Second Edition

Objective **Biotechnology**

for Competitive Examinations

is the thoroughly revised, updated, and enlarged edition of the book. This book has its origin in the analysis of the questions being asked in the examinations conducted by ASRB for ARS, ICAR-JRF/ SRF/NET, UGC-NET, SAUs/CATET, UPSC, PCS, ICMR, CSIR, NAARM, DBT, NDRI, IARI/IVRI, JNU, BHU, Thsti and various agricultural universities. This book is an attempt to provide necessary guidance to the students of biotechnology in preparing for different competitive examinations. The majority of the questions given in this book have been designed to assess the candidate's understanding of the subject. The book contains more than 7000 scientifically constructed multiple-choice questions. This is an endeavor to present currently relevant questions in a user-friendly systematic manner, which will give the readers an idea about the model questions and help them to be focused. The book will serve as an efficient tool to prepare for various competitive examinations.

Salient features of the book

- A whole lot of objective-type questions with their solutions.
- A new enriched section on data interpretation.
- Questions from recent years' examination papers (compiled on a memory basis) have been incorporated.
- Model papers for different examinations.
- For complete understanding, units have been divided into individual chapters and each chapter is supplemented with a sufficient number of multiple-choice questions
- This is the only book with previous years solved papers

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is Professor and Head, Department of Agricultural Biotechnology, College of Agriculture, and also Director of Training and Placement, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, UP. Dr Sengar has about 30 years of professional experience in different aspects of educational planning, administration, institution building, teaching, and research. He has supervised 14 MSc and 20 PhD students as an advisor and as a co-guide member of 78 PhD and 80 MSc students. He has published more than 214 research papers in India and foreign journals of repute. He has published 1072 popular articles in Hindi and English in important journals and magazines. He has also published 18 books for the scientific community and farmers. He is on the editorial boards and review committees of some prestigious journals.

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is Associate Professor, Department of Agriculture, Swami Vivekanand Subharti University, Meerut. He has 11 years of teaching experience and has published more than 40 research/review papers, 10 Hindi popular articles in national magazines, 10 international and 4 national book chapters, and written 1 international and 3 national books. He received a national fellowship during his PhD, and has qualified for ICAR's All India Examination, ICAR-SRF, and NET (National Eligibility Test) examination. He has received a young biotechnologist award from the Society of Scientific and Social Development and he also received the Young Fellow award from Agricultural Technology Development Society, the Best Scientist Award from the IMRF Society, the Best Teacher Award, and the Young Scientist Associate Award-2021 from SRDA Society.

Dedicated to Education

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Second Edition

Objective **Biotechnology** *for* Competitive Examinations

Sengar
Kumar

CBSPD

Second Edition

Objective **Biotechnology**

for Competitive Examinations

for all the examinations conducted by ASRB for ARS, ICAR-JRF/SRF/NET, UGC-NET, SAUs/CATET, UPSC, PCS, ICMR, CSIR, NAARM, DBT, NDRI, IARI/IVRI, JNU, BHU, Thsti, and various universities

Highlights

1. **More than 7000 Questions with Answers**
2. **Topic-wise MCQs**
3. **Recommended for Use in Self-study of Objective Questions**
4. **Develops Capacity for Problem-solving**

CBSPD *Dedicated to Education*

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RS Sengar

Amit Kumar

Contents

General Information

EXAM SCHEME

TIME: 3 Hours **Max. Marks: 200**

Single paper test having Multiple choice questions (MCQs) is divided in three parts:

Part A

This part shall carry 20 Questions pertaining to general aptitude with emphasis on logical reasoning graphical analysis, analytical and numerical ability, quantitative comparisons, series formation, puzzles, etc. The candidates shall be required to answer any 15 questions. Each question shall be of two marks. The total marks allocated to this section shall be 30 out of 200.

Part B

This part shall contain 50 Multiple choice questions (MCQs) generally covering the topics given in the syllabus. A candidate shall be required to answer any 35 questions. Each question shall be of two marks. The total marks allocated to this section shall be 70 out of 200.

