# SAGE University, Bhopal

## School of Sciences

# M.Sc. (BIOTECHNOLOGY)

II Year Syllabus

SESSION: 2020-21

## PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

**PEO1:** Understand and apply the concepts of Biology, Biotechnology, and Instrumentation for pursuing higher studies and successful careers in the industry.

**PEO2**: Apply the acquired theoretical skills in the broad area of biotechnology for the development of society.

**PEO3:** Participate in individual and team-oriented, activities aiding constructive thinking to work on multidisciplinary projects.

**PEO4:** Demonstrate professional and ethical attitude with the awareness of current issues that impact social entailment of their work, including its impact on safety, health, and the environment for sustainable development.

**PEO5:** To promote awareness of continuous education and to introduce them to professional ethics and codes of professional practice.

## PROGRAMME OUTCOMES (POs)

On completion of the program, the students will have:

**PO1:** An ability to apply knowledge of Biotechnology, Science, and Mathematics.

**PO2:** An ability to design and conduct experiments, as well as to analyze and interpret data.

**PO3:**An ability to design a system, component, or process to meet desired needs within realisticconstraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

**PO4:** An ability to identify, formulates, and thinks critically to analyze results and discussions of the experimental outcome to solve biotechnological problems.

**PO5:** An ability to function with multidisciplinary teams and maintain integrity in performing work as a member or leader.

**PO6:** Make decisions and judgments by drawing logical conclusions using sound quantitative and statistically-based reasoning.

**PO7:**They should be able to assess the elements of a problem and develop and test a solution based on logic and the best possible information.

**PO8:** Articulate about issues relating to the subject with peers/ team members/other stakeholders, and undertakes remedial measures/studies, etc.

**PO9:**The broad educationis necessary to understand the impact of Biotechnology solutions in a global, economic, environmental, and societal context.

**PO10:** Comprehensive knowledge of biotechnology and skills to analyze problems involving different biological techniques.

# CURRICULUM COMPONENTS OF M. Sc. BIOTECHNOLOGY

| Components | Credits |
|---|---|
| Program Core (18 Courses) | **72** |
| Program Elective (Discipline Electives) (06Courses) | **24** |
| Program Elective (Generic Electives) (04 Courses) | **08** |
| Ability & Skill Development (Ability Enhancement Courses) (04 Courses) | **10** |
| Ability & Skill Development (Skill Enhancement Courses) (06 Courses) | **12** |
| Project-Based Learning (PBL)/MOOCs (04 courses) | **08** |
| Project (02 Courses) | **10** |
| **Total** | **144** |

# SCHEME

# M. Sc. (BIOTECHNOLOGY)

| | Semester First | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Code** | **Course Title** | **Contact Hours per Week** | | | **Credits** | **ESE Duration (Hours)** | **Weightage (Theory)** | | | | | | **Weightage (Practical)** | | | **Total** |
| | | **L** | **T** | **P** | | | **MSE** | **ASG** | **TA** | **ATTD** | **ESE** | **TOT** | **CE^** | **ESE** | **TOT** | **GT** |
| **BT20M101** | Biochemistry | 4 | - | - | 4 | 3 | 30 | 05 | 05 | 10 | 50 | 100 | - | - | - | 100 |
| **BT20M102** | Cell and Molecular Biology | 4 | - | - | 4 | 3 | 30 | 05 | 05 | 10 | 50 | 100 | - | - | - | 100 |
| **BT20M103** | Biochemical and Molecular Techniques | 4 | - | - | 4 | 3 | 30 | 05 | 05 | 10 | 50 | 100 | - | - | - | 100 |
| **BT20M104** | Microbiology | 2 | - | - | 2 | 3 | 30 | 05 | 05 | 10 | 50 | 100 | - | - | - | 100 |
| **BT20M105** | Genetics | 2 | - | - | 2 | 3 | 30 | 05 | 05 | 10 | 50 | 100 | - | - | - | 100 |
| **Refer Table 1** | DSE- I | 3 | - | - | 3 | 3 | 30 | 05 | 05 | 10 | 50 | 100 | - | - | - | 100 |
| **BT20M108** | LAB- I | - | - | 4 | 2 | 2 | - | - | - | - | - | - | 50 | 50 | 100 | 100 |
| **BT20M109** | LAB- II | - | - | 4 | 2 | 2 | - | - | - | - | - | - | 50 | 50 | 100 | 100 |
| **PB20M101** | Project Based Learning- I | - | - | 4 | 2 | 2 | - | - | - | - | - | - | 50 | 50 | 100 | 100 |
| **Total** | | | | | **25** | | | | | | | | | | | **900** |

