

UGC Net Life Science Syllabus PDF Download

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UNIT 1. MOLECULES AND THEIR INTERACTION RELEVANT TO BIOLOGY

A. Structure of atoms, molecules, and chemical bonds.

B Composition, structure, and function of biomolecules

- Carbohydrates
- Lipids
- Proteins
- Nucleic acids
- Vitamins

C. Stabilizing interactions

- Van der Waals force
- Electrostatic force
- 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. Principles of catalysis

- Enzymes and enzyme kinetics
- Enzyme regulation
- Mechanism of enzyme catalysis
- Isozymes

G. Conformation of proteins

- Ramachandran plot
- Secondary structure
- Protein Domains
- Protein Motif
- Protein folds

H. Conformation of nucleic acids

- DNA Helix

- A-DNA
- B-DNA
- Z-DNA
- t-RNA
- Micro-RNA

I. Stability of

- Proteins
- Nucleic acids.

J. Metabolism of

- Carbohydrates
- Lipids
- Amino acids
- Nucleotides
- Vitamins.

UNIT 2. CELLULAR ORGANIZATION

A) Membrane structure and function

- Structure of model membrane
- Structure of lipid bilayer
- Membrane protein diffusion
- Osmosis
- Ion channels
- Active transport
- Membrane pumps
- Mechanism of sorting and regulation of intracellular transport
- Electrical properties of membranes

B) Structural organization and function of intracellular organelles

- Cell wall
- Nucleus
- Mitochondria
- Golgi bodies
- Lysosomes
- Endoplasmic reticulum
- Peroxisomes
- Plastids
- Vacuoles
- Chloroplast
- Structure & function of the cytoskeleton

- Role of cytoskeleton in motility
- C) Organization of genes and chromosomes
 - Operon concept
 - Unique and repetitive DNA
 - Interrupted genes
 - Gene families
 - Structure of chromatin and chromosomes
 - Heterochromatin
 - Euchromatin
 - Transposons
- D) Cell division and cell cycle
 - Mitosis and meiosis
 - Their regulation
 - Steps in the cell cycle
 - Regulation and control of the cell cycle
- E) Microbial Physiology
 - Growth yield and characteristics
 - Strategies of cell division
 - Stress response

UNIT 3. FUNDAMENTAL PROCESSES

- A) DNA replication,
 - DNA repair
 - DNA recombination
 - Unit of replication
 - Enzymes involved in replication
 - Replication origin and replication fork,
 - Fidelity of replication
 - Extrachromosomal replicons
 - DNA damage and repair mechanisms
 - Homologous and site-specific recombination
- B) 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
- Polyadenylation
- Structure and function of different types of RNA
- RNA transport

C) 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
- Translational proof-reading
- Translational inhibitors
- Post- Post-translational modification of proteins

D) Control of gene expression at the transcription and translation level

- Regulating the expression of
 - Phage
 - Viruses
 - Prokaryotic genes
 - Eukaryotic genes
- Role of chromatin in gene expression and gene silencing

UNIT 4. CELL COMMUNICATION AND CELL SIGNALING

A) Host-parasite interaction

- Recognition and entry processes of different pathogens like bacteria and viruses into animal and plant host cells
- Alteration of host cell behavior by pathogens
- Virus-induced cell transformation
- Pathogen-induced diseases in animals and plants
- Cell-cell fusion in both normal and abnormal cells.

B) Cell signaling Hormones and their receptors

- Cell surface receptors
- Signaling through G-protein coupled receptors

- Signal transduction pathways
- Second messengers
- Regulation of signaling pathways
- Bacterial and plant two-component systems
- Light signaling in plants
- Bacterial chemotaxis
- Quorum sensing

C) Cellular communication

- Regulation of hematopoiesis
- General principles of cell communication
- Cell adhesion and roles of different adhesion molecules
- Gap junctions
- Extracellular matrix
- Integrins
- Neurotransmission and its regulation.

D) 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 for uncontrolled cell growth.

E) Immunology

- The innate and adaptive immune system
- Cells and molecules involved in innate and adaptive immunity
- Antigens
- Antigenicity
- 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 infections of
- Bacteria (tuberculosis)
- Parasite (malaria)
- Virus (HIV) infections
- Congenital and acquired immunodeficiencies
- Vaccines

UNIT 5. DEVELOPMENTAL BIOLOGY

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
- Embryo sac development and double fertilization in plants
- Zygote formation
- Cleavage
- Blastula formation
- Embryonic fields

- Gastrulation and formation of germ layers in animals
- Embryogenesis
- Establishment of symmetry in plants
- Seed formation and germination.