Part C

This part shall contain 75 questions that are designed to test a candidate's knowledge of scientific concepts and/or application of the scientific knowledge to arrive at the solution to the given scientific problem. A candidate shall be required to answer any 25 questions. Each question shall be of four marks. The total marks allocated to this section shall be 100 out of 200.

There will be negative marking @25% for each wrong answer.

To enable to candidates to go through the questions, the question paper booklet shall be distributed 15 minute before the scheduled time of the Exam. The answer sheet (OMR sheet) shall be distributed at the scheduled time of the Exam.

SYLLABUS

Part A

This part shall carry 20 questions pertaining to General aptitude with emphasis on logical reasoning graphical analysis, analytical and numerical ability, quantitative comparisons, series formation, puzzles, etc. The candidates shall be required to answer any 15 questions, each question shall be of two marks. The total marks allocated to this section shall be 30 out of 200.

Common Syllabus for Part B and C

1. Molecules and their Interaction Relevant to Biology
2. Cellular Organization
3. Fundamental Processes
4. Cell Communication and Cell Signalling
5. Developmental Biology
6. System Physiology—Plant
7. System Physiology—Animal
8. Inheritance Biology
9. Diversity of Life Forms
10. Ecological Principles
11. Evolution and Behavior
12. Applied Biology
13. Methods in Biology

CSIR-UGC National Eligibility Test (NET) for Junior Research Fellowship and Lecturership

Type your text

SYLLABUS FOR LIFE SCIENCES PAPER I AND PAPER II

1. Molecules and their Interaction Relevant to Biology

A. Structure of atoms, molecules and chemical bonds.

Type your text

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

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

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, tertiary and quaternary structure; domains; motif and folds).

H. Conformation of nucleic acids (A-, B-, Z-,DNA), tRNA, micro-RNA).

I. Stability of protein and nucleic acid structures.

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

2. Cellular Organization

A. Membrane structure and function: Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, ion 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 cytoskeleton and its role in motility.

C. Organization of genes and chromosomes: Operon, interrupted genes, gene families, structure of chromatin and chromosomes, unique and repetitive DNA, heterochromatin, euchromatin, transposons.

D. Cell division and cell cycle: Mitosis and meiosis, their regulation, steps in cell cycle, and control of cell cycle.

E. Microbial Physiology: Growth, yield and characteristics, strategies of cell division, stress response.

3. Fundamental Process

A. DNA replication, repair and recombination: Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms.

B. RNA synthesis and processing: Transcription factors and machinery, formation of initiation complex, transcription activators and repressors, 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- translational modification of proteins.

D. Control of gene expression at transcription and translation level: Regulation of phages, viruses, prokaryotic and eukaryotic gene expression, role of chromatin in regulating gene expression and gene silencing.

4. Cell Communication and Cell Signaling

A. **Host parasite interaction:** Recognition and entry processes of different pathogens like bacteria, 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 receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant two-component signaling systems, bacterial chemotaxis and 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

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 and 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.

6. System Physiology-Plant

A. **Photosynthesis:** Light harvesting complexes; mechanisms of electron transport; photoprotective mechanisms; CO_2 fixation-C_3, C_4 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 and transport; physiological effects and mechanisms of action.
E. **Sensory photobiology:** Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; stomatal movement; photoperiodism and 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 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 (pathogen and insects) and abiotic (water, temperature and salt) stresses; mechanisms of resistance to biotic stress and tolerance to abiotic stress

7. System Physiology-Animal

A. **Blood and circulation:** Blood corpuscles, haemopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, haemoglobin, immunity, haemostasis.
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 above.
C. **Respiratory system:** comparison of respiration in different species, anatomical consideration, transport of gases, exchanges of gases, waste elimination, neural and chemical regulation of respiration.

D. Nervous system: Neurons, action potential, gross neuroanatomy of the brain and spial cord, central and peripheral nervous system, neural control of muscle tone and posture.

E. 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.

F. Sense Organ: Vision, hearing and tactile response

G. 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, neuroendocrine regulation.

8. Inheritance Biology

A. Mendelian principles: Dominance, segregation, independent assortment, deviation from Mendelian inheritance.

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, 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 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, site-specific recombination.

