NEP Syllabus: 4 years: Department of Zoology: RKMV

ZOOLOGY Major:

1st semester:

1ZOOCOC1: Taxonomy, Evolution and Adaptation (75 marks) (3+1 credits)

1. Taxonomy – Levels of taxonomy (alpha, beta and gamma taxonomy, micro and macro taxonomy),
1. scope of taxonomy.
2. Systematics – Place of Systematics in Biology, contribution of Systematics in Biology.
3. Classification (Phenetic and Cladistics); Concept of dendogram and cladogram.
4. Character state transitions, Manhattan and Euclidean distance in taxonomy.
5. Biological Species concept, Subspecies, Polytypic species, Sibling species and Ring species.
6. Type concept – names of primary and secondary types, their definitions and applications.
7. RNA world & Origin of life (Chemical origin only).
8. Types of biodiversity, biodiversity and human welfare, mega diversity zones and biodiversity hot
9. spots with special reference to India.
10. Modes of speciation – Sympatric, Allopatric and Parapatric; Isolation and its role in speciation (pre mating and post mating).
11. Natural selection, Synthetic theory. Concept of selection: stabilizing, directional and disruptive with example. Genetic drift, founder effect and population bottleneck.
12. Punctuated equilibrium (Eldredge and Gould Theory), phyletic gradualism, Molecular clock, molecular phylogeny, neutral theory.
13. Evolution in bird, man, horse.
14. Geological timescale and paleontology.
15. Bathymetric and discontinuous distribution; Barriers and dispersals - types and their impact on animal distribution.
16. Zoogeographical realms – names & animal distribution according to Wallace scheme, Avian and Mammalian faunal distribution in different realms.
17. Adaptive radiation (with special reference to Darwin's finches and marsupials).

1ZOOCOC1: Laboratory Course (25 marks)

1. Preparation of Taxonomic Keys for animals (using ant, spider and fish);
2. Study of animals from museum specimens to analyze adaptive features for cursorial (Horse, cheetah, ostrich, kangaroo), aquatic (Rohu, Whale, duck), desert (Camel, Horned toad), volant (Columba, Bat, Draco, Rhacophorus, Exocoetus) and deep-sea adaptations (Anglerfish, Ipnops, Chimaera)
3. Phylogenetic tree construction and analysis (distance and character based).
4. Visit to Indian museum
5. Lab Note Book and Viva voce

1ZOOSEC1: Biology of Insects (Full marks 75) (2+1 credits)

1. Basis of insect classification; Classification of insects up to orders (Ruppert and Barnes, 1994)
2. External Features; Head – Eyes, Types of antennae, Mouth parts with respect to feeding habits Thorax: Wings, wing articulation and mechanism of flight, Types of Legs adapted to diverse habitat Abdominal appendages and genitalia
3. Structure and physiology of Insect body systems- digestive, respiratory, endocrine and nervous system Photoreceptors: Types, Structure and Function, Metamorphosis: Types and Neuroendocrine control of metamorphosis.
4. Social insects with special reference to termites, Trophallaxis in social insects such as ants, termites.
5. Insect communication: chemical, acoustic. Theory of co-evolution, role of allelochemicals in host plant mediation, host plant interaction, Host-plant selection by phytophagous insects, Major insect pests in paddy
6. Aquatic insects and their influence in aquaculture.

1ZOOSEC1P (PRACTICAL)

1. Study of life cycle of Mosquito
2. Study of different kinds of antennae, legs and mouth parts of insects
3. Mounting of insect wings of any insects
4. Methodology of collection, preservation and identification of insects.
5. Morphological studies of various castes of Ant, Termite
6. Study of major insect pests of paddy and their damages
7. Study of Mulberry silk moth as beneficial insect
8. Control of aquatic insects.

1ZOOVAC1: Bioinformatics-1 (Full marks 50) (2 credits)

1. Bioinformatics: basic concept and application in various fields.
2. Concept of databases and example of some important databases: NCBI, Ensembl, Uniprot etc.
3. Concept of sequence homology, Orthologs, Paralogs and Xenologs. Sequence alignment: local vs. global alignment, BLAST, FASTA and CLUSTAL.
4. Finding Orthologous genes using reciprocal BBH method.
5. Concept of network biology: nodes, edges and network connectivity. Using cytoscape to visualize and analyse protein-protein interaction network.

2nd semester:

2ZOOCOC1: Genetics (75 marks)

1. **Mendelian Genetics and its Extension:** Principles of Inheritance; Chromosome theory of inheritance; Laws of Probability; incomplete dominance and co-dominance; Multiple alleles;
2. Lethal alleles; Epistasis; Pleiotropy; Environmental effects on phenotypic expression; sex linked inheritance; Polytene Chromosome & Lampbrush Chromosome.
3. Structure and function of DNA, RNA, nucleosome concept.
4. **Linkage, Crossing Over and Chromosomal Mapping:** Linkage and crossing over, Cytological basis of crossing over, Recombination frequency as a measure of linkage intensity, Interference and coincidence; Somatic cell genetics – an alternative approach to gene mapping.
5. **Mutations:** Chromosomal Mutations: Deletion, Duplication, Inversion, Translocation, Aneuploidy and Polyploidy; Gene mutations: Induced versus Spontaneous mutations, Reverse versus Suppressor mutations, Molecular basis of Mutations in relation to UV light and chemical mutagens, Detection of mutations: CLB method, Balanced lethal, Autosomal mutation detection (curly, lobe), Attached X method.
6. **Chromosomal Aberration**: Types and examples from *Drosophila* and humans only.
7. **Population Genetics**: Brief idea of Hardy-Weinberg equilibrium; calculating allele & genotype frequency, mathematical calculation of frequency changes in mutation, migration.
8. **Cytoplasmic inheritance:** Shell coiling in snail and kappa particle in *Paramoecium*

