# 20. ZOOLOGY

1. Diversity of animal life
2. Cytology and molecular biology
3. Inheritance biology
4. Evolution and animal behavior
5. Applied biology
6. Animal physiology and endocrinology
7. Animal ecology
8. Molecules and their interactions
9. Developmental biology of animals
10. Vertebrate oesteology
11. Methods in biology

**1- Diversity of animal life**

**I. Principles and methods of taxonomy:**

- **i.** Concepts of species and hierarcheal taxa.
- **ii.** Biological nomenclature
- **iii.** Classical and quantitative methods of taxonomy of animals.
- **iv.** Evolutionary relationships among taxa.

**A- Non Chordata**

**Protozoa**

i. General characteristics of Protozoa
ii. Protozoa: locomotion, reproduction, osmoregulation in Protozoa
iii. Disease causing protozoan: *Plasmodium, Entamoeba*

**Porifera**

i. General characteristics of Porifera.
ii. Canal system in Porifera.
iii. Organization and affinities in Porifera.

**Coelenterata**

i. General characteristics of Coelenterata
ii. Polymorphism in Coelenterata

**Platyhelmenthes**

i. General characteristics of Platyhelmenthes
ii. Parasitic adaptations.
iii. Life History and pathogenecity of *Faciola hepatica, Taenia solium*

**Aschelmenthes**

i. General characteristics of Aschelmenthes
ii. Life history and pathogenecity of *Ascaris lumbricoides.*

**Annelida**

i. General characteristics of Annelida.
ii. Adaptive radiations.
iii. Segmental organs.

**Arthropoda**

i. General characteristics of Arthopoda
ii. Larval forms of Crustacea.
iii. Mouth parts of insects.
iv. Social life in wasps, ants and termites.

**Mollusca**

i. General characteristics of Mollusca
ii. Torsion in gastropods.

**Echinodermata**

i. General characteristics of Echinodermata.
ii. Water vascular system.

**B- Chordata**

i. General characteristics, organization and affinities of Hemichordata, Cephelochordata and Urochordata.
ii. General organization and affinities of Ostrachoderms, Dipnoi and Holocephali.

iii. **Amphibia**: Origin of tetrapods, general characteristics of Amphibia and parental care.

iv. **Reptilia:** General characteristics and origin of reptiles, affinities of Rhynchocephalia and Crocodelia, poisonous and non-poisonous snakes of India, venom and anti-venom.

v. **Aves**: General characteristics, migration and flightless birds.

vi. **Mammalia**: Origin and evolution of mammals, dentition in mammals and affinities of Prototheira and Metatheria.

**2- Cytology and molecular biology**

I. **Structure, organization and functions of animal cell organalles:** Nucleus, mitocondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes and ribosomes.

II. **Membrane structure and functions:** Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, membrane pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes.

III. **Chromosomes:** Structure and types of eukaryotic chromosomes

IV. **Cell Division and Cell Cycle:** Mitosis and meiosis, their regulation, steps in Cell cycle, regulation and control of cell cycle.

V. **Molecular structure of DNA and RNA:** DNA replication, repair and recombination, unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extra-choromosomal replication, DNA damage and repair mechanism, homologous and site specific recombinations.

VI. **RNA synthesis and processing:** Transcription factors and machinery, formation of initiation complex, transcription activator and repressor, RNA polymerases, capping,

elongation, and termination, RNA processing, RNA editing, splicing, and polyadenylation, structure and function of different types of RNA, RNA transport).

VII. **Protein synthesis and processing:** Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, genetic code, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, and translational proof-reading, translational inhibitors, post-translational modification of proteins.

VIII. **Control of protein synthesis.**

IX. **Control of gene expression at transcription and translation level:** Regulating the expression of phages, viruses, prokaryotic and eukaryotic genes, role of chromatin in gene expressing and gene silencing.

X. **Cell signaling:** Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant two-component systems, bacterial chemotaxis and quorum sensing.