9. Diversity of Life Forms

A. Principles and methods of taxonomy: Concepts of species and hierarchical taxa, biological nomenclature, classical and quantititative methods of taxonomy of plants, animals and microorganisms.

B. Levels of structural organization: Unicellular, colonial and multicellular forms; levels of organization of tissues, organs and systems; comparative anatomy.

C. Outline classification of plants, animals and microorganisms: Important criteria used for classification in each taxon; classification of plants, animals and microorganisms; evolutionary relationships among taxa.

D. Natural history of Indian subcontinent: Major habitat types of the subcontinent, geographic origins and migrations of species; common Indian mammals, birds; seasonality and phenology of the subcontinent.

E. Organisms of health and agricultural importance: Common parasites and pathogens of humans, domestic animals and crops.

10. Ecological Principles

A. The Environment: Physical environment; biotic environment; biotic and abiotic interactions.

B. Habitat and niche: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.

C. 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.

D. Species interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.

E. Community ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.

F. **Ecological succession:** Types; mechanisms; changes involved in succession; concept of climax.
G. **Ecosystem:** Structure and function; energy flow and mineral cycling (CNP); primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine).
H. **Biogeography:** Major terrestrial biomes; theory of island biogeography; biogeographical zones of India.
I. **Applied ecology:** Environmental pollution; global environmental change; biodiversity-status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches.
J. **Conservation biology:** Principles of conservation, major approaches to management, Indian case studies on conservation/management strategy (Project Tiger, Biosphere reserves).

11. Evolution and Behaviour

A. **Emergence of evolutionary thoughts:** Lamarck; Darwin–concepts of variation, adaptation, struggle, fitness and 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 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 multicellular organisms; major groups of plants and animals; stages in primate evolution including Homo. 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.
D. **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 and modifications; isolating mechanisms; speciation; allopatricity and sympatricity; convergent evolution; sexual selection; co-evolution.
E. **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; 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.

12. 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 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.

13. 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 analysis, such as micro array 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, floweytometry and immunofluorescence microscopy, detection of molecules in living cells, *in situ* localization by techniques such as FISH and GISH.

C. **Biophysical methods:** Analysis of biomolecules using UV/visible, fluorescence, circular dichroism, NMR and ESR spectroscopy, structure determination using X-ray diffraction and NMR; 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, etc.

E. **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.

F. **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.

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.

I. **Computational methods:** Nucleic acid and protein sequence databases; data mining methods for sequence analysis, web-based tools for sequence searches, motif analysis and presentation.

Syllabus for Agricultural Biotechnology in ICAR–NET Examination

Unit 1: Cell Structure and Function

Prokaryotic and eukaryotic cell architecture, Cell wall, plasma membrane, Structure and function of cell organelles: vacuoles, mitochondria, plastids, golgi apparatus, ER, peroxisomes, glyoxisomes. Cell division, regulation of cell cycle, Protein secretion and targeting, Cell division, growth and differentiation.

Unit 2: Biomolecules and Metabolism

Structure and function of carbohydrates, lipids, proteins and nucleic acids, Synthesis of carbohydrate, glycolysis, HMP, Citric acid cycle and metabolic regulation, Oxidative phosphorylation and substrate level phosphorylation, Vitamins, plant and animal hormones. Functional molecules, antioxidants, nutrient precursor, HSPs, anti-viral compounds.

Unit 3: Enzymology

Enzymes, structure conformation, classification, assay, isolation, purification and characterization, catariysis specificity, mechanism of action, active site, regulation of enzyme activity, multienzyme complexes, immobilized enzymes and protein engineering, immobilized enzymes and their application.

Unit 4: Molecular Genetics

Concept of gene, Prokaryotes as genetic system, Prokaryotic and eukaryotic chromosomes, methods of gene isolation and identification, Split genes, overlapping genes and pseudo genes, Organization of prokaryotic and eukaryotic genes and genomes including operan, exon, intron, enhancer promoter sequences and other regulatory elements. Mutation – spontaneous, induced and site-directed, recombination in bacteria, fungi and viruses, transformation, transduction, conjugation, transposable elements and transposition.