2ZOOCOC1: Laboratory Course (25 marks)

1. Mendelian laws and gene interaction using *Drosophila* crosses.
2. Gene mapping using marker-based data from *Drosophila*.
3. Study of rat, human Karyotype.
4. Pedigree analysis of some human inherited traits.
5. Preparation of Polytene Chromosome form *Drosophila* larva.

2ZOOSEC1: Apiculture (Full marks 75)

1. Apis and Non-Apis Bee species and their identification. General Morphology of Apis Honey Bees.
2. Social Organization of Bee Colony. Role of pheromone. Bee dance.
3. Bee Pasturage, Selection of Bee Species for Apiculture.
4. Artificial Bee rearing (Apiary), Beehives – Newton and Langstroth box, Modern Bee Keeping
5. Equipments. Methods of Extraction of Honey (Indigenous and Modern).
6. Bee Keeping Industry – Recent Efforts, Modern Methods in employing artificial Beehives for cross
7. pollination in horticultural gardens.
8. Products of Apiculture Industry and its Uses – Honey, Bees Wax, Propolis, Pollen, bee venom etc.
9. Bee Diseases and Enemies, Control and Preventive measures.

2ZOOSEC1P: Laboratory Course

1. Mouthparts, sting apparatus of honey bee (*Apis indica*)
2. Identification and comparative study of worker, drone and queen of *Apis indica, Apis dorsata, Apis*
3. *mellifera*
4. Demonstration of different parts of artificial bee hive (Langstroth box)
5. Visit to Apiary and industrial visit.

2ZOOVAC1 (50 marks)

1. Concept of molecular phylogeny: Using 18S rDNA sequence to construct phylogenetic tree of Mammals.
2. Basic principle and use of DNA bar coding in species identification.
3. Primer designing and validation for Polymerase Chain Reaction: Basic concept and implementation.
4. Visualization of biological macromolecules (protein) by Python Molecule Viewer (PyMol).
5. Molecular docking: Basic concept of molecular docking. Using Autodock for computationally determine protein-ligand interactions.

3rd semester:

3ZOOMJC1: Classification; structure-function relationship in different non-chordates (75 marks) (3+1 credits)

1. **Origin of life**: Unicellularity to multicellularity and further advancement of body plan. Understanding life forms; Phylogeny and the tree of life.
2. **Protozoa:** Classification up to Phyla (following the scheme of Levine *et. al.,* 1981); Locomotion - Microfibrils (*Amoeba*), (b) Flagella (*Euglena*), (c) Cilia (*Paramoecium*); Feeding and Nutrition in Protozoa; Reproduction - Conjugation and autogamy (*Paramoecium*)
3. **Porifera**: Classification up to living Subclass (following Ruppert and Barnes, 1994); Structural organisation of *Sycon*; Canal systems in sponges.
4. **Cnidaria**: Classification up to living Subclass (following Ruppert and Barnes, 1994); Polymorphism in Siphonophores and its evolutionary significance; Regeneration and movement in *Hydra*; Reproduction – Metagenesis (*Obelia*); Coral reefs – Types, distribution in India.
5. **Ctenophora**: Classification up to living Subclass (following Ruppert and Barnes, 1994);
6. **Platyhelminthes**: Classification up to living Subclass (following Ruppert and Barnes, 1994);
   Fasciola: life history, parasitic adaptations and evolution of parasitism; Excretion – Flame Cells (*Taenia*).
7. **Nematoda**: Classification up to living Subclass (following Ruppert and Barnes, 1994); *Ascaris*: life history and parasitic adaptations.
8. **Annelida**: Classification up to living Subclass (following Ruppert and Barnes, 1994); Evolutionary significance of metamerism; Closed circulation and Excretion (Nephridia) in earthworm.
9. **Arthropoda**: Classification up to living Subclass (following Ruppert and Barnes, 1994); Feeding & Digestion-Macrophagy (*Periplaneta*); Respiration-respiratory pigments (Haemoglobin & Haemocyanin); gills, traechea and book lung (prawn, cockroach, spider); Open Circulation in Cockroach; Excretion - Malpighian tubules (cockroach), green gland (prawn); Sexual Reproduction (cockroach); moulting, locomotion and metamorphosis in insects.
10. **Mollusca**: Classification up to living Subclass (following Ruppert and Barnes, 1994); Torsion and detorsion in gastropods; Respiration - Ctenidium & pulmonary sac (*Pila*); Neural Integration in Mollusca.
11. **Echinodermata**: Classification up to living Subclass (following Ruppert and Barnes, 1994); Water vascular system in *Asterias*, Echinoderm larval forms.

Suggested readings:

1. Campbell, N.A. and Reece, J. B. (2008) Biology 8th Ed. Pearson Benjamin Cummings, San
2. Francisco. Raven, P.H et al (2006) Biology 7th edition Tata McGrawHill Publications, New Delhi.
3. Griffiths, A.J.F et al (2008) Introduction to Genetic Analysis, 9th edition, W.H. Freeman & Co.NY.