^Two assessment by panel of expert

**L-Lecture, T-Tutorial, P-Practical, ESE-End Semester Exam. MSE- Mid Semester Exam, ASG- Assignment, TA- Teacher's Assessment, ATTD-Attendance, TOT-Total, CE-Continuous Evaluation, GT- Grand Total.**

| | Semester Second | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Code** | **Course Title** | **Contact Hours per Week** | | | **Credits** | **ESE Duration (Hours)** | **Weightage (Theory)** | | | | | | **Weightage (Practical)** | | | **Total** |
| | | **L** | **T** | **P** | | | **MSE** | **ASG** | **TA** | **ATTD** | **ESE** | **TOT** | **CE^** | **ESE** | **TOT** | **GT** |
| **BT20M201** | Immunology | 4 | - | - | 4 | 3 | 30 | 05 | 05 | 10 | 50 | 100 | - | - | - | 100 |
| **BT20M202** | Bioinformatics | 4 | - | - | 4 | 3 | 30 | 05 | 05 | 10 | 50 | 100 | - | - | - | 100 |
| **BT20M203** | Genetic Engineering | 4 | - | - | 4 | 3 | 30 | 05 | 05 | 10 | 50 | 100 | - | - | - | 100 |
| **BT20M204** | Genomics and Proteomics | 2 | - | - | 2 | 3 | 30 | 05 | 05 | 10 | 50 | 100 | - | - | - | 100 |
| **BT20M205** | Molecular Diagnostics | 2 | - | - | 2 | 3 | 30 | 05 | 05 | 10 | 50 | 100 | - | - | - | 100 |
| **Refer Table 2** | DSE- II | 3 | - | - | 3 | 3 | 30 | 05 | 05 | 10 | 50 | 100 | - | - | - | 100 |
| **BT20M208** | LAB- III | - | - | 4 | 2 | 2 | - | - | - | - | - | - | 50 | 50 | 100 | 100 |
| **BT20M209** | LAB- IV | - | - | 4 | 2 | 2 | - | - | - | - | - | - | 50 | 50 | 100 | 100 |
| **PB20M201** | Project Based Learning- II | - | - | 4 | 2 | 2 | - | - | - | - | - | - | 50 | 50 | 100 | 100 |
| **Total** | | | | | **25** | | | | | | | | | | | **900** |

^Two assessment by panel of expert

**L-Lecture, T-Tutorial, P-Practical, ESE-End Semester Exam. MSE- Mid Semester Exam, ASG- Assignment, TA- Teacher's Assessment, ATTD-Attendance, TOT-Total, CE-Continuous Evaluation, GT- Grand Total**

| | Semester Third | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Code** | **Course Title** | **Contact Hours per Week** | | | **Credits** | **ESE Duration (Hours)** | **Weightage (Theory)** | | | | | | **Weightage (Practical)** | | | **Total** |
| | | **L** | **T** | **P** | | | **MSE** | **ASG** | **TA** | **ATTD** | **ESE** | **TOT** | **CE^** | **ESE** | **TOT** | **GT** |
| **BT20M301** | Bioprocess Engineering and Technology | 4 | - | - | 4 | 3 | 30 | 05 | 05 | 10 | 50 | 100 | - | - | - | 100 |
| **BT20M302** | Critical Analysis of Classical Papers and Emerging Technologies | 4 | - | - | 4 | 3 | 30 | 05 | 05 | 10 | 50 | 100 | - | - | - | 100 |
| **BT20M303** | Plant and Animal Biotechnology | 4 | - | - | 4 | 3 | 30 | 05 | 05 | 10 | 50 | 100 | - | - | - | 100 |
| **BT20M304** | Bio-entrepreneurship | 4 | - | - | 4 | 3 | 30 | 05 | 05 | 10 | 50 | 100 | - | - | - | 100 |
| **Refer Table 3** | DSE- III | 3 | - | - | 3 | 3 | 30 | 05 | 05 | 10 | 50 | 100 | - | - | - | 100 |
| **BT20M309** | LAB- V | - | - | 8 | 4 | 2 | - | - | - | - | - | - | 100 | 100 | 200 | 200 |
| **PB20M301** | Project Based Learning- III | - | - | 4 | 2 | 2 | - | - | - | - | - | - | 50 | 50 | 100 | 100 |
| **Total** | | | | | **25** | | | | | | | | | | | **800** |

