UNIVERSITY OF GOUR BANGA

PG Syllabus in Zoology (under NEP, 2020)

w.e.f. Session: 2026-2027

Two years PG after three years UG

(Academic Year – First)

Semester	Subject type	Paper Code	Paper Name	Marks*	Duration in end semester examination	Credit
I	DSC	ZOOL-DSC-101	Advances in Non-chordates and Chordates	20+20+10** = 50	2 hrs.	4
		ZOOL-DSC-102	Cell Biology and Genome Biology	20+20+10** = 50	2 hrs.	4
		ZOOL-DSC-103	Physiology and Developmental Biology	20+20+10** = 50	2 hrs.	4
		ZOOL-DSC-104	Practical (Laboratory Course)	40+10** = 50	4 hrs.	4
	DSE#	ZOOL-DSE-105(A)	Radiation Biology and Photobiology	20+20+10** = 50	2 hrs.	4
		ZOOL-DSE-105(B)	Advances in Histology and Histochemistry	20+20+10** = 50	2 hrs.	
		ZOOL-DSE-105(C)	SWAYAM MOOCs Course	50	---	
	SEC	ZOOL-SEC-106	Trends in Biostatistics and Bioinformatics	20+20+10** = 50	2 hrs.	4
Total marks & credit in Semester - I				**300**		**24**
II	DSC	ZOOL-DSC-201	Advances in Parasitology & Vector Biology and Advances in Immunology	20+20+10** = 50	2 hrs.	4
		ZOOL-DSC-202	Advances in Ecology & Environmental Biology and Advances in Behavioral Biology	20+20+10** = 50	2 hrs.	4
		ZOOL-DSC-203	Molecular Genetics and Biochemistry	20+20+10** = 50	2 hrs.	4
		ZOOL-DSC-204	Practical (Laboratory Course)	40+10** = 50	4 hrs.	4
	DSE#	ZOOL-DSE-205(A)	Traditional Medicine and Alternative Medicine	20+20+10** = 50	2 hrs.	4
		ZOOL-DSE-205(B)	Biodiversity and Conservation Biology	20+20+10** = 50	2 hrs.	
		ZOOL-DSE-205(C)	SWAYAM MOOCs Course	50	---	
	SEC	ZOOL-SEC-206	Advances in Biotechnology	40+10** = 50	2 hrs.	4
Total marks & credit in Semester - II				**300**		**24**

(Academic Year – Second)

Semester	Subject type	Paper Code	Paper Name	Marks*	Duration in end semester examination	Credit
III	DSC	ZOOL-DSC-301	Applied Microbiology and Bioinformatics	20+20+10** = 50	2 hrs.	4
	DSE#	ZOOL-DSE-302(A)	Neurobiology	40+10** = 50	2 hrs.	4
		ZOOL-DSE-302(B)	Endocrinology	40+10** = 50	2 hrs.	
		ZOOL-DSE-302(C)	SWAYAM MOOCs Course	50	---	
	DSE#	ZOOL-DSE-303(A)	Environmental Toxicology	40+10** = 50	2 hrs.	4
		ZOOL-DSE-303(B)	Forensic Toxicology	40+10** = 50	2 hrs.	
	DRP	ZOOL-DRP-304	Advanced Research Methodology	40+10** = 50	2 hrs.	4
		ZOOL-DRP-305	Dissertation / Research Project / Entrepreneurship	100	---	8
Total marks & credit in Semester - III				**300**		**24**
IV	DSC	ZOOL-DSC-401	Taxonomy & Evolution and Applied Zoology	20+20+10** = 50	2 hrs.	4
	DSE#	ZOOL-DSE-402(A)	Nanobiotechnology and Clinical Microbiology	20+20+10** = 50	2 hrs.	4
		ZOOL-DSE-402(B)	Life Style & Metabolic Disorder	40+10** = 50	2 hrs.	
		ZOOL-DSE-402(C)	SWAYAM MOOCs Course	50	---	
	DSE#	ZOOL-DSE-403(A)	Advanced Phytomedicine and Drug Discovery	40+10** = 50	2 hrs.	4
		ZOOL-DSE-403(B)	Public Health and Community Medicine	40+10** = 50	2 hrs.	
	DRP	ZOOL-DRP-404	Dissertation / Research Project / Entrepreneurship	150	---	12
Total marks & credit in Semester - IV				**300**		**24**

**For each of the theory and practical papers in Semester -I –II, -III, & IV, 10 out of 50 marks have been allotted for Internal Assessment.*

***For internal assessment (10 marks), the allotted time is 30 min.*

#In each Semester, Students have to opt any one (01) DSE papers from the groups of DSE papers [i.e., any one from (A) or (B) or (C)]

Semester – I

ZOOL-DSC-101: Advances in Non-chordates and Chordates

Learning objectives

The course "Advances in Non-chordates and Chordates" will:

- analyze the origin, diversity and phylogeny of non-chordate and chordate groups using molecular and morphological criteria.
- explain structural organization and functional adaptations of major systems (nutrition, respiration, excretion, locomotion, nervous, sensory) in non-chordates and chordates.
- evaluate parasitic adaptations and life-history strategies of representative non-chordate parasites in relation to host–parasite interactions and disease.
- interpret biomechanical and physiological principles underlying vertebrate biological design, thermoregulation, flying and gliding.
- integrate concepts of molecular taxonomy, ectodermal placodes and evolutionary trends to understand chordate evolution.

Learning outcomes

- Students will classify major non-chordate phyla and chordate groups, justifying their placement using contemporary molecular phylogeny and traditional morphology.
- Students will compare and contrast functional organization of key systems (digestive, respiratory, excretory, nervous, sensory) across representative invertebrates and vertebrates.
- Students will describe parasitic forms (e.g. *Entamoeba histolytica*, *Giardia*, *Taenia* spp., myiasis) and explain their pathogenesis and control measures.
- Students will explain vertebrate thermoregulatory strategies in ectotherms and endotherms, including adaptations to extreme environments.
- Students will apply biomechanical principles to analyze skull design, support, movement, and the evolution of flying and gliding in vertebrates.

Group A: Advances in Non-chordates **25 marks (20 end semester + 5 IA)**

1. **Origin and diversity:** All non-chordate phyla; concept of protists, parazoa and metazoan; molecular taxonomy and phylogeny of non-chordates.

2. **Nutrition and metabolism:** Nutrition in protozoa – types and mode of feeding; feeding diversity in insects; filter feeding in Crustacea and Mollusca – functional mechanism.
3. **Growth and development:** Crustacean moult-inhibiting hormones: structure, function, and cellular mode of action; physiology of diapause and moulting in insects and crustaceans.
4. **Nervous system and sense organs:** Trends of neural evolution in invertebrate phyla; photoreception, photosensitivity and photic adaptation in non-chordates; statocysts as balancing organ in molluscs; intelligence in cephalopods; neuroendocrine regulation in insects.
5. **Respiratory and excretory system:** Structural components and functional aspects; physiology of respiration in aquatic insects; osmoregulation in *Amoeba*, insect, Crayfish and crustaceans; excretory structures and functions in helminthes, annelids and insects.
6. **Movement and locomotory organs:** Ciliary and flagellar movements; hydrostatic evasive movements in ctenophora and hydrostatic skeleton in annelids; insect flight mechanism.
7. **Parasitic forms of nonchordates:** Biology and pathogenesis of *Entamoeba histolytica*, *Giardia*, *Taenia* spp.; myiasis – causes, pathogenesis and control; parasitic adaptations in *Sacculina* sp.; hyperparasitism in insects.

Group B: Advances in Chordates **25 marks (20 end semester + 5 IA)**

1. **Origin of Chordate:** Molecular taxonomy and phylogeny of chordates; ectodermal placodes and the evolution of the vertebrates.
2. **Biological design:** Biomechanics of support and movement; embryology and phylogeny of skull; cranial kinesis; skull function and design.
3. **Cardiovascular and respiratory system:** Structural components and physiological functions; embryonic development and modifications of the cardiovascular system; lymphatic system; different modification of respiratory system in fish; double mode of respiration in birds.
4. **Nervous system and sensory organs:** Peripheral nervous system; central nervous system; general sensory organs; special sensory organs in fishes, reptiles and bat.
5. **Thermoregulatory changes in Vertebrates:** Definition and scope of thermoregulation; relationship with homeostasis and energy balance in vertebrates; thermoregulation in ectothermic and endothermic vertebrates; adaptations to extreme environments; ontogenetic, evolutionary and applied perspectives of thermoregulation.
6. **Flying and gliding:** Types, mechanisms, principles, adaptations and significance.