4. Barnes, R.D. Invertebrate Zoology (1982) 4th Edition. Holt Saunders International Edition
5. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. & J.I., Spicer (2002) The Invertebrates: A New Synthesis. 3rd Edition. Blackwell Science.
6. Barrington, E.J.W. (1979) Invertebrate Structure and Functions. 2nd Ed. E.L.B.S. and Nelson.
7. Boradale, L.A. and Potts, E.A. (1961) Invertebrates: A Manual for the use of Students. Asia Publishing Home.
8. Bushbaum, R. (1964) Animals without Backbones. University of Chicago Press.

Laboratory Course: Dissection and identification of Non-chordates (Full marks 25)

1. **Study of internal organ systems** of *Periplaneta* (mouth parts, general nervous system, digestive system, reproductive systems)
2. **Identification of Non Chordate Specimens with systematic position up to Genus** (two), *Plasmodium vivax, Paramoecium, Scypha*, *Obelia,* Sea-anaemone, *Aphrodite, Nereis, Heteronereis, Sabella, Serpula, Chaetopterus, Pheretima, Ascaris, Hirudo,* Scorpion, *Limulus, Palamnaeus, Palaemon, Daphnia, Balanus, Sacculina*, *Lamellidens, Achatina, Loligo, Chiton, Dentalium,* Starfish, *Cucumaria, Antedon*
3. **Identification of the Larval Forms:** (one) *Ephyra, Nauplius, Zoea, Mysis, Megalopa, Glochidium, Trochophore, Veliger, Bipinnaria*
4. **Lab Note Book** and **Viva voce**

3ZOOMJC2: Ultrastructure of a cell (75 marks) (3+1 credits)

1. **Tools and techniques of studying cell microscopy**-Principles of Light microscopy; Phase contrast microscopy; Fluorescence microscopy, Confocal microscopy; Electron microscopy (EM)- scanning EM and scanning transmission EM. **Analytical** - Flow cytometry- fluorochromes, fluorescent probe and working principle. **Separation** - Sub-cellular fractionation- differential and density gradient centrifugation.
2. **Composition of Cells:** Cell wall, Molecules of cell, cell membranes and cell Proteins: Fluid mosaic model, freeze fracture technique)
3. **The Nucleus:** Nuclear Envelope - structure of nuclear pore complex, nuclear lamina; Transport across Nuclear Envelope; Chromatin: molecular organization, Nucleolus and rRNA processing.
4. **Protein Sorting and Transport:** The Endoplasmic reticulum; The Golgi Apparatus; Mechanism of Vesicular Transport; Lysosomes.
5. **Mitochondria, Chloroplasts and Peroxisomes:** Structural organization, Function, Marker enzymes, Mitochondrial biogenesis; Protein import in mitochondria; Semiautonomous nature of mitochondria and chloroplast; Chloroplast DNA; Peroxisomes' assembly.
6. **Cytoskeleton and Cell Movement:** Extracellular Matrix; Structure and organization of actin filaments; actin, myosin and cell movement; intermediate filaments; microtubules.
7. **Cell Cycle and its regulation:** Concept of cell cycle check points and molecular regulation, concept of normal & transformed cells, role of proto-oncogene, tumour suppressor genes, Molecular mechanism of proto-oncogene activation.

8. **Cell Signalling:** Signalling molecules and their receptor (GPCR, RTK, JAK-STAT, TGF-β, Notch) functions of cell surface receptors; Intracellular signal transduction pathways.
9. **Cell Death:** Brief outline of apoptosis, necrosis, autophagy, pyroptosis and ferroptosis; apoptotic signalling pathways (extrinsic, intrinsic and granzyme) and significance.

Suggested readings:

1. Bruce Alberts, 7th edition, 2022. Molecular Biology of Cell.
2. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons.Inc.
3. De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.
4. Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
5. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009. The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.

Laboratory Course: Methods in Cell Biology (Full marks 25)

1. Demonstration and description of compound microscope; Measurement of size (length/breath) by occular and stage micrometry.
2. Preparation of single cell suspension from spleen and cell viability study by Trypan Blue Exclusion method
3. Study of meiotic stages from Grasshopper
4. Isolation of Bone Marrow Cells and preparation of metaphase chromosome from Rat/Mouse by Giemsa Staining.
5. Lab Note Book and Viva voce

3ZOOSEC1: Fishery Science (Full marks: 50 marks) (2+1 credits)

1. Relevance and scope; Recognition of culturable fishes.
2. Role of water quality in aquaculture; Fishing crafts and gears; Extensive, semi-intensive and intensive culture of fish, Pen and cage culture, Polyculture, Composite fish culture, induced breeding, Interaction of hatchery and wild fish, Preservation and processing of harvested fish. Innovative aquaculture practices; Fishery by-products.
3. Ecological zonations, characteristics and biodiversity of freshwater, estuarine and marine ecosystems, Exclusive Economic Zone – potentials and exploitation, Remote sensing and GIS for fish stock analysis.
4. Fish Nutrition, Stages of nutrient acquisition, Feed formulation, processing, storage and application, Estimation of fish growth.
5. Fish diseases: bacterial, viral and parasitic, Factors of fish health and integrated health management, Cells and tissues of the immune system of fish.
6. Aquarium fish keeping - potential scope as cottage industry, Exotic and endemic species of aquarium fishes. Common characters and sexual dimorphism of Guppy, Molly, Gold

fish, Angel and Butterfly fish, Food and feeding of aquarium fishes, Use of live fish feed organisms, Aquarium maintenance.