^Two assessment by panel of expert

**L-Lecture, T-Tutorial, P-Practical, ESE-End Semester Exam. MSE- Mid Semester Exam, ASG- Assignment, TA- Teacher's Assessment, ATTD-Attendance, TOT-Total, CE-Continuous Evaluation, GT- Grand Total**

| | Semester Fourth | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Code** | **Course Title** | **Contact Hours per Week** | | | **Credits** | **ESE Duration (Hours)** | **Weightage (Theory)** | | | | | | **Weightage (Practical)** | | | **Total** |
| | | **L** | **T** | **P** | | | **MSE** | **ASG** | **TA** | **ATTD** | **ESE** | **TOT** | **CE^** | **ESE** | **TOT** | **GT** |
| **Refer Table 4** | DSE-IV/ MOOC- I | 4 | - | - | 4 | 2 | 30 | 05 | 05 | 10 | 50 | 100 | - | - | - | 100 |
| **BT20M402** | Project | - | - | 40 | 20 | 2 | - | - | - | - | - | - | 250 | 250 | 500 | 500 |
| **Total** | | | | | **24** | | | | | | | | | | | **600** |

^Two assessment by panel of expert

**L-Lecture, T-Tutorial, P-Practical, ESE-End Semester Exam. MSE- Mid Semester Exam, ASG- Assignment, TA- Teacher's Assessment, ATTD-Attendance, TOT-Total, CE-Continuous Evaluation, GT- Grand Total**

# LIST OF DISCIPLINE SPECIFIC ELECTIVES (DSE)

| Table 1: Semester One (DSE- I) | | |
|---|---|---|
| **S.No.** | **Course Code** | **Course Title** |
| 1. | **BT20M106** | Microbial Genetics |
| 2. | **BT20M107** | Statistics and Computer Application for Biologists |

| Table 2: Semester Second(DSE- II) | | |
|---|---|---|
| **S.No.** | **Course Code** | **Course Title** |
| 1. | **BT20M206** | Microbial Enzyme Technology |
| 2. | **BT20M207** | R Programming |

| Table 3:Semester Third(DSE- III) | | |
|---|---|---|
| **S.No.** | **Course Code** | **Course Title** |
| 1. | **BT20M307** | Intellectual Property Rights, Bio-safety and Bioethics |
| 2. | **BT20M308** | Environmental Biotechnology |

| Table 4: Semester Fourth (DSE- IV) | | |
|---|---|---|
| **S.No.** | **Course Code** | **Course Title** |
| 1. | **BT20M401** | Nanotechnology |
| 2. | **BT20M403** | Pharmaceutical and Drug Designing |
| | | MOOC-I |

# Syllabus
# SEMESTER I

**Core Course-I**

| COURSE CODE | BIOCHEMISTRY | Total Lec.:60 |
|---|---|---|
| **BT20M101** | | **4-0-0** |
| **Learning Objectives** | • This course enables student to understand fundamental principles of biochemistry.<br>• Basic structure and function of biomolecules is discussed.<br>• The cellular chemistry interplay of amino acid structure and chemistry, protein structure, carbohydrate chemistry, nucleic acid chemistry, enzyme kinetics and enzyme inhibition.<br>• Lipid biochemistry is discussed in biological context. | |
| **Pre-requisite** | Nil. | |

