# BIOTECHNOLOGY

**Aims:**

1. To enable candidates to acquire the knowledge and develop an understanding of how materials are provided by biological agents to provide goods and services.
2. To appreciate the role played by biotechnology in improving health care for human beings.
3. To understand the interdisciplinary nature of this subject.
4. To create awareness about the appreciation of biological processes to industries.
5. To develop the ability to appreciate biological phenomenon in nature and the contribution of biotechnology to human welfare.
6. To develop scientific attitude towards biological phenomenon.

## CLASS XI

*There will be two papers in the subject*

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|---|---|
| ***Paper I:** Theory:* | *3 hours ... 70 marks* |
| ***Paper II**: Practical:* | *3 hours ... 15 marks* |
| *Project Work* | *… 10 marks* |
| *Practical File* | *… 5 marks* |

### PAPER I –THEORY- 70 Marks

*There will be **one** paper of **three** hours duration divided into **two** parts.*

***Part 1 (20 marks)** will consist of compulsory short answer questions, testing knowledge, application and skills relating to elementary/fundamental aspects of the entire syllabus.*

***Part 2 (50 marks)** will consist of **eight** questions out of which the candidates will be required to answer **five** questions. Each question in this part shall carry 10 marks.*

### 1. Introduction to Biotechnology

(a) Historical background and the future of Biotechnology: definition and a brief introduction of the traditional techniques which are now covered under the heading Biotechnology and different ways the present man is utilising the traditional principles for the betterment of mankind.

*Kitchen, the first biotechnological laboratory - reasoning behind the technology involved in simple biological products like curd, beer and wine. A brief note on the causative micro-organisms.*

*Application of these technologies for large-scale production, with special reference to fermentation. Quality control management of the products, good laboratory practices and a brief note on international marketing.*

(b) Basic concepts of Biochemical technology: What does the biochemical technology mean? An understanding of various principles and statistical methods involved in research under the umbrella of biotechnology.

*Concept of buffer, pH, physical variables, dimensions and units. Fluid flow and mixing, heat and mass transfer, growth kinetics and fermentation process. An understanding of bio-reactors. Concept of probability, methods of sampling, collection of data – primary and secondary data, classification and tabulation, confidence levels, idea of sampling, distribution and standard error.*

(c) Scope and importance of biotechnology: different branches of biotechnology and different regulatory, social, ethical and legal issues that a biotechnologist comes across while doing the work.

*Names, definitions and importance of various fields that can be covered under biotechnology such as - agricultural/ plant biotechnology, animal biotechnology/medical biotechnology, industrial biotechnology, immunology and health care, energy, environment and services.*

*Intellectual Property Rights (IPRs) in biotechnology- concept of intellectual property, intellectual property rights and the choice of intellectual property rights protection. Various types of IPRs. Concept of patenting and its need. Process patenting and product patenting. Various precautions to be taken while carrying*

*out biotechnological work. Various types of intellectual property rights.*

*Concept of ethical, legal and social issues with one common example. How these issues are being tackled at national and international level.*

*Bio safety issues: release of genetically modified organisms into the environment.*

*Bridging the gap between bioscience, engineering and technology.*

**2. Cell Biology**

(a) Cell - Basic unit of life: Justification of cell as a basic unit of life. A brief note on the cell components with special reference to nucleus and its components. Various cytological techniques used in counting and identifying the cell and chromosomes.

*An understanding of cell components, their structure, and functions - cell wall, cell membrane, cytoplasmic reticulum, golgi apparatus, mitochondria, ribosomes, vacuoles, plastids, lysosomes, nucleus and other important inclusions of the cell. Differentiation between plant and animal and prokaryotic and eukaryotic cellular systems.*

*Chromosomal structure and composition – organisation of chromatids, concept of homologous and non-homologous chromosomes, sister and non-sister chromatids, classification of chromosomes on the basis of position of the centromere on the chromosome, basic idea about telomere, chromatin and nucleosome. An idea about banding patterns and their application.*

*Concept of chromosomal number in different species, e.g. man and mouse.*

*Techniques in cytology - microscopy, cell sorting and counting, karyotyping and banding techniques.*

(b) Cell Division and cell cycle: necessity for a cell to divide. Types of cell division and various other activities of cell such as biochemical transformations.

*Types and significance of cell division and a brief note about the different stages of cell division.*

*Concept of crossing over, chiasmata.*

*Basic concept of cell cycle and cell cycle regulation.*

*Cell communication and signal transduction, movement, nutrition, gaseous exchange, internal transport and maintenance of the internal transport and cell reproduction.*

*Biochemical Transformations:*

*An understanding of biochemical transformations, different biochemical pathways involved in respiration - aerobic and anaerobic.*

*Aerobic respiration - Glycolysis, Kreb's cycle, electron transport chain and oxidative phosphorylation.*

*Anaerobic respiration - lactic acid formation, fermentation and lactic acid alcohol formation.*

*Photosynthesis – brief historical account and light and dark reactions.*

(c) Errors in cell division: what happens if the cell does not divide normally? An understanding of different numerical and structural abnormalities which can be detected with the help of a microscope.

