Program as Per NEP

P.G. (First Year) - First semester

Entry requirement	3-year bachelor's degree (120 credits), and candidates who have met the entrance requirements, including specified levels of attainment, in the programme admission regulations.				
Semester	**Course Category**	**Course title**	**Credits**		**Total Credit**
			T	**P**	
I	Core	Core-I: ZC-01 Molecular Biology of the Cell	5		
		Core-II: ZC-02 Microbiology & Parasitology	5		
		Core-III: ZC-03 Animal Structure & Function	5		
		Core Lab-I: ZCL-01 Based on Core-I, II & III		3	
	Elective (Any 1 out of Minimum 2 electives)	Elective-I: ZE-01 (Anyone from ZE-01 basket) (ZEF-01/ZEEnt-01/ZEEvs-01)	4		
		Elective Lab-I: ZEL-01 Based on ZEF-01/ZEEnt-01/ZEEvs-01		2	
Total			**19**	**05**	**24**

P.G. (First Year) - Second semester

Semester	**Course Category**	**Course title**	**Credits**		**Total Credit**
			T	**P**	
II	Core	Core-IV: ZC-04 Immunology	5		
		Core-V: ZC-05 Toxicology	5		
		Core-VI: ZC-06 Advanced Developmental Biology	5		
		Core Lab-II: ZCL-02 Based on Core-IV, V, & VI		3	
	Elective (Any 1 out of Minimum 2 electives)	Elective-II: ZE-02 (Anyone from ZE-02 basket) (ZEF-02/ZEEnt-02/ZEEvs-02)	4		
		Elective Lab-II: ZEL-02 Based on ZEF-02/ZEEnt-02/ZEEvs-02		2	
Total			**19**	**05**	**24**

Elective Basket ZE-01 & ZE-02: Paper code with Paper title					
ZE-01	**ZEF-01**	Fish Biology-I	**ZE-02**	**ZEF-02**	Fish Biology-II
	ZEEnt-01	Entomology-I		**ZEEnt-02**	Entomology-II
	ZEEvs-01	Environmental Biology-I		**ZEEvs-02**	Environmental Biology-II

P.G. (Second Year) - Third semester

P.G. First year with 40 credits					
Semester	**Course Category**	**Course title**	**Credits**		**Total Credit**
			T	**P**	
III	Core	Core-VII: ZC-07 Ecology & Wildlife Conservation	5		
		Core-VIII: ZC-08 Instrumentation & Biostatistics	5		
		Core-IX: ZC-09 Biochemistry	5		
		Core Lab-III/I: ZCL-03 Based on Core-VII, VIII, & IX		3	
	Elective (Any 1 out of Minimum 2 electives)	Elective-III: ZE-03 (Anyone from ZE-03 basket) (ZEF-03/ZEEnt-03/ZEEvs-03)	4		
		Elective Lab-III: ZEL-03 Based on ZEF-03/ZEEnt-03/ZEEvs-03		2	
Total			**19**	**05**	**24**

P.G. (Second Year) - Fourth semester

Semester	**Course Category**	**Course title**	**Credits**		**Total Credit**
			T	**P**	
IV	Core	Core-X: ZC-10 Animal Physiology	5		
		Core-XI: ZC-11 Endocrinology	5		
		Core-XII: ZC-12 Animal Taxonomy & Evolution	5		
		Core Lab IV: ZCL-04 Based on Core-X, XI, & XIII		3	
	Elective (Any 1 out of Minimum 2 electives)	Elective-IV: ZE-04 (Anyone from ZE-04 basket) (ZEF-04/ZEEnt-04/ZEEvs-04)	4		
		Elective Lab-IV: ZEL-04 Based on ZEF-04/ZEEnt-04/ZEEvs-04		2	
Total			**19**	**05**	**24**

Note: In lieu of elective (Theory and Practical = 4+3 credits) the department may allot dissertation (7 credits) in the beginning of 3rd semester to the students securing more than 75% in the 1st & 2nd Semester together.

Elective Basket ZE-03 & ZE-04: Paper code with Paper title					
ZE-03	**ZEF-03**	Applied Fish Biology	**ZE-04**	**ZEF-04**	Methodology in Fish Biology
	ZEEnt-03	Applied Entomology		**ZEEnt-04**	Methodology in Entomology
	ZEEvs-03	Applied Environmental Biology		**ZEEvs-04**	Methodology in Environmental Biology

Program outcomes

The M.Sc. (Two-year) Zoology is designed to impart advanced theoretical and practical knowledge to students in the field of animal physiology, taxonomy, evolution, cell biology, molecular biology, microbiology, parasitology, biochemistry, immunology, endocrinology, toxicology, developmental biology, instrumentation, ecology & wildlife conservation. The students will acquire proficiency in a range of laboratory techniques. The curriculum promotes critical thinking and problem-solving abilities in the students and the application of different techniques in the field of life sciences. Emphasis is given on ethical research practices and effective scientific communications. The program enables the students to get employment in the Government & private sectors, various research institutions etc. and help them to develop entrepreneurship skills for self-employment.

Course outcomes

Students will develop skills in teamwork and interdisciplinary collaborations, preparing them for careers in academia, agriculture sector, pharma, and other allied life sciences.

Semesters	Course Name	Course Outcomes
1st Semester	ZC-01 Molecular Biology of the Cell	Students will come out with the knowledge of the structure, function, & working mechanism of cells in the body. Students will also gain an understanding of mechanisms of cellular signaling, cell cycle regulation, and cytoskeletal dynamics; processes of cellular transformation, malignancy, apoptosis, and idea of basics of stem cells, their applications and tissue renewal.
	ZC-02 Microbiology & Parasitology	This course provides a deep understanding of microbes, parasites, their diseases, and preventive measures. Students will gain knowledge of classification, physiology, and microbial genetics; microbiological techniques - sterilization, culturing, and isolation; biology and life cycles of parasitic protozoa and helminthes, and the role of arthropod vectors in disease transmission.
	ZC-03 Animal Structure & Function	The course provides a comprehensive understanding of animal structure and function, including locomotion, digestion, respiration; comparative anatomy and physiology of invertebrates as well as vertebrates; evolution of complex body systems; adaptations in various animal groups such as flight adaptations in birds and aquatic adaptations in mammals.
	ZCL-01 Core Lab-I	This lab course provides students with hands-on experience and practical skills related to life forms, cell structure, and their functions. Students will develop proficiency in microscopic techniques and cell biology experiments; lab techniques to isolate and analyze DNA & RNA; identification and characterization of microorganisms, life

			cycles of parasites, structure & function of animal systems.
	ZE-01 Elective-I	Fish Biology I	This course imparts in-depth knowledge of systematics, phylogeny, distribution, and classification of fish, general characters, and affinities of Agnatha, Placoderms, Holocephali, and Dipnoi. Students will also gain knowledge of the structure and development of Scales and Fins of fishes, skeletal system, alimentary canal and its associated glands, as well as the structure and functioning of heart, gills and urinogenital system of teleosts.
		Entomology I	This course provides knowledge to describe the external morphology of insects, including body structure, segmentation, and appendages. The students will also be able to classify insects into different orders, understanding their general characters, habits, habitats and the role of insects in ecosystems and potential impacts on human.
		Environmental Biology I	This course provides an overview of environmental biology and its applications. Students will acquire knowledge of terrestrial and aquatic biomes, key ecological concepts like habitat fragmentation, community patterns, population dynamics, and the impact of invasive species, pollutants on ecosystems, and human health.
	ZEL-01 Elective Lab-I		It provides practical training related to the elective course ZE-01
2nd Semester	ZC-04 Immunology		Students will acquire comprehensive knowledge of immunity with an understanding of the application of immunological tools for animal and human well-being. Students will gain knowledge about the components and mechanisms of the immune system; types of immunity, immune responses, hypersensitivity, transplantation, vaccines, autoimmune diseases and immunotherapy.
	ZC-05 Toxicology		It provides a deep understanding of basic concepts of toxicology (toxicants- types, kinetics, & dynamics). The student will also acquire knowledge and be able to explain the mechanisms of toxicity and interactions of toxicants with biomolecules; effect of pollutants, heavy metals, pesticides, endocrine disruptors and human health.
	ZC-06 Advanced Developmental Biology		This course imparts comprehensive knowledge of recent advances in developmental biology. It provides insights into gametogenesis, fertilization, early embryonic development, embryonic induction, organogenesis, including limb development, metamorphosis, regeneration, apoptosis and their significance. Students will be able to understand embryonic stem cells, cloning of animals, ageing, teratogenesis, and congenital growth abnormalities.
	ZCL-02 Core Lab-II		This lab course provides students with hands-on experience and practical skills in laboratory techniques. The students will be able to understand immunological concepts,