| UNIT | CONTENT | HOURS |
|---|---|---|
| **I** | Chemical basis of life:Miller-Urey experiment, abiotic formation of amino acid oligomers, composition of living matter; Water – properties of water, essential roleof water for life on earth pH, buffer, maintenance of blood pH and pH of gastric juice, pH optima of different enzymes (pepsin, trypsin and alkaline phosphatase), ionization and hydrophobicity, emergent properties of biomolecules in water, biomolecular hierarchy, macromolecules, molecular assemblies. | 10 |
| **II** | Protein Structure: Structure-function relationships: amino acids – structure and functional group properties, peptides and covalent structure of proteins, elucidation of primary and higher order structures, Ramachandran plot, evolution of protein structure, protein degradation and introduction to molecular pathways controlling protein degradation, structure-function relationships in model proteins like ribonucleaseA, myoglobin,hemoglobin, chymotrypsin *etc*.; basic principles of protein purification; tools to characterize expressed proteins; Protein folding: Anfinsen's Dogma, Levinthal paradox, co-operativity in protein folding, free energy landscape of protein folding and pathways of protein folding, molten globule state, chaperons, diseases associated with protein folding, introduction to molecular dynamic simulation. | 10 |
| **III** | Enzyme Kinetics: Enzyme catalysis – general principles of catalysis; quantitation of enzyme activity and efficiency; enzyme characterization and Michaelis-Menten kinetics; relevance of enzymes in metabolic regulation, activation, inhibition and covalent modification; single substrate enzymes; concept of catalytic antibodies; catalytic strategies with specific examples of proteases, carbonic anhydrases, restriction enzymes and nucleoside monophosphate kinase; regulatory strategies with specific example of hemoglobin; isozymes; role of covalent modification in enzymatic activity; zymogens. | 15 |
| **IV** | Biomolecules:Sugars - mono, di, and polysaccharides with specific reference to glycogen, amylose and cellulose, glycosylation of other biomolecules - glycoproteins and glycolipids; lipids - structure and properties of important members of storage and membrane lipids; lipoproteins. Self-assembly of lipids, micelle, biomembrane organization - sidedness and function; membrane bound proteins - structure, properties and function; transport phenomena ;nucleosides, nucleotides, nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical structure; difference in RNA and DNA structure and their importance in evolution of DNA as the genetic material | 10 |
| **V** | Bioenergetics-basic principles: equilibria and concept of free energy; coupledinterconnecting reactions in metabolism; oxidation of carbon fuels; recurring motifs in metabolism; Introduction to GPCR, Inositol/ DAG/PKC and Ca++ signaling pathways; glycolysis and gluconeogenesis; reciprocal regulations and non-carbohydrate sources of glucose; Citric acid cycle, entry to citric acid cycle, citric acid cycle as a source of biosynthetic precursors; Oxidative phosphorylation; importance of electron transferinoxidative phosphorylation; F1-F0 ATP Synthase; shuttles across mitochondria; regulation of oxidative phosphorylation; Photosynthesis – chloroplasts and two | 15 |

| | | |
|---|---|---|
| | photosystems; proton gradient across thylakoid membrane; Calvin cycle and pentosephosphate pathway; glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, roles of epinephrine and glucagon and insulin in glycogen metabolism; Fatty acid metabolism; protein turnover and amino acid catabolism; nucleotide biosynthesis; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and mevalonate pathway; elucidation of metabolic pathways; logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; principles of metabolic regulation; steps for regulation. | |

| **Course Outcomes as per Bloom's Taxonomy** | |
|---|---|
| **CO1** | Students will **understand**[2] the basic role of carbohydrates, lipids, nucleic acids, and proteins in living organisms and the chemical basis of life |
| **CO2** | Students will**understand**[2]the relationship between chemical structure and biological function |
| **CO3** | They will **correlate** structure-function aspects and evaluate to metabolism |
| **CO4** | They will **understand**[2]the chemistry behind reactions occurring in living systems |
| **CO5** | Students will be able to **correlate** this understanding at the organism level. |
| **Text Books:** | • J M Berg, J L Tymoczko, and L Stryer, Biochemistry, VI Edition, 2006, W.H Freeman and Co.<br>• Satyanarayana, U, Biochemistry, V Edition, 2017, Elsevier. |
| **Reference Books:** | • B Buchanan, W Gruissem, and R Jones, Biochemistry and Molecular Biology of Plants, 2000, American Society of Plant Biologists.<br>• D L Nelson, M M Cox, Lehninger Principles of Biochemistry, 4th Edition, 2004, WH Freeman and Company, New York, USA.<br>• W G Hopkins and P A Huner, Introduction to Plant Physiology, 2008, John Wiley and Sons.<br>• F B Salisbury and C W Ross, Plant Physiology, 1991, Wadsworth Publishing. |