7. Elementary ideas of advancements in technology for shell fish culture, Technology of stock improvement - cryopreservation, hybridization, polyploidy, Transgenesis, xenogenesis, sex reversal and breeding.
8. Zebra fish as a model organism in research, Environmental risk of aquatic organisms for genetic biotechnology, Genetic conservation, gene banking and maintaining genetic quality of fishes.
9. Causes of aquatic pollution: Agricultural, Industrial, Sewage, Thermal and Oil spills, Eutrophication, Management and conservation, Legislations, Sewage treatment, Water quality assessment - BOD and COD.

Laboratory Course Details: 25 marks

1. Identification of culturable shell and fin fishes, prawns, major carps, exotic carps and some ornamental fishes ***Shellfish:*** *Macrobrachium rosenbergii, Penaeus monodon, Lamellidens, Loligo, Octopus* ***Finfish:*** *Scoliodon, Hippocampus, Heteropneustes, Clarias, Anabas, Lates, Labeo rohita, Catla catla, Cirrhinus mrigala, Labeo bata, Hypophthalmicthyes molitrix, Ctenopharyngodon idella, Cyprinus carpio, Exocoetus, Tenulosa ilisha,*
2. Study of different types of scales (through permanent slides/ photographs).
3. Study of crafts and gears used in fisheries (Photoghaphs)
4. Study of air breathing organs in *Heteropneustes, Anabas* and *Clarias*.
5. Project Report on a visit to any fish farm/pisciculture unit.
6. Lab Note Book and Viva voce

Suggested Readings:

1. Bone Q and R Moore, Biology of Fishes, Talyor and Francis Group, CRC Press, U.K.
2. Chaudhuri. S, 2017: Economic Zoology, NCBS.
3. Evans D. H. and J. D. Claiborne, The Physiology of Fishes, Taylor and Francis Group, CRC Press, U.K.
4. Khanna S.S. and H.R. Singh, A text book of Fish Biology and Fisheries, Narendra Publishing House.
5. Nelson JS. 2006. Fishes of the World, 4th Edn. Wiley.
6. Srivastava, C.B.L. Fish Biology, Narendra Publishing House.
7. von der Emde, R.J. Mogdans and B.G. Kapoor. The Senses of Fish: Adaptations for the Reception of Natural Stimuli, Springer, Netherlands.
8. Fish and fisheries of India by Jhingran, V.G.

4th semester:

4ZOOMJC1: Classification; structure-function relationship in different chordates (75 marks)

1. Introduction & Origin of chordates; Basic concept of chordate classification; Protochordate -General features and Phylogeny of Hemichordates, Urochordates and Cephalochordates; Agnatha- General features of living Agnathans and classification upto classes.
2. Classification up to living Subclass of Fish; up to living Order of Amphibia, Reptilia and Aves; up to Infra-class of Mammals (following the scheme of J. Z. Young, 1981).
3. Structure of pharynx and feeding mechanism in *Branchiostoma* sp.
4. Metamorphosis in *Ascidia* - justification in the light of survival of the species.
5. Accessory respiratory structure in teleosts (*Anabas, Heteropneustes, Clarias, Channa*); swim bladder in fish.
6. Receptor Biology: lateral line sense organ in fish
7. Paedomorphosis with special reference to Axolotl larva.
8. Non-poisonous and poisonous snakes; Poison apparatus and biting mechanism of poisonous snake.
9. Distinguishing features of Ratites and Carinates; Feather of Birds – its type and structure,
10. Exoskeletal structure in Mammals – hair, horns and antlers
11. Functional anatomy of ruminant stomach in cow.
12. Echolocation in Bat, Dolphin

Laboratory Course (Full marks 25)

1. **Study of internal organ systems of a chordate specimens:** *Tilapia*- digestive & urinogenital systems, brain & pituitary, *Rohu*- Weberian ossicle
2. **Identification of Chordate Specimens with systematic position upto Genus** (one) *Branchiostoma, Petromyzon, Labeo, Anabas*, *Exocoetus*, *Scolidon, Rhacophorous, Ichthyophis, Necturus, Varanus, Draco,* Axolotl larva, *Tylototriton, Hemidactylus, Naja,* Chiroptera.
3. **Lab Note Book & Viva-voce**

Suggested readings:

1. Kardong, K.V. (2005) Vertebrates Comparative Anatomy, Function and evolution. 4th Edition. McGraw-Hill Higher Education.
2. Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. 9th Edition. The McGraw-Hill Companies.
3. Young, J.Z. (2004). The life of vertebrates. 3rd Edition. Oxford university press.
4. Hall B.K. and Hallgrimsson B. (2008).
5. Strickberger's Evolution. 4th Edition.
6. Jones and Bartlett Publishers,Inc.

