Syllabus

Ph.D Research Entrance Test (RET) in Zoology

(With effect from the session 2022-2023)

The Ph.D Research Entrance Test (RET) syllabus in Zoology has been placed in the meeting of Departmental Research Committee (DRC) in Zoology held on 07th April 2022. The members of DRC recommended the syllabus and the same was subsequently submitted to the Secretary, PG Faculty Council, University of Kalyani on 10th April 2022, for approval from the University Authority. The Faculty Council of the University of Kalyani has approved the final syllabus on .....2022.

Chairman,
DRC, Department of Zoology
University of Kalyani,
Kalyani, W.B.
India

Preamble

Ph.D Research Entrance Test (RET) in Zoology

The Ph.D Research Entrance Test (RET) in Zoology have two papers:

A. **(Written Test): Full Marks 50** (25 Marks on Research Methodology+25 Marks on SubjectSpecific)
B. **(Interview/Viva-Voce): Full Marks 50** (15 Marks for Research methodology, 15 Marks forSubject Specific and 20 Marks for the presentation on proposed research and competence)

Keeping the importance of research in present scenario and to enhance the quality of research, the Ph.D Research Entrance Test (RET) in Zoology has been designed for the students to continue with the Ph.D. programme in the department. The programme aims at facilitating the research students andto culture essential quality research among the students who joined the Ph.D. programme from the academic year 2022-23.

The details of research methodology and discipline-specific topics are given below.

Ph.D Research Entrance Test (RET)
Department of Zoology, University of Kalyani
Effective from 2022- 2023 Session

A. (Written Test): Full Marks 50				
	Topics		**Full Marks**	
	Research Methodology		25	
	Subject Specific: Zoology		25	
	Total Marks		**50**	

B. (Interview/Viva-Voce): Full Marks 50 (15 Marks for Research methodology, 15 Marks for Subject Specific and 20 Marks for the presentation on proposed research and competence)				
	Topic		**Full Marks**	
	Research methodology		15	
	Subject Specific: Zoology		15	
	Presentation on proposed research and competence		20	
	Total Marks		**50**	

Question Pattern

Written Test	Interview/Viva-Voce
For written test only Pattern of questions: preferably multiple choice questions (single/multi-select)/ rank order scaling questions/ text slider questions/ likert scale questions/ stapel scale questions/ constant sum questions/demographic questions/ analytical questions/ any other types of questions as selected fit by respective RAC– carrying 1/2/3/4/ marks each.	The interview/ viva voce shall be organized in the Department through institutional notification when the candidates shall be required to discuss their research interest/ area/ research methodology through a presentation before the DRC (including academic marks and research publication).

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	Topics (Contents)	Marks (FM 25)
	Unit 1: Introduction to Research Methodology; Research – Definition and its Importance; Types of Research; Importance of Survey of Literature; Formulation of research question and objectives; Research design – developing a research plan; Types of research methods.	
	Unit 2: 1.Techniques for Studying Cell: i. Basic Concepts of Microscopy: Magnification, Resolution, Limit of Resolution, Chromatic Aberrations. Types of microscopy: Bright Field Microscopy, Dark Field Microscopy, Phase Contrast Microscopy and Differential Interference Contrast Microscopy, Fluorescence Microscopy and Confocal microscopy. ii. Electronic Imaging Systems- Electron Microscopy- TEM Vs. SEM, Different fixation and staining techniques for EM, freeze-etch and freeze-fracture methods for EM, image processing methods in microscopy. iii. Basic concept of Flow cytometry. 2. Cell Fractionation Methods: i) Ultracentrifugation ii) Gradient Centrifugation. 3. Separation of Cellular Constituents: i) Chromatography: ion exchange; gel filtration and HPLC. ii)Electrophoresis-PAGE, SDS-PAGE (One and Two dimensional). 4. Methods for the analysis of gene expression (RNA and protein), large scale gene expression study-Basics of designing a microarray, image analysis and normalization, annotations. 5. Spectroscopy: UV-spectroscopy, Circular Dichroism, surface plasma resonance methods. 6. Blotting Methods: Southern, Northern & Western blotting. RFLP, RAPD and AFLP techniques. 7. Pesticide Formulation. 8. Bioinformatics: Database search tool; Sequence alignment and database searching; Computational tools and biological databases, NCBI, EMBL, PDB,Sequence similarity search tools; BLAST and FASTA, Phylogenetic analysis with the program PHYLIP, DISTANCES and GROWTREE.	
	Unit 3: **Biostatistics:** 1. Measures of Central Tendencyand dispersal.	