**Core Course-II**

| COURSE CODE | CELL AND MOLECULAR BIOLOGY | Total Lec.:60 |
|---|---|---|
| **BT20M102** | | **4-0-0** |
| **Learning Objectives** | • The objectives of this course are to sensitize the students to the fact that as we go down the scale of magnitude from cells to organelles to molecules.<br>• The understanding of various biological processes becomes deeper and inclusive.<br>• A student should be equipped to understand three fundamental aspects in the biological phenomenon: a) what to seek; b) how to seek; c) why to seek? | |
| **Pre-requisites:** | **None** | |
| **UNIT** | **CONTENT** | **HOURS** |
| **I** | Dynamic Organization of a cell: Universal features of cells; cell chemistry and biosynthesis: chemical organization of cells; internal organization of the cell-cell membranes: structure of cell membranes and concepts related to compartmentalization in eukaryotic cells; intracellular organelles: endoplasmic reticulum and Golgi apparatus, lysosomes and peroxisomes,ribosomes, cellular cytoskeleton, mitochondria, chloroplasts, and cell energetics; nuclear compartment: nucleus, nucleolus, and chromosomes. | 8 |
| **II** | Chromatin Structure and dynamics: Chromatin organization - histone and DNA interact genome: structure and assembly of eukaryotic and prokaryotic DNA polymerases, DNA-replication, repair and recombination; chromatin control: gene transcription and silencing by chromatin- Writers,-Readers and –Erasers; Transcriptional control: Structure and assembly of eukaryotic and prokaryotic RNA Polymerases, promoters and enhancers, transcription factors as activators and repressors, transcriptional initiation, elongation and termination; post-transcriptional control: splicing and addition of cap and tail, mRNA flow through nuclear envelope into cytoplasm, breakdown of selective and specific mRNAs through interference by small non-coding RNAs (miRNAs and siRNAs), protein translation machinery, ribosomes-composition and assembly; universal genetic codes, degeneracy of codons, Wobble hypothesis; Iso-accepting tRNA; mechanism of initiation, elongation and termination; co- and post-translational modifications, mitochondrial genetic code translation product cleavage, modification and activation. | 12 |
| **III** | Cell Signalling and trafficking: Molecular mechanisms of membrane transport, nuclear transport, transport across mitochondria and chloroplasts; intracellular vesicular trafficking from endoplasmic reticulum through Golgi apparatus to lysosomes/cell exterior. | 10 |
| **IV** | Manipulating and studying cells: Isolation of cells and basics of cell culture; observing cells under a microscope, different types of microscopy; analyzing and manipulating DNA, RNA, and protein. | 10 |
| **V** | Cell cycle and it's regulation: cell division: mitosis, meiosis, and cytokinesis; cell differentiation: stem cells, their differentiation into different cell types and organization into specialized tissues; cell-ECM and cell-cell interactions; cell receptors and trans-membranesignaling; cell motility and migration; cell death: different modes of cell death and their regulation.Mutations, proto-oncogenes, oncogenes and tumor suppressor genes, physical, chemical, and biological mutagens; types of mutations; intra-genic and inter-genic suppression; transpositions- transposable genetic elements in prokaryotes and eukaryotes, the role of transposons in the genome; viral and cellular oncogenes; tumor suppressor genes; structure, function, and mechanism of action; activation and suppression of tumor suppressor genes; oncogenes as a transcriptional activator. | 20 |
| **Course Outcomes as per Bloom's Taxonomy** | | |
| **CO1** | Students will be able to **understand**[2] cell structure and organization. | |
| **CO2** | Students will be able to critically **evaluate**[3] the diversity in structure-function relationship of cellular components. | |
| **CO3** | They will know the scope of cell biology and **understand**[2] the flow of genetic information. | |

