# BIOTECHNOLOGY

Framework of CBCS Syllabus for BIOTECHNOLOGY (Honours) from 2019-20

## Semester – I

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Name of the Course</th>
<th>Paper</th>
<th>CP (Credit Point)</th>
<th>CH (Credit Hour)</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Core</td>
<td>C1: Microbiology</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>Core</td>
<td>C2: Plant Diversity &amp; Physiology</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>GE-A</td>
<td>GE 1A: Paper I from either subjects [Zoology / Botany / Chemistry]</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>AECC – I</td>
<td>Environmental Science</td>
<td>4</td>
<td>40</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Total Paper</td>
<td></td>
<td>4</td>
<td>22</td>
<td>220</td>
</tr>
</tbody>
</table>

## Semester – II

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Name of the Course</th>
<th>Paper</th>
<th>CP (Credit Point)</th>
<th>CH (Credit Hour)</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Core</td>
<td>C3: Cell Biology and Genetics</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>Core</td>
<td>C4: Animal Diversity &amp; Physiology</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>GE-B</td>
<td>GE 2B: Paper from remaining 02 subjects other than that opted in first semester [Zoology / Botany / Chemistry]</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>AECC - II</td>
<td>MIL Communication (Odia/ Alt English)</td>
<td>4</td>
<td>40</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Total Paper</td>
<td></td>
<td>4</td>
<td>22</td>
<td>220</td>
</tr>
</tbody>
</table>

## Semester – III

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Name of the Course</th>
<th>Paper</th>
<th>CP (Credit Point)</th>
<th>CH (Credit Hour)</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Core</td>
<td>C5: Molecular Biology</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>Core</td>
<td>C6: Biochemistry and Metabolism</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>Core</td>
<td>C7: Biostatistics and Computer Applications</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>GE-A</td>
<td>GE 3A: Paper II of the subject opted in first semester [Zoology / Botany / Chemistry]</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>SEC- 1</td>
<td>SEC–1: Communicative English</td>
<td>4</td>
<td>40</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Total Paper</td>
<td></td>
<td>5</td>
<td>28</td>
<td>280</td>
</tr>
</tbody>
</table>
### Semester – IV

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Name of the Course</th>
<th>Paper</th>
<th>CP (Credit Point)</th>
<th>CH (Credit Hour)</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Core</td>
<td>C8: Immunology</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>Core</td>
<td>C9: Plant Biotechnology</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>Core</td>
<td>C10: Animal Biotechnology</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>GE-B</td>
<td>GE 4B, Paper II of the subject opted in second semester Zoology / Botany / Chemistry</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>SEC – 2</td>
<td>SEC–2: Enzymology / Basics of Forensic Science / Mushroom culture/ Sericulture</td>
<td>4</td>
<td>40</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td><strong>Total Paper</strong></td>
<td></td>
<td><strong>5</strong></td>
<td><strong>28</strong></td>
<td><strong>280</strong></td>
</tr>
</tbody>
</table>

### Semester – V

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Name of the Course</th>
<th>Paper</th>
<th>CP (Credit Point)</th>
<th>CH (Credit Hour)</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Core</td>
<td>C 11: Genetic Engineering</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>Core</td>
<td>C 12: Genomics and Proteomics</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>DSE 1</td>
<td>DSE 1: Biotechniques</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>DSE 2</td>
<td>DSE 2: Bioinformatics</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td><strong>Total Paper</strong></td>
<td></td>
<td><strong>4</strong></td>
<td><strong>24</strong></td>
<td><strong>240</strong></td>
</tr>
</tbody>
</table>

### Semester – VI

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Name of the Course</th>
<th>Paper</th>
<th>CP (Credit Point)</th>
<th>CH (Credit Hour)</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Core</td>
<td>C 13: Bioethics and Biosafety</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>Core</td>
<td>C 14: Bioprocess Engineering and Technology</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>DSE 3</td>
<td>DSE 3: Bioentrepreneurship</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>DSE 4</td>
<td>DSE 4: Medical Microbiology (to be opted by students securing below 60%) / Project Report &amp; Seminar*</td>
<td>6</td>
<td>NA</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td><strong>Total Paper</strong></td>
<td><strong>4</strong></td>
<td><strong>24</strong></td>
<td><strong>180</strong></td>
<td><strong>400</strong></td>
</tr>
</tbody>
</table>

**Grand Total** | **26** | **148** | **1480** | **2600**

*Project 80 + 20 Viva*

* AECC – Ability Enhancement Compulsory Course  * SEC – Skill Enhancement Course
* DSE – Discipline Specific Elective  * GE – Generic Elective

*Hons students has to opt two Generic Elective Subjects. *SubjectsA& B (containing 2 Papers) from subjects available other than Core (Hons.) Subject. Subject - A for Semester 1 & 3 another subject B for Semester 2 & 4.

* GE – Generic Elective [To be opted by +3, Biotechnology (Hons.)]
Two subjects among three subjects viz., Zoology / Botany / Chemistry to be chosen (02 papers/ Subject i.e. Total 04 papers/ 02 subjects) other than Core as Generic Elective.

<table>
<thead>
<tr>
<th>Subject</th>
<th>GE Paper-I</th>
<th>GE Paper-II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zoology</td>
<td>Animal Diversity (Non-Chordate), Physiology and Endocrinology</td>
<td>Animal Diversity (Protochordata and Chordata), Developmental Biology and Immunology</td>
</tr>
<tr>
<td>Botany</td>
<td>Industrial and Environmental Microbiology</td>
<td>Botany and Plant Biotechnology</td>
</tr>
</tbody>
</table>

Any two subjects among three subjects and each Subject contains two papers (Subject-A with two papers at Semester I & III [GE-1A & GE-3A] and another Subject B with two papers for Semester II & IV [GE-2B & GE-4B] is to be opted.

* GE – Generic Elective [To be opted by +3, Science (Hons.) other than Biotechnology]*

<table>
<thead>
<tr>
<th>Subject</th>
<th>Generic Elective Papers</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Paper-I</td>
<td>Paper-II</td>
</tr>
<tr>
<td>Biotechnology</td>
<td>Biochemistry and Molecular Biology</td>
<td>Recombinant DNA Technology</td>
</tr>
<tr>
<td></td>
<td>Paper-III</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Environmental Biotechnology and Bioethics</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Paper-IV</td>
<td>Bioprocess Technology &amp; Entrepreneurship</td>
</tr>
</tbody>
</table>

BIOTECHNOLOGY Papers for HONOURS Students

Core course – 14 papers, Discipline Specific Elective – 4 papers
Generic Elective for non Biotechnology students – 4 papers. In case University offers 2 subjects as GE, then papers 1 and 2 will be the GE paper.

Marks per paper - Midterm: 15 marks, Practical: 25 marks, End term: 60 marks, Total: 100 marks, Credit per paper – 6: Theory-4, Practical-2, Teaching hours per paper – 40 hours theory classes+ 20 hours practical classes

C 1: MICROBIOLOGY

Unit-I
Fundamentals, History and Evolution of Microbiology. Classification of microorganisms: Microbial taxonomy, criteria used, including molecular approaches, Microbial phylogeny, Microbial Diversity: Distribution and characterization Prokaryotic and Eukaryotic cells, Morphology and cell structure of major groups of microorganisms e.g. Bacteria, Algae, Fungi, Protozoa, Archea (Halophyles, Methanogens, Thermophyles), Virus (structure of viruses, Bacterial, plant, animal and tumor viruses, DNA- and RNA- viruses.

Unit-II
Cultivation and Maintenance of microorganisms: Nutritional categories of micro-organisms, methods of isolation, Purification and preservation. Microbial growth: Growth curve, Generation time, synchronous batch and continuous culture, measurement of growth and factors affecting growth of bacteria.

**Unit-III**
Microbial Metabolism: Metabolic pathways, amphi-catabolic and biosynthetic pathways

**Unit-IV**
Control of Microorganisms: By physical, chemical and chemotherapeutic Agents, Water Microbiology: Bacterial pollutants of water, coliforms and non coliforms. Sewage composition and its disposal.
Food Microbiology: Important microorganism in food Microbiology: molds, Yeasts, bacteria.

**Practical:**
1. Isolation of bacteria & their biochemical characterization.
2. Staining methods: simple staining, Gram staining, spore staining, negative staining, hanging drop.
3. Preparation of media & sterilization methods, Methods of Isolation of bacteria from different sources.
4. Determination of bacterial cell size by micrometry.
5. Enumeration of microorganism - total & viable count.