	2. Measures of Variation. 3. Concept of Probability and significant test, Probability Distribution (Binomial, Poisson and normal). 4. Graphical representation of biological data: Box plot analysis, leaf and stem diagram. 5. Test of Hypothesis, Students' *t*-test and z-test and their application. 6. Analysis of Variance (ANOVA). 7. Nonparametric tests: Chi-square test and Wilcoxon sign-rank test,Linear Regression, Correlation analysis and rank Correlation analysis	
	Total	**25**

Reference Books:

1.Zar, J.H. (2013) Biostatistical Analysis

2. Pagano M., Gauvreau, K, (2000), Principles of Biostatistics.

3.Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology 2018, ISBN: 9781316677056

4.Biochemistry Laboratory: Modern Theory and Techniques, Latest Edition, Rodney Boyer, Pearson Prentice Hall™ is a trademark of Pearson Education,

	Topics (Contents)	Marks (FM 25)
Non-Chordate Biology	1. Origin & Evolution of Metazoans. 2.Cell organelles in Protozoa: Golgi, Mitochondria, Kinetoplast, Pellicle and Cuticle. 3. Cell association and cellular differentiation in Protozoa. 4.Osmoregulation in Protozoa and Nematodes. 5. Sense organs and their importance - Chemoreception, photoreception and mechanoreception; sensory organelles and reaction for stimuli in protozoa. 6. Organs and process of reproduction in major invertebrate groups. 7. Structural organization of respiratory organs in major invertebrate groups; factors affecting respiration. 8. Photogenic organs in insects: structure, mechanism and significance of light production.	
Chordate Biology	1. Blood and cardiovascular system: Blood pressure and baroreceptors, blood volume regulation; cardiac cycle, myogenic and neurogenic heart, origin and conduction of heart beat, ECG and its implications, neural and chemical regulation of functions of heart. 2. Respiratory system: Comparative account of respiratory pigments; transport and exchange of gases. 3. Nervous system: Gross anatomy of brain and spinal cord; cranial nerves, neural control of muscle tone. 4.Thermoregulation: Importance of body temperature in animal physiology, heat exchange interactions between animals and environment, thermoregulation in ectotherms and endotherms, physical, chemical, neural regulation of body temperature; acclimation and acclimatization. 5. Circulatory systems: General plan, Hemodynamics. Cardiovascular response to extreme conditions like exercise, diving and haemorrhage. Neural control of cardiovascular system. Immune responses. 6. Digestive system: Acquisition of Energy, Types of feeding, Digestion (motility and Secretions), Metabolism, and absorption, Physiology of gastrointestinal system (mammals) including neural and hormonal regulatory mechanisms.	
Biosystematics and Taxonomy	1. Species concept: a. Biological species concept, difficulties in application of biological species concept. b. Nomenclature rules, ICZN: The code; amendments and applications c. Concept of Type. 2. Character and character states in taxonomy: a. Types of character: primitive and advanced, missing, polymorphic, micro, cryptic and internal.	