XI. **Cancer:**

Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, apoptosis, therapeutic interventions of uncontrolled cell growth.

## 3- INHERITANCE BIOLOGY

**A) Mendelian principles :** Dominance, segregation, independent assortment.
**B) Concept of gene :** Allele, multiple alleles, pseudoallele, complementation tests
**C) Extensions of Mendelian principles :** Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters.
**D) Gene mapping methods :** Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids.
**E) Extra chromosomal inheritance :** Inheritance of Mitochondrial genes, maternal inheritance.
**F) Microbial genetics :** Methods of genetic transfers – transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes.
**G) Human genetics :** Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.
**H) Quantitative genetics :** Polygenic inheritance, heritability and its measurements, QTL mapping.
**I) Mutation :** Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis.
**J) Structural and numerical alterations of chromosomes :** Deletion, duplication, inversion, translocation, ploidy and their genetic implications.
**K) Recombination :** Homologous and non-homologous recombination including transposition.

## 4- EVOLUTION AND ANIMAL BEHAVIOUR

A. Emergence of evolutionary thoughts
Lamarck; Darwin–concepts of variation, adaptation, struggle, fitness and natural selection; Mendelism; Spontaneity of mutations; The evolutionary synthesis, evidences of organic evaluation.

B. Origin of cells and unicellular evolution:
Origin of basic biological molecules; abiotic synthesis of organic monomers and polymers; concept of Oparin and Haldane; experiment of Miller (1953); the first cell; evolution of prokaryotes; origin of eukaryotic cells; evolution of unicellular eukaryotes; anaerobic metabolism, photosynthesis and aerobic metabolism.

C. Paleontology and evolutionary history:
The evolutionary time scale; eras, periods and epoch; Major events in the evolutionary time scale; origins of unicellular and multi cellular organisms; major groups of animals; major fossil records, evolution of horse, elephant and man.

D. Molecular evolution:
Concepts of neutral evolution, molecular divergence and molecular clocks; molecular tools in phylogeny, classification and identification; protein and nucleotide sequence analysis; origin of new genes and proteins; gene duplication and divergence.

E. The mechanisms:
Population genetics: populations, gene pool, gene frequency; Hardy-Weinberg law; concepts and rate of change in gene frequency through natural selection, migration and random genetic drift; adaptive radiation; isolating mechanisms; speciation; allopatricity and sympatricity; convergent evolution; sexual selection; co-evolution.

F. Brain, behavior and evolution:
Approaches and methods in study of behavior; proximate and ultimate causation; altruism and evolution-group selection, kin selection, reciprocal altruism; neural basis of learning, memory, cognition, sleep and arousal: biological clocks: development of behavior: chemical, visual, light and audio communication in animals: Use of space and territoriality: mating systems, parental care: aggressive behavior; habitat selection and optimality in foraging; migration, orientation and navigation; domestication and behavioral changes, social organization in insects.

## 5- APPLIED BIOLOGY:

a. Microbial fermentation and production of small and macro molecules.
b. Application of immunological principles, vaccines, diagnostics. Tissue and cell culture methods for animals.
c. Transgenic animals, molecular approaches in diagnosis and strain identification.
d. Genomics and its application to health and agriculture, including gene therapy.
e. Bio-resources and uses of biodiversity.
f. Breeding in plants and animals, including marker – assisted selection
g. Bioremediation and phytoremediation
h. Biosensors
i. Common parasites and pathogens of humans and domestic animals.
j. A brief study of silk culture, apiculture, lac culture, vermiculture, pearl culture and fish culture.
k. Insects used in medicines, bio-control and food.
l. Integrated pest management.

## 6- ANIMAL PHYSIOLOGY AND ENDOCRINOLOGY

**A. Blood and circulation** - Blood corpuscles, haemopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, hemoglobin, immunity, haemostasis, coagulation of blood.