C) Morphogenesis and organogenesis in animals

- 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
- Regeneration in vertebrates
- Differentiation of neurons
- Post embryonic development
- Larval formation
- Metamorphosis
- Environmental regulation of normal development
- Sex determination

D) Morphogenesis and organogenesis in plants

- Organization of shoot and root apical meristem
- Shoot and root development
- Leaf development and phyllotaxy
- Transition to flowering
- Floral meristems and floral development in *Arabidopsis* and *Antirrhinum*

E) Programmed cell death, aging, and senescence

UNIT 6. SYSTEM PHYSIOLOGY - PLANT

A. Photosynthesis

- Light harvesting complexes
- Mechanisms of electron transport
- Photoprotective mechanisms
- CO₂ fixation-C₃, C₄, and CAM pathways.

B. Respiration and photorespiration

- Citric acid cycle
- Plant mitochondrial electron transport and ATP synthesis
- Alternate oxidase
- Photorespiratory pathway.

C. Nitrogen metabolism

- Nitrate and ammonium assimilation
- Amino acid biosynthesis.

D. Plant hormones

- Biosynthesis
- Storage
- Breakdown
- Transport
- Physiological effects
- Mechanisms of action.

E. Sensory photobiology

- Structure, function, and mechanisms of action of
 - Phytochromes
 - Cryptochromes
 - Phototropins
- Stomatal movement
- Photoperiodism
- Biological clocks.

F. Solute transport and photoassimilate translocation – uptake, transport and translocation of water, ions, solutes, and macromolecules from soil, through cells, across membranes, through the xylem and phloem

- Transpiration
- Mechanisms of loading and unloading of photoassimilates.

G. Secondary metabolites

- Biosynthesis of terpenes, phenols, and nitrogenous compounds and their roles.

H. Stress physiology

- Responses of plants to biotic stress (pathogen and insects)
- Abiotic stress (water, temperature, and salt)
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UNIT 7. SYSTEM PHYSIOLOGY - ANIMAL

A. Blood and circulation

- Blood corpuscles
- Hemopoiesis
- Formed elements
- Plasma function
- Blood volume
- Blood volume regulation
- Blood groups
- Hemoglobin
- Immunity
- Hemostasis.

B. Cardiovascular System

- Comparative anatomy of heart structure
- Myogenic heart
- Specialized tissue
- ECG – its principle and significance
- Cardiac cycle
- Heart as a pump
- Blood pressure
- Neural and chemical regulation of all the above.

C. Respiratory system

- Comparison of respiration in different species
- Anatomical considerations
- Transport of gases
- Exchange of gases
- Waste elimination
- Neural and chemical regulation of respiration.

D. Nervous system

- Neurons
- Action potential
- Gross neuroanatomy of the brain and spinal cord
- Central and peripheral nervous system
- Neural control of muscle tone and posture.

E. Sense organs

- Vision, hearing, and tactile response.

F. Excretory system

- Comparative physiology of excretion
- Kidney
- Urine formation
- Urine concentration
- Waste elimination
- Micturition
- Regulation of
- Water balance
- Blood volume
- Blood pressure
- Electrolyte balance
- Acid-base balance

G. Thermoregulation

- Comfort zone
- Body temperature – physical, chemical, neural regulation, acclimatization.

H. Stress and adaptation

I. Digestive system

- Digestion
- Absorption
- Energy balance
- BMR.

J. Endocrinology and reproduction

- Endocrine glands
- Basic mechanism of hormone action
- Hormones, and diseases
- Reproductive processes
- Gametogenesis
- Ovulation
- Neuroendocrine regulation

UNIT 8. INHERITANCE BIOLOGY

A) Mendelian principles

- Dominance, segregation, independent assortment.

B) Concept of gene

- Allele
- Multiple alleles
- Pseudo allele
- 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
- Development of mapping population in plants.

E) Extra chromosomal inheritance

Inheritance of Mitochondrial and chloroplast genes

Maternal inheritance.

F) Microbial genetics

- Methods of genetic transfers
 - Transformation
 - Conjugation
 - Transduction
 - Sexduction
- 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 versus somatic mutants
- Insertional mutagenesis.

J) Structural and numerical alterations of chromosomes

- Deletion
- Duplication
- Inversion
- Translocation
- Ploidy, and their genetic implications.

K) Recombination

- Homologous recombination
- Non-homologous recombination including transposition.