*Concept of non-disjunction: meiotic non-disjunction and mitotic non-disjunction. Non-disjunction in sex chromosomes – Turner's syndrome and Klienfelter's syndrome, identification and symptoms. Importance of these syndromes in studying human behavioural genetics.*

*Numerical chromosomal aberrations with respect to autosomes, i.e. Down's syndrome/ trisomy 21.*

*Structural chromosomal abnormalities – deletions, duplications, translocations, inversions, ring chromosomes and uniparental disomy.*

*Chromosomal abnormalities and gene mapping.*

*Polyploidy and its significance in plants.*

**3. Growth and Development in living beings**

(a) Animal and plant development: development of a complete organism from zygotic cell in both plants and animals. An understanding of defence strategies in all types of living organisms.

*Animal development – zygote to a stage of complete development of the foetus in a stage where it can absorb food.*

*Plant development. Fertilised ovules to a complete plant.*

*Immune response in plants and animals - immune system in higher animals, concept of immunity, immunisation, antigen and antibody. Various cells involved in immune system in humans. An introduction to human leukocyte antigens. Types of immunity - innate and acquired. ELISA Technique (Enzyme Linked Immuno Sorbant Assay).*

*Plant pathogen interaction. Secondary metabolism.*

*Defence strategies in microbes and insects.*

(b) Biodiversity and evolution of populations: an understanding of biodiversity in both plants and animals and the concept of population. *Significance of biodiversity, Indian plants and animals.*

*Concept and value of biodiversity. Understanding the concept of biodiversity. To appreciate various reasons for valuing and conserving biodiversity (ethical, moral, economic, aesthetic). An understanding of speciation, types of speciation - allopatric and sympatric; concept of ecosystem; adaptation and natural selection.*

*Organisation of life, size and complexity, interaction with the environment.*

**4. Genetics**

(a) Laws of Inheritance: how can one establish if a trait/disease is genetic or environmental? An account of Mendel's experiments. Different types of genetic inheritance and various complicating factors in genetic research.

*Mendel's experiment on pea plant and his conclusions - law of segregation and law of independent assortment.*

*Concept of trait, gene, allele, phenotype, genotype, homozygosity, heterozygosity and hemizygosity. Types of inheritance.*

*Pedigree construction using different standard symbols.*

*Construction of pedigree showing different modes of inheritance, autosomal inheritance - dominant, co-dominant and recessive.*

*Sex chromosome inheritance - with special reference to X chromosomal inheritance with suitable examples.*

*Mitochondrial / cytoplasmic inheritance.*

*Establishment of genetic reasons for a trait - family and twin studies.*

*Various problems in genetic research - variable expressivity, incomplete penetrance, one gene several effects, one phenotype several genes and Lyon's hypothesis.*

(b) Gene Mapping: mapping of genes on chromosomes using linkage analysis. An understanding of mutations and cancer genetics.

*Mapping of genes on chromosomes with respect to genetic diseases.*

*Basic concept of linkage and crossing over. Genetic recombination, concept of centi morgan (cM), Morgan's experimental results, explanation of linkage and mapping with suitable examples, discovery of DNA as the genetic material.*

*Concept of mutation and various factors causing mutations.*

*Cancer genetics: a brief note.*

(c) Genes in populations: how do genes behave in populations from generation to generation? Various ways of studying population genetics.

*Concept of gene pool and allele frequency, polymorphism, definition of Hardy Weinberg law, its applications.*

*Possibility of disease resistant and susceptible genes in population. Concept of pharmacogenetics and pharmacogenomics.*

## PAPER II

### PRACTICAL WORK – 15 Marks

Candidates are required to complete the following experiments.

1. Preparation of Buffers:

   *This experiment should be done to make the basics clear to the students and for this, the approach should be to utilise easily available chemicals at reasonable costs. For this "Phosphate buffer, Acetate buffer and Borate buffer" are good for practice. (pH 5 & pH 8).*

2. Colour reactions of Carbohydrates:

   *The following experiments should be performed:*

   - *Iodine test for starch, etc.*
   - *Benedict's test for reducing sugar.*
   - *Fehling's test.*

3. Colour reaction for Proteins:

   *The tests to perform are:*

   - *Biuret test.*
   - *Bradford test (it can be qualitative as well as quantitative – for qualitative assessment the extent of colour development can be used as rough estimate).*

4. Study of various stages of Mitosis and Meiosis:

   *The students should be given practice in preparing slides for study of mitosis by crush smear method. They should be able to identify different stages (at least four stages). For the study of meiosis, the students should be shown permanent slides of meiosis and they should be able to identify at least six stages of meiosis from the slides.*

   *The requirement for this set of experiments is Acetocarmine stain slides, coverslips, microscopes and spirit-lamp.*