**Text Books:**
2. Prescott/Harley/Klein's Microbiology, by Joanne Willey (Author), Linda Sherwood (Author), Chris Woolverton (Author), McGraw Hill Education; 7 edition

**Suggested Readings**

**C 2: PLANT DIVERSITY AND PLANT PHYSIOLOGY**

**Unit-I**
Algae: General character, classification& economic importance.
Fungi: General characters, classification& economic importance.
Lichens: Classification, general structure, reproduction and economic importance.
Bryophytes: General characters, classification& economic importance.
Unit-II
General characters of pteridophytes, affinities with bryophytes & gymnosperms, classification, economic importance.
Gymnosperms: General characters, classification, geological time scale, theories of fossil formation, types of fossils.
Life histories of Cycas & Pinus, economic importance of gymnosperms.

Unit-III
Plant water relations: Importance of water to plant life, diffusion, osmosis, plasmolysis, imbibition, guttation, transpiration, stomata & their mechanism of opening & closing.
Micro & macro nutrients: criteria for identification of essentiality of nutrients, roles and deficiency systems of nutrients, mechanism of uptake of nutrients, mechanism of food transport.
Growth and development: Definitions, phases of growth, growth curve, growth hormones (auxins, gibberlins, cytokinins, abscisic acid, ethylene).

Unit-IV
Physiological role and mode of action, seed dormancy and seed germination, concept of photoperiodism and vernalization
Photosynthesis- Photosynthesis pigments, concept of two photo systems, photophosphorylation, calvin cycle, CAM plants, photorespiration, compensation point
Nitrogen metabolism- inorganic & molecular nitrogen fixation, nitrate reduction and ammonium assimilation in plants.

Practical:
1. Comparative study of thallus and reproductive organs of various algae mentioned in theory.
2. Separation of photosynthetic pigments by paper chromatography.
3. Study of various types of lichens.
4. Demonstration of aerobic respiration.
5. Preparation of root nodules from a leguminous plant.
6. Demonstration of plasmolysis by Tradescantia leaf peel.

Text Books:

Suggested Reading:
4. Plant Physiology, Author: Salisbury & Ross, Pub: WADSWORTH C engage learning
C-3: CELL BIOLOGY & GENETICS

Unit-I


Unit-II
Extracellular Matrix: Composition, molecules that mediate cell adhesion, membranes receptors for extra cellular matrix, macromolecules, regulation of receptors expression and function. Signal transduction.

Structure and functions; Lysosomes, Vacuoles and micro bodies, Ribosomes, Mitochondria, Chloroplasts, Nucleus: Chromosomes and their structure.

Unit-III
Historical developments in the field of genetics. Organisms suitable for genetic experimentation and their genetic significance.

Cell Cycle: Mitosis and Meiosis: Control points in cell-cycle progression in yeast. Role of meiosis in life cycles of organisms.


Unit-IV
Structure and characteristics of bacterial and eukaryotic chromosome, chromosome morphology, concept of euchromatin and heterochromatin. packaging of DNA molecule into chromosomes, concept of cistron, exons, introns, genetic code, gene function.

Chromosome and gene mutations: Definition and types of mutations, causes of mutations, position effects of gene expression, chromosomal aberrations in human beings, abonormalities– Aneuploidy and Euplody.

Sex determination and sex linkage: Mechanisms of sex determination, Environmental factors and sex determination, sex differentiation, Barr bodies, dosage compensation, genetic balance theory, Fragile-X-syndrome and chromosome, sex influenced dominance, sex limited gene expression, sex linked inheritance.

Practical:
1. Study of plasmolysis and de-plasmolysis.
2. Study of structure of any prokaryotic Eukaryotic cell.
3. Microtomy: Fixation, Block making, Section cutting, Double staining of animal tissues like liver, Oesphagus, Stomach, pancreas, Intestine, Kidney, Ovary, testes.
5. Preparation of Nuclear, mitochondria & cytoplasmic fractions.
7. Karyotyping with the help of photographs.

Text Books:

Suggested Readings

C 4: ANIMAL DIVERSITY AND PHYSIOLOGY

Unit-I
Proto-chordates: Outline of classification, General features.

Outline of classification of Non-Chordates up to subclasses. Coelomata, Acoelomata, Symmetries, Deutrostromes, Protostomes.


Unit-II
Proto-chordates: Outline of classification, General features and important characters of Herdmania, Branchiostoma.

Origin of Chordates Pisces: Migration in Pisces, Outline of classification.

Amphibia: Classification, Origin, Parental care, Paedogenesis.

Reptilia: Classification, Origin.

Aves: Classification, Origin, flight- adaptations, migration.

Mammalia: Classification, Origin, dentition.
Unit-III
Digestion: Mechanism of digestion & absorption of carbohydrates, Proteins, Lipids and nucleic acids. Composition of bile, Saliva, Pancreatic, gastric and intestinal juice.


Unit-IV
Mechanism of working of heart: Cardiac output, cardiac cycle, Origin & conduction of heartbeat.

Mechanism of generation & propagation of nerve impulse, structure of synapse, synaptic conduction, saltatory conduction, Neurotransmitters

Unit-V
Different endocrine glands– Hypothalamus, pituitary, pineal, thymus, thyroid, parathyroid and adrenals, hypo & hyper-secretions, Mechanism of action of hormones (insulin and steroids).

Practical:
2. Identification & Classification upto order of the following: Proto-chordata: Salpa, Doliolum, Herdmania, Branchiostoma.
3. Finding the coagulation time of blood.
4. Determination of blood groups.
5. Determination of Haemoglobin.
6. Counting of mammalian RBCs.
7. Determination of TLC and DLC.

Text Books:

Suggested Reading:

C5: MOLECULAR BIOLOGY
Unit-I
DNA structure and replication: DNA as genetic material, Structure of DNA, Types of DNA, Nucleosome, Packaging of DNA molecule into chromosomes, Replication of DNA in prokaryotes and eukaryotes: Semiconservative nature of DNA replication, Bi-directional replication, DNA polymerases, The replication complex: Pre-priming proteins, primosome, replisome, Rolling circle replication, Unique aspects of eukaryotic chromosome replication, Fidelity of replication.

Unit-II
DNA damage, repair and homologous recombination: DNA damage and repair: causes and types of DNA damage, mechanism of DNA repair: Homologous recombination: models and mechanism.

Unit-III
Transcription and RNA processing: RNA structure and types of RNA, Transcription in prokaryotes: Prokaryotic RNA polymerase, role of sigma factor, promoter, Initiation, elongation and termination of RNA chains Transcription in eukaryotes: Eukaryotic RNA polymerases, transcription factors, promoters, enhancers, mechanism of transcription initiation, promoter clearance and elongation RNA splicing and processing: processing of pre-mRNA: 5 cap formation, polyadenylation, splicing, rRNA and tRNA splicing.

Unit-IV
Prokaryotic and eukaryotic translation: ribosome structure and assembly, Charging of tRNA, amino acyl tRNA synthetases, Mechanism of initiation, elongation and termination of polypeptides, Post translational modifications of proteins Regulation of gene expression and translation: Regulation of gene expression in prokaryotes: Operon concept (inducible and repressible system), Genetic code and its characteristics.

Practical:
1. Preparation of solutions for Molecular Biology experiments.
2. Isolation of chromosomal DNA from animal/bacterial cells.
3. Agarose gel electrophoresis of genomic DNA.
4. Quantitation of DNA by Spectrophotometry.
5. Extraction of protein
6. SDS PAGE and Native PAGE

Text Book:

Suggested Readings
1. Cell and Molecular Biology - By Robertis&Robertis, Publ: Waverly
2. Genes - By B. Lewin - Oxford Univ. Press
C6: BIO-CHEMISTRY AND METABOLISM

Unit-I

Carbohydrates Metabolism: Reactions, energetic and regulation. Glycolysis: Fate of pyruvate under aerobic and anerobic conditions. Pentose phosphate pathway and its significance, Glucose-6-phosphatase,Glycogenolysis and glycogen synthesis. TCA cycle, Electron transport chain, Oxidative phosphorylation,

Unit-II
Amino acid & Proteins: Structure and properties of Amino acids, Types of Proteins and their Classification, Different levels of structural organization of proteins, Fibrous and globular proteins.

Enzymes: Nomenclature and classification of Enzymes, Holoenzyme, apoenzyme, Cofactors, coenzyme, prosthetic groups, Enzyme activity, Specific activity,

Unit-III

Unit-IV

Practical:
1. To study activities of any enzyme under optimum conditions.
2. Preparation of buffers.
4. Qualitative and quantitative tests for Carbohydrates and lipids.
5. Qualitative and quantitative estimation of proteins.