Suggestive readings:

- Anderson, D. T. (Ed.) (2001). Invertebrate Zoology. 2nd ed. Oxford University Press.

- Barnes, R. D. and Ruppert, E. E., (1996). Invertebrate Zoology. 6th ed. Brooks Cole.
- Ruppert, E. E., Fox, R. and Barnes R. D. (2003). Invertebrate Zoology: A Functional Evolutionary Approach. 7th ed. Brooks Cole.
- Barrington, E. J. W. (1981). Invertebrate Structure and function. 2nd ed.
- ELBS and Nelson. Brusca, R. C. and Brusca, G. J. (2002). Invertebrates. 4th ed. Sinauer Associates.
- Meglitsch, P. A. and Schram, F. R. (1991). Invertebrate Zoology. Oxford University Press.
- Pechenik, J. A. (1998). Biology of the Invertebrates. 4th Ed. McGraw Hill.
- Kardong, K. V. (2018). *Vertebrates: Comparative Anatomy, Function, Evolution*. 8th Ed. McGraw Hill.
- Pough, F. H., Bemis, W. E., & McGuire, B. (2022). *Vertebrate life*. 11th Ed. Oxford University Press, USA.
- Hildebrand, M., & Goslow, G. (2001). *Analysis of vertebrate structure*. 5th Ed. John Wiley & Sons, USA.

ZOOL-DSC-102: Cell Biology and Genome Biology

Learning objectives

The course "Cell Biology and Genome Biology" will:

- describe membrane structure, dynamics and transport processes underlying cellular homeostasis.
- explain structural organization and functions of intracellular organelles, cytoskeleton and cell cycle regulation.
- analyze cellular signaling pathways, cell–cell communication and mechanisms of cancer and apoptosis.
- explain genome organization in prokaryotes, eukaryotes and organelles, and approaches for genetic and physical mapping.
- evaluate functional genomics concepts (transcriptome, proteome, metabolome), genome expression and evolution.

Learning outcomes

- Students will interpret experimental data on membrane transport, electrical properties and receptor-mediated signaling.
- Students will relate organelle structure to function and predict consequences of dysfunction at cellular and organismal levels.
- Students will outline molecular events in cell cycle progression, regulation and misregulation leading to cancer and apoptosis.

- Students will compare different mapping strategies (linkage, restriction mapping, FISH, STS mapping, sequencing) for genome analysis.
- Students will learn about genome maintenance, recombination, transposition, and the roles of structural, functional, epigenomic and metagenomic approaches.

Group A: Cell Biology **25 marks (20 end semester + 5 IA)**

1. **Biological membrane structure and function:** Model structure and membrane dynamics; electrical properties and transport of molecules across membrane.
2. **Structural organization and function of intracellular organelles:** Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes and vacuoles; structure & function of cytoskeleton.
3. **Cell division and cell cycle:** Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle.
4. **Cell signaling:** Signaling through different cell surface receptors, second messengers, regulation of signaling pathways.
5. **Cellular communication:** Regulation of hematopoiesis; general principles of cell communication; cell adhesion and roles of different adhesion molecules; gap junctions, tight junctions and extracellular matrix.
6. **Cancer biology and apoptosis:** Causes, types and mechanisms.

Group B: Genome Biology **25 marks (20 end semester + 5 IA)**

1. **Organization and structure of genome:** Definition of genome, genomic complexity, human genome, viral and bacterial genomes, organelle genome, architecture of mitochondrial genome, model prokaryotic and eukaryotic genome – features and variation; concept of polymorphism and conservation of genome organization.
2. **Mapping genome:** Genetic mapping; DNA markers, linkage mapping, physical mapping, restriction mapping; fluorescence in situ hybridization; sequence tagged site mapping; sequencing genomes.
3. **The Human Genome Project:** Origin of the project; the mapping phase of the Human Genome Project; sequencing the human genome; the future of the project.
4. **Understanding how genomes functions:** Concepts of transcriptome, proteome and metabolome; transcriptome: the RNA content of the cell, coding and non-coding RNA, processing of precursor RNA, transcriptomics and its application; Concepts of proteome: the protein content of the cell,

protein structure, amino acid diversity and protein diversity, the multiplicity of protein function; Concepts of metabolome: understanding the biological system.

5. **Accessing the genome:** Genome architecture inside the eukaryotic nucleus, chromatin modifications and genome expression, DNA modification and genome expression.
6. **Microbial genetics:** Methods of genetic transfer – transformation, conjugation, transduction, mapping genes by interrupted mating.
7. **Population Genetics:** Genetic structure of populations; Hardy-Weinberg principle; genetic variation in natural population; gene frequencies and forces.
8. **Maintenance and Evolution of genome:** Regulation of eukaryotic genome replication; homologous and site-specific recombination; transposition; the origin of genome; acquisition of new genes; noncoding DNA and genome evolution.
9. **Concept of Genomics:** General concept, application and scopes of structural and functional genomics, epigenomics, metagenomics.

Suggestive readings:

- Bruce Alberts, Rebecca Heald, Alexander Johnson, David Morgan, Martin Raff, Keith Roberts, Peter Walter, Molecular biology of the cell, 7th ed., W. W. Norton & Company, Inc.
- Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Angelika Amon, Kelsey C. Martin, Molecular Cell Biology, 8th ed, W. H. Freeman and Company.
- Janet Iwasa, Wallace Marshall, Karp's Cell and Molecular Biology Concepts and Experiments, 9th ed. John Wiley & Sons, Inc.
- Geoffrey M. Cooper, The Cell: a molecular approach, 8th ed., Sinauer Associates.
- Jeff Hardin, James P. Lodolce, Becker's World of the Cell, 10th ed., Pearson Education, Inc.
- Thomas D. Pollard, William C. Earnshaw, Jennifer Lippincott-Schwartz, Graham T. Johnson, Cell biology, 3rd ed., Elsevier, Inc.
- Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. Lewin's cell biology 3rd ed. Burlington, MA: Jones & Bartlett Learning.
- Brown (2007). Genomes 3. Garland Science Publishing
- Brown (2023). Genomes 5. CRC Press
- Lesk (2025). Introduction to genomics. Oxford University Press

ZOOL-DSC-103: Physiology and Developmental Biology

Learning objectives

- Explain cellular physiology including fluid, electrolyte and acid–base balance and homeostatic disorders.
- Describe mechanisms and regulation of muscle contraction, blood physiology, neurophysiology, respiration, nutrition and sports physiology.
- Analyze fundamental concepts of development, including cell potency, specification, induction, morphogenetic gradients and cell fate.
- Explain molecular and genetic control of pattern formation in *Drosophila* and vertebrates, including HOX genes and axis formation.
- Evaluate hormonal regulation of metamorphosis and mechanisms of regeneration, aging and programmed cell death.

Learning outcomes

- Students will interpret physiological data (e.g. ECG, blood pressure, respiratory measures) and relate them to normal function and clinical disorders.
- Students will describe neural mechanisms underlying sensation, sleep and memory, and relate them to health and disease.
- Students will distinguish different modes of reproduction and cleavage patterns and explain their biochemical and cellular bases.
- Students will outline genetic networks controlling anterior–posterior and dorso–ventral patterning in key model organisms.
- Students will discuss endocrine control of metamorphosis, mechanisms of regeneration and cellular events underlying aging and senescence.

Group A: Physiology **25 marks (20 end semester + 5 IA)**

1. **Cellular physiology:** Structural components and function; nucleus and organelle associated disorders; fluid, electrolyte and acid-base balance; homeostatic disorders.

2. **Muscle physiology:** Classification and comparative study; molecular basis of muscle contraction; metabolism of muscle; muscle disorders.
3. **Physiology of blood:** Blood as a tissue; life cycle of RBC; blood coagulation; disorders of the blood; cardiac cycle; ECG; blood pressure and clinical disorders of the blood vascular system.
4. **Neurophysiology:** Nerve impulse propagation and synaptic transmission and disorders of the brain; physiology of vision, smell, taste and hearing and their clinical disorders; sleep – types and disorders; memory – stages and category.
5. **Physiology of respiration:** Inspiration and expiration; cellular transport of carbon dioxide and oxygen; regulation of respiration.
6. **Nutritional physiology:** Foods, vitamins and minerals; digestion and absorption of foods; disorders of the digestive system; nutrigenomics – basic concept.
7. **Sports physiology:** Effects and benefits of exercise and yoga on health and life style management in human.

