BIOTECHNOLOGY (878)

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:

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

1. Introduction to Biotechnology

(i) Historical background; definition; a brief introduction of the traditional and modern techniques of Biotechnology and their applications.

Definition of biotechnology by OECD and EFB; contributions of Karl Ereky and Louis Pasteur; use of various fermented products in ancient civilisations;

Kitchen (traditional), the first biotechnological laboratory -reasoning behind the technology involved in simple biological products like curd and beer; names of microorganisms involved in their production.

Application of these technologies for large-scale production, with special reference to fermentation (Beer production only). Quality control management of the products, good laboratory practices.

(ii) Scope and importance of biotechnology: different branches of biotechnology and different regulatory guidelines; ethical, legal and social issues (ELSI) that a biotechnologist comes across while doing the work. Various organisations in the field of biotechnology.

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

Intellectual Property Rights (IPRs) in biotechnology- concept of intellectual property, types of IPR and its need; intellectual property rights and the choice of intellectual property rights protection. Discovery and invention; Concept of patenting, trademark, trade secrets, copyright, geographical indications and PBRs and their need.

Concept of ethical, legal and social issues with one common example IVF.

Biosafety issues: release of genetically modified organisms into the environment and their impact; GEAC and its objectives.

Biotechnology - global and Indian scenario. Various institutes, centres and funding agencies - NBTB, CCMB, ICGEB, ICMR, ICAR, DBT, DST which deal with biotechnology and bioinformatics in India: names only.

(iii) Basic concepts of Biochemical technology and biostatistics: What does the biochemical technology mean? An understanding of various statistical methods involved in biotechnology.

Concept of buffer, type and preparation of buffers, pH, physical variables; fermentation; An understanding of bio-reactors, idea of sampling – quadrat and transect; measures of central tendency – mean, median, mode; standard deviation and standard error; concept of probability – theoretical and experimental.

2. Cell Biology

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

Differentiation prokaryotic and eukaryotic cellular systems.

Structure of bacteria (in brief, with reference to plasmid). Gram+ and Gram- bacteria.

An understanding of cell components, their ***basic*** *structure and functions - cell wall, cell membrane, cytoplasmic reticulum, Golgi apparatus, mitochondria, ribosomes, vacuoles, plastids, lysosomes, nucleus and other important inclusions of the cell.*

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 (Q, R, C and G) and their application.

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

Techniques in cytology – microscopy (light and electron microscope), karyotyping and centrifugation (principle and applications only).

(ii) Cell Division and cell cycle: types of cell divisions 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 – mitosis and meiosis.

Basic concept of cell cycle and cell cycle regulation – CdK method only, definition of Mitotic Index.

Biochemical Transformations:

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

Aerobic respiration - Glycolysis, Krebs' cycle, electron transport chain and oxidative phosphorylation.

Anaerobic respiration - lactic acid, fermentation and alcohol fermentation – definition only.

(iii) Errors in cell division: what happens if the cell does not divide normally? An understanding of different numerical and structural abnormalities.

Concept of mutation: causes; types –somatic, germinal, spontaneous, induced, gene, chromosomal and genomatic mutations, euploidy, aneuploidy, monosomy, nullisomy, trisomy and tetrasomy; various factors causing mutations.

Concept of non-disjunction: meiotic non-disjunction and mitotic non-disjunction. Non-disjunction in sex chromosomes – Turner's syndrome and Klinefelter's syndrome - chromosomal composition and symptoms only.

Numerical chromosomal aberrations with respect to autosomes, i.e. Down's syndrome –chromosomal composition and symptoms only.

Structural chromosomal abnormalities – deletions, duplications, translocations, inversions.

Polyploidy and its significance in plants.

Inborn errors of metabolism - basic concept and examples like albinism, sickle cell anaemia, phenylketonuria and alkaptonuria.