Text Book:

Suggested Readings:
5. Biochemistry, 4th edition by U Satyanarayana and U Chakrapani, Elsevier India

**C7: BIOSTATISTICS AND COMPUTER APPLICATIONS**

**Unit-I**
Statistical methods and Developmental models: Graphical representation of statistical data, Mean, Poisson and Binomial, Distribution, Arithmetic, Geometric and Harmonic means, Median, Mode; Design of experiments,

**Unit II**
Analysis of Variance, Standard Deviation, Standard error of mean, Correlation and regression of two variables, Test of significance, Probability, sampling, measurement and distribution of attributes, t-test, chi-square test, F-test. Collection, Classification and Tabulation of data.

**Unit III**
Basic concept of computer: - Introduction, different components of computer, basic design of computer. Introduction to operating system, different management (processor, memory, device, file), Processor management-Process concept ,Threads,CPU Scheduling Process scheduling, Deadlocks ,Process synchronization. Memory management – Memory allocation rule, Swapping, Overlay, Paging, Demand paging, segmentation, virtual memory. Device management, File management.

**Unit IV**
Computer application, DOS command, MS-Office, MS-Access, MS-Excel, MS-Power point, Assessing Internet. Services: Browsing, Downloading, e-correspondence.


**Practical:**
1. Calculation of mean, median & mode taking biological samples.
2. Calculation of standard error of mean.
3. Chi-square test using biological samples.
4. DOS commands (Internal & External).
5. Some basic programs in C.
6. Programs on Decision making branching.
7. Programs Decision making Looping.
8. Programs on operators.

**Text Books:**
Suggested Readings:
1. Taxmann's Information Technology by Dr. Sushila Madan.

C8: IMMUNOLOGY

Unit-I
Immune Response - An overview, components of mammalian immune system, molecular structure of Immuno-globulins or Antibodies, Humoral & Cellular immune responses, T-lymphocytes & immune response (cytotoxic T-cell, helper T-cell, suppressor T-cells), T-cell receptors, genome rearrangements during B-lymphocyte differentiation, Antibody affinity maturation class switching, assembly of T-cell receptor genes by somatic recombination.

Unit-II
Regulation of immunoglobulin gene expression clonal selection theory, allotypes & idiootypes, allelic exclusion, immunologic memory.

Unit-III
Major Histocompatibility complexes class I & class II MHC antigens, antigen processing and presentation.
Immunity to infection- immunity to different organisms, pathogen defence strategies, avoidance of recognition. Autoimmune diseases, Immunodeficiency diseases, AIDS.

Unit-IV
Vaccines & Vaccination adjuvants, cytokines, DNA vaccines, recombinant vaccines, bacterial vaccines, viral vaccines, vaccines to other infectious agents, passive & active immunization. Introduction to immunodiagnostics RIA, ELISA.

Practical:
1. Differential leucocytes count.
2. Total leucocytes count.
3. Total RBC count.

Text Book:
Suggested Readings
3. Essentials of Immunology by Roitt (Blackwell scientific publication).

C9: PLANT BIOTECHNOLOGY

Unit I
Introduction, Cryo and organogenic differentiation, Types of culture: Seed, Embryo, Callus, Organs, Cell and Protoplast culture. Micropopagation Axillary bud proliferation, Meristem and shoot tip culture, cud culture, organogenesis, embryogenesis.

Unit- II
In vitro haploid production Androgenic methods: Anther culture, Microspore culture andogenesis Significance and use of haploids, Ploidy level and chromosome doubling, diplodization, Gynogenic haploids, factors effecting gynogenesis, chromosome elimination techniques for production of haploids in cereals.

Unit - III
Protoplast Isolation and fusion Methods of protoplast isolation, Protoplast development, Somatic hybridization, identification and selection of hybrid cells, Cybrids, Potential of somatic hybridization limitations. Somaclonal variation Nomenclature, methods, applications basis and disadvantages.

Unit - IV

Practical:
1. Preparation of complex nutrient medium (Murashige & Skoog’s medium)
2. To selection, Prune, sterilize and prepare an explant for culture.
3. Significance of growth hormones in culture medium.
4. To demonstrate various steps of Micropropagation

Text Book:
1. Introduction to Plant Biotechnology, H.S. Chawla, Science Publishers, 2002

Suggested Readings:
C 10: ANIMAL BIOTECHNOLOGY

Unit I
Equipments and materials for animal cell culture: Design and layout of culture room, Basic equipments used in cell culture, Sterilization and aseptic techniques.

Culture media: General considerations in media design, Natural media, synthetic media. Primary culture and its maintenance.

Unit II
Various methods of cell separation, Cell cloning: Dilution cloning and isolation cloning, Transformation of cells, Organ culture, In vitro Fertilization, Embryo culture. Three dimensional culture.

Unit III
Gene transfer methods in Animals – Microinjection, Embryonic Stem cell, gene transfer, Retrovirus & Gene transfer.

Unit IV

Practical:
1. Sterilization techniques: Theory and Practical: Glass ware sterilization, Media sterilization, Laboratory sterilization
2. Sources of contamination and decontamination measures.
3. Cell counting and cell viability
4. Preparation of Hanks Balanced salt solution
5. Preparation of Minimal Essential Growth medium

Text Book:
1. Animal cell culture techniques, Ian Freshney, Wiley-Leiss

Suggested Readings:
1. Tissue Culture – Methods and Applications by Paul F. Kruse Jr. and M. K. Patterson, Jr.
2. Cell Culture LabFAX, M. Butler and M. Dawson, Bios scientific Publications Ltd
4. Plant cell and Tissue Culture for the production of Food Ingradients by Fu, Singh and Curtis
5. Handbook of plant tissue culture, ICAR, publications & information division, New Delhi.
C 11: GENETIC ENGINEERING

Unit-I
Molecular tools and applications- restriction enzymes, ligases, polymerases, alkaline phosphatase. Gene Recombination and Gene transfer: Transformation, Episomes, Plasmids and other cloning vectors (Bacteriophage-derived vectors, artificial chromosomes), Microinjection, electroporation, Ultrasonication, Principle and applications of Polymerase chain reaction (PCR), primer-design, and RT- (Reverse transcription) PCR.

Unit-II
Restriction and modification system, restriction mapping. Southern and Northern hybridization. Preparation and comparison of Genomic and cDNA library, screening of recombinants, reverse transcription., Genome mapping, DNA fingerprinting, Applications of Genetic Engineering Genetic engineering in animals: Production and applications of transgenic mice, role of ES cells in gene targeting in mice, Therapeutic products produced by genetic engineering-blood proteins, human hormones, immune modulators and vaccines (one example each).

Unit-III
Random and site-directed mutagenesis: Primer extension and PCR based methods of site directed mutagenesis, Random mutagenesis, Gene shuffling, production of chimeric proteins, Protein engineering concepts and examples (any two).

Unit-IV
Genetic engineering in plants: Use of Agrobacterium tumefaciens and A. rhizogenes, Ti plasmids, Strategies for gene transfer to plant cells, Direct DNA transfer to plants, Gene targeting in plants, Use of plant viruses as episomal expression vectors.

Practical:
1. Isolation of chromosomal DNA from plant cells
2. Isolation of chromosomal DNA from E.coli
3. Qualitative and quantitative analysis of DNA using spectrophotometer
4. Plasmid DNA isolation
5. Restriction digestion of DNA
6. Demonstration of PCR

Text Book:

Suggested Readings:
5. Biotechnology by B.D.Singh (Kalyani Publishers).
C 12: GENOMICS & PROTEOMICS

Unit-I
Introduction to Genomics, DNA sequencing methods manual& automated: Maxam& Gilbert and Sangers method. Pyrosequencing, Genome Sequencing: Shotgun & Hierarchical (clone contig) methods, Computer tools for sequencing projects: Genome sequence assembly software.

Unit-II
Managing and Distributing Genome Data: Web based servers and softwares for genome analysis: ENSEMBL, VISTA, UCSC Genome Browser, NCBI genome. Selected Model Organisms Genomes and Databases.

Unit-III
Introduction to protein structure, Chemical properties of proteins. Physical interactions that determine the property of proteins. Short-range interactions, electrostatic forces, van der waal interactions, hydrogen bonds, Hydrophobic interactions.

Determination of sizes (Sedimentation analysis, gel filtration, SDS-PAGE); Native PAGE, Determination of covalent structures Edman degradation.