Group B: Developmental Biology **25 marks (20 end semester + 5 IA)**

1. **Basic concepts of development:** Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; genomic equivalence and the cytoplasmic determinants.
2. **Mode of reproduction and differentiation:** Gametogenesis, spermatogenesis, oogenesis, vitellogenesis and chemo-differentiation; fertilization, parthenogenesis and its significance; types of cleavage, mechanism of cleavage, chemical changes during cleavage.
3. **Embryonic induction and competence theory:** Inducing agents and mechanism of induction; concept of organizer and embryonic inductions; embryonic stem cells and their applications.
4. **Body pattern formation:** Origin of anterior-posterior and dorso-ventral polarity in *Drosophila*: involvement of maternal, segmentation and homeotic genes; organization of HOX gene in vertebrates.
5. **Growth and development:** Axis formation in Amphibians, Nieuwkoop centre and primary organizer; axis formation in birds and mammals: involvement of pattern forming genes.
6. **Metamorphosis and regeneration:** Role of hormones in metamorphosis of insects and frog; regeneration: modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration.
7. **Programmed cell death, aging and senescence:** Definition, mechanism and significance.

Suggestive readings:

- Hill et.al. (2016). Animal Physiology. Sinauer

- Hall (2010). Guyton and Hall Textbook of Medical Physiology. Elsevier Health Sciences
- Arias, A. M. and Stewart, A. (2002). Molecular Priciples of Animal Development. 1st ed. Oxford University Press.
- Balinsky (1981). Introduction to Embryology. 5th ed.
- Holt Rinehart & Winston.Carlson, B. M. (1999). Patten's Foundations in Embryology. 6th ed.
- McGraw Hill. Gilbert S. F. (1999). Embryology. Sinauer Associates, Sunderland, Massachusetts.
- Gillbert, S.F. (2006). Developmental Biology. 8th ed. Sinauer Associates.
- Kalthoff, K., (2001). Analysis of Biological Development. 2nd ed. McGraw Hill. Moody, S.A. (Ed.) (2007). Principles of Developmental Genetics. Academic Press.
- Shostak, S. (1991). Embryology – An Introduction to Developmental Biology.
- Harper Collins. Slack, J. M. W. (2006). Essential Developmental Biology. 2nd ed. Blackwell Publishing.
- Twyman, R.W. (2001). Instant Notes-Developmental Biology. Viva Books Private Ltd.
- Wilt, F. H. and Hake, S. C. (2004). Principles of Developmental Biology. W. W. Norton Company.
- Wolpert, L. (2007). Principles of Development. 3rd ed. Oxford University Press.

ZOOL-DSC-104: Practical (Laboratory Course) 50 marks (40 end semester + 10 IA)

Learning objectives

- Develop competency in classical zoological dissection and display of anatomical systems in representative invertebrates and vertebrates.
- Acquire skills in cytological preparations, staining and karyotype analysis for chromosomal abnormalities and syndromes.
- Perform basic haematological, physiological and developmental biology practicals, including BMI, WBC differential counts and chick embryo studies.
- Execute DNA isolation, restriction digestion, electrophoresis and chromosomal preparations in a molecular biology context.
- Document laboratory findings systematically and interpret results in relation to theoretical concepts.

Learning outcomes

- Students will prepare high-quality anatomical and histological specimens from insect and fish models and interpret their organization.
- Students will produce mitotic, meiotic and polytene chromosome spreads and identify key stages and anomalies.
- Students will identify common chromosomal syndromes using karyotypes and relate these to clinical phenotypes.
- Students will perform basic molecular biology techniques (DNA isolation, restriction digestion, electrophoresis) and analyze banding patterns.
- Students will maintain organized laboratory records and critically discuss observations in relation to theory.

Practicals:

1. Isolation of genomic DNA/Restriction digestion mapping/Transformation in *E. coli*.
2. Dissection and display of the anatomical systems of cockroach and house fly.
3. Preparation of stained haemolymphatic film for identification of haemocytes of insects.
4. Demonstration / Display of the anatomical system of fresh water edible fish.
5. Slide preparation of different types of scales in fishes.
6. Histological staining of pre-prepared Chordate specimen slides.
7. Preparation of meiotic chromosome from grasshopper testis and identification of the stages.
8. Preparation of polytene chromosomes from *Chironomous* / *Drosophila* larvae.
9. Preparation of mitotic chromosome from whole blood.
10. Cytological staining of Barr body.
11. Identification of Turner syndrome, Klinefelter syndrome, Down syndrome, Edward syndrome and Patau syndrome using the karyotype.
12. Analysis of karyotype from human chromosome.
13. Determination of Body Mass Index (BMI) and interpretation of results.
14. Differential counting of WBCs (mammalian).
15. Test for colour vision and physiological interpretation.
16. Study of the life cycle of *Drosophila* / mosquito.
17. Preparation and identification of chick embryo: 24h, 48h, 72h and 96h.
18. Microtomy of chick embryo for histological slide preparation; staining and identification of the tissues.

ZOOL-DSE-105(A): Radiation Biology and Photobiology

Learning objectives

- Explain principles of radioisotopes in biology, including decay, half-life and autoradiography.
- Describe applications of radioactivity in labelling, dilution techniques, pulse–chase experiments and dating methods.
- Analyze molecular and cellular effects of ionizing radiation and principles of radiotherapy and radiation diagnosis.
- Explain fundamental concepts of photobiology, sensory photo-reception and circadian photo-reception.
- Evaluate biological clocks, photoperiodism and environmental/clinical aspects of artificial lighting and light pollution.

Learning outcomes

- Students will calculate basic radioisotope parameters and design simple biological experiments using radio-tracers.
- Students will discuss molecular mechanisms of radiation damage and protective strategies in radiobiology.
- Students will describe vertebrate photoreceptors, phototransduction pathways and non-image-forming responses to light.
- Students will relate circadian rhythms and photoperiodism to ecological and medical contexts, including sleep and mood disorders.
- Students will outline spectroscopic and photometric techniques (fluorimetry, flame photometry, AAS, X-ray crystallography) used in photobiology.

Group A: Radiation Biology **25 marks (20 end semester + 5 IA)**

1. **Radioisotopes in biology:** Role of ^{3}H, ^{14}C, ^{32}P, ^{131}I, ^{35}S in biological system; concept of half-life, decay constant; autoradiography and their applications.
2. **Applications of radioactivity:** Labelling of proteins and nucleic acids, dilution techniques, pulse chase method, carbon dating, substrate product relationship (cholesterol biosynthesis) and bond cleavage specificity.
3. Molecular and cellular radiology.
4. Radiotherapy and radiation diagnosis.
5. Radiobiological basis of radiation protection.

Group B: Photobiology **25 marks (20 end semester + 5 IA)**

1. **Fundamentals of photobiology and sensory photo-reception:** Photobiology definition and scope; Physical basis – Electromagnetic spectrum, biologically relevant wavebands (UV, visible, IR); irradiance, fluence, fluence rate; action spectra and threshold phenomena; Biological light perception – vertebrate photoreceptors, basic phototransduction events and non-image-forming responses.
2. **Biological clocks and photoperiodism:** Concepts of biological rhythms and vertebrate circadian systems; photoperiodism and seasonal timing; ecological and applied aspects.
3. **Applied and environmental photobiology:** Effects of artificial lighting and light pollution on vertebrate behaviour, physiology and health – examples from wildlife and humans; clinical and public-health aspects – ageing and circadian photo-reception, sleep disorders, mood, metabolic and visual implications of circadian disruption.
4. **Spectroscopic and photometric techniques in photobiology:** Spectroscopic techniques – principles and applications; Fluorimeter: principle of fluorescence and applications in cell/animal photobiology; principles and applications of turbidimetry, flame photometry and atomic absorption spectroscopy; X-ray crystallography.