			including immune cells and immunoglobulins, and apply toxicological principles to analyze the effects of toxic substances on living organisms. Students will visualize and understand the complex concepts of developmental biology through ICT tools and models.
	ZE-02 Elective-II	Fish Biology II	This course imparts comprehensive knowledge of specialized characteristics of fishes, including accessory and respiratory organs, weberian ossicles, electric organs and luminescent organs. Students will also gain an in-depth understanding of the social, reproductive, migratory, foraging and parental behaviors of fish. Additionally, they will acquire detailed knowledge of fish physiology, embryology and endocrinology.
		Entomology II	This course imparts knowledge of the structure and physiology of the digestive, circulatory, respiratory, nervous, sensory and reproductive systems of insects. Students will also understand early embryology & developmental processes of insects, parasitism, predation, and social life in insects.
		Environmental Biology II	It imparts knowledge of natural resources, concept of sustainable development, protected areas, biodiversity conservation, global environmental problems, natural disasters, and hazards in hills. It also provides insights into the application of remote sensing and GIS in environmental management.
	ZEL-02 Elective Lab-II		It provides practical training related to the elected subject ZE-02
3rd Semester	ZC-07 Ecology & Wildlife Conservation		The course imparts a deep understanding of ecosystems, biodiversity and Indian wildlife. It provides insights into the ecological principles, ecosystem concepts, wildlife conservation strategies, including protected areas, captive breeding and translocation projects; wildlife population estimation techniques- including transects, camera traps tranquilisation, immobilization and radio-telemetry.
	ZC-08 Instrumentation & Biostatistics		The course imparts knowledge of the principles and applications of various microscopy and instrumentation techniques, including chromatography and electrophoresis in biological research. Students will be able to analyze data using descriptive and inferential statistics; interpret results with statistical tests; use statistical software- MS Excel and SPSS to analyze biological data.
	ZC-09 Biochemistry		It provides knowledge about the chemistry, classification, structure & functional diversity of biomolecules. Students will be able to correlate the physiological significance of enzymatic reactions to the metabolic processes and the role of bio-molecules in homeostasis.
	ZCL-03		It provides hands-on experience and practical skills in

	Core Lab-III		various laboratory techniques. The students will be able to apply ecological principles to understand habitat structure and biodiversity; analyze abiotic parameters in water samples; use various instruments to analyze biological samples; practical skills in biochemistry related to enzyme assays & protein estimation.
	ZE-03 Elective-III	Applied Fish Biology	This course orients students to the current status and future prospects of aquaculture, fish farming systems, including farm preparation and maintenance, fish nutrition, induced breeding & hatching techniques, harvesting & post-harvesting practices. The curriculum also addresses fish diseases, health management for cultured and ornamental fish and insights into capture fisheries.
		Applied Entomology	This course orients students to the applied aspects of entomological study. The students will have a knowledge on sericulture, apiculture, lac culture, life history traits of vegetables, store grain and fruit pests, termite and its control, insecticides- uses & mode of action, integrated pest management.
		Applied Environmental Biology	This course orients students to address the environmental challenges and develop sustainable solutions. The students will have a knowledge of analyzing and mitigating the environmental pollution; to apply bioremediation techniques for ecosystem restoration; environmental impact assessments and integrated pest management strategies.
	ZEL-03 Elective Lab-III		It provides practical training related to the elected subject ZE-03
4th Semester	ZC-10 Animal Physiology		The course provides a comprehensive understanding of the function and mechanisms of the body system and the chemical processes. Students will be able to understand the physiological mechanisms of respiration, digestion, excretion, cardiovascular and nervous system, neuromuscular transmission, sensory physiology, including visual and auditory processes and thermoregulation.
	ZC-11 Endocrinology		This course imparts a comprehensive understanding of various endocrine glands and their role in chemical integration. It also provides understanding about the hormonal regulation of the reproductive process, including gonadal functions, hormonal disorders; the role of chemical messengers- in cellular communication, signaling pathways regulating the physiological processes and behaviors.
	ZC-12 Animal Taxonomy & Evolution		The course provides a comprehensive understanding of the basic concepts of animal taxonomy and evolution. The students will have a knowledge of the principles of animal taxonomy, classification and nomenclature; taxonomic characters, keys and molecular approaches to classify

			animals; population genetics, speciation; evolutionary mechanisms, including natural selection, genetic drift, molecular evolution; speciation and human evolution.
	ZCL-04 Core Lab IV		The students will develop practical skills in animal physiology, including blood analysis and measurement of physiological parameters; develop understanding of the structure and function of endocrine glands and behaviour; taxonomic principles and evolutionary concepts; ICT tools and charts to study complex biological concepts and processes.
	ZE-04 Elective-IV	Methodology in Fish Biology	This course aims to impart both knowledge and skills related to the methods & techniques critical for understanding various facets of fish biology. Key topics include fish stock assessment and sustainable exploitation, fishing methods, habitat ecology, age and growth studies, analysis of food and feeding habits, reproductive behavior, fecundity estimation and life history traits.
		Methodology in Entomology	This course orients the students with various methods of survey, sampling, collection and preservation of insects. Students will be able to have knowledge of various tools and equipment used in the collection, transport and lab rearing of larvae and adults; insect taxonomy and uses of catalogues.
		Methodology in Environmental Biology	This course orients students to the skills needed for designing and conducting environmental research. The students learn to measure and analyze environmental parameters, statistical analysis and software tools to interpret data and research findings for effective environmental management and conservation.
	ZEL-04 Elective Lab-IV		It provides practical training related to the elected subject ZE-04

Paper - I **No. of Credits = 5**

ZC-01: Molecular Biology of the Cell

UNIT I

Plasma membrane: Structure- organisation, lipids, proteins & glucoconjugates; liposomes, black membrane; function- ionic transport, transporter proteins, types of transport (symport, antiport, active & passive), endocytosis and exocytosis.

Endomembrane system: intracellular compartments/organelles involved in protein sorting, secretory and endocytic pathway.

UNIT II

Mitochondria: Ultrastructure, chemiosmotic process, respiratory chain, ATP synthetase, and genetic organisation.

Cytoskeleton: Nature and function of the cytoskeletal filaments, cilia and flagella, molecular motors

Cell junctions, cell adhesion and the extracellular matrix.

UNIT III

Cell signaling, general principles of cell signaling, signaling via G-protein-linked cell-surface receptors, enzyme-coupled cell-surface receptors, intracellular mediators, target cell adaptation

Cell cycle: overview, cell cycle control system, mechanism and control of cell division.

UNIT IV

Cellular transformation and malignancy, retroviruses

The molecular genetics of cancer and apoptosis

Basic knowledge of stem cells and tissue renewal

Recommended Books:

1. Alberts, B., Heald, R., Johnson, A., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2022). Molecular biology of the cell: seventh international student edition, WW Norton & Company.
2. B. Sarkar: Cell Structure and Function, Medtech, ISBN: 978-9385998362
3. Karp et al. (2020) Karp's Cell and Molecular Biology: Concepts and Experiments, Ninth edition, Wiley
4. Lodish et al. (2016) Molecular Cell Biology, 8th edition, W. H. Freeman & Co Ltd.
5. P.K. Gupta: Cell Biology, Himalaya Publishing House, ISBN: 978-9350246696
6. P.S. Verma & V.K. Agarwal: Cell Biology (Cytology, Biomolecules and Molecular Biology, S Chand Publishing, ISBN: 978-9385676147
7. Sarkar B. (2017) Cell structure and Function, MEDTCH Publication 978-93-85998-36-2

Paper - II **No. of Credits = 5**

ZC-02: Microbiology & Parasitology

Microbiology

Unit I

General features of microorganisms; classification of bacteria & staining techniques

Physiology, genetics, & reproduction of animal viruses

Pathological significance of bacteria and viruses

Bacteriophages, lysogenic & lytic cycle

Microbial enzymes; microbes and fermentation

Unit II

Physical and chemical methods of sterilization

Microbial cultures techniques; media enrichment techniques (formulation & optimization)

Types of microbial products

Cell lines & cloning

Bacterial growth and metabolism

Isolation and selection of industrially important microorganisms

Parasitology

Unit III

Introduction to parasites: parasitism and different types of animal associations, mode of transmission, morphological adaptation in different groups of parasites, zoonosis and larva migrans

Parasitic infections and their monitoring

Protozoan parasites: biology, life cycle and diseases caused by selected pathogenic protozoans of man, preventive and control measures (*Entamoeba*, *Trypanosomes*, *Leishmania, Trichomonas, Giardia* & *Plasmodium*)

Unit IV

Helminth parasites: biology, life history and preventive measures of economically important helminth parasites of man and domesticated animals (*Ascaris*, *Schistosoma*, *Fasciola*, *Wuchereria*, & *Taenia*)

Introduction to arthropods and vectors of human diseases: mosquitoes (dengue, yellow fever, chikungunya, zika fever, japanese encephalitis), lice, flies & ticks

Chemical, biological & environmental control of arthropod vectors

Recommended Books:

1. D.K. Sharma: Microbiology: Alpha Science, ISBN: 978-1842657508.
2. Davis: Microbiology (3rd ed.) Harper & Row, Publ. Inc., 1980
3. K.D. Chatterjee (2009): Parasitology (Protozoology and Helminthology) XIII Edition. CBS Publications and Distributors.
4. L. S. Roberts & J. Janovy (2009): Foundation of Parasitology, 8th edition, McGraw Hill Higher Education, Boston.
5. Pelczar: Microbiology, Tata McGraw Hill,1993
6. R.C. Dubey: A Textbook of Microbiology: S. Chand & Company, ISBN: 978-9355015273.
7. Smyth (1994): Introduction to Animal Parasitology, Cambridge University Press.