4ZOOMJC2: Principles of Ecology & Environmental Biology, Wildlife Biology (75 marks)

1. **Ecology, Ecosystem, Biome, Biosphere and Ecosphere:** Definition, types and examples of ecosystems; Abiotic Factors: Laws of limiting factors- Liebig's law of minimum and Shelford's law of tolerance; a brief account of light and temperature as limiting factors; Energy flow through an ecosystem- food chains, food web, trophic levels, grazing and detritus type of food chains, Y- shaped food chain in forest; one example of food web- Terrestrial or Aquatic; Nutrient cycle.
2. **Population & its Growth:** Unitary and modular populations, its unique and group attributes -population density, natality, mortality, life tables, fecundity tables, survivorship curves, age ratio, sex ratio. Population dispersal and distribution; Exponential/Malthusian and Sigmoid growth patterns, Verhulst-Pearl growth equation, 'r' and 'k' strategies; Animal's space and resource use; Resource partitioning; Coupled oscillations of predator and prey population – modelling. Intrinsic mechanism- Density dependant fluctuations and oscillations; Extrinsic mechanism- Density independent, environmental and climatic factors; Population interactions- types in a tabular form with examples; Niche concept, Gause's principle of competitive exclusion with laboratory and field examples, Lotka Volterra Equation for prey predator interaction.
3. **Community Structure & Function:** Characteristics of community diversity, diversity index, types of biodiversity species richness, abundance, species area relationship, community stratification, ecotone/edge effect; Succession, stages of primary succession, climax community, brief idea on El nino, La nina and their consequences.
4. **Types of biodiversity**, biodiversity and human welfare, mega diversity zones and biodiversity hot spots with special reference to India
5. **Major environmental issues**; Global warming, Acid rain, Photochemical smog, Eutrophication, Bioremediation, carbon printing and carbon budgeting. Basic idea of Ecotoxicology and Xenobiotics; Environmental audit and impact assessment
6. **Concept of wildlife**, wildlife heritage of India, reasons for wildlife depletion in Indian context; Concept of threatened fauna – IUCN categories. Protected area concept – Sanctuary, National Park, Biosphere reserve, Core Zone, Buffer Zone, Corridor concept; Conservation reserves; Principles of GPS. Scheduled I of wild life protection Act, 1972 and importance of schedules in conservation. JFM & Arabari model for conservation – key stone, flagship and umbrella species; Special management program with special reference to Tiger project. Man–animal conflict (man- tiger and man-elephant) – causes and concern.

4ZOOMJC2: Laboratory Course (Full marks 25)

1. Determination dissolved oxygen & carbon dioxide in a water sample
2. Principles of GPS
3. Study of the life table and fecundity table, plotting of the three types of survivorship curves from the hypothetical data.
4. Use of pH meter for estimation of pH in water and soil samples
5. Identification of soil arthropods & Zooplanktons
6. Productivity estimation.

7. Lab Note Book, Field Note Book & Viva-voce

Suggested readings:

1. Colinvaux, P. A. (1993). Ecology. II Edition. Wiley, John and Sons, Inc.
2. Krebs, C. J. (2001). Ecology. VI Edition. Benjamin Cummings.
3. Odum, E.P., (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole.
4. Ricklefs, R.E., (2000). Ecology. V Edition. Chiron Press.
5. Joseph, B., Environmental studies, Tata Mc Graw Hill.
6. Mohapatra Textbook of Environmental Biotechnology IK publication.
7. Thakur, I. S., Environmental Biotechnology, I K Publication.
8. Divan Rosencraz, Environmental laws and policies in India, Oxford Publication.
9. Michael Allabay, Basics of environmental science, Routledge Press.
10. Rana SVS, Environmenta lpollution – Health and Toxicology, Narosa Publication.
11. Miller, G.T. 2002. Sustaining the earth, an integrated approach. (5th edition) Books/Cole, ThompsonLearning, Inc.
12. Chapman, J.L., Reiss, M.J. 1999. Ecology: Principles and applications (2nd edition) Cambridge UniversityPress.
13. Ghosh, S.K., Singh, R. 2003. Social forestry and Forest Management. Global Vision Pub

4ZOOMJC3: Molecular Biology-1 (Full marks 50)

1. **Properties of DNA:** Chargaff's rule, Re-naturation and De-naturation, Hyper-chromic shift, c-value paradox.
2. **DNA Replication: In prokaryotes:** Semi-conservative replication; unit of replication; enzymes involved, replication origin, replication fork, replication slippage; **Transcription in prokaryotes**: Transcription factors: Transcription activators, Repressors, Motifs (only Basic helix loop helix [BHLH], Leucine zipper – definition and example). Formation of initiation complex (in Prokaryotes), RNA polymerase, chain elongation and termination.
3. **RNA processing**: Polyadenylation, methyl capping, splicing and transport.
4. **Protein synthesis in prokaryotes**: Formation of initiation complex, initiation factors, elongation and elongation factors, termination.
8. **Regulation of gene expression**: Operon concept (inducible and repressible viz. Lac and Tryptophan operon).
9. **Epigenetic regulation of gene expression**: DNA methylation (CpG) and histone acetylation.Genomic imprinting, Human Disease, molecular techniques to detect epigenetic modifications (ChIP, COBRA)**.**
10. **Recombination**: Homologous recombination, Holliday Model of recombination, definition and example of site specific and transpositional recombination; Gene conversion.
11. **DNA repair mechanism**: Base and nucleotide excision repair in bacteria, Mismatch repair, SOS repair.
12. **Transposable Genetic Element**: Concept of transposon and retrotransposon, Characteristic features of IS element in bacteria, SINE and LINE element in mammals and their role in chromosomal aberration.
13. **Cancer genetics**: Concept of normal and transformed cell; role of proto-oncogene, tumour suppressor genes, Molecular mechanism of proto-oncogene activation.
14. **Molecular basis and detection technique for human genetic disorders**: Sickle cell Anemia, Thalassemia, Hemophilia.