Suggestive readings:

- Powsner, R. A., Palmer, M. R., & Powsner, E. R. Essentials of nuclear medicine physics, instrumentation, and radiation biology 3rd ed. Springer.
- Tubiana, M., Dutreix, J., Wambersie, A., & Pierquin, B. Introduction to radiobiology. Taylor & Francis.
- Joiner, M. C., & van der Kogel, A. J. Basic clinical radiobiology 4th ed. Hodder Arnold.
- Forshier, S. Essentials of radiation biology and protection 2nd ed. Clifton Park, NY: Delmar Cengage Learning.
- Björn, L. O. (2016). *Photobiology: The Science of Light and Life*. Springer.
- Smith, K. C. (2013). *The science of Photobiology*. Springer Science & Business Media.

ZOOL-DSE-105(B): Advances in Histology and Histochemistry

Learning objectives

- Explain principles of tissue collection, fixation, processing, staining and general histological organization of major organ systems.

- Describe histopathological changes in selected organ systems and their correlation with clinical conditions and toxic injuries.
- Evaluate developments in digital histology, 3D histology and advanced optical microscopy techniques.
- Explain foundations of histochemistry, classical reactions and enzyme histochemistry.
- Analyze principles and applications of immunohistochemistry, immunofluorescence, in situ hybridization and advanced integrated histochemistry.

Learning outcomes

- Students will identify normal histology of gastrointestinal, respiratory, excretory, lymphoid, endocrine and nervous systems.
- Students will recognize key histopathological patterns in liver, cardiovascular and nervous systems and relate them to disease processes.
- Students will compare conventional histology with digital and slide-free imaging and discuss their translational relevance.
- Students will select appropriate histochemical and immunohistochemical techniques for demonstrating specific biomolecules or markers.
- Students will describe multiplex IHC, hyper-spectral imaging and computational pathology approaches.

Group A: Advances in Histology **25 marks (20 end semester + 5 IA)**

1. **General principles and techniques and histology of major organ systems:** Scope of histology – relation to anatomy, pathology, developmental biology and zoology; histology vs histopathology; tissue collection and fixation, processing and staining; general histological organization and functional morphology of gastrointestinal tract, respiratory system, excretory system, lymphoid and immune organs, endocrine organs.
2. **Histopathology – Morphological Basis of Disease:** Histopathology of selected organ systems: liver (fatty change, hepatitis, cirrhosis), cardiovascular system (atherosclerosis and infarction), nervous system (neuropathology of alcoholism), toxic injuries (e.g. methanol); Neoplasia – benign vs malignant tumors, carcinoma vs sarcoma; histopathology of breast and prostate tumors as examples.
3. **Digital and advanced histology:** Evolution from conventional to digital histology – slide scanning, whole-slide imaging, telepathology; advantages and limitations; 3D histology and slide-free optical microscopy; Reflectance and fluorescence confocal microscopy.

4. **Translational histology and emerging directions:** Frozen section protocols; emerging slide-free, label-free optical histology in surgery; itegration of histology with molecular and omics approaches; computational pathology and artificial intelligence.

Group B: Advances in Histochemistry **25 marks (20 end semester + 5 IA)**

1. **Foundations of histochemistry and enzyme histochemistry:** Definition, scope and goals of histochemistry; general principles: fixation and preservation of chemical constituents; classical histochemical reactions (PAS for glycogen/glycoproteins; Feulgen reaction for DNA; Sudan dyes, Oil Red O for lipids).
2. **Immunohistochemistry (IHC) and Immunofluorescence:** Principles of IHC – antigen–antibody interactions, direct vs indirect methods, chromogenic vs fluorescent detection; importance of fixation, antigen retrieval and blocking; Applications of IHC – localization of hormones and peptides in endocrine cells; tumor markers and diagnostic panels.
3. **In Situ Hybridization (ISH) and molecular histochemistry:** Principles of ISH – detection of DNA, mRNA, microRNA in tissue sections; probe design and labeling; techniques and variants – chromogenic ISH, FISH (fluorescence in situ hybridization), RNAscope and high-sensitivity RNA ISH.
4. **Integrated and advanced histochemistry:** Fluorescent multiplex IHC and advanced imaging – simultaneous detection of multiple markers, spectral unmixing, quantitative image analysis; label-free and hyperspectral methods – photoacoustic imaging, Raman/IR-based techniques, hyperspectral and multispectral imaging in digital/computational pathology.

Suggestive readings:

- Bancroft, J. D. and Gamble, M. (2002). Theory and practice of Histological Technique. Churchill Livingstone.
- Bloom, W. and Fawcett, D. W. (1998). A Textbook of Histology. 12th sub ed. W.B. CRC Press. Fawcett, D. W. (2001). Bloom and Fawcett: Concise Histology.
- Arnold.Kiernan, J. A. (1999). Histology and Histochemical Methods: Theory and Practice. 3rded, Butterwork Heinemann.
- Leeson, T. S., Leeson, C. R. and Paparo, A. A. (1988). Text/Atlas of Histology. 1st Ed. W. B. Saunders Company.
- Ross, M, H., Reith, E. J. and Romell, L, J. (1998). Histology: a text and atlas. 2nd ed.
- Williams and Wilkins. Ross, M. H. and Reith, E. (1985). Histology: A Text and Atlas. Harper and Row Publishers.

- Sharma, B. K. (1991). Techniques in Microscopy and Cell Biology. Tata-McGraw Hill.
- Stoward, P. J. and Everson Pearse, A. G. (1991). Histochemistry: Theory and Practical. 4th ed. Churchill Living Stone.
- Pellicciari, C., Biggiogera, M., & Malatesta, M. (2023). *Histochemistry of single molecules: Methods and Protocols*. Humana.

ZOOL-SEC-106: Trends in Biostatistics and Bioinformatics

Learning objectives

- Explain foundational concepts of biostatistics, biological data types and experimental study designs.
- Perform data summarization, graphical representation and computation of measures of central tendency and dispersion.
- Analyse probability distributions, hypothesis testing, parametric and non-parametric tests, correlation, regression and ANOVA.
- Explain basic concepts of bioinformatics, major sequence and structural databases and information retrieval.
- Describe sequence alignment, molecular phylogenetics, structural bioinformatics, multi-omics and web-based bioinformatics resources.

Learning outcomes

- Students will design simple biological experiments and select appropriate sampling and study designs.
- Students will summarize data using graphs and descriptive statistics and interpret variability and distribution patterns.
- Students will apply basic statistical tests and interpret p-values, confidence intervals and model outputs.
- Students will retrieve biological information from sequence and structural databases and perform basic sequence alignment tasks.
- Students will discuss applications of phylogenetic analysis, structural bioinformatics, multi-omics and molecular modeling in modern Zoology.

Group A: Trends in Biostatistics **25 marks (20 end semester + 5 IA)**

1. **Foundations of biostatistics and biological data:** Role of biostatistics in experimental biology, ecology, toxicology, fisheries, epidemiology and omics research; basic terminologies: population, sample, parameters, variables (qualitative/quantitative, discrete/continuous), primary vs secondary

data; study designs – observational vs experimental, randomized, stratified and clustered designs; replication and randomization biological experiments.

2. **Data summarization, frequency distributions and visualization:** Grouped and ungrouped data, frequency tables, relative frequencies; graphical representation – pie chart, bar diagram, histogram, frequency polygon, ogives, scatter diagram and linear graph; descriptive measures – central tendency (mean, median, mode); dispersion – range, mean deviation, variance, standard deviation, coefficient of variation.
3. **Probability distributions, hypothesis testing parametric and non-parametric trends:** Binomial and Poisson distributions; normal distribution – properties, z-scores, skewness and kurtosis; fitting and assessing normality; hypothesis testing and tests of significance – null and alternative hypotheses, type I and type II errors, p-values, confidence intervals, one- and two-tailed tests; parametric tests: t-test, Z-test, Chi-square test (goodness-of-fit, contingency tables); non-parametric tests – Mann–Whitney U, Wilcoxon matched pairs, Kruskal–Wallis.
4. **Correlation, regression, ANOVA and Generalized Linear Models (GLM):** Correlation: Pearson's and Spearman's correlation coefficients; Simple and multiple regression – least squares, model specification, R^2, residual analysis; analysis of variance (ANOVA): one-way and two-way ANOVA; F-test; overview of generalized linear models (GLMs).