Unit 5: Gene Expression

Expression of genetic information, operon concept, Transcription – mechanism of transcription in prokaryotes and eukaryotes, transcription unit, regulatory sequences and enhancers, activators, repressors, co-activators, Co-repressors in prokaryotes and eukaryotes, inducible genes and promoters, Transcription factors post transcriptional modification and protein transport, DNA-protein interaction, Genetic code. Mechanism of translation and its control, post translational modifications.

Unit 6: Molecular Biology Techniques

Isolation and purification of nucleic acids. Nucleic acids hybridization: Southern, northern and western blotting hybridization. Immune response monoclonal and polyclonal antibodies and ELISA, DNA sequencing. Construction and screening of genomic and C-DNA libraries. Gel electrophoretic techniques. Polymerase chain reactor spectroscopy, rtPCR ultracentrifugation, chromatography, FISH, RIA etc.

Unit 7: Gene Cloning

Restriction enzymes and their uses. Salient features and uses of most commonly used vectors i.e. plasmids, bacteriophages, phagmids, cosmids, BACs, PACs and YACs, binary vectors, expression vectors. Gene cloning and sub-cloning strategies, chromosome walking, genetic transformation, Basis of animal cloning. Biology. Risk assessment and IPR.

Unit 8: Molecular Biology

Ribosome structure and function. Protein biosynthesis in prokaryotes and ekaryotes. Post-translational modification. Gene regulation, RNA processing and Post transcriptional modifications. Bioprospecting, biofortification, gene pryrimiding and gene fusion, nbozyme technology.

Unit 9: Plant Molecular Biology

Photoregulation and phytochrome regulation of nuclear and chloroplastic gene expression. Molecular mechanism of nitrogen fixation. Molecular biology of various stresses, *viz.* abiotic stresses like drought, salt, heavy metals and temperature; and biotic stresses like bacterial, fungal and viral diseases. Signal transduction and its molecular basis, molecular mechanism of plant hormone action mitochondrial control of fertility, structure, organization and regulation of nuclear gene concerning storage proteins and starch synthesis.

Unit 10: Tissue Culture

Basic techniques in cell culture and somatic cell genetics. Regulation of cell cycle and cell division.. Clonal propagation. Concept of cellular totipotency. Anther culture, somaclonal and gametoclonal variations. Hybrid embryo culture and embryo rescue, somatic hybridization and cybridization. Application of tissue culture in crop improvement. Secondary metabolite production. *In vitro*, mutagenesis, cryopreservation and plant tissue culture repository.

Unit 11: Plant Genetic Engineering

Isolation of genes of economic importance. Gene constructs for tissue-specific expression. Different methods of gene transfer to plants, *viz.* direct and vectormediated. Molecular analysis of transformants. Potential applications of plant genetic engineering for crop improvement, i.e. insect-pest resistance (insect, viral, fungal and bacterial disease resistance), abiotic stress resistance, herbicide resistance, storage protein quality, increasing shelf-life, oil quality, Current status of transgenics, biosafty norms and controlled field trials and release of transgenics (GMOs).

Unit 12: Molecular Markers and Genomics

DNA molecular markers: Principles, type and applications; restriction fragment length polymorphism (RFLP), amplified fragment length polymorphism (AFLP), randomly amplified polymorphic DNA sequences (RAPD), Simple sequence repeats (SSR), Single nucleotide polymorphism (SNP), Structural and functional genomics, gene mapping, genome mapping, gene tagging and comparative genomics and application of genomics.

Syllabus for ICAR's All India Entrance Examination for Admission to PG Degree Programmes and ICAR–JRF (PGs)

Biotechnology (Agriculture Science)

Section 1: Cell Structure and Function

Ultrastructure of prokaryotic and eukaryotic cells. Cyloskelton. Cell wall and plasma membrane. Cell organelles including vacuoles, plastids, galgi apparatus, ER, peroxisomes, glyoxisomes, etc., their organization and function. Cell division. Different stages of mitosis and meiosis.