**B. Cardiovascular System:** Comparative anatomy of heart structure, myogenic heart, specialized tissue, ECG – its principle and significance, cardiac cycle, heart rate, stroke volume and cardiac output, blood pressure, neural and chemical regulation of heart.

**C. Respiratory system** - Comparison of respiration in different species, anatomical considerations, transport of gases, exchange of gases, respiratory quotient, waste elimination, neural and chemical control of respiration.

**D.** **Nervous system** –Gross neuroanatomy of the brain and spinal cord, central and peripheral nervous system, structure and types of neurons, origin and transmission of nerve impulse through axon and synapse. Action potential, neurotransmitters, neuro-inhibitors and reflexes.

**E.** **Sense organs** - Vision, hearing and tactile response, chemo receptors.

**F.** **Excretory system** - Comparative physiology of excretion, kidney, types of nitrogenous wastes in animals, urine formation and urine concentration, regulation of water balance, blood volume, blood pressure, electrolyte balance, acid-base balance and hormonal control of urine formation.

**G.** **Thermoregulation** - Comfort zone, body temperature – physical, chemical, neural regulation, acclimatization.

**H.** **Enzymes and vitamins:** Types of enzymes and vitamins and their role in human physiology.

**I.** **Digestive system** - Digestion, absorption, energy balance, BMR.

**J.** **Muscular system –** Types of muscles, physiology of muscle contraction and single muscle twitch.

**K.** **Endocrinology and reproduction** – Classification of hormones, endocrine glands, their secretions and functions, basic mechanism of hormone action, hormones and diseases, gametogenesis, ovulation, neuroendocrine regulation, hormonal regulation of carbohydrates, lipids, proteins, nucleic acids and metabolism: reproductive cycles in vertebrates and hormonal control

**L.** **Innate and adaptive immune system** Cells and molecules involved in innate and adaptive immunity, antigens, antigenicity and immunogenicity. B and T cell epitopes, structure and function of antibody molecules. generation of antibody diversity, monoclonal antibodies, antibody engineering, antigen-antibody interactions, MHC molecules, antigen processing and presentation, activation and differentiation of B and T cells, B and T cell receptors, humoral and cell-mediated immune responses, primary and secondary immune modulation, the complement system, toll-like receptors, cell-mediated effector functions, inflammation, hypersensitivity and autoimmunity, immune response during bacterial (tuberculosis), parasitic (malaria) and viral (HIV) infections, congenital and acquired immunodeficiencies, vaccines.

## 7- ANIMAL ECOLOGY

**The environment:** Physical environment; biotic environment; biotic and abiotic factors and their interactions.
**Habitat and niche:** Concept of habitat and niche; niche width and overlap; fundamental and

realized niche; resource partitioning; character displacement.
**Population ecology:** Characteristics of a population; population growth curves; population regulation; life history strategies (*r* and *K* selection); concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations.
**Species interactions:** Types of interactions, intra-specific and inter-specific competition, herbivory, carnivory, symbiosis.
**Community ecology:** Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.
**Ecological succession:** Types; mechanisms; changes involved in succession; concept of climax.
**Ecosystem ecology:** Ecosystem structure; ecosystem function; energy flow and mineral cycling (carbon, nitrogen, oxygen and phosphorus); food chain, food web and ecological pyramids, primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine).
**Biogeography:** Major terrestrial biomes; theory of island biogeography; bio-geographical zones of India.
**Applied ecology:** Global environmental change; biodiversity: status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches.
**Conservation biology:** Principles of conservation, major approaches to management of natural resources, conservation/management strategy (project tiger, project elephant, national parks, sanctuaries and biosphere reserves ) in India.
**Environmental pollution:** noise, air, water and soil pollution, their sources and control measures: acid rains, global warming, green house effect and depletion of ozone layer.
**Ecological adaptations in vertebrates**.

## 8- MOLECULES AND THEIR INTERACTIONS

A. Structure of atoms, molecules and chemical bonds.

B Composition, structure and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins).

C. Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction).

D Principles of biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics, colligative properties).

E. Bioenergetics, glycolysis, oxidative phosphorylation, coupled reaction, group transfer, biological energy transducers.

F. Conformation of proteins (Ramachandran plot, secondary structure, domains, motif and folds).

G. Conformation of nucleic acids (helix (A, B, Z), t-RNA, micro-RNA).

H. Stability of proteins and nucleic acids.

I. Metabolism of carbohydrates, lipids, amino acids nucleotides and vitamins.

## 9- DEVELOPMENTAL BIOLOGY OF ANIMALS

**A) Basic concepts of development :** Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting;

mutants and transgenics in analysis of development

**B) Gametogenesis, fertilization and early development:** Production of gametes, cell surface molecules in sperm-egg recognition in animals; types of eggs, zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis. development of brain, eye and heart in chick**.**

C) **Morphogenesis and organogenesis in animals :** Types of metamorphosis and hormonal control of metamorphosis, cell aggregation and differentiation in *Dictyostelium*; axes and pattern formation in *Drosophila*, amphibia and chick; organogenesis – vulva formation in *Caenorhabditis elegans*, eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development- larval formation, metamorphosis; environmental regulation of normal development; sex determination.

D) **Organizer concept**: Embryonic induction, primary organizer and its morphological differentiation, origin of primary organizer, inductive interactions, nature of inductive signal (possible mechanism of neural induction), competence.

**E. Placentation in Mammals**: Placenta, Classification of placenta, physiology and functions of placenta, placentitis

**10-VERTEBRATE OESTEOLOGY**: Endoskeleton of *Scoliodon*, frog, varanus, fowl and rabbit

**11-METHODS IN BIOLOGY**

A. **Molecular biology and recombinant DNA methods:**

Isolation and purification of RNA, DNA (genomic and plasmid) and proteins, different separation methods.

Analysis of RNA, DNA and proteins by one and two dimensional gel electrophoresis, isoelectric focusing gels.

Molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems. Expression of recombinant proteins using bacterial, animal and plant vectors. Isolation of specific nucleic acid sequences

Generation of genomic and cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors. In vitro mutagenesis and deletion techniques, gene knock out in bacterial and eukaryotic organisms. Protein sequencing methods, detection of post translation modification of proteins. DNA sequencing methods, strategies for genome sequencing.

Methods for analysis of gene expression at RNA and protein level, large scale expression, such as micro array based techniques

Isolation, separation and analysis of carbohydrate, protein and lipid molecules RFLP, RAPD and AFLP techniques

B. **Histochemical and immunotechniques**

Antibody generation, detection of molecules using ELISA, RIA, western blot, Immune-precipitation, fluocytometry and immune-fluorescence microscopy, detection of molecules in living cells, in situ localization by techniques such as FISH and GISH.

C **Biophysical method:**

Molecular analysis using UV/visible, fluorescence, circular dichroism, NMR and ESR spectroscopy Molecular structure determination using X-ray diffraction and NMR,

Molecular analysis using light scattering, different types of mass spectrometry and surface plasma resonance methods.

D **Statistical methods:**

Measures of central tendency and dispersal; probability distributions (Binomial, poisson and normal); sampling distribution; difference between parametric and non-parametric statistics; confidence interval; errors; levels of significance; regression and correlation; t-test; analysis of variance; $X^2$ test; basic introduction to muetrovariate statistics.

E. **Microscopic techniques:**

Visulization of cells and subcellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells, scanning and transmission microscopes, different fixation and staining techniques for EM, freeze-etch and freeze-fracture methods for EM, image processing methods in microscopy.

F. **Methods in field biology:**

Methods of estimating population density of animals and plants, ranging patterns through direct, indirect and remote observations, sampling methods in the study of behavior, habitat characterization: ground and remote sensing methods.