3. Biomolecules and related techniques

(i) Introduction to biomolecules- definition and types. Carbohydrates, proteins, lipids, vitamins and enzymes – their structure and properties.

Biomolecules – definition and types

Structure and functions of carbohydrates.

Sugars and derivatives; classification of some important mono, di and polysaccharides - glucose, fructose, glycogen, cellulose, chitin and peptidoglycan. Physical and chemical properties of sugars.

Structure, functions and classification of proteins i.e. simple, complex and derived; building blocks of proteins - the amino acids: chemical structure, types (acidic, basic and neutral); physical and chemical properties of amino acids. 3D - structure of proteins. Different types of protein structures - primary, secondary (alpha helix, beta pleated sheet and random structures), tertiary, quaternary; protein sequencing by MALDI-MS.

Structure and functions of lipids – fatty acids and alcohol; types (simple, conjugated and derived lipids with one example of each); chemical and physical properties of lipids.

Vitamins: Definition, types (fat soluble and water soluble vitamins); co-enzyme forms of water soluble vitamins; deficiency diseases of vitamins.

Enzymes: Structure and functions of enzymes: chemical nature of enzymes; characteristics and properties of enzymes. An understanding of enzyme activity on the basis of activation energy; mechanism of enzyme action - lock and key model; induced fit hypothesis; factors affecting enzyme activity (temperature, pH, substrate concentration, enzyme concentration, inhibitors (competitive, non-competitive).

Optical activity of biomolecules (dextrorotatory and laevorotatory).

Concept of supramolecular assembly.

(ii) Techniques used for separation of biomolecules

Ion exchange chromatography and paper chromatography.

4. Developmental Biology and Immunology

(i) Animal and plant development: development of an organism from zygotic cell in both plants and animals.

Animal development – fertilisation, zygote to blastocyst formation.

Plant development. Double fertilisation including formation of primary endosperm nucleus.

(ii) An understanding of defence strategies in living organisms.

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

Secondary metabolites in plants and their significance

Defence strategies in bacteria – endospores and R plasmids.

5. Genetics

(i) Laws of Inheritance: An account of Mendel's experiments. Different types of genetic inheritance.

Mendel's experiment on pea plant and his laws of inheritance.

Concept of trait, gene, allele, phenotype, genotype, homozygosity, heterozygosity and hemizygosity. Types of inheritance: autosomal inheritance - dominant, co-dominant, recessive, polygenic, pleiotropic and cytoplasmic inheritance (plastidial inheritance).

Pedigree construction using different standard symbols.

Sex chromosome inheritance - with special reference to X chromosomal inheritance with suitable examples (colour blindness and haemophilia).

(ii) Gene Mapping: mapping of genes on chromosomes using linkage analysis. Cancer and its genetics.

Mapping of genes on chromosomes with respect to COV (Crossing Over Value).

Basic concept of linkage (types not required) and crossing over. Genetic recombination.

Cancer: Causes (physical, chemical, biological – TSG and oncogenes); diagnosis and treatment.

(iii) 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, definition of Hardy Weinberg law, its applications.

Possibility of disease resistant and susceptible genes in population. Definition and application of pharmacogenetics and pharmacogenomics.

PAPER II

PRACTICAL WORK – 15 Marks

Candidates are required to complete the following experiments.

1. Determination of blood group by using antisera.

   The students can perform this experiment on their own blood groups. 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.

2. Identification of different types of blood cells by preparing blood smear using Leishmann's stain.

   Requirements: Blood sample, disposable needles, slides, Leishmann's stain. Make a blood smear on a slide, use the stain to colour the smear, wash and observe under microscope.

3. Instruments – their names, use and principles (if applicable).

   Water bath, pH meter, weighing balance, desiccators, microfiltration unit, magnetic stirrer, LAF, haemocytometer, micropipette, vortex mixer, colorimeter/spectrophotometer, hot air oven, autoclave, incubator, electrophoresis chamber, colony counter, autoclave, hot plate.