Section 2: Biomolecules and Metabolism

Structure, characterization and functions of carbohydrates, lipids, proteins and nucleic acids, isolation and purification of enzymes, their classification, catalytic ste, mechanism of action, regulation of enzyme activity, basic enzyme kinetics, inhibition, immobilized enzymes and their application, Catabolism, syntheses of carbohydrate, glycolysis, HMP, citric acid cycle, purine and pyrimidine biosynthesis, metabolic regulation, bioenergetics, etc. Oxidative phosphorylation and substrate level phosphorylation.

Section 3: Molecular Genetics

Concept of gene mutation, recombination, transformation, transduction, conjugation and transpositon. Organisation of prokaryotic and eukaryotic genes and genomes including operon, exon intron, enhance sequences and other regulatory elements in prokaryotes and eukaryotes.

Section 4: Gene Expression

Replication, transcription and transposition of genetic material prokaryotes and eukaryots. RNA processing and posttranscriptional modifications, post-translational modification and their significance. DNA modification and repair mechanism. Function of mitochondrial and chloroplast genome.

Section 5: Biophysical

Photoregulation and phytochrome regulation of nuclear and chloroplastic gene expression. Molecular biology of light and dark reaction of photosynthesis. Molecular mechanism of nitrogen fixation, nitrate reductase, and genetics of nif genes. Molecular biology of various stresses. viz. drought, salt, heat and cold. Signal transduction.

Section 6: Molecular Biology Techniques

Isolation and hybridization of nucleic acids. Cot analysis, southern, northern and western blottings and hybridization. Construction and screening of genomic and DNA libraries. Current methods of radioactive and nonradioactive labelling of proteins and nucleic acids. DNA sequencing. Restriction fragment length polymorphism (RFLP), randomly amplified polymorphic DNA sequences (RAPD), gene mapping, genome mapping, gene tagging and targetting, polymerase chain reaction (PCR). DNA synthesis, monoclonal and polyclonal antibodies, ribozyme, antisense RNA methodology, radioimmune assay, enzymelinked immunosorbent assay (ELISA).

Section 7: Gene Cloning

Restriction enzymes. Salient features and uses of most commonly used vectors i.e., plasmids, bacteriophages, phagmids and cosmids: expression vectors. Cloning, sub-cloning strategies and transformation. Plant genetic vectors.

Section 8: Tissue Culture

Basic technizues in cell culture and somatic cell genetics. Clonal propagation. Concept of cellular totiopotency. Anther and pollen culture for haploid and double haploid production; somatoclonal and gametoclonal variations. Hybrid embryo culture, somatic hybridization and hybridization. Gemplasm conservation and exchange. Plant bioreactors and production of industrial compounds. Application of tissue culture in crop improvement.

Section 9: Plant Genetic Engineering

Isolation of genes of interest. Gene constructs for tissue specific expression. Different methods of gene transfer to plants viz. direct and vector mediated. Potential applications to crop improvement through plant genetic engineering, i.e. specific and non-specific resistance (defence) genes to disease, pest and herbicide resistance. Storage protein quality, stress resistance and post-harvest, production of secondary metabolites and alien proteins. Current status of transgenics.

Section 10: Fermentation Technology

Principles of fermentation processes, bioreactors and biosensors. Protein engineering. Single cell proteins

Syllabus for Environmental Science in UGC–NET

Unit 1 Introduction

Definition, principles and scope of Environmental Science

Earth, Man and Environment, Ecosystems, pathways in Ecosystem

Physic-chemical and Biological factors in the environment

Geographical classification and zones

Structure and composition of atmospheres, hydrosphere, lithosphere, Mass and energy transfer across the variation interfaces, material balance, First and Second law of thermodynamics, heat transfer processes. Scale of meteorology, pressure, tempreture, precipitation, humidity, radiation and wind.

Atmospheric stability, inversions and mixing heights, windroses

Natural resources, conservation and sustainable development

Unit 2 Environmental Chemistry

FUNDAMENTALS of Environmental chemistry: Stochiometry, Gibbs' free energy, chemical potential, chemical equilibria, acid-base reaction, solubility products, solubility of gases in water, the carbonates system, unsaturated and saturated hydrocarbons, radionuclides.