Paper - III **No. of Credits = 5**

ZC-03: Animal Structure & Function

Unit I

Locomotion in protozoa
Hydrostatic movement in coelenterata, annelida & echinodermata
Feeding pattern and digestion in lower metazoan, mollusca & echinodermata

Unit II

Types of coeloms, metamerism
Organs & mechanism of respiration: gills, lungs & trachea
Organs & mechanism of excretion: coelom ducts, nephridia & malpighian tubule
Larval forms of invertebrates

Unit III

Vertebrate integument & its derivatives
Appendicular skeleton in amphibia, reptilia, aves & mammalia
Evolution of heart, portal & lymphatic system
Biting mechanism of snakes & adaptive radiation in reptiles

Unit IV

Urinogenital system & nervous system
Organs & mechanism of respiration in aquatic & terrestrial vertebrates
Flight adaptations in aves & mammals
Aquatic adaptations in mammals
Dentition in mammals

Recommended Books:

1. Barrington E.J.W. Invertebrate structure and function. Thomas Nelson and sons Ltd., London.
2. Kingslay J.S, Outlines of Comparative anatomy of vertebrates, Central Book Depot, Allahabad.
3. Kotpal, R.L. Modern T.B. of Zoology Vertebrates 5th ed. (2021). Rastogi Publication Meerut.
4. Pandey B.N. & Mathur V. Biology of Chordates (2018) PHI Learning Pvt Ltd Delhi
5. Russet Hunter W.D.D. Biology of higher invertebrate The Macmillan Co. Ltd., London.
6. Waterman A.J. Chordate Structure and Functions Macmillan Co. New York.

Lab - I **No. of Credits = 5**

ZCL-01: Core Lab Course I, Based on Core Paper ZC-01, ZC-02, & ZC-03

A complete record of laboratory work will be maintained by every student. The practical work will consist of the following:

Molecular Biology of the Cell

1. Microscopic measurement of cells and microorganisms
2. Permanent slides of cell division (mitosis & meiosis)
3. Study of different stages of mitosis by squash technique
4. Study of different stages of meiosis in grasshopper testis
5. Slide preparation of interphase nuclei in buccal epithelium
6. Study of polytene chromosomes in drosophila larvae.
7. Preparation of blood smear
8. Preparation of solutions for molecular biology experiments.
9. Isolation of dna from animal tissue
10. DNA and RNA concentration and purity estimation using UV-vis spectrophotometer
11. RNA estimation using the Orcinol method

Microbiology & Parasitology

1. Transfer of bacteria: aseptic techniques
2. Preparation of smears and simple staining
3. Gram staining of microorganisms
4. Acid-fast staining
5. Study of museum specimens of parasites
6. Study of life stages of *Entamoeba*, *Trypanosoma* & *Plasmodium* through permanent Slides/microphotographs
7. Study of adult and life stages of *Fasciola*, *Schistosoma* & *Wuchereria* through permanent slides/micro photographs/live material

Animal Structure & Functions

1. Study of permanent slides of protozoa (*Amoeba*, *Paramecium* and *Euglena*)
2. Demonstration of ciliary and flagellar movement in the protozoan
3. Study of permanent slides of larval forms in invertebrates
4. Study of appendicular skeleton of frog, varanus, fowl & rabbit
5. Mounting of fish scales and gills
6. Study of mechanism of respiration in aquatic and terrestrial vertebrates (chart/model/video)
7. Museum specimens of invertebrate and vertebrate animals

Paper - IV (Elective-I: ZE-01) **No. of Credits = 4**

ZEF-01: Fish Biology-I

UNIT I

Introduction and history of ichthyology; systematics and phylogeny

Origin and evolution, zoogeographical distribution

Schemes of classification of fossil and recent fishes

General characters of teleost and elasmobranch fishes

UNIT II

Agnatha: characters, basic biology and affinities of cyclostomes and ostracoderms

Placoderms: general characters and affinities.

Holocephali: salient features, external and internal morphology and affinities

Dipnoi: salient features and affinities.

UNIT III

Comparative morphology of teleosts and elasmobranchs; integuments (teleosts & elasmobranchs), colouration and its significance, mechanism of colour change

Exoskeleton: structure and development of placoid and non-placoid scales

Fins and their origin

Skeletal system: skull, vertebrae, girdles, opercular bones & pharyngeal bones

UNIT IV

Comparative morphology of organs in teleosts and elasmobranchs: alimentary canal and associated glands, modifications based on different feeding behaviour

Structure of heart, afferent and efferent branchial arteries, structure of gill and pseudo-branch

Brain and cranial nerves

Urinogenital system

Recommended Books:

1. Ayappan & Jena. Handbook of Fisheries and Aquaculture, Directorate of Information & Publication of Agriculture, ICAR Publication, New Delhi 110012
2. Gupta, S.K. and Gupta, P.C. General and Applied Ichthyology (Fish and Fisheries). S Chand Publications, New Delhi- 110055
3. Khanna, S.S. and Singh, H.R. A textbook of Fish Biology and Fisheries. Narendra Publishing House, Delhi- 110006
4. Pandey & Shukla. Fish and Fisheries 4th Edition 2021 Rastogi Publication Meerut 250002
5. Sarkar U.K., Fisheries Biology: New approaches and changing perspectives (2021). Narendra Publishing House. ISBN: 978-9389996579

Paper - IV (Elective-I: ZE-01) **No. of Credits = 4**

ZEEnt-01: Entomology-I

UNIT I

Introduction to external morphology: body wall and segmentation

Head: structure of head, appendages and antennae

Thorax: pro, meso and metathorax; legs

Wings: origin, structure, and articulation

Abdomen: structure, appendages; external female and male genitalia

UNIT II

Classification of insects with special reference to different orders

General characters, habits, habitats, importance of the insect orders- Collembola, Protura, Diplura, Thysanura, Ephemerida, Placoptera, & Odonata

General characters, habits, habitats, importance of the insect orders- Embioptera, Orthoptera, Phasmida, Dermaptera, Blattaria, Menteodea, Isoptera & Zoraptera.

UNIT III

General characters, habits, habitats, importance of the insect orders- Psocoptera, Thysanoptera, Heteroptera, Homoptera, Anoplura, Neuroptera, Megaloptera & Trichoptera.

UNIT IV

General characters, habits, habitats, importance of the insect orders- Coleoptera, Strepsiptera, Hymenoptera, Lepidoptera, & Diptera

Recommended Books:

1. Ananthakrishnan TR: Applied Entomology
2. Ayyar, TVR: Handbook of Economic Entomology for South India, International Book & Periodical Supply Service, 1984.
3. Bhutani DK & Jotwani MG: Insects in Vegetables, Periodical Expert Book Agency
4. Community development & Co-operation, New Delhi, 1968.
5. Evans JW: Insect Pests and Their Control, Periodical Expert Book Agency, 1984.
6. Mehta PR & Varma BK: Plant Protection, Directorate of Extension, Ministry of Food,
7. Metcal & Flint: Destruction and useful Insects, Tata McGraw-Hill, 1979

Paper - IV (Elective-I: ZE-01) **No. of Credits = 4**

ZEEvs-01: Environmental Biology-I

UNIT I

Introduction to environmental biology, its multidisciplinary nature and scope
Components of environment: atmosphere, lithosphere & hydrosphere
Climate (micro, regional, and global)
Hydrological cycle & soil profile

UNIT II

Terrestrial biomes of the world, their characteristics and major biota (grassland, desert, forest, tundra)
Aquatic biomes (lotic, lentic, marine, estuaries & coral reef),
Wetlands of india
Environmental adaptations: aquatic, aerial, desert, arboreal, fossorial & defensive

UNIT III

Island biogeography theory
Habitat fragmentation, habitat selection, corridors, community patterns (gradients and continuum) and community indices
Ecological niche
Population cycles and fluctuations; dispersal, intra & inter-specific relationship
Models of succession: pioneer & climax concept

UNIT IV

Concept of biological indicators; biological monitoring, indicator organisms
Invasive species and its impact
Biological Control: Biomagnification, bioassimilation & bioaccumulation
Elementary Toxicology, Xenobiotics: carcinogenic (heavy metals, radioactive substances, & pesticides) and their chemical nature

Recommended Books:

1. Omkar: Concepts of Toxicology, Shoban Lal Nagin Chand & Co. 64. B Bungalow Road, Delhi Ecology and Environment
2. Singh, H. R. Environmental biology. S Chand & Company, New Delhi., 2014
3. V.V. Metelev, A.I. Kanaev & N.G. Dzasokhova: Water Toxicology Amerind Pub. Co. Pvt. Ltd., New Delhi.