	b. Character state transition, environmental effect and their significances, artifacts and special characters. c. Taxonomic key: types and their role in classification. 3. Phenetic method of classification- a. Numerical phenetics and numerical taxonomy. b. Preparation of data matrix and similarity matrix using distance method (Manhattan distance and Euclidian distance). c. Cluster analysis (different methods) 4. Cladistic method of classification – a. Cladistics and cladogram, terminologies in cladistics. b. Methods of measuring evolutionary transitions c. Homoplasy, parsimony and character conflict. 5. Polyphasic concept in biosystematics – a. Biochemical taxonomy, cytotaxonomy and molecular taxonomy. b. DNA barcoding. c. Phylogenetic trees: construction and analysis; types.	
Parasitology	1. Concept of parasitism, symbiosis commensalism and mutualism. 2. Host-parasite interaction: immunopathological consequences in parasitic infections. 3. Classification of Protozoa and Helminths. 4. *Entamoeba* and Blood Flukes in Humans. 5. Microspora: Structure and life history of *Nosema bombycis* -impact on sericulture. 6. Mode of transmission of *Plasmodium*, *Trypanosoma* and Piroplasm. 7. Zoonosis with particular reference to *Toxoplasma and Schistosoma*	
Ecology, Environment and Wildlife Biology	1. The Ecosystem: Gaia hypothesis, cybernetic nature and stability of the ecosystem, ecosystem management and optimization. Macroecology: concept and consequences. Principles of Thermodynamics, energy flow and ecological energetics. 2. Niche theory: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement. (Lotka-Volterra model, Isoclines, Niche prediction). 3. Community: Structure and Gradient analysis, Structure of biotic community. Community patterns: diversity and stability. Community boundary: Ecotone and edge types, Edge effect and edge species, Leibig's Law of the minimum. 4. Population attributes: Growth forms and mathematics of growth, Life Table - (Cohort and Static); survivorship curves, generation time, net reproductive rate, gross reproductive rate, vital index. Life history strategies:	

	Evolution of life history traits, strategies related to longevity; clutch size; life history optimization. 5. Metapopulation: Concept, models, structure and dynamics. 6. Major terrestrial biomes: Theory of island biogeography, Biogeographical zones of India. 7. Concept of Environment: Structure, radiation balance, UN movements on environment. 8. Theory and analysis of conservation: Stochastic perturbations, population viability analysis, recovery strategy for threatened species: Different approaches for conservation – in-situ and ex-situ, In-situ conservation-problems and prospects; Sanctuaries, National parks, Community Reserves and Conservation Reserves; Biosphere Reserve, EIA and EIS. 9. Conservation biology of important wild animals: Conservation status, habit & habitat, threats and conservation management of the following animals: Olive Ridley Turtle / Greater one-horned *Rhinoceros*/ Ganges river dolphin. 10. Basic Concept of Wildlife Biology: Wildlife wealth of India; Threatened wildlife and IUCN status - Concept of Extinct, Critically Endangered, Endangered, Vulnerable and rare species; concept of corridor.	
Developmental Biology	1. Overview of early embryonic development and morphogenesis. 2. Basic concepts in Developmental Biology: potency, induction, germ cell migration, competence,commitment, specification, determination and differentiation, morphogenetic gradient and fate map. 3. Axis specification in *Drosophila*: role of maternal effect genes, patterning of early embryo by zygotic genes, gap genes, pair– rule genes, segment polarity genes, homeotic selector genes- bithorax and antennapedia complex. 4. Axis specification in vertebrates: Early patterning in vertebrates - Symmetry breaking, Nieuwkoop center. Wnt and cadherin signaling, TGFβ signaling in early developmental process, asymmetric gene expression. 5. General concepts of organogenesis: Development and patterning of vertebrate limb, homeobox genes in patterning, signaling in patterning of the limb; Insect imaginal discs–organizing center in patterning of the leg and wing, the homeotic selector genes for segmental identity; insect compound eye. 6. Postembryonic development: growth, cell proliferation, growth hormones; aging- genes involved in alteration in timing of senescence 7. Regeneration– Epimorphic regeneration of reptile	

