

Part-I

1.
 - (a) The water vascular system is regarded as a unique evolutionary innovation among invertebrates. Critically examine its structural organization and explain how it contributes to locomotion, feeding and survival in different classes of echinoderms.
 - (b) Cell signalling is fundamental to the maintenance of multicellular life. Critically evaluate the role of plasma membrane organization and intracellular signalling pathways in regulating cellular responses.
 - (c) Behaviour is not merely a response to external stimuli but an adaptive trait shaped by evolution. Compare innate and learned behaviour, highlighting the neural mechanisms responsible for learning and memory.
 - (d) A newly discovered amphibian population exhibits delayed metamorphosis, reduced immune competence and poor survival in a polluted habitat. Analyse the possible developmental, immunological and environmental factors responsible for these observations, and suggest suitable approaches to validate your hypothesis.
2. (a) Critically compare Darwinism and Neo-Darwinism in explaining biological evolution. How have modern genetic discoveries modified the original concept of natural selection ?

(b) Explain the molecular basis of oxidative phosphorylation. Discuss how alterations in mitochondrial function influence ATP production and overall metabolic efficiency.

(c) Recombinant DNA technology has transformed modern biological sciences. Discuss the principles of gene cloning and evaluate its applications in medicine and animal biotechnology.

(d) Habitat fragmentation often leads to behavioural modifications before visible changes occur in population size. Critically analyse how ecological factors and behavioural adaptations together influence the long-term survival of animal populations.

3. (a) Explain the significance of cell-cycle checkpoints in maintaining genomic stability. Discuss the consequences of checkpoint failure in relation to apoptosis and uncontrolled cell proliferation.

(b) Compare glycolysis, gluconeogenesis and the pentose phosphate pathway with respect to their physiological significance and metabolic regulation.

(c) Critically discuss the Biological Species Concept. Evaluate its usefulness and limitations in the classification of organisms showing asexual reproduction and hybridization.

✓ The successful colonization of terrestrial habitats by vertebrates required coordinated anatomical and physiological adaptations. Examine how evolutionary modifications in body organization and homeostatic mechanisms facilitated this transition.

4. ✓(a) Explain the molecular mechanism of antigen recognition and discuss the significance of the Major Histocompatibility Complex (MHC) in adaptive immunity.

✓(b) Discuss the process of vertebrate limb development. Evaluate the role of molecular signalling centres in establishing limb pattern and polarity.

✓(c) Explain the principles of chromatography and electrophoresis. Compare their suitability for the separation and characterization of different classes of biomolecules.

✓(d) A newly identified vertebrate species exhibits unique morphological characteristics but shows remarkable genetic similarity with an already described species. Critically evaluate how taxonomy, molecular evidence and evolutionary principles should be integrated before assigning its systematic position.

Part-II

5. (a) Explain the phenomenon of genetic linkage and crossing over. Critically discuss their significance in chromosome mapping and inheritance studies.
- X (b) Ecological succession is a dynamic process rather than a predictable sequence of events. Critically examine the mechanisms governing succession and evaluate the present status of the climax community concept.
- (c) Discuss the physiological mechanisms involved in thermoregulation and osmoregulation in vertebrates. How do these mechanisms contribute to environmental adaptation ?
- X (d) A freshwater fish population inhabiting a river receiving industrial effluents exhibits reduced reproductive success and altered metabolic activity. Analyse the possible biochemical, physiological and ecological mechanisms responsible for these changes, and suggest suitable experimental approaches to verify your explanation.
6. (a) Describe the structure and life cycle of retroviruses. Discuss their role in oncogenesis with suitable examples.
- (b) Explain the process of regeneration in amphibian limbs. Critically examine the cellular and molecular events responsible for successful regeneration.

(c) Discuss the principles of fluorescence microscopy and electron microscopy (SEM and TEM). Compare their applications and limitations in modern biological research.

(d) Developmental processes are ultimately controlled by gene expression. Critically analyse how DNA replication, transcriptional regulation and embryonic induction together ensure normal vertebrate development.

(a) Explain the origin and evolution of mammals. Discuss the major anatomical innovations that distinguish mammals from their reptilian ancestors.

(b) Describe the structure and functions of enzymes. Critically examine the importance of allosteric enzymes, isoenzymes and ribozymes in biological regulation.

(c) Explain the principles of Integrated Pest Management (IPM). Discuss its significance in sustainable agriculture and biodiversity conservation.

(d) Advances in biotechnology have enabled the production of transgenic animals for biomedical applications. Evaluate the scientific principles involved and discuss the ethical, ecological and biosafety concerns associated with their use.

8. (a) Discuss the factors responsible for the geographical distribution of animals. Evaluate the influence of geological history, dispersal and geographical barriers on present-day faunal distribution.
- (b) Explain the hormonal regulation of stress responses in vertebrates. Discuss the role of endocrine coordination in maintaining homeostasis under adverse environmental conditions.
- (c) Discuss the role of mutations in generating genetic variation. Compare spontaneous and induced mutations with respect to their mechanisms and biological significance.
- (d) A newly identified mutation produces abnormal limb development in an experimental vertebrate model. Design a strategy to identify the responsible gene and explain how modern molecular and biotechnological techniques can be used to validate its function.