Chemical Compostion of Air: Classification of elements, chemical speciation. Particles, ions and radicles in the atmosphere. Chemical processes for formation of inorganic and organic particulate matter. Thermochemical and photochemical reaction in the atmosphere. Oxygen and ozone chemistry. Chemistry of air pollutants, photochemical smog.

Water Chemistry: Chemistry of water, concept of DO, BOD, COD, sedimentation, coagulation, filtration and redox potential

Soil chemistry: Inorganic and organic components of soil, Nitrogen pathways and NPK in soils, toxic chemicals in the Environment- air, water: Pesticides in water. Biochemical aspects of arsenic, cadmium, lead, mercury, carbon monoxide, O3 and PAN pesticides, insecticides, MIC, carcinogens in the air

Principles of Analytical Methods: Titrimetry, Gravimetry, Colourimetry, Spectrophotometry, Chromatography, Gas Chromatography, Atomic absorption Spectrophotometry, GLC, HLC, Electrohoresis, X-rays fluorescence, X-ray diffraction, flame photometry

Unit 3 Ecology and Environment

Definition, principles and scope of ecology, human ecology and human settlement, evolutions, origin of life and speciation

Ecosystems: structure and functions, abiotic and biotic components, energy flows, food chains, food web, ecological pyramids, types and diversity

Ecological succession, population, community ecology and parasitism, prey-predator relationship common flora and fauna in India-Aquatic: phytoplankton, zooplankton and macrophytes; terrestrial Forest' Endangered and threatened species

Biodiversity and its conservation: Definition, 'Hotspots' of biodiversity, strategies for biodiversity conservation, National parks and sanctuaries, Gene pool

Microflora of Atmosphere: Air sampling techniques; identification of aeroallergens: air borne disease and allergies

Environmental Biotechnology: fermentation technology, vermiculture technology, biofertilizer technology

Unit 4 Environmental Geosciences

Environmental Geosciences-Fundamental concept.

The earth systems and Biosphere: Conservation of matter in various geospheres-Lithosphere hydrospheres, atmosphere and biosphere. Energy budget of the earth. Earth's thermal environment and seasons. Ecosystems flow of energy and matter. Co existence in communities-food webs. Earth's major ecosystem- terrestrial and aquatic. General relationship between landscape, biomes and climate. Climates of India , Indian Monsoon, EI Nino, droughts, tropical cyclones and western Disturbances

Earth's processes and Geological Hazards: Earth's processes: concept of residence, time and rates of natural cycles, catastrophic geological hazards. Study of floods, landslides, earthquakes, volcanism and avalanche. Predictin and perception of the hazards and adjustments to hazardous activities.

Mineral Resources and Environment: Resources and reserves, minerals and population. Oceans as new area for exploration of mineral resoureces, ocean ore and recycling of resources. Environmental impact of exploitation, precessing and smelting of minerals

Water resources and Environment: Global water balance. Ice sheets and fluctuations of sea levels Origin and compositin of sea water. Hydrological cycle. Factors influencing the surfaces water.

Types of water. Resources of oceans .Ocean pollution by toxic wastes. Human use of surface and groundwaters. Groundwater pollution

Land use planning. The land use plan. Soil sryeys in relation to land use planning. Methods of site selection and evaluation

Environmental Geochemistry: Concept of major, trace and REE. Classification of trace elements mobility of trace elements, Geochemical cycles, biogeochemials factors in environmental health. Human use, trace elements and health. Possible effects of imbalance of some trace elements. Diseases induced by human use of land

Principles of remote sensing and its application in Environmental Sciences, Application of GIS in Environmental managements.

Unit 5 Sources of Energy

Sun as source of energy: Solar radiation and its spectral characteristics; fossil fuels- Classification composition, physic-chemical characteristics and energy content of coal, petroleum and natural gas principles of generation of hydroelectric power, tidal ocean thermal energy conversion, wind, geothermal genergy, solar coliectors, photovoltaics, solar ponds; nuclear energy-fission and fusion;magnetohydrodynamic power, bioenergy-energy from biomass and biogas, anaerobic digestion, energy use pattern in different parts of the world

Environmental implication of energy use: CO_2 emissions, global warming: air and thermal pollution; radioactive waste and radioactivity from nuclear reactors; impacts of large-scale exploitation of solar, wind, hydro and ocean energy