	(salamander) limb; Morphollaxis regeneration in *Hydra*. 8. Programmed cell death in developmental biology	
Cytogenetics and Human Genetics	1. Organization and Structure of Genomes: Organization and nature of eukaryotic nuclear DNA, Size and complexity of eukaryotic genome; transposable elements, retrotransposons, SINE, LINE, Alu and other repeat elements, pseudogenes, segmental duplications; super coiling of DNA; Classes of DNA, Giant chromosomes: study model for chromosome organization and gene expression; Virus and Bacterial genomes, Mitochondrial genome. 2. Cell cycle, Apoptosis and Cancer: Phases of Cell cycle, Check Points, Regulation of cell cycle; MPF, cyclins and cyclin-dependent kinases; Concepts of Apoptosis:Regulators of Apoptosis, Caspases, Pathways of apoptosis; Cell Senescence, Necrosis; Cancer-Types and Stages, Carcinogens, Tumor suppressor genes and Proto-oncogenes induction to oncogenes. 3.DNA Replication and Recombination: Topology, Variations and Nature of Replication; Replicon, Replicator, Fidelity and Processivity of replication; "Hayflick limit" and Telomerase activity; Regulation of Replication-Cell Cycle synchronization, Origin Firing, Licensing, DNA damage response; Drugs and Inhibitors targeting replication-antibacterial, antiviral and anticancer; Extrachromosomal Replicons; Homologous Recombination and DNA Repair. 4. Human genetics: Basic concept and introduction to the structure of human genome; human genome and mapping.Human genome project and the age of genomics, Concepts and application of Bioinformatics. 5. Human karyotype; karyotype and nomenclature of metaphase chromosome bands. 6. Chromosome anomalies and Structural Variants. 7. Molecular Pathology: Loss of function, Gain of function; Mitochondrial disorders. 8. Genetic analysis of complex traits and disease. 9. Human genetics and society: genetic testing; human rights; genetic counseling. 10.Quantitative genetics; variance; heritability and its measurement; inbreeding and cross breeding; QTL.	
Animal Physiology	1.Respiratory function of blood:Respiratory pigments – types, distribution and brief chemistry. Structure and function of haemoglobin- i) in adult and ii) during embryonic life. Transport of oxygen and carbon dioxide in blood and body fluids, Regulation of respiration. 2. Physiology of muscle contraction and proteins associated with muscle contraction: Physiology of muscle contraction, Chemical nature of contractile elements,	

	actin nucleation, actin treadmilling, myosin types, structure, Role of structural and regulatory proteins in muscular contraction (profilin, cofilin, thymosin, troponin, tropomysin, Arp 2/3 complex),ATP and signal molecules in muscular contraction, neuromuscular junction and its functioning. 3. Physiology of excretion: Formation of urine,Physiology of ultrafiltration, reabsorption, tubular secretion Counter current theory of urine concentration, Regulation of urine formation, Renal regulation of acid- base balance. 4.Synaptictransmission; types of synapses,Pre- and postsynaptic structure and function, Steps in Synaptic Transmission, chemistry and modes of neurotransmitter release, proteins in synaptic transmission: SNARE hypothesis:synapsins, synaptobrevin, synaptotagmin, SNAPand NSF, synaptic plasticity, toxins in synaptic transmission. 5. Cytoskeleton, Extracellular matrix, gap junctions, integrins, cell adhesion molecules and their functions. 6. Intracellular protein trafficking for secretory and non-secretory cells: Protein synthesis, Protein sorting and targeting to organelles; signal sequences, vesicle transport, packaging, storage and release, Targeting of proteins to lysosomes for degradation; Receptor mediated endocytosis.	
Biochemistry and Metabolic Processes	1. Proteins: Protein folding and protein stability 2. Bioenergetics (anaerobic and aerobic respiration, oxidative and substrate level phosphorylation) basic concept of ETC and ATP synthesis, uncouplers. Spontaneous reaction (concept of -vedel G). Thermodynamic principles and steady-state conditionsof living organism. 3. Amino acid metabolism: Amino acid classification, Urea cycle. 4. Carbohydrate metabolism: Carbohydrates of physiologic significance Glycolysis, Gluconeogenesis, Hexose monophosphate Shunt, Glycogenesis and glycogenolysis, Control and regulation of carbohydrate metabolism 5. Biosynthesis of cholesterol, control of cholesterol biosynthesis,lipoproteins and types of cholesterol transport 6. Enzymes: Kinetic analysis of enzyme-catalyzed reaction, Michaelis-Menten Equation, Lineweaver-Burk's plot, Eadie–Hofste plot, Bi-substrate Reactions, enzyme inhibitions, Regulation of enzyme activity, Allosteric control of enzyme activity 7. Chemistry of free radicals and antioxidants. 8. Vitamins and minerals: Role of vitamins as coenzymes.	