UNIT 9. DIVERSITY OF LIFE FORMS:

A. Principles & methods of taxonomy

- Concepts of species and hierarchical taxa
- Biological nomenclature
- Classical & quantitative methods of taxonomy of plants, animals, and microorganisms.

B. Levels of structural organization

- Unicellular, colonial and multicellular forms.
- Levels of organization of tissues, organs & systems.
- Comparative anatomy
- Adaptive radiation
- Adaptive modifications.

C. Outline classification of plants, animals & microorganisms:

- Important criteria used for classification in each taxon.
- Classification of plants, animals, and microorganisms.
- Evolutionary relationships among taxa.

D. Natural history of the Indian subcontinent:

- Major habitat types of the subcontinent
- Geographic origins
- Migrations of species.
- Common Indian mammals, birds.
- Seasonality and phenology of the subcontinent.

E. Organisms of health & agricultural importance

- Common parasites and pathogens of humans, domestic animals, and crops.

F. Organisms of conservation concern:

- Rare, endangered species.
- Conservation strategies.

UNIT 10. ECOLOGICAL PRINCIPLES

The Environment

- Physical environment
- Biotic environment;
- Biotic and abiotic 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,
- Interspecific competition
- Herbivory
- Carnivory
- Pollination
- Symbiosis.

Community Ecology

- Nature of communities
- Community structure and attributes
- Levels of species diversity and its measurement
- Edges and ecotones

Ecological Succession

- Types of Ecological Succession
- Mechanisms of Ecological Succession
- Changes involved in succession
- Concept of climax.

Ecosystem Ecology

- Ecosystem structure
- Ecosystem function
- Energy flow
- Mineral cycling (Carbon cycle, Nitrogen cycle, Phosphorus, Oxygen cycle, Sulfur cycle)
- Primary production and decomposition
- Structure and function of some Indian ecosystems
- Terrestrial (forest, grassland) and aquatic (freshwater, marine, estuarine).
- Biogeography
- Major terrestrial biomes
- Theory of island biogeography
- Biogeographical zones of India.

Applied Ecology

- Environmental pollution
- 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
- Indian case studies on conservation/management strategy
- (Project Tiger, Biosphere reserves).

UNIT 11. EVOLUTION AND BEHAVIOUR

A. Emergence of evolutionary thoughts

- Lamarck
- Darwin—concepts of variation, adaptation, struggle, fitness & natural selection
- Mendelism; Spontaneity of mutations
- The evolutionary synthesis.

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
- 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 plants and animals
- Stages in primate evolution including Homo.

D. Molecular Evolution:

- Concepts of neutral evolution
- Molecular divergence
- 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 the 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
- Social communication
- Social dominance
- Use of space and territoriality
- Mating systems
- Parental investment and Reproductive success
- Parental care
- Aggressive behavior

- Habitat selection and optimality in foraging
- Migration, orientation, and navigation
- Domestication and behavioral changes

UNIT 12. APPLIED BIOLOGY

- A. Microbial fermentation and production of small and macromolecules.
- B. Application of immunological principles, vaccines, and diagnostics.
Tissue and cell culture methods for plants and animals.
- C. Transgenic animals and plants, molecular approaches to diagnosis and strain identification.
- D. Genomics and its application to health and agriculture, including gene therapy.
- E. Bioresource and uses of biodiversity.
- F. Breeding in plants and animals, including marker-assisted selection
- G. Bioremediation and phytoremediation
- H. Biosensors

UNIT 13. METHODS IN BIOLOGY

- A. Molecular Biology and Recombinant DNA methods:
 - Isolation and purification of
 - RNA
 - DNA (genomic and plasmid)
 - 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 knockout 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 microarray-based techniques
- Isolation, separation, and analysis of carbohydrate and lipid molecules
- RFLP, RAPD, and AFLP techniques

B. Histochemical and Immunotechniques

- Antibody generation
- Detection of molecules using ELISA, RIA, western blot, immunoprecipitation, flowcytometry, and immunofluorescence 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
- X² test;
- Basic introduction to Multivariate statistics, etc.

E. Radiolabeling techniques:

- Detection and measurement of different types of radioisotopes normally used in Biology
- Incorporation of radioisotopes in biological tissues and cells,
- Molecular imaging of radioactive material
- Safety guidelines.

F. Microscopic techniques:

- Visualization 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.

G. Electrophysiological methods:

- Single neuron recording
- Patch-clamp recording
- ECG
- Brain activity recording,
- Lesion and stimulation of brain
- Pharmacological testing
- PET, MRI, fMRI, CAT

H. 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.