L4ZOOMJC3: Laboratory Course (Full marks 25)

1. Protein isolation & estimation by Bradford/Lowry's method
2. Gel electrophoresis (SDS & Native PAGE); Western Blot Technique
3. HPLC: Demonstration
4. Laboratory notebook and viva voce

Suggested readings:

1. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Ed. John Wiley & Sons.Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th Ed. Lippincott Williams and Wilkins, Philadelphia.
3. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009. The World of the Cell.7th edition. Pearson Benjamin Cummings Publishing, San Francisco.
4. Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R., 2008 Molecular Biology of the Gene 8th edition. Cold Spring Harbour Lab. Press, Pearson Pub.

4ZOOMJC4: Biochemistry (Full Marks - 50)

1. **Carbohydrates:** Structures and properties of important mono-, di- and polysaccharides.

2. **Lipids:** Structures, properties and functional significance of fatty acids, triglycerides and steroids.
3. **Amino acids and Proteins:** Structure and general properties of amino acids, four levels of structures in proteins; metabolism of amino acids; transamination and oxidative and non-oxidative deamination; Nucleic acid metabolism – Purine salvage pathway.
4. **Carbohydrate Metabolism:** Glycolysis, Fermentation, Citric acid cycle, pentose phosphate pathway, Gluconeogenesis, Shuttle systems (Malate-aspartate shuttle, Glycerol 3-phosphate shuttle, and Cori cycle), Glycogen metabolism.
5. **Lipid Metabolism:** Biosynthesis and β-oxidation of saturated (Palmitic acid) & unsaturated (Linoleic acid) fatty acids, Ketogenesis, Types and properties of lipoproteins.
6. **Protein Metabolism:** Catabolism of amino acids: Transamination, Deamination and Urea cycle, Fate of glucogenic and ketogenic amino acids with examples of serine and leucine respectively.
7. **Intermediary Metabolism:** Inter-relationship of carbohydrates, lipid and protein metabolism.
8. **Enzymes:** Introduction, kinetics, mechanism of action, inhibition, allosteric enzymes.
9. **Oxidative Phosphorylation:** Oxidative phosphorylation in mitochondria, Respiratory chain, ATP synthase, Inhibitors and Uncouplers.
10. **Spectrophotometry and separation;** Mass spectrometry; NMR, X-ray diffraction analysis; Chromatography paper, thin-layer, gel-filtration, ion-exchange, affinity and High-Performance Liquid Chromatography (HPLC).

Laboratory Course (Full marks 25)

1. Enzymology:

a) Study of the action of salivary amylase at optimum condition.
b) Effect of pH on the action of salivary amylase.
c) Effect of temperature on the action of salivary amylase.

2. Biochemistry:

Qualitative tests for Carbohydrate (Starch, Sucrose, Maltose Fructose, Glucose), Protein (Albumin, Gelatin, Peptone), fat, uric acid (in Alkaline solution) and urea (Tests to be performed – Red Litmus Test, Hypobromite test, Biuret test, Millon's test, Iodine test, Benedict's test, Barfoed test, Seliwanof's test); Quantitative Techniques - Colorimetric estimation of total protein in the given solution.

4. **Lab note Book & Viva voce**

Suggested readings:

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006). Biochemistry. 6th Ed. W.H Freeman and Co.
2. Nelson, D. L., Cox, M. M. and Lehninger, A.L. (2009). Principles of Biochemistry. 4th Ed. W.H Freeman and Co.
3. Murray, R. K., Granner, D. K., Mayes, P. A. and Rodwell, V. W. (2009). Harper's Illustrated Biochemistry. 28th Ed. Lange Medical Books/McGraw-Hill.

5th semester:

5ZOOMJC1: Developmental biology (Full marks 75)

1. **Introduction**: History, Principles of development, developmental patterns; Role of genes in development. Major signalling pathways during early development (Notch, Hedgehog, Wnt); Developmental plasticity and polyphenism; Experimental embryology; Amniocentesis.
2. **Early Embryonic Development**: Gametogenesis- Spermatogenesis and oogenesis; Types of eggs: Fertilization- changes in gametes, mono- and polyspermy; The early development of C elegans; The early development of Xenopous- cleavage, Gastrulation, Embryonic induction and organizers; The early development of chick-cleavage; Gastrulation.
3. **Later Embryonic Development**: Differentiation of germ layers- Formation of neural tube (development of CNS and eye); Fate Map; Extra embryonic membranes in birds and human; **Implantation** of embryo; **Placentation** - structure, types and physiology of placenta.
4. **Post-Embryonic Development**: Metamorphosis- changes and hormonal regulation of melamorphosis in insects and amphibians, Regeneration - modes of regeneration- epimorphosis; Morphallaxis and compensatory regeneration (with one example), Concept of Ageing and model (*C. elegans*).
5. **Implications of Developmental Blology:** Medical implications: Infertility -Diagnosing Infertility, IVF, Teratogenesis - teratogenic agents and effect of teratogens on embryonic development.
6. **Stem Cell:** ES and adult stem cell - characteristic features; definition of potency and niche; markers in human stem cell: potential application of stem cells as regenerative medicine. Molecular markers of human stem cells, including Oct4, Sox2, Nanog, and others; insights into the epigenetic regulation of stemness and lineage commitment.
7. **Sex Determination:** Sex determination in *Drosophila*, man and *C. elegans*. Chromosomal mechanisms, Environmental factors effecting sex determination, Barr bodies, Dosage compensation - *Drosophila*: Hyper activation of ♂*X* by *msl, mle* and *roX* RNA followed by *histone Ac16* acetylation; Human: Inactivation of ♀*X* by *XIST* RNA followed by DNA methylation; *C. elegans.*