5. Preparation of Karyotypes:

   *Demonstration of any metaphasic plate of mitosis (pea onion root tips).*

   *Diad formation, pairing of homologous chromosomes during meiosis.*

6. Determination of Blood Groups:

   *The students can perform this experiment on their own and work out their own blood group. Proper instructions however are to be given for 'prick' – e.g. (a) Sterilize finger with alcohol/disinfectant. (b) Use only disposable sterile needle. (c) Use the needle only once and destroy it. (d) Do not prick or use blood drop in an indiscriminatory way.*

7. Constructing of pedigrees showing different types of inheritance:

   *The students are to establish Mendel's Laws of inheritance by selecting varied seeds/flowers with different colours out of the lot provided to them. They can also perform exercises and numericals on monohybrid and dihybridisation.*

   *Additionally, they can be asked to set up sets to show –*

   - *Incomplete dominance.*
   - *Epistasis.*

8. Usage of pH meter:

   *To measure the pH of a given sample by pH meter or sensitive pH strips/handheld pH meter.*

### PROJECT WORK AND PRACTICAL FILE – 15 Marks

**Project Work – 10 Marks**

Candidates are to creatively execute **one** project/assignment on any aspect of Biotechnology. Teachers may assign or students may choose any one project of their choice. The report should be kept simple, but neat and elegant. No extra credit shall be given for type-written material/decorative cover, etc.

**Practical File – 5 Marks**

Teachers are required to assess students on the basis of the practical file maintained by them during the academic year.

## LIST OF EQUIPMENT FOR BIOTECHNOLOGY PRACTICALS FOR CLASSES XI & XII

1. Table-top Centrifuge
2. Vortex - Mixer
3. Thermostatic water-bath
4. Spectrophotometer (UV visible range)
5. Refrigerator
6. pH meter
7. Air-dry oven
8. Autoclave (Vertical)
9. Desiccators
10. Micro-filtration unit
11. Chromatography columns
12. TLC Plates
13. DNA gel photographs showing plasmid and chromosomal DNA bands
14. Colourimeter
15. Magnetic stirrer with hot plate
16. Laminar flow cabinet (Vertical)
17. Weighing Balance (Electrical)
18. Hot plate
19. Binocular Microscope
20. Haemocytometer
21. Colony counter
22. Antiserum
23. Antibodies
24. Micropipettes
25. Microcentrifuge

## LIST OF ABBREVIATIONS TO BE STUDIED

1. NBTB- National Biotechnology Board
2. DBT- Department of Biotechnology
3. DST- Department of Science and Technology
4. CSIR- Council of Scientific and Industrial Research
5. IARI- Indian Agricultural Research Institute
6. ICMR- Indian Council of Medical Research
7. NBRI- National Botanical Research Institute
8. CIMAP- Central Institute of Medicinal and Aromatic Plants
9. CDRI- Central Drug Research Institute
10. CCMB-Centre for Cellular and Molecular Biology
11. HGRI- Human Genome Research Institute
12. NII- National Institute of Immunology
13. NBPGR- National Bureau of Plant Genetic Resources
14. ICGEB-International Centre for Genetic Engineering and Biotechnology
15. NHGRI- National Human Genome Research Institute
16. IBPGR- International Board of Plant Genetic Resources
17. EBI- European Bioinformatics Institute
18. DDBJ- DNA Databank of Japan
19. EMBL- European Molecular Biology Laboratory
20. BLAST- Basic Local Alignment Search Tools
21. TIGR- The Institute of Genomic Research
22. IEF- Isoelectric Focusing
23. RCF- Relative Centrifugal Force
24. HEPA- High Efficiency Particulate Air
25. CFTR- Cystic Fibrosis Transmembrane Conductance Regulator Gene
26. NCBI- National Centre for Biotechnology Information
27. EST- Expressed Sequence Tag
28. ARS- Autonomously Replicating Sequence

29. GM- Genetically Modified
30. ddNTP- Dideoxynucleoside Triphosphate
31. STS- Sequence Tagged Sites
32. PCR- Polymerase Chain Reaction
33. VNTR- Variable Number of Tandem Repeats
34. RAPD - Random Amplification of Polymorphic DNA
35. RFLP- Restriction Fragment Length Polymorphism
36. PAGE- Polyacrylamide Gel Electrophoresis
37. SCP- Single Cell Protein
38. HGP- Human Genome Project
39. HBsAg- Hepatitis B Surface Antigen
40. Km- Michaelis Menton Constant
41. SSB- Single Strand Binding Protein
42. IFN- Interferon
43. DBM- Diazobenzene Oxymethyl
44. AFLP- Amplified Fragment Length Polymorphism
45. SNP- Single Nucleotide Polymorphism
46. CPU- Central Processing Unit
47. GST- Genome Sequence Tag
48. GDB – Genome Database
49. MGD – Mouse Genome Database
50. YAC – Yeast Artificial Chromosome
51. BAC – Bacterial Artificial Chromosome
52. PDB - Protein Data Bank
53. PIR - Protein Identification Resources