Lab - II **No. of Credits = 2**

ZEL-01: Elective Lab course I, Based on one from Elective Basket ZE-01

(ZEF-01/ZEEnt-01/ZEEvs-01)

Paper - I **No. of Credits = 5**

ZC-04: Immunology

Unit I

Introduction to immunology
Components of the immune system: primary and secondary lymphoid organs
Types of immunity: innate immunity vs. Acquired immunity
Antigens: essential features of antigens, antigenic determinants
Adjuvants & immunoglobulins: structure, functions & types

Unit II

Immunity and its types: active, passive, cell-mediated & humoral immunity
Immune response: primary and secondary response
Cellular components: neutrophils, macrophages, dendritic cells and Natural Killer (NK) Cells
Inflammation: acute vs. Chronic inflammation
Cytokines and their role
Complement System: Activation, functions and regulation
Adaptive Immunity: Characteristics, Cells (T & B Cells) & Major Histocompatibility Complex (MHC)

Unit III

Introduction to hypersensitivity: types and pathogenicity
Introduction to transplantations
Vaccines: types & applications
Blood Groups: AB, Rh System, significance, practical application & Erythroblastosis fetalis

Unit IV

Techniques in Immunology: RIA, ELISA, Western Blotting & Immunofluorescence
Immunotherapy: Monoclonal antibodies & hybridoma technology
Immunodeficiencies: Primary and secondary immunodeficiencies
Autoimmune Diseases: Mechanisms and examples (rheumatoid arthritis & lupus)

Recommended Books:

1. A. Paul: Textbook of Immunology: Books & Allied Pvt. Ltd., ISBN: 978-9384294724.
2. A.K. Abbas: Basic Immunology: Elsevier India, ISBN:978-8131259573.
3. B. Annadurai: A Textbook of Immunology & Immuno Technology: S. Chand & Company, ISBN: 978-8121928076.
4. Elgert & Elgert: Immunology.
5. Kuby: Immunology (4th ed.).
6. Roitt, Male & Brostoff: Immunology (3rd ed).

Paper - II **No. of Credits = 5**

ZC-05: Toxicology

Unit I

Definition and scope of toxicology
Branches of toxicology (environmental, clinical, forensic & industrial)
Basic principles of toxicology: dose-response relationship, toxicokinetics (absorption, distribution, metabolism & excretion), toxicodynamics (mechanisms of action)
Types of toxins (chemical, biological & physical)

Unit II

Cellular and molecular mechanisms of toxicity
Interaction of toxicants with biomolecules (proteins, DNA & lipids)
Xenobiotics and their toxic effects
Biotransformation of xenobiotics (phase I & phase II reactions)
Toxicity at the level of organs and systems

Unit III

Toxicological screening methods (acute, sub-acute & chronic toxicity testing)
Bioassays and toxicity testing models
In vitro and in vivo testing approaches
Ethics & regulations for the use of laboratory animals in toxicity studies
Carcinogenicity, mutagenicity & teratogenicity

Unit IV

Pollutants and their effects on ecosystems
Heavy metals (lead, mercury & cadmium) toxicity
Pesticides and herbicides: mechanisms of action and environmental impact
Endocrine disruptors and their role in wildlife and human health
Case studies of environmental toxicities

Recommended Books:

1. Balram Pani: Textbook of Toxicology: Dreamtech Press, Wiley, ISBN-13: 978-9389520279.
2. D.E. Hathway: Molecular aspects of Toxicology: The Royal Society of Chemistry, ISBN 9780851860688.
3. Hans Marquardt: Toxicology: Academic Press, ISBN-13: 978-0124732704.
4. Omkar: Concepts of Toxicology: Gangarams Book Bureau, ISBN: 978819329344.
5. P.K. Gupta: Fundamental of Toxicology- Essential Concepts and Applications: Academic Press. ISBN: 9780128054260

Paper - III **No. of Credits = 5**

ZC-06: Advanced Developmental Biology

UNIT I

Gonadal differentiation: development and differentiation of sperm and oocytes, physical and biochemical characteristics of semen

Ovarian follicular growth and differentiation: structural and hormonal changes during major developmental events

Biochemical changes in ovum during vitellogenesis and ovulation process

Ovum transport in mammals, Multiple Ovulation and Embryo Transfer Technology (MOET)

Fertilization: Process and events, pre-fertilization events, physical and chemical changes at Fertilization, Capacitation, Acrosomal reaction and penetration, Activation of oocyte and amphimixis

UNIT II

Embryonic induction and competence theory: inducing agents and mechanism of induction

Concept of organizer and embryonic inductions

Development in drosophila: cleavage, gastrulation; molecular basis of development- maternal-effect genes, segmentation genes and homeotic selector genes

Early embryonic development in vertebrates (frog & chick): cleavage- types and significances, fate maps, blastulation, gastrulation- morphogenetic cellular movements and mechanism of axes & germ layers formation

UNIT III

General concept of organogenesis: limb morphogenesis- development and patterning of vertebrate limb, proximal, distal and dorso-ventral axis formation

Extra-embryonic membranes in birds, implantation of embryo in humans, placenta (structure, types & functions); cloning of animals by nuclear transfer

UNIT IV

Metamorphosis: Amphibian metamorphosis; aging- mechanism & concept, regeneration: modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration

Apoptosis: Definition, mechanism and significance

Embryonic stem cells and their applications; teratogenesis- teratogenic agents and their effects on embryonic development, congenital and cancerous growth

Recommended Books:

1. Analysis of Biological Development, Kalthoff (2nd Ed., 2000), McGraw-Hill Science, New Delhi, India.
2. Balinsky: An Introduction to Embryology. W.B. Saunders Company. Philadelphia and London.
3. Berill: Development Biology. Tata McGraw-Hill Publishing Co. Ltd.
4. Gilbert: Developmental Biology (10th Ed). Sinauers Associates Publ. Massachusetts, 2010.
5. Principles of Development, Wolpert, Beddington, Brockes, Jessell, Lawrence, Meyerowitz, (3rd Ed., 2006), Oxford University Press, New Delhi, INDIA.
6. Singh I.: Human Embryology (2021) Jaypee Brothers

Lab - I **No. of Credits = 3**

ZCL-02: Core Lab Course II, Based on Core Paper ZC-04, ZC-05, & ZC-06

A complete record of laboratory work will be maintained by every student. The practical work will consist of the following:

Immunology

1. Identification of various immune cells with the help of charts/photographs
2. Study of different immunoglobulins with the help of charts/photographs
3. Determination of total red blood cells and white blood cells in the blood sample
4. Estimation of serum proteins
5. Study of lymphoid organs through permanent slides/charts/models
6. Testing of blood groups
7. ELISA

Toxicology

1. Care and maintenance of laboratory animals
2. Toxic substances: waste water, carcinogens, heavy metals, pesticides, and insecticides
3. Study of acute, sub-acute, chronic and sub-chronic toxicity
4. Calculation of LC50 with the help of data provided
5. Study of behavioural responses (fish/insects/any available animal) to some important toxicants
6. Dose-response relationship
7. Analysis of toxicants by chromatography (paper, TLC & GC)
8. Effect of toxicants on haematological and biochemical indices

Advanced Developmental Biology

1. Study of different types of eggs from collected/preserved material
2. Study of whole mounts and sections of developmental stages of frog (cleavage stages, blastula, gastrula, neurula & tail bud stages) through permanent slides/ICT tools/models/charts/photographs.
3. Study of developmental stages of whole mounts of chick embryo (upto 48 hours of incubation) through permanent slides/ ICT tools/ models/ photographs
4. Study of the development of chick by window preparation
5. Study of the different types of placenta through charts/models/ICT tools
6. Study of apoptosis, cancers, and teratogenesis with the models/charts/ICT tools
7. Study of cloning techniques with the help of ICT tools/models/charts/photographs
8. Study of the reproductive system in mammals with the help of ICT tools/models/charts/photographs

Paper - IV (Elective-II: ZE-02) **No. of Credits = 4**

ZEF-02: Fish Biology-II

UNIT I

Accessory respiratory organs in fishes
Swim bladder and its modifications, gas secreting complex and its functions
Weberian ossicles: Structure and arrangement, working mechanism and functions
Electric organs: Structure, mechanism of electric discharge and functions
Bioluminescence: Luminescent organs, mechanism of light emission and significance
Sound production in fishes

UNIT II

Fish behavior: Social, ecological, reproductive, migratory, and foraging behavior
Parental care in fishes
Receptor organs: Eye, acoustico-lateralis system, olfactory organs, and taste buds
Migration in fishes: Patterns, causes, and factors influencing
Parental care and viviparity in fishes
Pheromones and their role in sexual behavior of fish

UNIT III

Fertilization and development of fish eggs (teleost)
Cleavage, blastulation, gastrulation and fate map; hatching and post-embryonic development
Respiration: Functional organization of gill lamellae, blood supply of gill, mechanism of gas exchange and counter-current mechanism.
Physiology of excretion and osmo-regulation, mechanism of water-salt balance in freshwater, marine and estuarine fishes
Reproductive physiology: Spawning patterns, stimulating factors and follicular atresia
Haemopoiesis: Composition of blood, haemopoietic tissues, and synthesis of haemoglobin
Physiology of thermo-regulation in fishes

UNIT IV

Pituitary gland: Micro-anatomy, hormones of pituitary and their physiological actions
Structure and functions of thyroid and pancreatic islets in fishes
Location and functions of corpuscles of stannius, pineal and urophysis in fishes

Recommended Books:

1. Gupta S.K. Fish & Fisheries Digest Part 3 Light & Electricity (2022). ISBN: 9798784666574
2. Khanna S. S. & Singh H.R.: A Text Book of Fish Biology & Fisheries, Narendra Publ. House, 2014
3. Kyle: The Biology of Fishes, 2007.
4. Munshi J.D. & Munshi J.S.D.: Fundamentals of Freshwater Biology, Narendra Publ. House, 1995.
5. Ojha J.: Biology of Hill Stream Fish, Narendra Publication House, 2002.
6. Srivastava C.B.L.: Fish Biology, Narendra Publication House, 2008.