4. Finding out the pH of water by using pH meter or pH paper on tap water and water containing acid, base.

   Take tap water in three test tubes, add two drops of dil. HCl in one, two drops of NaOH in the second while leaving the third test tube with tap water. Use pH meter or pH paper to find their specific pH.

5. Observation of steps of mitosis by using the root tip of onion.

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

6. Measurement of mitotic index.

   Mitotic index is the ratio of number of cells undergoing mitosis to the number of cells in the field.

$$MI = \frac{\textit{No. of cells showing mitosis}}{\textit{Total no. of cells in the field}}$$

7. Observation of various stages of meiosis under microscope.

   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.

8. Effect of temperature on curdling of milk by using *Lactobacillus* bacteria at 37°C, 60°C and 10°C.

   Optimum temperature for curdling of milk is 37°C due to active form of bacteria at this temperature; it is inactive at low temperature and dies at high temperature.

9. Food tests:

   (i) Carbohydrates – starch by iodine solution turning blue - black in colour.

   Reducing and non-reducing sugars by using Fehling's solution / Benedict's solution – reducing the cupric ion (blue) to cuprous ion (red).

(ii) Protein test – Biuret test, Xanthoproteic and Millon's test

(a) ***For Biuret test*** *–The protein produces deep blue – violet colour due to the involvement of cupric ion in the product formed.*

(b) ***For Millon's Reagent*** *– A pinkish red colour is observed with mercuric chloride.*

(c) ***For Xanthoproteic Test****: When concentrated nitric acid is boiled with protein a yellow colour is observed. On addition of ammonium hydroxide or liquor ammonia orange yellow precipitate is obtained.*

(iii)Lipids – Sudan III, Acrolein test, paper test

(a) Sudan III is a red fat-soluble dye used for identification of the presence of lipids, triglycerides and lipoproteins. It reacts with the lipids or triglycerides and gives red colour.

(b) Acrolein test is used to detect fat. When fat is heated strongly in the presence of potassium bisulphate/ sodium bisulphate ($KHSO_4$/$NaHSO_4$) that acts as a dehydrating agent, the glycerol is dehydrated to form an unsaturated aldehyde called acrolein that gives a pungent and irritating odour.

10. Finding out the purity of milk by using lactometer.

    Put the instrument in milk. If it sinks down and reaches the mark 'M' mentioned on lactometer, it means that the milk is pure or if not, it means that the milk is impure. If the milk is mixed with water, it would sink higher than mark 'M'. If it stands at the mark 3 it means that the milk is 75% pure and respectively 2 for 50% purity and 1 for 25% purity.

11. Construction of pedigree showing different types of inheritance.

    The students are to observe the traits like, rolling of the tongue/ attached earlobe/ widow's peak.

12. Preparation of karyotypes.

    Demonstration of any metaphasic plate of mitosis.

13. Sampling methods – quadrat and transect by using different techniques.

    To be done in groups. Use yellow and green pea seeds. Make a quadrat (30 cm X 30 cm) with blocks of 6 cm X 6 cm. Spread the seeds randomly on the table top. Put the quadrat and count the number of yellow and green peas per block; find the frequency of each type of pea seed.

14. Data collection – primary and secondary.

    Collect any type of primary data and secondary data, tabulate the data and draw conclusion.

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.