Unit 6 Sources of Pollution

Air: natural and anthropogenic sources of pollution. Primary and secondary pollutant. Transport and diffusion of pollutants. Gas laws governing the behaviour of pollutants in the atmosphere. Methods of monitoring and control of air pollution SO_2, NOx, Co, SPM. Efects of pollutants on human beings, plants, animals, materials and on climate, Acid rain. Air quality standards

Water: Types, sources and consequences of water pollution. Physic-chemical and bacteriological sampling and analysis of water quality standards, seqage and waste water treatment and recycling. Water quality standard

Soil: Physic-chemical and bacteriological sampling as analysis of soil quality. Soil pollution control. Industrial waste effluents and heavy metals, their interactins with soil components. Soil micro-organisms and their function. Degradation of different insecticides, fungicides and weedicides in soil. Different kind of synthetic fertilizers and their interactions with different components of soil.

Noise: Sources of noise pollution, measurement of noise and indices, effect of meterological parameters on noise propagation. Noise exposure levels and standards, noise control and abatement measure.. impact of noise on human health

Mairine: Source of marine pollution and control, Criteria employed for disposal of pollutants in Radioactive and thermal pollution.

Unit 7 Environmental Impact Analysis

Introduction to environmental impact analysis

Environmental impact statement and environmental management plan

EIA guidelines 1994, notification of Government of India

Impact assessment methodologies

Generalized approach to impact analysis

Procedure for reviewing environmental impact analysis and statement
Guidelines for environmental audit
Introduction to environmental planning
Base ling information and prediction
Restoration and rehabilitation technology
Landuse policy for india
Urban planning for india
Rural planning and landuse pattern
Concept and strategies of sustainable development
Cost benefit analysis
Environmental priorities in India and sustainable development

Unit 8 Solid Wastes Managements

Sources and generation of solid wastes, their characterization, chemical composition and classification. Different methods of disposal and management of solid wastes. Recycling of wastes material. Waste minimization technologies

Hazardous wastes management and handling rules, 1989, Resource management, disaster management and risk analysis

Environment protectin-issures and problems, International and national efforts for environment protection, provision of constitution of India regarding environment (Article 48 A and 58A)

Environmental policy resolution, Legislation, Public policy strategies in pollution control, wildlife protection Act, 1972 amended 1991, Forest Conservation Act, 1980, Indian Forests Act (Revised)1982, Air (Prevention and control of pollution) Act, 1981 as amended by Amendment Act, 1987 and Rule 1982, Motor Vehicle Act, 1988, the water (prevention and control of pollution Act, 1974 as amended up to 1988 and Rules 1975. The environment (Protection) Act, 1986 and Rule 1986 scheme of labelling of environmentally friendly products, public liability Insurance Act, 1991 and Rule 1991

Unit 9 Statistical Analysis in Environmental Studies

Basic elements and tools of statistical analysis; probability, ampling, measurement and distribution of attributes; Distribution- normal, t and ÷, postion and binomial, arithmetic, geometric and harmonic means, moments, matrices, simultaneous linear equations; tests of hypothesis and significance

Introduction to environmental system analysis; approaches to development of models; linear simple and multiple regression models, validation and forecasting. Models of population growth and interactions- Lotka-Volterra model, Leslie's matrix model, point source stream pollution model, box model, Gaussian plume model

Unit 10 Environmental Education and Awareness

Environmental Education and Awareness

Environmental ethics and global imperatives

Global environmental problems-ozone depletion, global warming and climatic change

Current environmental issues in India; context: Narmada Dam, Tehri Dam, Almetti Dam, soil erosion, formation and reclamation pf Usar, alkaline and saline soil

Waste lands and their reclamation
Desertification and its control
Vehicular pollution and urban air quality
Depletion of natural resource
Biodiversity conservation and Agenda 21
Waste disposal, recycling and power generation, fly ash utilization
Water crises-conservation of water
Environmental hazards
Eutrophication and restoration of Indian Lakes
Rain water harvesting
Wet land conservation
Epidemiological issues (e.g. Goitre, Fluorosis, Arsenic).