Group B: Trends in Bioinformatics **25 marks (20 end semester + 5 IA)**

1. **Introduction to Bioinformatics:** Preliminary concept of bioinformatics; origin, history, and scope of Bioinformatics; importance and use of Bioinformatics; applications and limitations of Bioinformatics.
2. **Major Bioinformatics databases and resources:** Introduction to biological databases; sequence and structural databases; functional and other databases; information retrieval from biological database.
3. **Sequence analysis and alignment:** Sequence similarity, file formats for sequences, sequence patterns and profiles; homology and alignment: pairwise sequence alignment, global & local alignment; basic concept of scoring matrices; BLAST and PSI-BLAST tools; multiple sequence alignment and its application.
4. **Molecular Phylogenetics:** Basics of phylogenetics, phylogenetic tools, methods of phylogenetic tree preparation.
5. **Structural Bioinformatics:** Protein Data Bank (PDB), schematic representations of protein structure and analysis, protein structure classification database; computational protein structure prediction: homology modeling; prediction of RNA structure.

6. **Multiomics:** Genome mapping, assembly and comparison, functional genomics, bioinformatics associated with genomics, transcriptomics, proteomics and metabolomics.
7. **Molecular modeling and drug designing:** Molecular visualization – Rasmol and Pymol, molecular docking, definition of drugs and its advances, pharmacophore identification and novel drug design; structure based drug design.
8. **Web-based resources:** NCBI and EBI; MEDLINE and SCI.

Suggestive readings:

- Rosner, B. A. (2000). *Fundamentals of Biostatistics*. Duxbury Resource Center.
- Norman, G. R., & Streiner, D. L., PhD. (2000). Biostatistics: The Bare Essentials.
- Dandekar and Kunz (2023). Bioinformatics: An Introductory Textbook. Springer
- Mount (2004). Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor Laboratory Press
- Lesk (2019). Introduction to Bioinformatics, Oxford University Press

Semester – II

ZOOL-DSC-201: Advances in Parasitology & Vector Biology and Advances in Immunology

Learning objectives

- Explain classification, molecular taxonomy and ecological niches of parasites and concepts of parasitism.
- Describe life cycles, diagnosis, treatment and control protocols for key protozoan and helminth parasites of public health importance.
- Analyse immunoparasitology, host immune responses, vaccine development and mechanisms of host invasion and immune evasion.
- Explain innate and adaptive immunity, antigen–antibody interactions, cytokines, hypersensitivity and autoimmunity.
- Evaluate transplantation immunology, tumour immunobiology, immunodiagnostics, biomarkers and modern vaccine strategies.

Learning outcomes

- Students will classify parasites based on taxonomy, habitat and host specificity and describe phases of parasitism.
- Students will outline zoonotic and socio-economic aspects of parasitic diseases and basic epidemiological measurements.
- Students will describe molecular mechanisms of host cell invasion, parasitic immune evasion and drug resistance.
- Students will explain components of innate and adaptive immunity, cytokine networks and types of hypersensitivity.
- Students will discuss autoimmunity, graft rejection, tumour immune escape, immunodiagnostic tools and principles of traditional and modern vaccines.

Group A: Advances in Parasitology & Vector Biology **25 marks (20 end semester + 5 IA)**

1. **Parasites and parasitism**: Classification and basic concept; molecular taxonomy of the parasites; microenvironment and the phases of parasitism; the vertebrate alimentary canal, blood, tissues and the other habitats; parasite-host specificity; parasitic adaptation; host-parasite interaction.
2. **Zoonotic and public health aspects**: Concept of Zoonosis and public health in relation to parasitic diseases; measurements of public health; socio-economic determinants of health; concept of epidemiology.

3. **Protozoan parasites**: Life cycle; diagnosis of infection, control and treatment protocol of Apicomplexa (malarial parasites, *Toxoplama gondii*); Flagellates (*Leishmania* spp. *Trypanosoma* spp.); physiology and biochemistry of Haemoflagellates
4. **Helminth parasites**: Life cycle; diagnosis of infection, control and treatment protocol of *Toxocaria canis*, *Echinococus* spp. *Schistosoma* spp. and filarial worms.
5. **Molecular Parasitology and immunology**: Immunoparasitology: immunity and immune response to parasitic infection; current status and future of vaccine development against parasitic infection; molecular mechanism of host cell invasion, parasitic evasion and suppression of the body's immune system.
6. **Diagnostic parasitology**: Microscopic diagnosis by examination of clinical samples (blood smears, stool, urine), faecal concentration techniques, rapid and simple stick test, QBC technique, different biochemical parameters; molecular diagnosis of parasitic infection; molecular markers for genetic variation in parasitic strains
7. **Chemotherapy and drug resistance**: Mechanism of action of antiparasitic drugs, drug resistance, and search for novel therapeutic compound.
8. **Biology and role of vectors**: Diptera (mosquitoes, sand flies); Ticks (soft and hard); mosquito refractoriness to insecticides: molecular basis; vector control strategies and integrated vector management.

Group B: Advances in Immunology **25 marks (20 end semester + 5 IA)**

1. **Innate immunity:** First and second line of defense of body – components and function; phagocytosis and inflammation – mechanism and importance; Complement systems – components and pathways of complement activation.
2. **Adaptive immunity:** Dual nature of the adaptive immune system – humoral and cell-mediated immunity; Antigens – nature, concept of epitopes and haptens; organization and function of immunoglobulin genes; antigen-antibody reaction and immune responses; T cells and B cells – types and activation; antigen-presenting cells.
3. **Cytokines:** Properties of cytokines, cytokine receptors, cytokine antagonists, cytokine secretion by TH1 and TH2 subsets, cytokine-related diseases; therapeutic uses of cytokines and their receptors.
4. **Hypersensitivity:** Gell and Coombs Classification, Type I to Type IV hypersensitivity.
5. **Autoimmunity and Transplantation Immunology:** Organ-specific and systemic autoimmune diseases; implication of CD4+ T cell, MHC, and TCR in autoimmunity; mechanisms for induction of autoimmunity; treatment of autoimmune diseases; distribution, structure, function and genetic

control of MHC, HLA typing; mechanisms of graft rejection; basic concept of bone marrow transplantation; fetus as allograft.

6. **Tumor immunobiology:** Evasive mechanisms of tumor cells; tumor specific antigens; immunosuppression in tumor microenvironment; immunotherapy of cancer; NK cells and dendritic cell therapy of cancer.
7. **Immunodiagnostics and biomarkers:** Application of immunological techniques in diagnosis – ELISA, rapid tests, Western blot, flow cytometry & FACS, immunohistochemistry; serological tests for infectious diseases; autoantibody profiling and allergy testing (IgE).
8. **Vaccines, immunization and emerging trends:** Principles of active and passive immunization; Traditional vaccine types (live, killed, toxoids, subunit); Designing modern vaccines – conjugate, recombinant, DNA/RNA, vector-based and nanoparticle vaccines; adjuvants and vaccine delivery.

Suggestive readings:

- Bogitsh, B. J. and Cheng, T. C. (2000). Human Parasitology. 2nd Ed. Academic Press, New York.
- Chandler, A. C. and Read. C. P. (1961). Introduction to Parasitology, 10th ed. John Wiley and Sons Inc.
- Chandra, G. (2000). Mosquito. Sree Bhumi Publication Co. Kolkata.
- Chatterjee, K. D. (1981).Parasitology (Protozoology and Helminthology).13th ed. CBS.
- Cheng, T. C. (1986). General Parasitology. 2nd ed. Academic Press, Inc. Orlando.U.S.A.
- Hati, A. K. (2001). Medical Entomology. Allied Book Agency, Kolkata.
- Hati, A. K. (2001). Medical Parasitology. Allied Book Agency, Kolkata.
- Noble, E. R. and Noble G. A. (1989). Parasitology. The Biology of animal Parasites. 6th ed.
- Schmidt, G. D. and Roberts, L. S. (2001). Foundation of Parasitology. 3rd ed. McGraw Hill Publishers.
- Schmidt, G. D. (1989). Essentials of Parasitology. Wm. C. Brown Publishers (Indian print;1990, Universal Book Stall).
- Smyth, J. D. (1994). Animal Parasitology. 3rd ed. Cambridge University Press.
- Soulsby, E. J. L. (1982). Helminths, Arthropods and Protozoa of domesticated animals. ELBS and Bailliere Tindall. London.
- Owen, J. A., Punt, J., Stranford, S. A., & Jones, P. P. Kuby immunology 7th ed. New York: W.H. Freeman.
- Paul, W. E. Ed. Fundamental immunology 7th ed. Philadelphia, PA: Lippincott Williams & Wilkins.