Paper - IV (Elective-II: ZE-02) **No. of Credits = 4**

ZEEnt-02: Entomology-II

UNIT I

Digestive system: Structure, physiology of digestion and absorption of different types of food. Structure of circulatory system: Haemolymph, its composition and function

Physiology of respiration, tracheal system, spiracles, respiration in aquatic insects

Nervous system: Structural basis, excretion: structure and physiology of malpighian tubules and their secondary functions

Reproduction: Male and female gonads

UNIT II

Structure of compound eye, mosaic vision

Production and reception of sound, light producing organs

Pheromones and hormones: Neurosecretion and co-ordination, metamorphosis: types, hormonal control of metamorphosis

UNIT III

Structure of the insect egg, maturation, cleavage, formation of blastoderm, gastrulation, blastokinesis, germ layers, various types of larvae and pupae, moulting, diapauses, oviparity, viviparity, and ovo-viviparity in insects

UNIT IV

Abiotic factors: Effect of temperature, light, and humidity on growth of insect population, biotic potential, malthusian principle, and dynamics of population fluctuation, hibernation, and aestivation

Biotic factors: Parasitism, predation, and social life in insects, phase theory of locust and parental care

Recommended Books:

1. Elzinga RJ: Fundamentals of Entomology, Prentice Hall of India Pvt. Ltd., 1978.
2. Essig EO: College Entomology, Satish Book Enterprise, Agra, 1982.
3. Mani MS, Introduction to High Entomology, Mathuen & Coy Ltd. 1962.
4. Mani MS: An Introduction to Entomology, National Book Trust, 1971.
5. Richard DW and Davies RG: A General Text Book of Entomology, Mathuen & Coy, Ltd.

Paper - IV (Elective-II: ZE-02) **No. of Credits = 4**

ZEEvs-02: Environmental Biology-II

UNIT I

Natural resources: Management and conservation
Renewable and non-renewable resources
Concept and currencies of sustainable development
Biodiversity and its conservation
Environmental protection laws

UNIT II

Concept of protected areas: sanctuaries, national parks and biosphere reserves
IUCN categories, biodiversity hot spots and conventions on biodiversity
International efforts in biodiversity conservation (UNFP, IUCN, WWF), CITES, UNESCO's World Heritage Mission, and Convention on Biological Diversity (CBD)

UNIT III

Global environmental problems: climate change, greenhouse effect, acid rain, ozone layer depletion, deforestation, desertification, marine pollution, and urbanization
Exposure to toxicants: routes and sites of exposure (inhalation, injection, and through food or intestinal)
Duration and frequency of exposure: acute, subacute, chronic, and sub chronic
Chemical nature of toxicants: Receptors and mechanism of action of DDT, lead (Pb) and UV rays

UNIT IV

Environmental problems/hazards in hills: earthquake, landslide, soil erosion, sedimentation, cloud burst, flash floods, and glacial retreat
Application of remote sensing and Geographical Information Systems (GIS) in Environmental Management
Disasters: Types and management

Recommended Books:

1. D.E. Hathway: Molecular aspects of Toxicology: The Royal Society of Chemistry, Burlington House, London.
2. Joshi, P C and Joshi, N. Ecology and Environment. Himalayan Publishing House, Delhi, 2005
3. Omkar: Concepts of Toxicology, Shoban Lal Nagin Chand & Co. 64. B Bungalow Road, Delhi Ecology and Environment
4. Singh, H. R. Environmental biology. S Chand & Company, New Delhi., 2014
5. V.V. Metelev, A.I. Kanaev & N.G. Dzasokhova: Water Toxicology Amerind Pub. Co. Pvt. Ltd., New Delhi.

M.Sc. Zoology 2nd Sem.

Lab - II **No. of Credits = 2**

ZEL-02: Elective Lab course II, Based on one from Elective Basket ZE-02 (ZEF-02/ZEEnt-02/ZEEvs-02)

Paper - I **No. of Credits = 5**

ZC-07: Ecology & Wild Life Conservation

Ecology

UNIT I

Limiting factors: Role of biotic and abiotic factors limit population distribution, Liebig's law of minimum, Shelford's law of tolerance and factor interaction

Habitat ecology**:** Concepts of habitats (desert, arid, semi-arid, subtropical, temperate, alpine, wetlands, marshes, riverine & lakes)

Forest types, vegetation structure and stratification, habitat fragmentation and ecotone edge effect

Habitat management, use of toposheets and GIS imageries

UNIT II

Population: Concepts, attributes, biotic potential, density, mortality, natality and intrinsic rate of natural increase

Population Growth: Logistic theory and stochastic models

Population Regulation: Density dependent and density independent factors, fluctuations, predation, prey-predator relationship and minimum viable population

Community: Concept and Characteristics, density, dominance, diversity, succession of communities

Ecosystem: Concept and types of Ecosystems, food chain, energy flow and ecological pyramids

Biogeochemical cycles

Wildlife Conservation

UNIT III

Biodiversity: Factors influencing biodiversity, endemism, indicator species and key stone species

Physiography of India: Biogeographic zones, biotic provinces and their faunal composition

Himalayan region: Altitudinal and latitudinal distribution of habitats and endangered fauna

Conservation strategies: IUCN Categories for Conservation, Indian Wildlife Protection Act, CITES, WWF, Project Tiger, elephant, musk deer, Great Indian bustard, translocation projects

captive breeding: Role of central zoo authority in conservation

Protected Area Network: Wildlife sanctuaries, national parks and biosphere reserves

UNIT IV

Wildlife population estimation techniques: transects, drive counts, point counts and quadrates

Population indices: Camera traps, natural marking, pug marks, dung, pallets, scats tags, and rings

Capturing, handling and immobilization of wildlife: types of traps, trap setting, methods for capturing (fish, reptiles, birds & mammals), darts, guns, drugs and antagonists used

Radiotelemetry: Radio collars, antenna, receivers and satellite collars (insects to mammals)

Use of biotechnology in conservation: collection, extraction and preservation of wild DNA samples

Amplification, sequencing and molecular markers

Recommended Books:

1. Krebs: Ecology (4th ed.) Harper Collins College Publisher
2. Richard D. Teague: A Manual of Wildlife Conservation Nataraj Publishers, 1989.
3. Smith RL: Ecology and Field Biology, Harper Collins Publ. 1996.
4. Sutherland, William: Ecological Census Techniques. Cambridge University Press

Paper - II **No. of Credits = 5**

ZC-08: Instrumentation & Biostatistics

Instrumentation

UNIT I

Principles and applications of microscopy: Light, Phase Contrast, Transmission Electron Microscopy (TEM & SEM), and Atomic Force Microscopy (AFM)
Microtome, Cryostat, Oven, BOD Incubator and Laminar Flow

UNIT II

Colorimeter, Spectrophotometer, Trans illuminator, Thermal Cycler and automated DNA Sequencer
Centrifugation: Clinical, High-speed and Ultracentrifuges
Types of Rotors

UNIT III

Chromatography: Paper Chromatography, Thin Layer Chromatography, and Gas Chromatography
Electrophoresis: Agarose, Polyacrylamide (PAGE) and Capillary Electrophoresis

Biostatistics

UNIT IV

Descriptive Statistics: Measures of central tendency and measures of dispersion
Skewness and Kurtosis, Simple Correlation and Linear Regression (Scatter Diagram, Regression Coefficients & Regression Lines)
Students-T, Chi-Square and F-Tests, Significance of testing and their Purpose
Statistical Software: MS Excel and SPSS

Recommended Books:

1. Hoel, P.G.: Elementary Statistics. John Wiley & Sons, Inc., New York.
2. Mahajan: Methods in Biostatistics, (4th ed.). Jaypee Bros. 1984.
3. Milton & Tsokos: Statistical Methods in Biological and Health Sciences, McGraw-Hill, 1983.
4. Rana S.V.S. Biotechniques (Theory & Practice) Rastogi Publication. ISBN: 978-81-7133-993
5. S. Prasad, Elements of Biostatistics 3rd Edition, Rastogi Publication. ISBN: 978-8171339853
6. Sharma, V.K.: Techniques in Microscopy and Cell Biology, Tata McGraw-Hill
7. Zar JH: Biostatistical Analysis. Pearson.