Unit-IV

Practical:
1. Use of SNP databases at NCBI and other sites
2. Detection of Open Reading Frames using ORF Finder
3. Proteomics 2D PAGE database
4. Software for Protein localization.
5. Native PAGE
6. SDS-PAGE

Text Books:
2. A. Malcolm Campbell Discovering Genomics, Proteomics and Bioinformatics, Pearson Education India; 2 edition

Suggested Readings:
C 13: ENVIRONMENTAL BIOTECHNOLOGY & BIOETHICS

Unit-I
Environment: Basic concepts and issues, Environmental modeling, Systems ecology, Ecosystem, Global Environmental Problems; Ozone depletion, Influence on Biodiversity of aquatic and terrestrial environment, Biodiversity of oceans, Estuaries and Lagoons.

Acid rain, Arid and semi-arid plant biotechnology, Green house technology, Environmental pollution and measures; Air, Water, Soil, Radioactive pollutions.

Unit-II

Unit-III
Bioleaching, Enrichment of ores by microorganisms (Gold, Copper and Uranium). Environmental significance of genetically modified microbes, plants and animals.

Unit-IV
Bioethics – Necessity of Bioethics, different paradigms of Bioethics – National & International. Ethical issues against the molecular technologies.

Introduction to intellectual property: Types of IP (Trademarks, Copyright & Related rights, Industrial design, Traditional knowledge, Geographical indications, Protection of GMOs).

Basics of patents (Types of patent application and Specifications), concept of Prior Art and patent filing procedures

Practical:
1. Calculation of Total Dissolved Solids (TDS) of water sample.
2. Calculation of BOD of water sample.
3. Calculation of COD of water sample.
4. A case study on clinical trials of drugs in India with emphasis on ethical issues.
5. Case study on women health ethics.
6. Case study on medical errors and negligence.

Text Book:

Suggested Readings:
C 14: BIOPROCESS ENGINEERING & TECHNOLOGY

Unit-I
Production of industrial chemicals, biochemicals and chemotherapeutic products. Propionic acid, butyric acid, 2-3 butanediol, gluconic acid, itaconic acid. Biofuels: Biogas, Ethanol, butanol, hydrogen, biodiesel, Microbial electricity, starch conversion processes.

Microbial polysaccharides; Microbial insecticides; microbial flavours and fragrances, newer antibiotics, anti-cancer agents, amino acids.

Unit-II

Unit-III
Purification & characterization of proteins, Upstream and downstream processing. Distribution of microbial cells, centrifugation, filtration of fermentation broth, ultra centrifugation, liquid extraction, ion-exchange recovery of biological products. Experimental model for design of fermentation systems, Anaerobic fermentations.

Unit-IV
Rate equations for enzyme kinetics, simple and complex reactions. Inhibition kinetics; effect of pH and temperature on rate of enzyme reactions. Mathematical derivation of growth kinetics, mathematical derivations of batch and continuous culture operations; single stage CSTR; mass transfer in aerobic fermentation; resistances encountered; overall mass transfer co-efficient (Ka) determination, factors depending on scale up principle and different methods of scaling up. Metabolic engineering of antibiotic biosynthetic pathways.

Practical:
1. Comparative analysis of design of a batch and continuous fermenter.
2. Calculation of Mathematical derivation of growth kinetics.
3. Solvent extraction & analysis of a metabolite from a bacterial culture.
4. Perform an enzyme assay demonstrating its hydrolytic activity (protease/peptidase/glucosidase etc.)
5. Production and analysis of Amylase.

Text Book:
1. Prescott & Dunn's Industrial Microbiology Paperback, 2004 by G. Reed (Author), CBS Publication

**Suggested Readings**
5. Salisbury, Whitaker and Hall. Principles of fermentation Technology

**Discipline Specific Elective 1**

**BIOTECHINIQUES**

**Unit-I**
Simple microscopy, phase contrast microscopy, fluorescence and electron microscopy (TEM and SEM), pH meter, absorption and emission spectroscopy

**Unit-II**
Principle and law of absorption fluorimetry, Colorimetry, Spectrophotometry (visible, UV, infrared), Centrifugation, Cell Fractionation Techniques, Isolation of sub-cellular organelles and particles.

**Unit-III**
Introduction to the principle of chromatography. Paper chromatography, thin layer chromatography, column chromatography: silica and gel filtration, affinity and ion exchange chromatography, gas chromatography, HPLC.

**Unit-IV**
Introduction to electrophoresis, polyacrylamide gel (native and SDS-PAGE), agarose-gel electrophoresis, immuno- electrophoresis, isoelectric focusing, Western blotting. Introduction to Biosensors and Nanotechnology and their applications.

**Practical:**
1. Native gel electrophoresis of proteins
2. Determination of absorption maxima of given chemicals.
3. SDS-polyacrylamide slab gel electrophoresis of proteins under reducing conditions.
4. Separation of amino acids by paper chromatography.
5. To identify lipids in a given sample by TLC.
6. To verify the validity of Beers law and determine the molar extinction coefficient of NADH.

**Text Books:**
Discipline Specific Elective 2

BIOINFORMATICS

Unit I
History of Bioinformatics. The notion of Homology. Sequence Information Sources, EMBL, GENBANK, Entrez, Unigene, Understanding the structure of each source and using it on the web.

Unit II
Protein Information Sources, PDB, SWISSPROT, TREMBL, Understanding the structure of each source and using it on the web.
Introduction of Data Generating Techniques and Bioinformatics problem posed by them-
Restriction Digestion, Chromatograms, Blots, PCR, Mass Spectrometry.

Unit-III
Sequence and Phylogeny analysis, Detecting Open Reading Frames, Introduction to BLAST, using it on the web, Outline of sequence Assembly, Pairwise Alignments, Interpreting results, Multiple Sequence Alignment, Phylogenetic Analysis.

Unit-IV
Searching Databases: SRS, Entrez, Sequence Similarity Searches-BLAST, FASTA, Data Submission. Genome Annotation: Pattern and repeat finding, Gene identification tools.

Practical:
1. Sequence information resource
2. Understanding and use of various web resources: EMBL, Genbank, Entrez, Unigene, Protein information resource (PIR)
3. Understanding and using: PDB, Swissprot, TREMBL
4. Using various BLAST and interpretation of results.
5. Retrieval of information from nucleotide databases.
6. Sequence alignment using BLAST.
7. Multiple sequence alignment using Clustal W.

Text Book:

Suggested Readings:
3. An introduction to Practical Biochemistry - T. Plummer
4. Experimental Biochemistry- V. Deshpande and B. Sasidhar Rao (A Student Companion)
5. Biophysics – Vastala Piramal (Dominent Publishers)

**Discipline Specific Elective 3**

**BIOENTERPRENEURSHIP**

**Unit I: Introduction**
Meaning, Needs and Importance of Entrepreneurship, Promotion of entrepreneurship, Factors influencing entrepreneurship, Features of a successful Entrepreneurship.

**Unit II: Establishing an Enterprise**
Forms of Business Organization, Project Identification, Selection of the product, Project formulation, Assessment of project feasibility.

**Unit III: Financing the Enterprise**
Importance of finance / loans and repayments, Characteristics of Business finance, Fixed capital management: Sources of fixed capital, working capital its sources and how to move for loans, Inventory direct and indirect raw materials and its management.

**Unit IV: Marketing Management**
Meaning and Importance, Marketing-mix, product management – Product line, Product mix, stages of product like cycle, marketing Research and Importance of survey, Physical Distribution and Stock Management.
Meaning of International business, Selection of a product, Selection of a market for international business, Export financing, Institutional support for exports.

**Text Book:**
1. Gupta CB, Khanka SS. Entrepreneurship and small Business Management, Sultan Chand and Sons

**Suggested Readings:**
2. Kalpan JM Patterns of Entrepreneurship

**Discipline Specific Elective 4**

**MEDICAL MICROBIOLOGY**

**Unit I**
Unit II
Pathogenesis, symptoms, laboratory diagnosis, preventive measures and chemotherapy caused by gram negative bacteria: *E. coli*, *N. gonorrhoea*, *N. meningitidis*, *S. typhi*, *S. dysenteriae*, *H. influenzae*, *V. cholerae*, *M. pneumoniae*, *Rickettsiaceae*, *Chlamydiae*.

Unit III
Diseases caused by viruses- Picornavirus, Orthomyxoviruses, Paramyxoviruses, Rhabdoviruses, Reoviruses, Pox virus, Herpes virus, Papova virus, Retro viruses (including HIV/AIDS) and Hepatitis viruses.

Unit IV
Fungal and Protozoan infections. Dermatophytoses (Trichophyton and Epidermophyton) Subcutaneous infection (Sporothrix, Cryptococcus), systemic infection (Histoplasma, Coccidoides) and opportunistic fungal infections (Candidiasis, Aspergillosis), Gastrointestinal infections (Amoebiasis, Giardiasis), Blood-borne infections (Leishmaniasis, Malaria).