- Abbas, A. K., Lichtman, A. H., & Pillai, S. Cellular and molecular immunology 9th ed. Elsevier.
- Paranjape, S. H. Advanced immunology. Mumbai: Himalaya Publishing House.
- Murphy, K., & Weaver, C. Janeway's immunobiology 9th ed. Garland Science.
- Delves, P. J., Martin, S. J., Burton, D. R., & Roitt, I. M. Roitt's essential immunology 13th ed. Wiley-Blackwell.

ZOOL-DSC-202: Advances in Ecology & Environmental Biology and Advances in Behavioral Biology

Learning objectives

- Explain limiting factors, acclimation, adaptation and niche concepts in diverse habitats and biomes.
- Describe trophic structure, energy flow, production patterns, population dynamics and community structure.
- Analyze environmental biology topics including biological indicators, invasive species and global environmental problems.
- Explain development, learning, memory, genetics and evolution of behavior.
- Evaluate social behavior, biorhythms, circadian clocks and molecular genetics of behavioral regulation.

Learning outcomes

- Students will interpret ecological models of population growth, regulation and predator–prey interactions.
- Students will describe community attributes, species diversity measures, guilds, keystone species and ecotones.
- Students will discuss impacts of climate change, pollution, deforestation, desertification and urbanization on biodiversity.
- Students will distinguish innate and learned behaviors and relate neural and hormonal mechanisms of behavior to adaptation.
- Students will explain Hamilton's rule, kin selection, altruism, eusociality and molecular basis of circadian rhythms.

Group A: Advances in Ecology & Environmental Biology 25 marks (20 end semester + 5 IA)

1. **Limiting factors**: Role of biotic and abiotic factors limiting population distribution; Liebig's law of minimum, Shelford's law of tolerance and factor interaction; acclimation and adaptation to high altitude and aerospace environment.

2. **Habitat ecology**: Concepts of habitats (desert, arid, semi-arid, subtropical, temperate, alpine, wetlands, marshes, riverine & lakes); concept of niche.
3. **Trophic structure & Energy flow**: Concept and types of ecosystems, food chain, food web complexity, ecological pyramids, Guilds, Keystone species; measuring production: patterns and limits of primary & secondary production.
4. **Population ecology**: Survivorship curves, life-tables, simple population dynamics models and their behavior, spatial ecology; population regulation: density-dependent and density independent mortality factors and their interactions; predation: predator and prey models, oscillation in population size; ecological modelling: concept, components and application.
5. **Community ecology**: Nature of communities, community structure and attributes; levels of species diversity and its measurement; edges and ecotone.
6. **Concept of Environmental Biology**: Biome (concept of biome, terrestrial biomes, aquatic biome, wetlands of India) environmental adaptation, concept of biological indicators; biological monitoring, indicator organisms; invasive species and its impact.
7. **Global environmental problems**: Climate change, greenhouse effect, acid rain, ozone layer depletion, deforestation, desertification, marine pollution, and urbanization.

Group B: Advances in Behavioral Biology **25 marks (20 end semester + 5 IA)**

1. **Development of behavior:** Significance of animal behavior, influence of environment, hormones and genes; cognition, neural control of behavior, adaptiveness of behavior.
2. **Learning and memory:** Innate behavior (orientation, kineses, taxes, motivation, tropism, reflex and nest building), learned behavior (sensitization and habituation, associative learning, imprinting, latent and insight learning, reasoning, instrumental conditioning, trial- and error, discrimination, biased and language learning); neural mechanism of learning; memory - nature, types and anatomy of memory, and memory storage.
3. **Evolution and genetics of behavior:** Genes and behavioral evolution, Hamilton's rule, kin selection, altruism, cost and benefits of social life, sex and sexual selection, phylogeny of behavior, genetic control of behavior (single and multiple gene effect).
4. **Social behavior:** Types of social groups, advantages of grouping, origin and roots to sociality, social organization – insects (honey bees, termites) and primates; cost and benefits of sociality, and evolution of eusocial behavior.
5. **Biorhythm and behavior:** Circadian rhythms, molecular genetics of the *Drosophila* clock, the mammalian clock, prion protein and Mad Cow Disease.

Suggestive readings:

- Chapman, R. L. and Reiss, M. J. (1998). Ecology – Principles and Applications. 2nd ed. Cambridge University Press.
- Dash, M. C., (2001). Fundamental of Ecology. 2nded. Tata McGraw-Hill Company.
- Freedman, B. (1989). Environmental Ecology. Academic press, Inc., PP. 424.
- Mukherjee, B. (1996). Environmental Biology. Tata McGraw-Hill Publishing Comp. Ltd.
- Odum, E. P. and Barret, G. W. (2005). Fundamentals of Ecology. 5th ed. Thompson Brooks/Cole. Ricklefs, R. E. and Miller, G. L. (2000). Ecology. 4th ed. W. H. Freeman and Company.
- Santra, S. (2005). Environmental Science. New Central Book Agency (P) Ltd.
- Smith, R. L. and Smith, T. M. (2001). Ecology and Field Biology. Benjamin Cummings Pearson Education.
- Smith, T. M and Smith, R. L. (2006). Elements of Ecology. 6thed. Pearson Education.
- Rubenstein (2023). Animal Behaviour. Oxford University Press.
- Sherman and Alcock (2013). Exploring Animal Behavior. Sinauer Associates

ZOOL-DSC-203: Molecular Genetics and Biochemistry

Learning objectives

- Explain gene properties, DNA structure, chromatin organization and nucleosome architecture.
- Describe DNA replication, recombination, repair, transposable elements and somatic recombination, especially in immune systems.
- Analyze transcription, RNA biology, RNA processing, translation and regulation of gene expression in prokaryotes and eukaryotes.
- Explain mutation types, molecular basis of cancer genetics, tumor progression and familial cancer syndromes.
- Describe macromolecular interactions, advanced protein structure, metabolic regulation, redox biology and key biochemical methods.

Learning outcomes

- Students will relate DNA and chromatin organization to gene function and regulation.
- Students will explain mechanisms of operon regulation in bacteria and gene regulation strategies in bacteriophages and eukaryotes.
- Students will describe molecular basis of mutations and interpret mutagenicity assays such as Ames test.

- Students will discuss oncogenes, tumor suppressor genes, DNA repair genes, genetic instability and cancer stem cells.
- Students will apply knowledge of protein structure, metabolic regulation, oxidative stress and biochemical techniques to toxicology and disease contexts.

Group A: Molecular Genetics **25 marks (20 end semester + 5 IA)**

1. **Properties and organization of genes:** DNA encoding RNA and polypeptides, chemical and physical structure of DNA, chromosomes, chromatin and the nucleosome.
2. **DNA metabolism:** DNA replication, recombination, DNA damage and repair, transposable elements and retrovirus, somatic DNA recombination and hypermutation in immune system.
3. **Gene expression:** Transcription in prokaryotes and eukaryotes, RNA as the epicentre of genetic information, the expanding repertoire of RNA, functional variabilities and rules of RNA(s), RNA splicing, genetic code and translation.
4. **Regulation of gene expression in bacteria and bacteriophages:** *lac, trp* and *ara operon* in *E. coli;* gene regulation strategies in bacteriophages.
5. **Gene expression regulation in eukaryotes:** Role of regulatory proteins, epigenetic mechanism, RNA interference, post transcriptional regulation.
6. **Molecular basis of mutation:** Spontaneous and induced mutation, base pair substitution, addition and deletion, changes in genetic information (Sickle cell RBC), mutations induced by chemicals (Ame's test to screen mutagenicity) and radiation.
7. **Cancer genetics:** Cellular transformation and tumorigenesis, cell cycle checkpoints and cancer, oncogenes and tumor suppressor genes; DNA repair genes and genetic instability, genetic heterogeneity and clonal evolution, familial cancers (Retinoblastoma, Wilms' tumour, Li-Fraumeni syndrome, colorectal cancer, breast cancer), genetic predisposition to sporadic cancer, tumour progression: angiogenesis and metastasis; cancer and environment: physical, chemical and biological carcinogens.
8. **Molecular medicine and gene therapy:** Stem cells: definition, characteristics, types and sources; stem cell therapy in humans; cancer stem cells; thalassemia (α and β): aetiology (molecular basis) and therapeutic aspects; ubiquitin proteasome system and role in Alzheimer's disease, Molecular pathogenesis of Parkinson's disease.