Paper - III **No. of Credits = 5**

ZC-09: Biochemistry

UNIT I

Enzymes: Classification, zymogens and their activation (protease & prothrombin)

Enzyme Substrate Complex: Concept of E-S complex, binding sites, active site, specificity, lock & key hypothesis, and induced–fit hypothesis,

Michaelis-Menten equation and its derivation, different plots for the determination of Km and Vmax

UNIT II

Carbohydrate Metabolism I: Pathway and regulation of glycolysis, gluconeogenesis, glycogenolysis, and glycogenesis

Carbohydrate Metabolism II: Citric acid cycle and its regulation, electron transport chain, oxidative phosphorylation, pentose phosphate pathway and its regulation

Amino Acid Metabolism: Overview of amino acid degradation, urea cycle (conversion of ammonia into urea, linkage between urea cycle & citric acid cycle) and its regulation

Conversion of nitrogen to ammonia by microorganisms and overview of amino-acid biosynthesis

UNIT III

Fatty acid metabolism: Fatty acid oxidation and regulation, oxidation of unsaturated fatty acids and odd chain fatty acids, β-oxidation in peroxisomes

Ketogenesis: Biosynthesis and utilization of ketone bodies, its overproduction and regulation

Fatty acid biosynthesis and regulation, reactions of fatty acid synthesis, synthesis of triglycerols, membrane phospholipids and prostaglandins

Cholesterol biosynthesis and regulation

UNIT IV

Nucleic Acid Metabolism: Purine & Pyrimidine- biosynthesis and regulation.

Formation of deoxyribonucleotides

Salvage pathway for purine and pyrimidine nucleotides, degradation of purines and pyrimidines into uric acid and urea, integration of metabolism

Recommended Books:

1. Berg, Tymoczko, Stryer: Biochemistry, 5th ed., WH Freeman and Company, 2003.
2. Garett & Grisham: Biochemistry, 4th ed., Brooks/Cole Cengage learning, 2010.
3. Lehninger: Principles of Biochemistry, 4th ed., Nelson & Cox, WH Freeman and Company, 2007
4. Murray, Granner, Rodwell: Harper's Illustrated Biochemistry, 27th ed. McGraw Hill, 2006
5. Voet & Voet: Biochemistry, 2nd ed., Wiley & Sons.
6. Wilson & Walker: Practical Biochemistry (4th ed.).

Lab - I **No. of Credits = 3**

ZCL-03: Core Lab Course III, Based on Core Paper ZC-07, ZC-08, & ZC-09

A complete record of laboratory work will be maintained by every student. The practical work will consist of the following:

Ecology & Wildlife Conservation

1. Museum specimens showing ecological adaptations
2. Visit to nearby forests to estimate and understand habitat structure
3. To identify wild animals based on pugmarks, hoof marks, hair, scat/pellets and calls
4. Visit to nearby streams, rivers, rivulets, lake, and pond ecosystem to study biotic communities
5. Determination of abiotic parameters (pH, DO, free CO_2, alkalinity, & turbidity) in water sample
6. Hands-on training to read Toposheets and GIS imageries
7. Field training on binoculars, spotting scopes, range finder, and camera traps
8. Set-up quadrates and transects in the field
9. Physiographic and biotic provinces map preparation
10. Ecological pyramids and biogeochemical cycles with the help of ICT tools/charts
11. Tranquilization and radio telemetry with the help of ICT tools/charts

Instrumentation & Biostatistics

1. Handling of different types of microscopes
2. Handling of BOD and laminar flow
3. Microtomy
4. Chromatography
5. Agarose gel preparation and electrophoresis
6. Data presentation (bar diagram, histogram, scatter plot, pie charts)
7. Descriptive statistics
8. Data analysis using different statistical software

Biochemistry

1. Demonstration of enzyme substrate complex with the help of ICT tools/charts
2. Demonstration of Km and Vmax, lineweaver-burk plot with the help of ICT tools/charts
3. Study of different biochemical cycles with the help of ICT tools/charts
4. Estimation of proteins using Lowry/Bradford's method
5. Colorimetric estimation of glucose
6. Determination of amino acids by Paper chromatography
7. Study of salivary amylase under optimal conditions

Paper - IV (Elective-III: ZE-03) **No. of Credits = 4**

ZEF-03: Applied Fish Biology

UNIT I

Aquaculture: Concept of Different Culture Systems: Extensive and Intensive Fish Culture, Re-circulatory Aquaculture System (RAS). Fish Culture: Ponds and Reservoirs, Rice Fields, Bheries, Cage Culture, Pen Culture, Mono and Poly culture

Preparation and maintenance of fish farm: fertility and pH maintenance, role of fertilizers, water quality and its maintenance, control of aquatic weeds, insects and predatory fishes

Fish nutrition: natural food and supplementary feeding

Procurement of stocking material from natural sources, induced breeding and use of new generation drugs, ovaprim, different hatching techniques and transport of fish seed

UNIT II

Culture of Common Carp and Exotic Trout, Prawn Culture

Sewage- Fed Fisheries and Integrated Fish Farming

Common Fish Diseases and Their Control

Mahseer and snow trout Fishery: Current status, problems and perspectives

Culture of Larvicidal Fishes, Characters, and Importance

UNIT III

Harvesting and Post-Harvesting: Fishing Gears Used in Inland Waters and Seas

Fish Preservation and Processing Techniques

Fish By-Products and their Uses

Fish Spoilage: Causes of Rigor Mortis, Precautions to Control Rancidity and Microbial Spoilage

Nutritive Value of Fish, Biochemistry of Fish Flesh of Indian Major Carps, Storage, Transportation, and Marketing

UNIT IV

Capture and Ornamental Fishery: Rivers, Lakes, Dams/Reservoir Fishery Problems and its perspectives

Estuarine Fishery: Characteristics and Species dynamics

Marine Fishery: Coastal, Offshore and Deep-Sea Fishery (Hilsa, Oil Sardine, Mackerel, Bombay Duck, Sole, Ribbon, Shark, and Rays), Exclusive Economic Zone (EEZ), Recreational Fishery and Cooperative Movements, Fish Farmers Development Agencies (FFDA), Climate Change and Fishery, Major, Marine and Freshwater Ornamental Fishes, their Food and Breeding Needs

Health Management of Ornamental Fishes, Specific Diseases and their Cure

Setting and Maintenance of Aquaria

Recommended Books:

1. Agarwal, N.K. Fish Reproduction APH Publishing Delhi. ISBN 978-8131303573
2. Jhingran V G: Fish and Fisheries of India. Hindustan Publication Corp.
3. R.K. Rath: Freshwater Aquaculture, 2nd ed., Scientific Publishers, 2000.
4. S.K. Gupta, P.C. Gupta: General and Applied Ichthyology, S. Chand & Comp., 2006.
5. Vadapalli Satyanarayana: Fish Culture, Narendra Publ. House, 2002.

Paper - IV (Elective-III: ZE-03) **No. of Credits = 4**

ZEEnt-03: Applied Entomology

UNIT I

Insects in Relation to Man: Sericulture, Apiculture and Lac Culture, its Parasites, Predators and Diseases
Insects of Veterinary Importance: Sand Fly, Horse Fly, Sucking Louse and Fleas

UNIT II

Brief Knowledge of Important Household, Vegetable, Store Grain and Fruit Pests with Special Reference to Distribution, Habits, Habitat, Nature of Damage, Life History and Control
Cutworm (*Agrotis ipsilon*), Cabbage caterpillar (*Pieris brassicae*), Rice weevil (*Sitophilus oryzae*), Mustard aphid (*Lipaphis erysimi*), Red cotton bug (*Dysdercus cingulatus*), and Woolly apple aphid (*Eriosoma lanigerum*)
Termite: Important Termites of Family Termatidae (*Odontotermis sp*.)