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 ABBREVIATIONS

1. CCMB:Centre for Cellular and Molecular Biology
2. CdK: Cyclin dependent Kinase
3. COV: Cross Over Value
4. CSIR: Council of Scientific and Industrial Research
5. DBT: Department of Biotechnology
6. DST: Department of Science and Technology
7. EFB: European Federation of Biotechnology
8. ELISA: Enzyme Linked Immuno Sorbent Assay
9. ELSI: Ethical, Legal and Social Issues

10. ETS/ETC: Electron Transport System / Electron Transport Cycle
11. FMN/FAD: Flavin Mono Nucleotide / Flavin Adenine Dinucleotide
12. GEAC: Genetic Engineering Approval Committee
13. HLA: Human Leucocyte – associated Antigen
14. ICAR: Indian Council for Agricultural Research
15. ICGEB: International Centre for Genetic Engineering and Biotechnology
16. ICMR: Indian Council for Medical Research
17. IEF : Iso Electro Focussing
18. IPP: Intellectual Property Right Protection Act
19. IPR: Intellectual Property Right
20. IVF: In–Vitro Fertilization
21. MALDI-MS: Matrix Assisted Laser Desorption Ionization – Mass Spectrometry
22. MI: Mitotic Index
23. NADPH/NADP: Nicotinamide Adenine Dinucleotide Phosphate (reduced) / Nicotinamide Adenine Dinucleotide Phosphate
24. NBTB: National Biotechnology Board
25. OECD: Organization for Economic Cooperation and Development
26. PBR: Plant Breeder's Right
27. TPP: Thiamine Pyrophosphate
28. TSG: Tumour Suppressor Gene

LIST OF EQUIPMENT FOR BIOTECHNOLOGY PRACTICALS FOR CLASS XI

1. Table-top Centrifuge
2. Vortex - Mixer
3. Thermostatic water-bath
4. Spectrophotometer (UV visible range)/ Colorimeter
5. Refrigerator
6. Lactometer
7. pH meter
8. Hot air oven
9. Autoclave
10. Desiccators
11. Micro-filtration unit
12. Incubator
13. Magnetic stirrer with hot plate
14. Laminar flow cabinet
15. Weighing Balance (Electrical)
16. Hot plate
17. Binocular Microscope
18. Haemocytometer
19. Colony counter
20. Antiserum
21. Electrophoresis chamber
22. Micropipettes

LIST OF ABBREVIATIONS TO BE STUDIED

1. BAC: Bacterial Artificial Chromosomes
2. BLAST: Basic Local Alignment Search Tool
3. CTAB: Cetyl Trimethyl Ammonium Bromide
4. DBM: Diazo–benzyl oxy–methyl paper
5. DDBJ: DNA Database/ Data Bank of Japan
6. ddNTP: Dideoxy Nucleoside triphosphate
7. DMEM: Dulbecco Modified Eagle Medium
8. EBI: European Bioinformatics Institute
9. EMBL: European Molecular Biology Laboratory
10. EST: Expressed Sequence Tag
11. FACS: Fluorescence Activated Cell Sorting
12. FASTA: Fast All
13. FBS: Foetal Bovine Serum
14. HEPA: High Energy Particulate Air
15. HGP: Human Genome Project
16. IBPGR: International Board of Plant Genetic Resources
17. ICGEB: International Centre for Genetic Engineering and Biotechnology
18. IFN: Interferon
19. LB medium: Luria and Bertani Medium
20. MS medium: Murashige and Skoog medium
21. NCBI: National Centre for Biotechnology Information
22. NHGRI: National Human Genome Research Institute
23. PAGE: Polyacrylamide Gel Electrophoresis
24. PCR: Polymerization Chain Reaction
25. PDB: Protein Database/ Data Bank
26. PHB: Poly 3–Hydroxyl Butyrate
27. PIR: Protein Information Resource
28. RFLP: Restriction Fragment Length Polymorphism
29. RNA: Ribonucleic acid
30. RPMI medium: Roswell Park Memorial Institute medium
31. SCP: Single Cell Protein
32. SDS – PAGE: Sodium Dodecyl Sulphate–Polyacrylamide Gel Electrophoresis
33. SNP: Single Nucleotide Polymorphism
34. SSBs: Single Stranded Binding Proteins
35. STS: Sequence Tagged Site
36. VNTR: Variable Number of Tandem Repeats
37. YAC: Yeast Artificial Chromosome