Group B: Biochemistry **25 marks (20 end semester + 5 IA)**

1. **Structure and interaction of biomolecules:** Macromolecular interactions – hydrogen bonding, ionic and hydrophobic interactions, van der Waals forces; role in folding, stability and complex

formation; Advanced protein structure: domains, motifs (helix–turn–helix, zinc fingers, leucine zippers), conformational changes and allostery; protein folding, misfolding, chaperones and aggregation (amyloids and prions).

2. **Metabolic regulation and systems biochemistry:** Principles of metabolic regulation; hormonal and nutrient sensing control; metabolic adaptation and disorders: obesity, metabolic syndrome, diabetes, inborn errors (phenylketonuria, glycogen storage diseases); Systems biochemistry trends – metabolic flux analysis; introduction to metabolomics (LC-MS/GC-MS-based profiling) in toxicology, disease biomarker discovery and environmental biology.
3. **Redox biology and its applications:** Concept of reactive oxygen species (ROS), reactive nitrogen species (RNS), antioxidant systems (glutathione, catalase, superoxide dismutase) and their physiological and pathological roles; redox-regulated transcription factors and signaling proteins; oxidative stress in neurodegeneration, cardiovascular disease and environmental toxicology.
4. **Methods in biochemistry:** Core biochemical techniques – Chromatography (paper/thin-layer, ion-exchange, gel filtration, affinity; HPLC); Electrophoresis – agarose gel for nucleic acids, native PAGE, SDS-PAGE, isoelectric focusing; Mass-spectrometry-based protein identification and quantitation; integration of biochemical data with genomics/transcriptomics; role in systems biology and personalized medicine.

Suggestive readings:

- Watson et al. (2014). Molecular Biology of the Gene. Pearson / Benjamin-Cummings.
- Krebs et al. (2018) Lewin's Gene XII, Jones and Bartlett
- Weaver RF (2012). Molecular Biology. McGraw Hill Higher Education.
- Voet. (2011). Biochemistry, Fourth Edition (WCS Int'l India).
- Nelson, D. L., & Cox, M. (2021). Lehninger Principles of Biochemistry: International Edition. WH Freeman.
- Devlin, T. M. (2006). Textbook of Biochemistry with Clinical correlations. Wiley-Liss.
- Hofmann, A., & Clokie, S. (2018). Wilson and Walker's Principles and Techniques of Biochemistry and Molecular biology. Cambridge University Press.

ZOOL-DSC-204: Practical (Laboratory Course) 50 marks (40 end semester + 10 IA)

Learning objectives

- Develop skills in parasitological smear preparation, staining and permanent mounting of parasites and vectors.
- Perform basic ecotoxicological assays (LC_{50}/LD_{50}), limnological estimations and biodiversity documentation.
- Conduct behavioral observations in insects and prepare structured behavioral reports.
- Execute lymphocyte isolation, immunodiagnostic tests (e.g. Widal, dot ELISA, immunodiffusion) and chromosomal banding.
- Perform biochemical estimations of biomolecules and electrophoretic analysis of proteins and DNA.

Learning outcomes

- Students will prepare diagnostic smears and permanent preparations for protozoan and helminth parasites and arthropod vectors.
- Students will estimate LC_{50}/LD_{50} values, interpret dissolved oxygen/carbon dioxide data and prepare Peoples' Biodiversity Registers.
- Students will document insect grooming and social organization and relate these to behavioral ecology concepts.
- Students will perform basic immunodiagnostic assays and interpret banding patterns in chromosomal preparations.
- Students will quantify proteins, nucleic acids and lipids and analyze electrophoretic profiles of biomolecules.

Practicals:

1. Study of smear preparation of gut contents of vertebrate/invertebrate hosts for protozoan and helminth parasites: staining and identification.
2. Permanent preparation of protozoan parasite/ arthropod parasites and vectors.
3. Fixation, staining and mounting of trematode and cestode parasites.
4. Determination LC_{50} / LD_{50} of chemical / biological agents against aquatic bioforms.
5. Estimation of dissolved oxygen/carbon dioxide in pond water.
6. Preparation of Peoples Biodiversity Register (PBR) for a particular region (following the guideline of West Bengal Biodiversity Board).
7. Preparation of behavioral study report.
8. Grooming behavior in cockroaches/house flies.

9. Observation on social organization in insects: Termite nest and caste system.
10. Separation of lymphocytes from whole blood and the estimation of live and dead cells..
11. Detection of *Salmonella* antigens by Widal test.
12. Test for the presence of analyte (antigen) using Dot ELISA.
13. Demonstration of immunodiffusion assays.
14. Chromosome Banding: C, G and NOR banding.
15. Biochemical estimation of protein (Lowry's method), DNA and RNA.
16. Estimation of lipid profile from blood.
17. Isolation and quantification of DNA from tissue/ blood samples.
18. Electrophoretic study of proteins by SDS–PAGE.
19. Restriction Digestion of Lambda-DNA/Plasmid/Genomic/Mitochondrial DNA and Electrophoresis.

ZOOL-DSE-205(A): Traditional and Alternative Medicine

Learning objectives

- Explain global and Indian frameworks of traditional, complementary and integrative medicine (TCIM), with emphasis on AYUSH systems.
- Describe foundational concepts, diagnostic approaches and pharmacotherapies in Ayurveda, Siddha, Homeopathy, Unani and Sowa-Rigpa.
- Analyze the role of yoga, meditation and naturopathy in health promotion and disease management.
- Explain principles of herbalism, phytotherapy, functional medicine, nutrigenomics and microbiome-based nutrition.
- Evaluate acupuncture, acupressure, mind–body and energy medicine, including magnet therapy and stress-management strategies.

Learning outcomes

- Students will discuss WHO traditional medicine strategies and national AYUSH policies and regulatory frameworks.
- Students will relate biodiversity and ethnomedicine to pharmacognosy and conservation of indigenous knowledge.
- Students will explain scientific evidence and limitations underlying yoga, meditation and naturopathy.
- Students will describe concepts of probiotics, prebiotics, synbiotics and nutrigenomic approaches to organ system detoxification.
- Students will critically evaluate biofield, energy healing and mind–body therapies in relation to chronic pain and stress management.

Group A: Traditional Medicine **25 marks (20 end semester + 5 IA)**

1. **Scope, policy and framework of traditional medicine:** Definitions and concepts: traditional, complementary and integrative medicine (TCIM); Global perspective – WHO Traditional Medicine Strategy; Indian context: AYUSH as a formal sector (Ayurveda, Yoga & Naturopathy, Unani, Siddha, Sowa-Rigpa, Homoeopathy); policy and regulation: AYUSH Ministry, National AYUSH Mission; Traditional Knowledge Digital Library (TKDL) for protecting indigenous knowledge.
2. **Ayurveda and Siddha – principles, practice and contemporary research:** Foundational concepts; Diagnostic and therapeutic approaches; biodiversity and ethnomedicine – plant, animal and mineral sources in Ayurvedic/Siddha drugs; links to ethnobotany and ethno-veterinary practices.
3. **Homeopathy, Unani and Sowa-Rigpa:** Homeopathy principles – law of similars, potentization, minimum dose; cntrast with allopathic pharmacology; regulatory aspects and research challenges; Unani medicine: humoral theory, lifestyle, diet and pharmacotherapy; regional practice in India; Sowa-Rigpa: Himalayan traditional medicine, diagnostic frameworks and herbal/mineral formulations.
4. **Yoga, Naturopathy and Meditation in health and disease:** Yoga – origins and philosophy; role in musculoskeletal, cardiovascular, respiratory and mental health; meditation and mind-body medicine – traditional practices (Dhyana) and modern evidence on stress reduction, autonomic balance and neuroplasticity; Naturopathy – principles; Indian institutions and integration into primary health care; WHO and global recognition – yoga and similar practices (Tai Chi) as complementary systems improving quality of life.

Group B: Alternative Medicine **25 marks (20 end semester + 5 IA)**

1. **Herbalism & Phytotherapy**: Organic plant-based compounds, essential oils, and botanical pharmacology.
2. **Nutrition & Functional Medicine**: Dietary therapeutics; the role of holistic dietary formulations; nutraceuticals and functional foods; diet and nutrition.
3. **Nutrigenomics**: Gut health, microbiome therapy, and personalized nutrition; concept of probiotics, prebiotics, and synbiotics; detoxification: nutritional perspectives of organ system detoxification.
4. **Acupuncture & Acupressure**: Traditional meridian systems, neurophysiological basis, and advanced pain management protocols.