Practical:
1. Identification of pathogenic bacteria (any two) based on cultural, morphological and biochemical characteristics.
2. Growth curve of a bacterium.
3. To perform antibacterial testing by Kirby-Bauer method.
4. To prepare temporary mounts of Aspergillus and Candida by appropriate staining.
5. Staining methods: Gram’s staining permanent slides showing Acid fast staining, Capsule staining and spore staining.

Text Book:
1. Ananthnarayan ,Paniker, Arti Kapil Ananthnarayan and Paniker’s Textbook of Microbiology, Universities Press (India) Private Limited

Suggested readings

DISCIPLINE SPECIFIC ELECTIVE 4: Project Reports& Seminar
Credits-6, Project Report: 60 marks, Seminar: 20 marks, Viva: 20 marks&Total: 100 Marks

- A selected Biotechnology based product
- Review articles
- Latest techniques and products of societal impact
- Contribution/discovery of Scientists in the field of Biotechnology
- Instrumentation and applications
- Scale up/ Down stream processing
- Models
- Bioinformatics tools
Generic Elective Paper-I

BIOCHEMISTRY AND MOLECULAR BIOLOGY

Unit-I

pH and buffers, Preparation and significance of buffers in biological system.

Carbohydrates: Structure, Function and properties of Monosaccharides, Disaccharides and Polysaccharides. Homo & Hetero polysaccharides, Glycoproteins and their biological functions.

Amino acid & Proteins: Structure and properties of Amino acids, Types of Proteins and their Classification, Different levels of structural organization of proteins.

Unit-II

Lipids: Structure and functions Classification, nomenclature and properties of fatty acids, essential fatty acids. Phospholipids, Sphingolipids, Glycolipids, Cerebrosides, Gangliosides, Cholesterol.


Unit-III

DNA structure and replication: DNA as genetic material, Structure of DNA, Types of DNA, Nucleosome, Replication of DNA in prokaryotes and eukaryotes: semiconservative nature of DNA replication.

Transcription and RNA processing: RNA structure and types of RNA, Transcription in prokaryotes and Eukaryotes, RNA splicing and processing: processing of pre-mRNA: 5 cap formation, polyadenylation, splicing, rRNA and tRNA splicing.

Unit-IV

Prokaryotic and eukaryotic translation: ribosome structure and assembly, Charging of tRNA, amino acid tRNA synthetases, Mechanism of initiation, elongation and termination of polypeptides, Post translational modifications of proteins.

Practical:
1. Preparation of buffers.
2. Separation of Amino acids by paper chromatography
3. Qualitative and quantitative estimation of proteins.
4. Isolation of chromosomal DNA from bacterial cells.
5. Agarose gel electrophoresis of genomic DNA.
6. Quantification of DNA by Spectrophotometry.

Text Books:

Suggested Readings
1. Biochemistry, 4th edition by U Satyanarayana and U Chakrapani, Elsevier India
5. Genes - By B. Lewin - Oxford Univ. Press

Generic Elective Paper-II

RECOMBINANT DNA TECHNOLOGY

Unit I
Molecular tools and applications- restriction enzymes, ligases, polymerases, alkaline phosphatase. Gene Recombination and Gene transfer: Transformation, Episomes, Plasmids and other cloning vectors (Bacteriophage-derived vectors, artificial chromosomes), Principle and applications of Polymerase chain reaction (PCR), primer-design, and Types of PCR.

Unit II
Restriction and modification system, restriction mapping. Southern and Northern hybridization. Preparation and comparison of Genomic and cDNA library, screening of recombinants, reverse transcription, Genome mapping, DNA fingerprinting, Applications of Genetic Engineering Therapeutic products produced by genetic engineering-blood proteins, human hormones, immune modulators and vaccines (one example each).

Unit III
Random and site-directed mutagenesis: Primer extension and PCR based methods of site directed mutagenesis, Random mutagenesis, Gene shuffling, production of chimeric proteins, Protein engineering concepts and examples (any two).

Unit IV
Genetic engineering in plants: Use of Agrobacterium tumefaciens and A. rhizogenes, Ti plasmids, Strategies for gene transfer to plant cells, Direct DNA transfer to plants, Gene targeting in plants, Use of plant viruses as episomal expression vectors.
Practical:
1. Isolation of chromosomal DNA from E.coli
2. Qualitative and quantitative analysis of DNA using spectrophotometer
3. Plasmid DNA isolation
4. Restriction digestion of DNA
5. Demonstration of PCR

Text Book:

Suggested Readings:
5. Biotechnology by B.D.Singh (Kalyani Publishers).

Generic Elective Paper-III

ENVIRONMENTAL BIOTECHNOLOGY AND BIOETHICS

Unit-I
Environment: Basic concepts and issues, Environmental modeling, Systems ecology, Ecosystem, Global Environmental Problems; Ozone depletion, Influence on Biodiversity of aquatic and terrestrial environment, Biodiversity of oceans, Estuaries and Lagoons.

Acid rain, Arid and semi-arid plant biotechnology, Green house technology, Environmental pollution and measures; Air, Water, Soil, Radioactive pollutions.

Unit-II

Unit-III
Bioleaching, Enrichment of ores by microorganisms (Gold, Copper and Uranium). Environmental significance of genetically modified microbes, plants and animals.

Unit-IV
Bioethics – Necessity of Bioethics, different paradigms of Bioethics – National & International. Ethical issues against the molecular technologies.
Introduction to intellectual property: Types of IP (Trademarks, Copyright & Related rights, Industrial design, Traditional knowledge, Geographical indications, Protection of GMOs).

Basics of patents (Types of patent application and Specifications), concept of Prior Art and patent filing procedures

**Practical:**
1. Calculation of Total Dissolved Solids (TDS) of water sample.
2. Calculation of BOD of water sample.
3. Calculation of COD of water sample.
4. A case study on clinical trials of drugs in India with emphasis on ethical issues.
5. Case study on women health ethics.
6. Case study on medical errors and negligence

**Text Book:**

**Suggested Reading:**
2. Waste Water Engineering, Metcalf and Eddy, Tata McGraw hill
3. Agricultural Biotechnology, S.S. Purohit
5. Introduction to Environmental Biotechnology, Milton Wainwright

**Generic Elective Paper-IV**

**BIOPROCESS ENGINEERING & TECHNOLOGY**

**Unit-I**
Production of industrial chemicals, biochemicals and chemotherapeutic products. Propionic acid, butyric acid, 2 - 3 butanediol, gluconic acid, Biofuels: Biogas, Ethanol, butanol, biodiesel, Microbial electricity.

Microbial polysaccharides; Microbial insecticides; microbial flavours and fragrances, newer antibiotics, anti-cancer agents, amino acids.

**Unit-II**
Production of microbial metabolite, Secondary metabolism its significance and products. Metabolic engineering of secondary metabolism for highest productivity. Enzyme and cell
immobilization techniques in industrial processing, enzymes in organic synthesis, proteolytic enzymes, hydrolytic enzymes, enzymes in food technology/organic synthesis.

**Unit-III**

Purification & characterization of proteins, Upstream and downstream processing. Distribution of microbial cells, centrifugation, filtration of fermentation broth, ultra centrifugation, liquid extraction, ion-exchange recovery of biological products. Experimental model for design of fermentation systems, Anaerobic fermentations.

**Unit-IV**

Rate equations for enzyme kinetics, simple and complex reactions. Inhibition kinetics; effect of pH and temperature on rate of enzyme reactions. Mathematical derivation of growth kinetics, mathematical derivations of batch and continuous culture operations; single stage CSTR; mass transfer in aerobic fermentation; resistances encountered; overall mass transfer co-efficient (Ka) determination, factors depending on scale up principle and different methods of scaling up. Metabolic engineering of antibiotic biosynthetic pathways.

**Practical:**
1. Comparative analysis of design of a batch and continuous fermenter.
2. Calculation of Mathematical derivation of growth kinetics.
3. Solvent extraction & analysis of a metabolite from a bacterial culture.
4. Perform an enzyme assay demonstrating its hydrolytic activity (protease/peptidase/glucosidase etc.)
5. Production and analysis of Amylase.