Fish Biology	1. Respiratory organs:Water breathing, Air-breathing, Swim bladder 2. Excretion and osmoregulation in fish. 3. Reproduction in fish: reproductive strategies, oviparity, viviparity, ovo-viviparity, parental care, maturity stages, breeding cycle 4. Structure and physiology of endocrine glands in fishes 5. Electroreception in fish, Electric organs 6. Determination of age of fish by scale and hard parts. 7. Poisonous and venomous fish. 8. Fish migration: Types, Theories and Significances 9. Different systems of aquaculture: Monoculture, polyculture; Definition, importance and types of Integrated fish farming. 10. Aquaculture methods: concept and significance, Different systems of aquaculture for carps and shrimps: Extensive, Semi-intensive, Intensive. 11. Ornamental fish culture: Background, classification, breeding of ornamental fish, common diseases and control. 12. Aquatic organisms: Distribution patterns of planktonic organisms, Phytoplankton-zooplankton relationships, Adaptation of planktonic organisms to different aquatic habitats, Periphytic communities, Benthos, Bio-indicators and Biomonitoring.	
Cell Biology	1. Fixation, staining and application: i) Solutions: Definition, Composition, Expression, Ideal & non-ideal Solution. ii) Chemical & physical effects of some primary fixatives: Formalin, alcohol, picric acid, acetic acid. iii) Source and chemical composition of some dyes: Basic fuchsin, carmine, hematin, hematoxylin, eosin. 2. Chemical composition and properties of fluorescence dye, principle and application: DAPI, Propidium Iodide, Acridine orange, Rhodamine, DCFDA, Hoechst 3. Morphogenesis: Morphogenetic processes, cell size and shape, Cell fusion, Cell death, Cell adhesion, morphogenetic movements, cell sorting, morphogenetic field, and regionalization 4. Stem cells: Application of Adult Stem Cells, iPS Cells; Stem cell niches; Trans-differentiation. 5. Teratogenesis: Genetic teratology, Environmental teratology, Developmental mechanism, Contribution of teratology to Developmental Biology. 6. Ageing: Cellular basis of aging, Causes of aging, Free Radical Theory of Aging, role of anti-oxidant enzymes in the process of aging, aging related disorders. 7. Physiology of cell division: Cell Cycle, synchrony in cell division, inhibition of cell division, source of	

	energy. 8. Cell-cell adhesion: types of cell binding, adhesive proteins, their role in cell-cell interaction, gap junctions, extracellular matrix, integrins, differentiation and movement of leukocyte into tissues.	
Basic Tools and techniques of animal biology	1. Microscopy: Basic concepts of light and electron microscopy (magnification, resolution, limit of resolution, chromatic aberrations). 2. Histochemical and immunological techniques: Tissue processing, microtomy, fixatives (types and function), staining, and immunohistochemistry. Antibody generation and antigen-antibody interaction. 3. Biophysical methods: Common spectroscopic methods, Electromagnetic radiation, Principle of spectroscopy. 4. Radiolabeling techniques: Properties of different types of radioisotopes normally used in biology, their detection and measurement; incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, safety guidelines. 5. Methods in field biology: Methods of estimating population density of animals, ranging patterns through direct, indirect and remote observations, sampling methods in the study of behavior, habitat characterization-ground and remote sensing methods.	
Immunobiology	1. Basic concepts of Immune System; Primary and Secondary Lymphoid Organs, Cells, Tissues and molecules of Immune System. 2. Innate immunity: Overview, features, epithelial barrier, neutrophils, macrophage functions, inflammation, NK cells, cross talk with adaptive immune system. 3. Humoral immune system: Structure and class switching of antibodies, B cell function, maturation and development. 4. Complement system and diseases. 5. Antigen presentation: Concept of haptens, determinants, conditions of antigenicity, superantigen, Dendritic cell, MHC, role of APCs. 6. Antigen Recognition: Antigen Receptor: T and B cell Receptor, Structure of Immunoglobulin and T-cell receptor, Antigen Receptor Diversity-Mechanism, Antigen Receptor Maturation and selection. 7. Vaccination and immunization: natural and artificial immunization; active immunization, vaccines. 8. Immuno-techniques: Antigen-Antibody Reaction Analysis-Agglutination, Diffusion etc. Isolation and culture of Immune cells, Antigen-Antibody reaction-RIA, ELISA, Visualization of Immune reaction In vivo and vitro- Immunofluorescence, FISH, GISH, immunohistochemistry.	