5. **Mind-Body and Energy Medicine**: Biofield Sciences: magnet therapy concepts and bio-magnetic applications for chronic pain; energy healing: principles and practices of Reiki and Pranic healing. Stress Management: meditation, sleep science, and the neuroscience of mind-body interactions.

Suggestive readings:

- Micozzi, M. S. (2018). *Fundamentals of Complementary, Alternative, and Integrative Medicine*. 6th ed. Elsevier.
- Freeman, L. W. (2009). *Mosby's Complementary & Alternative Medicine: A Research-Based Approach*. 3rd ed. Mosby Elsevier.
- Ernst, E., Pittler, M. H., Wider, B., & Boddy, K. (2008). *Oxford Handbook of Complementary Medicine*. Oxford University Press.
- Pizzorno, J. E., & Murray, M. T. (Eds.). (2020). *Textbook of Natural Medicine*. 5th ed. Elsevier.
- Mukherjee, P. K. (2019). *Quality Control and Evaluation of Herbal Drugs: Evaluating Natural Products and Traditional Medicine*. Elsevier.
- Khare, C. P. (Ed.). (2007). *Indian Medicinal Plants: An Illustrated Dictionary*. Springer.

ZOOL-DSE-205(B): Biodiversity and Conservation Biology

Learning objectives

- Explain concepts of genetic, species and ecosystem diversity and methods for their measurement.
- Describe causes and consequences of biodiversity loss and cryopreservation techniques.
- Analyze sampling techniques in biodiversity assessment and biodiversity prospecting linked to indigenous knowledge.
- Explain objectives, modes and management practices in wildlife conservation, protected area management and habitat conservation.
- Evaluate conservation laws, policies and international treaties relevant to biodiversity protection.

Learning outcomes

- Students will compute and interpret diversity indices and compare diversity across sites.
- Students will discuss genetic marker-based assessments of biodiversity and their applications in conservation.
- Students will select appropriate field sampling techniques (quadrats, transects, capture-recapture, traps) for different taxa.
- Students will explain in situ and ex situ conservation strategies, ecotourism prospects and human–wildlife conflict mitigation.

- Students will critically discuss Indian wildlife and biodiversity legislation and key international agreements (CBD, CITES, Ramsar).

Group A: Biodiversity **25 marks (20 end semester + 5 IA)**

1. **Biodiversity:** Definition, scope and constraints.
2. **Genetic diversity:** Nature and origin; measurement of genetic diversity; methods based on DNA and chromosomes; molecular marker techniques; determinants of genetic diversity.
3. **Species diversity:** History and origin; diversity indices; comparisons of species diversity of different sites.
4. **Ecosystem diversity:** Classification of ecosystems; measuring ecosystem diversity; major ecosystem types of the world; wetland ecosystems; agro-ecosystems.
5. **Loss of biodiversity:** Loss of genetic, species and ecosystem diversity.
6. **Cryopreservation:** Tools, techniques and application.
7. Biodiversity prospecting indigenous knowledge systems.
8. Sampling techniques in diversity measurement: quadrate, transect, capture-recapture, sweep netting, sticky trap and pitfall trap, etc.

Group B: Conservation Biology **25 marks (20 end semester + 5 IA)**

1. **Objectives of wildlife conservation:** History of wildlife conservation in India and abroad; different approaches of wildlife conservation; Red Data Book.
2. **Modes of conservation:** In situ and ex situ conservation, necessity for wildlife conservation, knowledge on core and buffer zone.
3. **Management for wild life protection:** Prospect of ecotourism / wild life tourism in forests; concept of climax.
4. **Man and wildlife:** Causes and consequences of human-wildlife conflicts with reference to elephant; mitigation of conflict – an overview; management of excess population
5. **Protected areas:** National parks and sanctuaries; community reserve; important features of protected areas in India.
6. **Conservation practices:** Tiger and Rhino conservation – reserves in India; management practices and challenges.
7. **Habitat Conservation:** Definition and values of natural habitat; importance of habitat conservation; approaches and methods for habitat conservation; habitat restoration.
8. **Conservation and legal frameworks:** Key conservation laws in India: Wild Life Protection Act, 1972, Forest Conservation Act, 1980, Biological Diversity Act, 2002, Forest Rights Act (FRA),

2006; Critical Wildlife Habitats (CWH), Eco-Sensitive Zones (ESZs), Compensatory Afforestation (CAMPA), International Regulations and Treaties: CBD, CITES, Ramsar Convention.

Suggestive readings:

- Krishnamurthy, K. V. An advanced textbook on biodiversity: Principles and practice. New Delhi, India: CBS Publishers & Distributors.
- Gaston, K. J. Biodiversity: A very short introduction. Oxford University Press.
- Wilson, E. O. The diversity of life. Cambridge, MA: Belknap Press of Harvard University Press.
- Basak, A. Environmental studies 1st ed. Pearson Education India. ISBN: 9788131721186.
- Ricklefs, R. Ecology: The Economy of Nature. W. H. Freeman & Co Ltd.
- Woodroffe, R., Thirgood, S. and Rabinowitz, A. People and Wildlife, Conflict or Co-existence? Cambridge University.
- Bookhout, T.A. Research and Management Techniques for Wildlife and Habitats (5th Ed) The Wildlife Society, Allen Press.
- Stiling, P. Ecology: Global insights and investigations 5th ed. New York, NY: McGraw-Hill Education.

ZOOL-SEC-206: Advances in Biotechnology — 50 marks (40 end semester + 10 IA)

Learning objectives

- Explain principles and applications of cell and tissue culture, including primary, continuous, organ and 3D cultures.
- Describe tools and techniques of recombinant DNA technology, promoter characterization and gene transfer methods.
- Analyze hybridoma technology, monoclonal antibody production and applications in diagnosis and therapy.
- Explain CRISPR/Cas9 genome editing, base and prime editing and associated off-target effects.
- Evaluate applications of rDNA technology in agriculture, medicine, industrial and environmental biotechnology, including biosafety and biosecurity issues.

Learning outcomes

- Students will outline steps in establishing and maintaining cell and tissue cultures and discuss their applications.
- Students will describe major vectors, restriction enzymes, cloning strategies and promoter analysis techniques (EMSA, footprinting).

- Students will explain methods of gene transfer and generation of transgenic animals, especially mice.
- Students will discuss principles and workflows of hybridoma production and monoclonal antibody applications.
- Students will critically evaluate genome editing technologies, GMOs, bioremediation and biowarfare/bioterrorism issues.

Topics:

1. **Cell and tissue culture:** Types, techniques and applications; primary and continuous cultures, organ culture, 3D culture and organoids.
2. **Recombinant DNA technology:** Definition, tools and techniques; isolation and purification of DNA/RNA; restriction enzymes, vectors, ligases, transformation, cloning, biosafety and application.
3. **Promoter characterization:** Promoter structure and analysis by reporter genes; electrophoretic mobility shift assay (EMSA) and DNA foot-printing; basics of gene expression regulation.
4. **Gene transfer techniques:** Electroporation, microinjection and transfection; viral and non-viral methods; transgenic mice: strategies and methods.
5. **Hybridoma technology:** Production and selection of hybridoma; Monoclonal antibody production, purification, types and applications in diagnosis and therapy.
6. **Genome editing:** CRISPR/Cas9 system; Guide RNA, Cas enzyme, DNA repair pathways, off-target effects, base editing and prime editing.
7. **Applications of rDNA technology:** Crop and livestock improvement; gene therapy (somatic and germ line); DNA drugs, RNA therapeutics and vaccines.
8. **Industrial and environmental biotechnology:** Industrial fermentation, bioreactors, enzyme production, bioremediation and synthetic biology.
9. **Safety issues related to biotechnology:** General principles and risk assessment; classification of natural organisms on the basis of hazards; assessing risk of genetically modified organisms; safety aspects of GM food and medicinal products on human beings; biowarfare and bioterrorism.

Suggestive readings:

- Glick and Pasternak (2003). Molecular Biotechnology. ASM Press
- Sambrook et al (2001). Molecular Cloning. CSHL
- Krenzer and Massey (2000). Recombinant DNA and Biotechnology. ASM Press.
- Primrose, S. B., & Twyman, R. (2006). *Principles of Gene Manipulation and Genomics*. John Wiley & Sons.