**Text Book:**
1. Prescott & Dunn's Industrial Microbiology Paperback, 2004 by G. Reed (Author), CBS Publication

**Suggested Readings:**
5. Salisbury, Whitaker and Hall. Principles of fermentation Technology

---

**Framework of Biotechnology Syllabus for Pass Students**
<table>
<thead>
<tr>
<th>Sl No</th>
<th>Name of the Course</th>
<th>Paper</th>
<th>CP (Credit Point)</th>
<th>CH (Credit Hour)</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DSC 1</td>
<td>Cell Biology and Genetics</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>DSC 2</td>
<td>Molecular Biology</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>DSC 3</td>
<td>Biochemistry and Metabolism</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>DSC 4</td>
<td>Genetic Engineering</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Total Paper</td>
<td></td>
<td>4</td>
<td>24</td>
<td>240</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Name of the Course</th>
<th>Paper</th>
<th>CP (Credit Point)</th>
<th>CH (Credit Hour)</th>
<th>MARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DSE 1</td>
<td>Bio-techniques</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>DSE 2</td>
<td>Bioinformatics</td>
<td>6</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Total Paper</td>
<td></td>
<td>2</td>
<td>12</td>
<td>120</td>
</tr>
</tbody>
</table>

BIOTECHNOLOGY Papers for PASS Students

Discipline Specific Core – 4 papers & Discipline Specific Elective – 2 papers

Marks per paper - Midterm: 15 marks, Practical: 25 marks, End term: 60 marks, Total: 100 marks, Credit per paper – 6: Theory-4, Practical-2, Teaching hours per paper – 40 hours theory classes + 20 hours practical classes

Discipline Specific Core Paper I

CELL BIOLOGY & GENETICS

Unit-I

Unit-II
Extracellular Matrix: Composition, molecules that mediate cell adhesion, membranes receptors for extra cellular matrix, macromolecules, regulation of receptors expression and function. Signal transduction.

Structure and functions; Lysosomes, Vacuoles and micro bodies, Ribosomes, Mitochondria, Chloroplasts, Nucleus: Chromosomes and their structure.

Unit-III
Historical developments in the field of genetics. Organisms suitable for genetic experimentation and their genetic significance. Cell Cycle: Mitosis and Meiosis: Control

**Unit-IV**

**Practical:**
1. Study of plasmolysis and de-plasmolysis.
2. Study of structure of any prokaryotic Eukaryotic cell.
3. Microtomy: Fixation, Block making, Section cutting, Double staining of animal tissues like liver, Oesphagus, Stomach, pancreas, Intestine, Kidney, Ovary, testes.
5. Preparation of Nuclear, mitochondria & cytoplasmic fractions.
7. Karyotyping with the help of photographs.

**Text Books:**

**Suggested Readings**

**Discipline Specific Core Paper 2**

**MOLECULAR BIOLOGY**
Unit-I
DNA structure and replication: DNA as genetic material, Structure of DNA, Types of DNA, Nucleosome, Packaging of DNA molecule into chromosomes, Replication of DNA in prokaryotes and eukaryotes: Semiconservative nature of DNA replication, Bi-directional replication, The replication complex: Unique aspects of eukaryotic chromosome replication, Fidelity of replication.

Unit-II
DNA damage, repair and homologous recombination: DNA damage and repair: causes and types of DNA damage, mechanism of DNA repair: Homologous recombination: models and mechanism.

Unit-III
Transcription and RNA processing: RNA structure and types of RNA, Transcription in prokaryotes: Prokaryotic RNA polymerase, role of sigma factor, promoter, Initiation, elongation and termination of RNA chains Transcription in eukaryotes: Eukaryotic RNA polymerases, transcription factors, mechanism of transcription initiation, RNA splicing and processing.

Unit-IV
Prokaryotic and eukaryotic translation: ribosome structure and assembly, Charging of tRNA, aminoacyl tRNA synthetases, Mechanism of initiation, elongation and termination of polypeptides, Post translational modifications of proteins, Regulation of gene expression and translation: Regulation of gene expression in prokaryotes: Operon concept

Practical:
1. Preparation of solutions for Molecular Biology experiments.
2. Isolation of chromosomal DNA from animal/bacterial cells.
3. Agarose gel electrophoresis of genomic DNA.
4. Quantitation of DNA by Spectrophotometry.
5. Extraction of protein.
6. SDS PAGE and Native PAGE.

Text Book:

Suggested Readings:
1. Cell and Molecular Biology - By Robertis&Robertis, Publ: Waverly
2. Genes - By B. Lewin - Oxford Univ. Press

Discipline Specific Core Paper 3

BIO-CHEMISTRY AND METABOLISM
Unit-I

Unit-II
Amino acid & Proteins: Structure and properties of Amino acids, Types of Proteins and their Classification, Different levels of structural organization of proteins, Fibrous and globular proteins. Enzymes: Nomenclature and classification of Enzymes.

Unit-III

Unit-IV

Practical:
1. To study activities of any enzyme under optimum conditions.
2. Preparation of buffers.
4. Qualitative and quantitative tests for Carbohydrates and lipids.
5. Qualitative and quantitative estimation of proteins.

Text Book:

Suggested Readings:
5. Biochemistry, 4th edition by U Satyanarayana and U Chakrapani, Elsevier India

Discipline Specific Core Paper 4
GENETIC ENGINEERING

Unit-I
Molecular tools and applications- restriction enzymes, ligases, polymerases, alkaline phosphatase. Gene Recombination and Gene transfer: Transformation, Episomes, Plasmids and other cloning vectors (Bacteriophage-derived vectors, artificial chromosomes), Microinjection, electroporation, Ultrasonication, PCR, primer-design, Reverse transcription PCR.

Unit-II
Restriction and modification system, restriction mapping. Southern and Northern hybridization. Preparation and comparison of Genomic and cDNA library, screening of recombinants, reverse transcription, Genome mapping, DNA fingerprinting, Applications of Genetic Engineering Genetic.

Unit-III
Random and site-directed mutagenesis: Primer extension and PCR based methods of site directed mutagenesis, Random mutagenesis, Gene shuffling, production of chimeric proteins, Protein engineering

Unit-IV
Genetic engineering in plants: Use of Agrobacterium tumefaciens and A. rhizogenes, Ti plasmids, Strategies for gene transfer to plant cells, Direct DNA transfer to plants, Gene targeting in plants.

Practical:
1. Isolation of chromosomal DNA from plant cells
2. Isolation of chromosomal DNA from E.coli
3. Qualitative and quantitative analysis of DNA using spectrophotometer
4. Plasmid DNA isolation
5. Restriction digestion of DNA
6. Demonstration of PCR

Text Book:

Suggested Readings:
5. Biotechnology by B.D.Singh (Kalyani Publishers).
Discipline Specific Elective Paper I

BIOTECHINIQUES

Unit-I
Simple microscopy, phase contrast microscopy, fluorescence and electron microscopy (TEM and SEM), pH meter, absorption and emission spectroscopy.

Unit-II
Principle and law of absorption fluorimetry, Colorimetry, Spectrophotometry (visible, UV, infrared), Centrifugation, Cell Fractionation Techniques, isolation of sub-cellular organelles.

Unit-III
Introduction to the principle of chromatography. Paper chromatography, thin layer chromatography, column chromatography: silica and gel filtration, affinity and ion exchange chromatography, gas chromatography, HPLC.

Unit-IV
Introduction to electrophoresis, polyacrylamide gel (native and SDS-PAGE), agarose-gel electrophoresis, immuno- electrophoresis, isoelectric focusing, Western blotting.

Practical:
1. Native gel electrophoresis of proteins.
2. Determination of absorption maxima of given chemicals.
3. SDS-polyacrylamide slab gel electrophoresis of proteins under reducing conditions.
4. Separation of amino acids by paper chromatography.
5. To identify lipids in a given sample by TLC.
6. To verify the validity of Beers law and determine the molar extinction coefficient of NADH.

Text Book:

Suggested Readings:
3. An introduction to Practical Biochemistry - T. Plummer
4. Experimental Biochemistry- V. Deshpande and B. Sasidhar Rao (A Student Companion)
5. Biophysics – Vastala Piramal (Dominent Publishers)
Discipline Specific Elective Paper I

BIOINFORMATICS

Unit I
History of Bioinformatics. The notion of Homology. Sequence Information Sources, EMBL, GENBANK, Entrez, Unigene, Understanding the structure of each source and using it on the web.

Unit II
Protein Information Sources, PDB, SWISSPROT, TREMBL, Understanding the structure of each source and using it on the web. Introduction of Data Generating Techniques and Bioinformatics problem

Unit-III
Sequence and Phylogeny analysis, Detecting Open Reading Frames, Introduction to BLAST, using it on the web, Outline of sequence Assembly, Pairwise Alignments, Interpreting results, Multiple Sequence Alignment.