5ZOOMJC1: Laboratory course:

1. (a) Chick - Study of developmental stages - primitive streak 24h, 48h, 72h, 96h by raising chick embryo in the laboratory. (b) Fish - Study of developmental stages.
2. Developmental processes in model insects with special emphasis on butterfly and *Drosophila melanogaster*. Techniques for maintaining and managing laboratory stocks for developmental studies.
3. Lab Note Book & Viva-voce.

Suggested readings:

1. Gilbert, S. F. Developmental Biology, 11" Edition, Sinauer Associates, Inc., Publishers. Sunderland, Massachusetts, USA.

2. Balinsky, B.I. (2008). An introduction to Embryology, International Thomson Computer Press.
3. Kalthoff. (2000). Analysis of Biological Development, II Edition, McGraw-Hill Professional.

5ZOOMJC2: Endocrinology and histology

1. **Structure and functions of endocrine glands**: Nature of hormones; Hypothalamus-principal nuclei involved in control of endocrine system, control of anterior pituitary hormones by hypothalamic releasing hormones (neuroendocrine mechanisms); Effects of abnormal secretions of hormones; Placental hormones.
2. **Hormonal Regulation and Integrative Endocrinology:**
    a. Overview of chemical messengers: classification of hormones based on chemical structure and function- kiromones, synomones, info-chemicals, semio-chemicals - their types, mode of action and behavior modulation.
    b. Homeostasis of Ca++ regulation and Blood glucose regulation.
    c. Mechanism of hormone action (cAMP, IP3, DAG, RTKs, Steroid hormones and Thyroxine, JAK STAT): Steroid and non-steroid hormones, hypothalamic regulatory peptides, endocrine tissues of the gastrointestinal endoderm.
    d. Biosynthesis, secretion, mode of action, functional significance and regulation of T3. T4 (including one associated disorder), Adrenalin, Nor-adrenalin (including one associated disorder), Insulin and Glucagon (including one associated disorder),
    e. Environmental signaling in sex reversals in fish and molluscs - role of endocrine disruption and signals.
    f. Endocrine regulation of estrous and menstrual cycle.
    g. Biological light production in animals: A. Chemistry of bioluminescence in insect and its significance. B. Electric organs in electric rays
    h. **Histology:** Basic principles of tissue fixation, preparation, embedding, sectioning and staining. Elementary ideas of stain & dyes and staining different biomolecules. Histology of Pituitary, Liver, Pancreas, Thyroid, Kidney, Ovary, Testes.

5ZOOMJC2: Laboratory course:

1. Histology identification of pancreas, liver, kidney, ovary and testes
2. Microtomy of rat/mice tissue and preparation by HE staining
3. Study of estrus cycle in rat.
4. Laboratory note and viva voce.

Suggested readings:

1. Fox T, Brooks A. Baidya B. (2015). Endocrinology. JP Medical, London.
2. Gardner DC, Shoback D. (20 11). Grecnspan's Basic and Clinical Endocrinology
3. Goodendor man HM. (2000). Basic Medical Endocrinology. Academic Press.
4. Jameson JL. (2010). Harrison's Endocrinology. McGraw Hill

5. Melmed S, Conn PM. (2005). Endocrinology: Basic and Clinical Principles. Humana Press.
6. Mediens, puy Rey K, Larsen PR. Kronerber H, (3016), Willian's Text Book of Endocrinology. Elsevier.
7. Molina PE. (2013). Endocrine Physiology, McGraw Hill Lange.

5ZOOMJC3: Physiology

1. Introduction: Introduction to animal physiology - Elementary ideas of size & scaling.
2. Digestive System: Outlines of structure & functions of gastrointestinal tract; Mechanical and chemical digestion of food; Absorptions of carbohydrates, lipids, proteins, water, minerals and vitamins.
3. Respiratory System: Structure & function of trachea and lung; Pulmonary ventilation; Respiratory volumes and capacities; Structure & function of haemoglobin; Transport of oxygen in the blood (oxygen-haemoglobin dissociation curve and its influencing factors), Carbon monoxide poisoning; Carbon dioxide transport in the blood; Bohr and Haldane effect, Chloride shift.
4. Excretory System: Mechanism and regulation of urine formation; Regulation of acid-base balance; nitrogenous wastes- ammonia, urea, uric acid, creatinine.
5. Heart: An outline structure of heart; Outlines of systemic, pulmonary and coronary circulations: Cardiac cycles; Blood pressure and its regulation; Electrocardiogram, portal circulation, Coagulation of blood.
6. Muscle: Comparative account of different types of muscles; Ultrastructure of skeletal muscle; Molecular and chemical basis of muscle contraction
7. Reproductive System: Structure & physiology of male and female reproductive systems; puberty, pregnancy
8. Physiology of hibernation and aestivation with reference to amphibians. reptilians and gastropods, Thermoregulation & Osmoregulation in vertebrates. [N.B. Brief account of alterations in respective systems in acoelomale, coelomate, exclusively aquatic vertebrate and mammals.]