Concept of Biodiversity and Evolution	1. Levels of species diversity and relationship; geographic distribution of biological diversity; biological hotspots; measuring biodiversity; interrelationship between diversity measures; pattern of local and regional biodiversity. 2. Threats to species diversity; natural and human induced threats and vulnerability of species extinction; Red data book; rarity, endemism, effective and minimum viable population, fragmentation of population; problems of genetic diversity; bottleneck; genetic drifts; inbreeding depression. 3. Biodiversity Resource Management, values and uses of biological diversity as source of foods, drugs and medicines. 4. Theories on relation between biodiversity and ecosystem function i. Species Complementarity ii. Sampling effect iii. Redundancy. 5. The economics of biodiversity and ecosystem function. 6. Landscape Ecology: a) Theories in landscape ecology. Hierarchy theory and the structure of the landscape, Percolation theory, The systems source sink, b) Scale and landscape, Scaling the landscape, Change of scale perception. Importance of parameters at different scales, c) Processes in the landscape: Disturbance, Fragmentation, Landscape connectivity, Corridors, d) Methods in landscape ecology, Spatial data processing, fractal geometry approach, urban ecology. 7. Remote sensing in landscape ecology, Geographic Information System, Spatially explicit population models (SEPM). 8. Organic evolution: concept and evidences (comparative anatomy, embryology, biogeography, palaeontology, genetics, biochemistry and physiology).	
Environmental Toxicology	1. Toxicology of pesticides: Scope, division, toxicantsandtoxicity, LD50, LC 50 and ED50, Dose-response relationship; Carcinogenic, Mutagenic and Teratogenic effects, Method of testing chemicals on insect and evaluation of toxicity. 2. Group Characteristics and function of pesticides: Organochlorines, Organophosphates insecticides, Carbamates, Pyrethroids, other plant origin bio-insecticides, neonicotinoids and nitrogenous insecticides; fumigants; IGRs, attractants, repellents and anti-feedants. Properties of few individual insecticides i.e. DDT, HCH (BHC), Lindane, Endosulfan, Parathion, Malathion, Carbaryl, Cypermethrin, etc. 3. Toxicants of public health hazards: Pesticides, Heavymetals, Radiation, food and additives. 4. Toxicokinetic and toxicodynamic: Absorption, distribution, Metabolism, elimination, organ toxicity. 5. Mode of action: Central Nervous system,	