Unit-IV
Searching Databases: SRS, Entrez, Sequence Similarity Searches-BLAST, FASTA, Data Submission. Genome Annotation: Pattern and repeat finding, Gene identification tools.

Practical:
1. Sequence information resource
2. Understanding and use of various web resources: EMBL, Genbank, Entrez, Unigene, Protein information resource (PIR)
3. Understanding and using: PDB, Swissprot, TREMBL
4. Using various BLAST and interpretation of results.
5. Retrieval of information from nucleotide databases.
6. Sequence alignment using BLAST.
7. Multiple sequence alignment using Clustal W.

Text Book:

Suggested Readings:
Four Optional SEC II Papers on BIOTECHNOLOGY:
Enzymology/ Basics of Forensic Science/ Mushroom culture/ Sericulture

Marks per paper - Midterm: 15 marks, Practical: 25 marks, End term: 60 marks, Total: 100 marks, Credit per paper – 6, Theory: 4 credits, Practical: 2 credits, Teaching hours per paper – 40 hours theory classes + 20 hours practical classes

Optional SEC II Paper 1
ENZYMEOLOGY

Unit - I
Isolation, crystallization and purification of enzymes, test of homogeneity of enzyme preparation, methods of enzyme analysis. Enzyme classification (rationale, overview and specific examples) Zymogens and their activation (Proteases and Prothrombin). Enzyme substrate complex: concept of E-S complex, binding sites, active site, specificity, Kinetics of enzyme activity, Michaelis-Menten equation and its derivation, Different plots for the determination of Km and Vmax and their physiological significance, factors affecting initial rate, E, S, temp. & pH. Collision and transition state theories, Significance of activation energy and free energy.

Unit – II

Unit – III

Unit – IV
Practical:
1. Purification of an enzyme from any natural resource
2. Quantitative estimation of proteins by Bradford/Lowry’s method.
3. Perform assay for the purified enzyme.
4. Calculation of kinetic parameters such as Km, Vmax, Kcat

Suggested Readings:
2. Harper’s illustrated Biochemistry by Robert K. Murray, David A Bender, Kathleen

Optional SEC II Paper 2

BASICS OF FORENSIC SCIENCE

Unit I
Introduction and principles of forensic science, forensic science laboratory and its organization and service, tools and techniques in forensic science, branches of forensic science, causes of crime, role of modus operandi in criminal investigation. Classification of injuries and their medico-legal aspects, method of assessing various types of deaths.

Unit II
Classification of fire arms and explosives, introduction to internal, external and terminal ballistics. Chemical evidence for explosives. General and individual characteristics of handwriting, examination and comparison of handwritings and analysis of ink various samples.

Unit III
Role of the toxicologist, significance of toxicological findings, Fundamental principles of fingerprinting, classification of fingerprints, development of finger print as science for personal identification,

Unit IV

Practical:
1. Documentation of crime scene by photography, sketching and field notes.
2. a. Simulation of a crime scene for training.
   b. To lift footprints from crime scene.
3. Case studies to depict different types of injuries and death.
4. Separation of nitro compounds (explosives)/ ink samples by thin layer chromatography.
5. Investigate method for developing fingerprints by Iodine crystals.
6. PCR amplification on target DNA and DNA profiling.
7. E-Mail Investigation, E-Mail Tracking, IP Tracking, E-Mail Recovery, Recovering deleted evidences, Password Cracking

**Suggested Readings:**

**Optional SEC II Paper 3**

**MUSHROOM CULTURE**

**Unit I**
Introduction, history of mushroom cultivation; biology of mushrooms; Nutritional value: (Proteins, amino acids, mineral elements, carbohydrates, fibers, vitamins); Medicinal value of mushrooms; Poisonous mushrooms and mushroom poisoning; edible mushrooms and cultivation in India and world; Mycorrhizal mushrooms and their role in plant growth

**Unit II**
Cultivation Technology: Infrastructure, equipments and substrates in mushroom cultivation: Polythene bags, vessels, inoculation hook, inoculation loop, love cost stove, sieves, culture racks, mushroom unit or mushroom house, water sprayer, tray, boilers, driers, pure culture, Spawn: types of spawn, preparation of spawn, mushroom bed preparation and factors affecting mushroom bed preparation; Compost: materials used for compost preparation, compost technology in mushroom production

**Unit III**
Casing; raw material used for casing, preparation of casing material; important sanitation during various stages of mushroom cultivation, Cultivation of important mushrooms: General process for the cultivation of *Agaricus bisporus*, *Pleurotus ostreatus* and *Volvariella volvacea* Pests and Pathogens of mushrooms and their management with reference to *Agaricus bisporus*.

**Unit IV**
Storage and food preparation from mushrooms: Methods of storage of mushroom cultivation, Long term and short term storage of mushrooms Foods/recipes from mushrooms; Mushroom research centers/farms: National level and regional level, Marketing of mushrooms in India and world.
Reference Books:

Optional SEC II Paper 4

SERICULTURE

Unit- I:
History and scope of Sericulture: General account of global production of mulberry and non-mulberry silk, silk route, Geographical distribution of mulberry and non-mulberry sericulture, scope of sericulture in India; Types of silkworms: Life history of mulberry silkworm, growth stages of mulberry silkworm, classification of silkworm, non-mulberry silkworm’s insects.

Unit-II:
Selection of silkworm breeds for rearing, estimation of mulberry leaf yield and assessment of leaf quality, estimation of brushing capacity requirements of rearing, disinfecting silkworm rearing house and appliances, silkworm rearing house, characteristics of rearing house, selection of site, Egg handling, Incubation & Chawki rearing; Pre-incubation care of silkworm eggs, incubation, black boxing, hatching, brushing of larvae, Late age silkworm rearing; Characteristics of late age silkworms, rearing methods, tray rearing, shelf rearing, floor rearing, advantages and disadvantages of shoot feeding and floor rearing, environmental conditions for silkworm rearing, leaf harvest, transportation and preservation, leaf quality and quantity, late age rearing, mechanization in silkworm rearing; Non- mulberry silkworm rearing; Tasar Silkworm Rearing, Oak Tasar Silkworm Rearing, Eri Silkworm Rearing, Muga Silkworm Rearing

Unit-III:
Silkworm seed technology : Silkworm egg production, embryonic development, diapause and non-diapause eggs, acid treatment, incubation of eggs in grainages through incubation chambers and related aspects; Silk Technology: Textile fibers: brief introduction to natural and synthetic fibers silk industry: general silk industry in various states of India cocoons: assessment of cocoon properties, silk reeling, cocoon stifling storage & preservation of cocoons in silk reeling units, cocoon cooking, silk reeling and re-reeling, raw silk testing, spun silk yarn, silk weaving;

Unit-IV:
Mulberry and Non-Mulberry food plants diseases and their management: Types of mulberry diseases, foliar diseases of mulberry and their management, leaf spot disease, powdery mildew disease, leaf rust disease, leaf blight disease, preparation of the spray solution, fungicides and their toxicity, equipments used for spraying the fungicides, precautions to be taken while spraying the fungicides, soil-borne diseases of mulberry, nursery diseases, root knot disease, root rot disease, types of diseases of non-mulberry silkworm host plants,
diseases of tropical tasar silkworm host plants, diseases of oak tasar silkworm host plants, diseases of muga silkworm host plants, diseases of eri silkworm host plants, tips on fungicides, Integrated disease management (IDM).

References Books:

***************************************************************************
### List of Minimum Instruments required for conducting Practicals

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Subject and Practical</th>
<th>Instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C-1: MICROBIOLOGY</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Isolation of bacteria &amp; their biochemical characterization.</td>
<td>1. Laminar Air Flow Bench</td>
</tr>
<tr>
<td></td>
<td>2. Staining methods: simple staining, Gram staining, spore staining, negative staining, hanging drop.</td>
<td>2. Incubator</td>
</tr>
<tr>
<td></td>
<td>3. Preparation of media &amp; sterilization methods,</td>
<td>3. Autoclave</td>
</tr>
<tr>
<td></td>
<td>4. Methods of Isolation of bacteria from different sources.</td>
<td>4. Microscope</td>
</tr>
<tr>
<td></td>
<td>5. Determination of bacterial cell size by micrometry.</td>
<td>5. TL Chromatography Jar</td>
</tr>
<tr>
<td></td>
<td>6. Enumeration of microorganism - total &amp; viable count.</td>
<td>6. Hot air oven</td>
</tr>
<tr>
<td></td>
<td>C-2: PLANT DIVERSITY AND PHYSIOLOGY</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. To study and plot the growth curve of <em>E. coli</em> using turbidometric method and to calculate specific growth rate and generation time.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. To study and plot the growth curve of <em>Aspergillus niger</em> by radical growth measurement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. To study the effect of pH on the growth of <em>E. coli</em>.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. To study the effect of temperature of <em>A. niger</em> by dry weight method &amp; demonstration of the thermal death time and decimal reduction time of <em>E. coli</em>.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Separation of photosynthetic pigment by paper chromatography</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DSE-1: BIOTECHNIQUES</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Separation of amino acids by paper chromatography.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. To identify lipids in a given sample by TLC.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GE-II: RECOMBINANT DNA TECHNOLOGY</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Identification of pathogenic bacteria (any two) based on cultural, morphological</td>
<td></td>
</tr>
</tbody>
</table>
and biochemical characteristics.