5ZOOMJC3: Laboratory course work:

1. Enumeration of RBC, WBC, differential count using hemocytometer
2. Estimation of hemoglobin by Drabkin's solution (Cyan Hb method)
3. Recording of blood pressure using sphygmomanometer
4. Laboratory note book and viva voce

Suggested readings:

1. Guyton and Hall Textbook of Medical Physiology, Edition**: 15th Edition (2020), Elsevier**
2. Human Physiology: From Cells to Systems, **Lauralee Sherwood, 10th Edition (2022), Cengage India.**
3. Eckert Animal Physiology: Mechanisms and Adaptations, **Randall, Burggren, French, 5th Edition**

4. **Ganong's Review of Medical Physiology, Edition**: 26th Edition (2019), McGraw-Hill Education India

5ZOOMJC4: Molecular Biology-2

1. **Genetic Material and its Features**: DNA topology and topoisomerase enzyme- linking number, twist number, writhing number. The Central Dogma.
2. **Chromosome**, chromatin and nucleosome: chromosome duplication and segregation, nucleosome, higher order chromatin structure. Organization of DNA in Prokaryotes (nucleoid), Eukaryotes (nucleosome-10 nm model, 30 nm model, scaffold arrangement).
3. **Replication of eukaryotic DNA:** Enzymes and proteins involved in DNA replication. Mechanism ofDNA replication Isolation of ARS of yeast, ORC, Licensing factors & control of eukaryotic DNA replication, role of MCM proteins. Replication of organelle genomes, maintenance of ends of linear DNAs; telomeric DNA and telomerase. inhibitors of DNA replication. Reverse transcription. Replication processes of extrachromosomal DNA (ecDNA) and mitochondrial DNA (mtDNA) in eukaryotic cells.
4. **Transcription in Eukaryotes**: major difference with prokaryotic system, important modifications of eukaryotic RNA: concept of introns and exons, RNA splicing, concept of alternative splicing, Polyadenylation and capping, Processing of rRNA and tRNA.
5. **Translation in Eukaryotes**: Translational machinery, Charging of tRNA, aminoacyl tRNAsynthetases, genetic code and its features, mechanism of initiation, elongation and termination of translation in eukaryotes, Fidelity of translation, Inhibitors of protein synthesis in eukaryote. Translation processes of extrachromosomal DNA (ecDNA) and mitochondrial DNA (mtDNA) in eukaryotic cells.
6. . **Post-Translational Modifications in Eukaryotes:** Mechanisms and functional significance of post-translational modifications (PTMs) in eukaryotic proteins. Types of PTMs (e.g., phosphorylation, acetylation, methylation, ubiquitination, glycosylation) and their roles in protein function, stability, localization, and cellular signaling.
7. **Gene editing**: Introduction to genetics and genetic engineering; RNA interference, limitations of genetic engineering; Genome engineering using Zinc Finger Nuclease (ZFN) Technology; Transcription activator-like effector nuclease (TALEN) Technology; Clustered regularly interspaced short palindromic repeats (CRISPR)/Cas9 technology: target identification, gRNA design, donor design, Disease modeling-Cancer, iPSc and animal models; Engineered immune cells for cancer therapy.
8. **Overview of non-coding RNAs (ncRNAs) in eukaryotes:** their roles in gene regulation, chromatin remodeling, and post-transcriptional control. Types of ncRNAs (e.g., microRNAs, long non-coding RNAs, small interfering RNAs, and ribosomal RNAs) and their involvement in cellular processes such as RNA silencing, splicing, and genomic imprinting.

5ZOOMJC4: Laboratory course work:

1. Isolation of DNA & quantification by Agarose Gel Electrophoresis
2. Multiplication of the isolated DNA by using PCR
3. Separation of amino acids using Paper chromatography
4. Laboratory notebook and viva voce

Suggested readings:

1. Watson JD, Baker TA, Bell SP, Gann A, Levine M and Losick R (2008) Molecular Biology oftheGene, 6th edition,Cold SpringHarbourLab. Press, Pearson Publication
2. Becker WM, Kleinsmith LJ, Hardin J and Bertoni GP (2009) The World of the Cell, 7'hedition, Pearson Benjamin CummingsPublishing, San Francisco
3. Burton E. Tropp Molecular Biology Genes to Proteins, 3"" Edition, Jones and BartlettPublishers
4. RobertF. Weaver,MolecularBiology, FourthEdition,McGraw-Hill InternationalPublishers.
5. De Robertis EDP and De Robertis EMF (2006) Cell and Molecular Biology, 8th edition.Lippincott Williams and Wilkins,Philadelphia
6. Karp G (2010) Cell and Molecular Biology: Concepts and Experiments, 6'h edition, JohnWiley&Sons.Inc.
7. Sambrook J and Russell DW. (2001). Molecular Cloning: A Laboratory Manual. 4h Edition, ColdSpringHarbourLaboratorypress.
8. Krebs J, Goldstein E, Kilpatrick S (2013). Lewin's Essential Genes, 3"' Ed., Jones and BartlettLearning
9. GardnerEJ,SimmonsMJ,Snustad DP(2008). Principlesof Genetics. 8"Ed. Wiley-India