	Acetylcholinesterase and unknown modes of action. Metabolism of insecticides: Phase I and Phase II reactions and metabolism of other pesticides. 6. Toxicological symptoms of Organochlorines, Organophosphorus, Carbamates, Pyrethroids, plant origin insecticides and other bio-insecticides.	
Endocrinology	1.Classification of hormones; general principles, nature of hormone receptors (cell surface receptors and intracellular receptors), and hormone signalling pathways (G-protein coupled receptors, Receptor Tyrosine Kinases, and steroid hormone signalling). 2. Biosynthesis, secretion andregulation of hormones: biosynthesis of Insulin, Post-Translational event and release. 3.Biosynthesis and function of steroid and thyroid hormones (T_3 and T_4) and their regulations. 4. Neuroendocrine system and neuro-secretion: neural control of glandular secretion; hypothalamic pituitary unit, neuroendocrine feedback 5. Physiological role of hormones: hormonal regulation of mineral metabolism and fluid volume 6. GI tract hormones: source, composition and function 7. Molecular basis of endocrinopathies: Disorders of pituitary hormone axis- thyrotoxicosis, hypothyroidism, Hashimoto's thyroiditis metabolic bone diseases, Cushing syndrome, Addison's diseases, androgen deficiency syndromes- testicular neoplasm, hormone-related cancers.	
Animal Behaviour	1. Introduction to animal behavior: History, foundation, approaches and methods 2. Learning and memory:Forms of learning and memory, learning and habitat selection - migration, navigation andorientation 3. Kinship: Relatedness, inclusive fitness. selfishness, altruism 4. Conflict: Sexual selection, aggression, competition, dominance, Infanticide. 5. Game theory- Models and strategies. 6. Communications: Channels, functions, origin and modification of signal, signal receiving mechanism. 7. Evolution of feeding behavior: optimal foraging theory.	
Microbiology	1. History of microbiology. 2. Bacteriology: Structure and function of capsule, pili, flagella, cell wall, cell membrane, outer-membrane, chromosome and plasmid. 3. Virology: Structural organization of viruses, Prions and viroids, Lytic cycle of bacteriophages, Lysogeny and lysogeny control, lysogenic conversion, induction and significance.	

	4. Animal and Veterinary Microbiology: Microbial interactions with animals (marine and freshwater invertebrates, ruminants), symbiotic light production, sulfide-based mutualism. 5. Disease causing microbes: *Escherichia coli* and *Streptococcus* spp. 6. Culture techniques: Microbial nutrition and growth; types of culture media, sterilization of culture media; culture techniques: pure cultures. 8. Industrial microbiology: Microbial fermentation; production and commercialization. 9.Mode of transmission, pathogenicity and prevention of microbial diseases: Air-borne (Tuberculosis), Food and waterborne (Typhoid) and Arthropod borne (JE and Yellow fever), SARS-COV 2 (infection and concept of herd immunity).	
Molecular Biology and Biotechnology	1. Transcriptional gene expression: positive and negative regulations, RNA polymerases, promoters and regulatory sequences, activators and repressors of transcription, transcription initiation by RNA polymerases, regulation of transcription factor activity, elongation and termination of transcription. 2. Post-transcriptional gene control: Regulation of Pre-mRNA Processing; Splicing, Types of introns and their splicing, evolution of introns, catalytic RNA, alternative splicing and proteome diversity, micro RNA and other non-coding RNAs. 3. RNA Transport, Translation and stability of RNA: Structure of nuclear membrane and nuclear pore complexes, processes of nuclear import and export and their regulation; Degradation of RNA; Translational machinery and translational control - energetics of amino acid polymerization, tRNAs and their modifications, aminoacyl tRNA synthetases, accuracy during aminoacylation of tRNA, regulation of initiation of translation in eukaryotes, elongation and its control, inhibitors of translations. 4. Basic recombinant DNA techniques: cutting and joining DNA molecules, restriction modification systems, various enzymes used in recombinant DNA technology, restriction maps and mapping techniques; nucleic acid probes, blotting techniques, DNA fingerprinting, foot-printing, methyl interference assay. Polymerase chain reaction– methods and applications. 5. Basic biology of cloning vectors: plasmids, phages, single stranded DNA vectors, high capacity vectors, retroviral vectors, expression vectors and other advanced vectors in use. Gene cloning strategies: methods of transforming *E. coli* and other cells with rDNA; methods of selection and screening of	

	transformed cells; construction of genomic and cDNA libraries; strategies of expressing cloned genes; phage display. 6. Manipulating genes in animals: gene transfer to animal cells, genetic manipulation of animals, transgenic technology, application of recombinant DNA technology; genetically modified organisms: gene knockouts, mouse disease models, gene silencing, gene therapy, somatic and germ- line therapy, Genome manipulation-CRISPR-Cas9 System.	
	Total	**25**