UNIT III

Origin of Pests, Insect Pest Control: Mechanical, Physical, Culture, and Biological
Genetic Control: Chemosterilants and Radiation
Integrated Pest Management (IPM), Role of Pheromones and Hormones in Insect Pest Management

UNIT IV

Legislative Control of Insect Pests and Quarantine Law
Nomenclature and Classification of Insecticides Based on Mode of Action and Chemical Nature
Environmental Factors Influencing Effectiveness of Insecticides, Persistence, Biodegradability, Hazards of Insecticides, Precautions and Antidotes

Recommended Books:

1. K.P Srivastava, G.S Dhaliwal, Gursharan Singh: A Textbook of Applied Entomology Vol-1, Publisher: Kalyani Publishers, Edition: 4th Edition,2023
2. Leland R. Brown, Robert E. Pfadt: Fundamentals of Applied Entomology, Macmillan, 1985
3. Manju Yadav: Applied Entomology, Discovery Publishing House, New Delhi, 2003/2004
4. PG Fenemore & amp; Alka Prakash: Applied Entomology, Wiley Eastern Limited. New Age International 1992/1995/ 2006/2014

Paper - IV (Elective-III: ZE-03) **No. of Credits = 4**

ZEEvs-03: Applied Environmental Biology

UNIT I

Air: air pollutants (chemistry, sources & control), air quality standards, carbon credits, carbon footprint, thermal pollution sources and effects
Water: Biochemical aspects of water pollutants (domestic, industrial & agricultural) waste
Water treatment (aerobic & anaerobic treatment processes), water quality standards
Case study-Ganga action plan
Noise pollution: effects of noise and its control

UNIT II

Radioactive fallouts, their effects and safe disposal
Solid waste management: sources and control methods (composting, vermiculture & biogas)
Hazardous waste and its management
Bioremediation (herbicides, pesticides, hydrocarbons, & oil spills)
Ecological restoration: wasteland its reclamation and restoration

UNIT III

Environmental Impact Assessment (EIA): case study of river valley projects and mining
Bioassay: dose-response relationships, frequency, response, and cumulative response
Statistical concepts (LD50-potency v/s toxicity)
Concept of hyper- and hypo-sensitivity factors affecting toxicity

UNIT IV

Ecological Experimentation and Models: Theories and hypothesis, experimentation (inductive & deductive methods)
Models: analytical and simulation models, validation and verification
Biological pest control: use of predators, parasites, parasitoids, and pathogens
Integrated pest management

Recommended Books:

1. Dey, S and Nasrin, B. Ecology of Aquatic Systems, MEDTECH, 2016
2. Joshi, P C and Joshi, N. Ecology and Environment. Himalayan Publishing House, Delhi, 2005
3. Singh, H. R. Environmental biology. S Chand & Company, New Delhi., 2014

M.Sc. Zoology 3rd Sem.

Lab - II **No. of Credits = 2**

ZEL-03: Elective Lab Course III, Based on one from Elective Basket ZE-03 (ZEF-03/ZEEnt-03/ZEEvs-03)

Paper - I **No. of Credits = 5**

ZC-10: Animal Physiology

UNIT I

Physiology of respiration: exchange of respiratory gases at the pulmonary surface, transport of respiratory gases by blood, factors affecting Oxyhaemoglobin Dissociation, neural, and chemical control of respiration

Physiology of digestion & absorption: functional anatomy of the gastrointestinal tract, gastrointestinal motility and its regulation, secretions of the gastrointestinal tract, liver and biliary system, digestion and absorption (proteins, fats & carbohydrates)

Physiology of excretion: formation of urine: functional anatomy of the kidney, glomerular filtration and its control, reabsorptions and secretions in the tubules, mechanisms of active transport, excretion and control (urea, sodium, potassium, & other ions), functions of aldosterone, antidiuretic hormone and renin-angiotensin system in renal physiology, Osmoregulatory mechanisms

UNIT II

Physiology of cardiovascular system: characteristics of vertebrate cardiac muscle, initiation, conduction and regulation of heart beat, cardiac cycle and cardiac output

ECG and myocardial infarction, blood pressure and its regulation, circulation (open & closed)

Blood composition & function: blood groups, cascade of biochemical reactions involved in coagulation of blood, lymphatic systems

UNIT III

Nervous system: Neuron, sensory and motor, ionic basis of resting and action potentials, significance of myelinated nerve fibers and velocity of conduction

Physiological anatomy of synapse, mechanism of synaptic transmission, transmitters (acetylcholine, norepinephrine, histamine, & gaba), reflexes and types

Neuromuscular physiology: structural proteins of muscle cells, actin-myosin complex and sliding filament theory of muscle contraction, excitation-contraction coupling

UNIT IV

Sensory physiology: Eye and visual processes- functional anatomy of the structural elements of the retina, Photochemistry of vision, extraretinal photoreception, visual adaptations in vertebrates

Ear and auditory processes: tympanic membrane and the Ossicular system, conduction of sound from tympanum to cochlea, functional anatomy of cochlea, sound transmission in cochlea, mechanism of thermoregulation (poikilotherms, homeotherms, & heterotherms), aestivation and hibernation

Recommended Books:

1. Jain A.K. Manual of Practical Physiology (2019) Arya publ.978-81-7855-846-2
2. Jain A.K. Text book of Physiology, Avichal Publication. Co. New Delhi (2021) 978-81-7739-575-4
3. Lauralee Sherwood, Hillar Klandorf, and Paul Yancey. Animal Physiology: From Genes to Organisms. Cengage Learning (2012)
4. Pandey B.N Zoology Series-Biochemistry Physiology & Endocrinology Tata McGraw Hill ISBN 978-00-71330-03-9
5. Richard W. Hill, Gordon A. Wyse, Margaret Anderson - Animal Physiology, 3rd Ed-Sinauer Associates, Inc. (2012)

Paper - II **No. of Credits = 5**

ZC-11: Endocrinology

UNIT I

Endocrine messengers: Hormones, neurohormones, hormone-like substances (neuronal peptides, autacoids, pheromones, & neurosecretion)

Hormone biosynthesis: protein peptide hormones (gonadotrophins, thyrotrophin, corticotrophin, steroids, & catecholamines)

Mechanism of action of steroid hormones and thyroid hormones, hormone receptors

UNIT II

Pituitary gland: Morphology and anatomy of Adeno and neuro hypophysis, adenohypophyseal and neurohypophyseal hormones, hypothalamic control of hypophyseal hormones

Pineal gland: Structure, secretion and function

GI-tract hormones: types and functions

UNIT III

Thyroid gland: Structure and thyroid hormones synthesis, secretion and transport, physiological and metabolic functions of thyroid hormones, thyroid hormone related disorders

Parathyroid gland: Structure and function

Pancreas: Structure, secretion, and function, regulation of insulin secretion, diabetes mellitus- types and management

Adrenal gland: Gross anatomy, corticosteroids and catecholamine; structure and function, renin angiotensin system

UNIT IV

Organisation and physiological actions of testis: Androgen binding protein, Inhibin, neuroendocrine control of testicular functions (GNRH regulation, FSH- effects on germinal epithelium, LH-effects on Leydig cells, negative feedback regulation)

Organisation and physiological actions of ovary: Folliculogenesis, ovulation, luteinization, ovarian cycles, seasonal reproductive cycles, causes of sexual dysfunctions in male and female, hormonal and immuno-contraceptives

Recommended Books:

1. Brooks: Essential Endocrinology (2006) New Age International
2. F.S. Greenspan & P.H. Forsham: Basic and Clinical Endocrinology Maruzen Asian Ed. Lange Medical Publ. USA, Singapore
3. Mac E. Hadley: Endocrinology, Prentice-Hall International ed.1988/1992.
4. Maurice Goodman: Basic and Medical Endocrinology, Raven Press.
5. Pandey BN & Sanjeev K Endocrinology (2019) Atlantic Pub.& Distributors
6. Sastry KV: Endocrinology & Reproductive Biology 1st Ed., 8th reprint 2021 Rastogi Publ.Meerut
7. Turner & Bagnara: General Endocrinology, WB Saunders Publisher

Paper - III **No. of Credits = 5**

ZC-12: Animal Taxonomy & Evolution

Animal Taxonomy

UNIT I

Taxonomy and its importance, systematics and evolution, stages of taxonomy (alpha, beta, & gamma)
Origin and development of taxonomy, zoological nomenclature, and its principles, ICZN, nomenclature and taxonomic hierarchy, concepts of taxon, rank and category, synonyms, homonyms and tautonyms, type concept
Biological classification: types of classification (artificial, natural & phylogenetic)
Taxonomic characters and taxonomic keys, problems in taxonomy

UNIT II

Concepts of species: biological species concept
Approaches in taxonomy: morphological, anatomical, developmental biology, numerical, ecological, ethological and molecular taxonomy, trends in taxonomy (biochemical, serological, numerical, & molecular phylogeny)
Molecular basis of animal taxonomy: genetic polymorphism, electrophoretic variations, amino acid sequencing for variety of proteins, DNA-DNA and DNA-RNA hybridization
Taxonomic collections, identification, description, preservation, and curation of collections

Evolution

UNIT III

Concepts of evolution and theories of organic evolution
Neo Darwinism and population genetics: Hardy-Weinberg law of genetic equilibrium
Destabilizing forces: natural selection, mutation, genetic drift, migration, and meiotic drive
Trends in evolution, molecular evolution (gene evolution, evolution of gene families & assessment of molecular variation)

UNIT IV

Speciation and modes of speciation (allopatric, peripatric, parapatric, & sympatric speciation)
Origin and mechanisms of reproductive isolation
Patterns of speciation: Gradualism and punctuated equilibrium.
Major trends in the origin of higher categories, micro and macro evolution
Ecological significance of molecular variations (genetic polymorphism)
Human evolution: key stages and ancestors

Recommended Books:

1. Huston A.M.: Biological Diversity, Cambridge University Press, Cambridge.
2. Hymen L.H.: The invertebrates (all volumes), McGraw-Hill, Philadelphia, USA.
3. Kapoor, V.C.: Theory and Practice of Animal Taxonomy, Oxford and IBH Publishing Co. Pvt. Ltd.
4. Species Evolution: Role of Chromosomal Change, Cambridge University Press.
5. Strickberger: Evolution, Jones, and Bartlett Publishers.
6. Verma A.: Principles of Animal Taxonomy, Alpha Science International Ltd.