<table>
<thead>
<tr>
<th>2</th>
<th>C-3: CELL BIOLOGY AND GENETICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Cell fractionation and determination of enzyme activity in organelles using sprouted seed or any other suitable source.</td>
</tr>
<tr>
<td>2.</td>
<td>Preparation of Nuclear, mitochondria &amp; cytoplasmic fractions.</td>
</tr>
<tr>
<td>3.</td>
<td>Microtomy: Fixation, Block making, Section cutting, Double staining of animal tissues like liver, Oesophagus, Stomach, pancreas, Intestine, Kidney, Ovary, testes.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>DSE-1: BIOTECHNIQUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Preparation of the sub-cellular fractions of rat liver cells.</td>
</tr>
<tr>
<td>2.</td>
<td>Preparation of protoplasts from leaves.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3</th>
<th>C-4: ANIMAL DIVERSITY AND PHYSIOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Counting of mammalian RBCs.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>C-8: IMMUNOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Differential leucocytes count.</td>
</tr>
<tr>
<td>2.</td>
<td>Total leucocytes count.</td>
</tr>
<tr>
<td>3.</td>
<td>Total RBC count</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4</th>
<th>C-5: MOLECULAR BIOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Isolation of chromosomal DNA from bacterial cells.</td>
</tr>
<tr>
<td>2.</td>
<td>Isolation of Plasmid DNA by alkaline lysis method</td>
</tr>
<tr>
<td>3.</td>
<td>Agarose gel electrophoresis of genomic DNA &amp; plasmid DNA.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>GE-II: RECOMBINANT DNA TECHNOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Isolation of chromosomal DNA from plant cells</td>
</tr>
<tr>
<td>2.</td>
<td>Isolation of chromosomal DNA from E.coli</td>
</tr>
<tr>
<td>3.</td>
<td>Qualitative and quantitative analysis of DNA using spectrophotometer</td>
</tr>
<tr>
<td>4.</td>
<td>Plasmid DNA isolation</td>
</tr>
<tr>
<td>5.</td>
<td>Restriction digestion of DNA</td>
</tr>
</tbody>
</table>

1. Centrifuge
2. Microtome
3. Compound Microscope

1. Haemocytometer
2. Microscope

1. Haemocytometer
2. Microscope

1. Centrifuge
2. Agarose gel casting tray and running Unit with powerpack
3. UV Transilluminator

41
### C-6: BIOCHEMISTRY & METABOLISM

1. To study activities of any enzyme under optimum conditions.
2. To study the effect of pH, temperature on the activity of salivary amylase enzyme.
3. Determination of pH optima, temperature optima, $K_m$ value, $V_{max}$ value, Effect of inhibitor (Inorganic phosphate) on the enzyme activity.

| 1. pH meter |
| 2. Water Bath |
| 3. Spectrophotometer/Colorimeter |
| 4. Digital balance |

### C-7- BIOSTATISTICS AND COMPUTER APPLICATIONS

1. DOS commands (Internal & External)
2. Some basic programs in C
3. Programs on Decision making branching
4. Programs Decision making Looping
5. Programs on operators

### DSE-2: BIOINFORMATICS

1. Sequence information resource
2. Understanding and use of various web resources: EMBL, Genbank, Entrez, Unigene, Protein information resource (PIR)
3. Understanding and using: PDB, Swissprot, TREMBL
4. Using various BLAST and interpretation of results.
5. Retrieval of information from nucleotide databases.
6. Sequence alignment using BLAST.
7. Multiple sequence alignment using Clustal W.

### C-9,C-10: PLANT AND ANIMAL BIOTECHNOLOGY,

**C-13: BIO-ETHICS AND BIO-SAFETY**

1. Primary culture of animal cells: Aspetic techniques, selection and isolation of organs, disaggregation (mechanical/enzymatic), seeding
2. Cell counting and cell viability

<p>| 1. Biosafety cabinet |
| 2. CO₂ Incubator |
| 3. Inverted microscope |
| 4. Laminar hood |</p>
<table>
<thead>
<tr>
<th></th>
<th>3. Preparation of plant tissue culture medium</th>
<th>Organ culture, Callus propagation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td><strong>GE-II: RECOMBINANT DNA TECHNOLOGY</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Demonstration of PCR</td>
<td>1. Polymerase chain reaction (PCR) machine</td>
</tr>
<tr>
<td>9</td>
<td><strong>DSE-1: BIOTECHNIQUES</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Native gel electrophoresis of proteins</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. SDS-polyacrylamide slab gel electrophoresis of proteins under reducing conditions.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>C-12: GENOMICS &amp; PROTEOMICS</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Native PAGE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. SDS-PAGE</td>
<td></td>
</tr>
</tbody>
</table>

***************************************************************************
## Faculty Training on Biotechnology Syllabus (21 Days)

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Subjects</th>
<th>Practicals (Hands on training/Demonstration)</th>
<th>Theory (hrs)</th>
<th>Practicals (hrs)</th>
<th>Numbers of Days</th>
</tr>
</thead>
</table>
| 1       | Microbiology                    | • Isolation of bacteria & their biochemical characterization.  
• Staining methods: simple staining, Gram staining, spore staining, negative staining, hanging drop.         | 4            | 6               | 2               |
| 2       | Cell Biology and Genetics       | • Study of structure of any prokaryotic Eukaryotic cell.  
• Microtomy: Fixation, Block making, Section cutting, Double staining of animal tissues  
• Cell division in onion root tip/insect gonads.                                                   | 4            | 6               | 2               |
| 3       | Molecular Biology               | • Isolation of chromosomal DNA from animal/bacterial cells.  
• Agarose gel electrophoresis of genomic DNA.  
• Quantitation of DNA by Spectrophotometry.  
• SDS-PAGE and Native PAGE                                                                          | 4            | 6               | 2               |
| 4       | Biochemistry and Metabolism     | • To study activities of any enzyme under optimum conditions.  
• Separation of Amino acids by paper chromatography.  
• Qualitative and quantitative tests for Carbohydrates and lipids.  
• Qualitative and quantitative estimation of proteins.                                                | 4            | 6               | 2               |
| 5       | Immunology                      | • Differential leucocytes count.  
• Total RBC count.  
• Haemagglutination assay  
• Haemagglutination inhibition assay.                                                                  | 4            | 6               | 2               |
| 6       | Plant Biotechnology             | • Preparation of complex nutrient medium (Murashige& Skoog’s medium)  
• To demonstrate various steps of Micropropagation                                                   | 4            | 6               | 2               |
<table>
<thead>
<tr>
<th></th>
<th>Animal Biotechnology</th>
<th>Cell counting and cell viability</th>
<th>Cell culture techniques</th>
<th>2</th>
<th>3</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Enzymology</td>
<td>Purification of an enzyme from any natural resource</td>
<td>Perform assay for the purified enzyme. Calculation of kinetic parameters such as Km, Vmax, Kcat</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>Genetic Engineering</td>
<td>Isolation of chromosomal DNA Qualitative and quantitative analysis of DNA Plasmid DNA isolation Restriction digestion of DNA Demonstration of PCR</td>
<td>4</td>
<td>6</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Biotechniques</td>
<td>Native gel electrophoresis of proteins Determination of absorption maxima of given chemicals To identify lipids in a given sample by TLC.</td>
<td>4</td>
<td>6</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Bioinformatics</td>
<td>Sequence information resource Understanding and use of various web resources: EMBL, Genbank, Entrez, Unigene, Protein information resource (PIR) Understanding and using: PDB, Swissprot, TREMBL Using various BLAST and interpretation of results Retrieval of information from nucleotide databases Sequence alignment using BLAST Multiple sequence alignment using Clustal W.</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Bioprocess Engineering and Technology</td>
<td>Comparative analysis of design of a batch and continuous fermenter Calculation of Mathematical derivation of growth kinetics.</td>
<td>4</td>
<td>6</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>