Lab - I **No. of Credits = 3**

ZCL-04: Core Lab Course IV, Based on Core Paper ZC-10, ZC-11, & ZC-12

A complete record of laboratory work will be maintained by every student. The practical work will consist of the following:

Animal Physiology

1. Preparation of hemin crystals from blood
2. Counting of RBC and WBC from blood using hemocytometer
3. Estimation of hemoglobin from blood
4. Estimation of sugar levels in urine samples using Benedict's method
5. Measurement of blood pressure and pulse rate at rest and after exercise
6. Measurement of rate of oxygen consumption
7. Examination of permanent slides of different organs of the animals
8. Detection of blood groups by antisera
9. Determination of 24 hrs body temperature cycles

Endocrinology

1. Examination of permanent slides of different endocrine glands
2. Endocrine disorders with the help of ICT tools/charts
3. Studying the release and action of various pituitary hormones with the help of ICT tools/charts
4. Studying the ovarian cycles (estrus & menstrual) with the help of ICT tools/charts
5. Understanding the role of contraceptives and IUDs with the help of ICT tools/charts
6. Understanding the causes of infertility in male and female animals
7. Understanding the role of endocrine glands in animal behaviour

Animal Taxonomy & Evolution

1. Composition assessment of the taxonomic diversity/biodiversity in different habitat
2. Influence of climatic conditions on taxonomic diversity in given habitat
3. Preparation of models showing the status of certain taxa or species in particular habitat
4. Study of evolutionary history (Eras & Epochs) with the help of ICT tools/charts
5. Study different types of fossils with the help of ICT tools/charts
6. Compare vestigial, analogous, and homologous organs using specimens/models/photographs
7. Understanding the evolution of horses and humans with the help of ICT tools/charts
8. Study of embryological evidences with the help of ICT tools/charts

Paper - IV (Elective-IV: ZE-04) **No. of Credits = 4**

ZEF-04: Methodology in Fish Biology

UNIT I

Physiography of pond, lake, streams, river, and reservoir, substrate conditions (hard & soft), particle size sampling for determining abiotic conditions, sample type, sampling frequency, sampling and preservation of water for laboratory analysis

Methods for determining physical environment: air and water temperature, current velocity, turbidity, and transparency

Methods for estimation of chemical environment: pH, conductivity, DO, free CO_2, alkalinity, hardness, chlorides, phosphate, and nitrate

UNIT II

Qualitative analysis, inventory of floral and faunal elements in aquatic ecosystems to class/order level,

Collection and quantitative analysis of biotic communities (density, percent composition), plankton and benthic communities (periphyton & macro invertebrates), multivariate analysis for comparing communities at different locations

Computation of indices: species richness, species diversity, Margalef diversity index

Similarity index: identification of fish fauna (carps & catfish), use of keys and monographs

UNIT III

Fish stocks (concept, test of homogeneity using morphometric & meristic analysis, Truss analysis, molecular techniques), length-weight relationship, relative condition factor

Quantitative estimation of dietary components (numerical, volumetric, gravimetric & points method), determining category of food (basic, secondary) and dietary habits (herbi, omni, & carnivore), feeding intensity (gastrosomatic index)

Determining stages of sexual maturity (macroscopic & microscopic methods), size at first maturity, spawning season and frequency (gonado-somatic index), fecundity

UNIT IV

Determination of age and growth in fishes by hard parts (scale, otolith, & operculum), length frequency method, identification of annuli, growth rate, back calculation method, estimation of harvestable size of fish, fishery biology of snow trout and golden mahseer, stock assessment, growth parameters, mortality exploitation rate, and ratio

FISAT software, fishing gears, and catch per unit effort (CPUE)

Recommended Books:

1. Agarwal, N.K. and Singh, G. The Ganga in the Himalayas: Fish Diversity and Environment. Narendra Publishing House, Delhi, 2021 ISBN 978-93-89996-81-4
2. Agarwal, N.K. Fish Reproduction APH Publishing Delhi, ISBN 978-8131303573
3. Bahuguna, P. and Dobriyal, A.K. Biology of the Ornamental Fish *Puntius conchonius* (Ham. Buch.), Narendra Publishing House, Delhi, 2019
4. Nautiyal P: Methods in fisheries Science & Aquatic Ecology. Dehradun 2019
5. Talwar, P.K. and Jhingran, A.G. Inland fishes. Oxford ad IBH Publishing Co., New Delhi

Paper - IV (Elective-IV: ZE-04) **No. of Credits = 4**

ZEEnt-04: Methodology in Entomology

UNIT I

Research methodology in entomology: introduction, role of entomology in agriculture (beneficial & harmful insects)

Medical entomology: disease vectors (mosquito, sand fly, tsetse fly, & pathogens), lifecycle, and diseases

Veterinary entomology: vector insects (ticks, mites, flies, & pathogens), lifecycle, and diseases

Entomology: principles, forensic entomological flies, use of human lice in forensic entomology, and importance

UNIT II

Types of sampling survey, different collection methods, collection of wild flies and domestic insects

Collecting insects in the wild area: tools and equipment, preparing and using baits, collecting from natural substances, collection permission from govt. Agency (forest department, state biodiversity board (SBB), & national biodiversity authority), transporting live adults or larvae

UNIT III

Preservation of insects, classification of insects up to the level of families with hands-on experience in identifying the families of insects and catalogues

Insect laboratory and rearing equipment, experimental designs in field and laboratory, techniques in insect taxonomy, mortality correction

Bioassay: principles, importance, factors affecting, procedures, apparatus used

UNIT IV

Trophic relationships, use of ecological data

Insect diversity: indices, richness, and rarity

Population estimates, coexistence and competition, distribution patterns

Study of terrestrial/aquatic insect biodiversity, physico-chemical parameters of water (turbidity, transparency, velocity, pH, temperature, CO_2 & DO, hardness)

Recommended Books:

1. K.P Srivastava, G.S Dhaliwal, Gursharan Singh: A Textbook of Applied Entomology Vol-1, Publisher: Kalyani Publishers, Edition: 4th Edition,2023
2. Leland R. Brown, Robert E. Pfadt: Fundamentals of Applied Entomology, Macmillan, 1985
3. Manju Yadav: Applied Entomology, Discovery Publishing House, New Delhi 2003/2004
4. PG Fenemore & amp; Alka Prakash: Applied Entomology, Wiley Eastern Limited. New Age International 1992/1995/ 2006/2014

Paper - IV (Elective-IV: ZE-04) **No. of Credits = 4**

ZEEvs-04: Methodology in Environmental Biology

UNIT I

Importance and need of environmental research, problem identification, objectives, significance, scope, and limitations

Literature survey, importance and designing of the problem to be undertaken

Field survey: site selection, source selection for data acquisition

Sampling strategies (sample size, frequency, bias, & error), project report preparation.

UNIT II

Measurement of solar radiation, wind velocity, air quality monitoring, measurement of oxides of nitrogen, carbon, sulphur, lead, tropospheric ozone, methane, aerosol, and pesticide

Stack sampling, sample collection for particulate matters (dust fall collection & high-volume sampler), indoor air pollutants (Radon) measurement

UNIT III

Water quality analysis: measurement of water temperature, velocity, depth, transparency, dissolved oxygen, free CO_2, pH, turbidity, hardness, alkalinity, BOD, COD, dissolved nutrients (nitrates, phosphates, sodium, potassium, chloride, etc.), and heavy metals

Sampling methods for terrestrial flora and fauna (quadrate method)

UNIT IV

Sampling methods for aquatic fauna and flora (plankton, periphyton, micro, macroinvertebrates, nekton)

Soil types, measurement of soil pH, water holding capacity, organic matter, soil nutrients (nitrate, nitrite, calcium, & magnesium), sampling of soil fauna, sampling of soil for microbial diversity

Application of statistical, descriptive, and regression analysis in environmental science: parametric and nonparametric tests, hypothesis testing, T-test, Z-test, F-test, multivariate test, Chi square test, and Kruskal Wallis test

Statistical software's: Excel, Statistica, SPSS, etc.

Recommended Books:

1. APHA. Standard Methods for Examination of Water and Wastewater. 22nd Edn., APHA, AWWA, WPCF, Washington DC, USA, 2012.
2. Edmondson TH. (ed). Freshwater biology, Ward. H B and Whipple, G H, John Wiley and Sons, NY, 1992.
3. Gupta, S.L. & Gupta, H. Research methodology (Text and cases with SPSS application). IBH Pvt Ltd, 2011
4. Welch, P.S. Limnological methods, Mc Graw Hill Book Co. NY.

M.Sc. Zoology 4th Sem.

Lab - II **No. of Credits = 2**

ZEL-04: Elective Lab Course IV, Based on one from Elective Basket ZE-04 (ZEF-04/ZEEnt-04/ZEEvs-04)