| | |
|---|---|
| **CO4** | Students will be able to **understand**[2] the cellcycle and implications of regulation and misregulation. |
| **CO5** | They will **apply**[5] **knowledge** gained to design experiments to manipulate cellular and molecular processes. |
| **Text Books:** | • G M Cooper, R E Hausman, The Cell: a Molecular Approach 6th edition, 2013,Sunderland.<br>• J Hardin, G Bertoni,Becker's World ofthe Cell 8th edition, L J Kleinsmith&W. M Becker, 2012, Benjamin Cummings. |
| **Reference Books:** | • B Alberts, B Johnson, A Lewis, J Raff, M Roberts, P Walter, Lewins Gene VI 2008, New York: Garland Science.<br>• H F Lodish,Molecular Cell Biology 8th edition, 2016, New York W H Freeman. |

**Core Course-III**

| COURSE CODE | BIOCHEMICAL AND MOLECULAR TECHNIQUES | Total Lec.:60 |
|---|---|---|
| **BT20M103** | | **4 – 0 –0** |
| **Learning Objectives** | • The objective of this laboratory course is to introduce students to experiments in biochemistry.<br>• The course is designed to teach students the utility of set of experimental methods in biochemistry in a problem oriented manner. | |
| **Pre-requisites** | Basics of biochemistry and molecular biology. | |

| UNIT | CONTENT | HOURS |
|---|---|---|
| **I** | Introduction to Biochemical and Molecular techniques. Microscopy:Phase contrast, con-focal, fluorescence, scanning& transmission electron microscopy. | 5 |
| **II** | Molecular analysis: DNA isolation and purification: (a) genomic and plasmid DNA, (b) RNA, (c) proteins. PCR, Principles, types of PCR. DNA sequencing: Various methods of DNA sequencing- Protocols and strategies for c-DNAcloning, analysis of genomic DNA by southern hybridization, amplification of DNA by the polymerase chain reaction, preparation of radio-labeled DNA and RNA probes, synthetic oligonucleotide probes, expression of cloned genes in cultured cells, screening expression with antibodies and oligonucleotides. Rapid DNA sequencing methods; Maxam-Gilbert technique, Sanger's Dideoxynucleotide sequencing, gene walking, foot printing, RNA sequencing. | 20 |
| **III** | Applied Molecular Techniques: Blotting: Principles, types of blotting, immune blotting-Southern, Northern, Western and Dot blots. Gene silencing: RNA interference (RNAi).Knockout, Knockdown. | 10 |
| **IV** | Biochemical Analysis: Chromatography &Spectroscopy: Gel filtration, ion exchange & affinity chromatography, TLC, HPLC, GC basic concept of Electrophoresis and Isoelectric focusing (IEF): Polyacrylamide gel electrophoresis (PAGE), agarose gel electrophoresis, Native PAGE, SDS-PAGE, 2D electrophoresis, mass spectrometry Principles, kinds of pH gradients used in IEF-free carrier ampholytes, immobilized pH gradients | 20 |
| **V** | Bioinformatics: Databases, sequence analysis, phylogenetic inference package, sites andcentres. | 5 |

| **Course Outcomes as per Bloom's Taxonomy** | |
|---|---|
| **CO1** | Students will**understand**[2]properties of biomolecules that are used for their analysis. |
| **CO2** | They will understand theprinciple**concepts** in using analytical and preparatory techniques. |
| **CO3** | Students will**understand**[2] and **analyze**[2]to quantify and assay for a biomolecule. |
| **CO4** | The student will be able to handle the equipment available and **identify**[2]the suitable and appropriate **experiments** for their research. |
| **CO5** | The student would have gained sufficient **knowledge**[2] about the assays and analyzing data |
| **Text Books:** | • J M Berg, J L Tymoczko and L Stryer, Biochemistry,VI edition, 2006, W.H Freeman.<br>• U Satyanarayana, Biochemistry, V edition, 2017, Elsvier. |
| **Reference Books:** | • H F Lodish, Molecular Cell Biology,8th edition, 2016, New York: W.H. Freeman.<br>• J EKrebs, B Lewin, S T Kilpatrick, Goldstein, Lewin's Genes XI, 2014, Sudbury: Jones and Bartlett. |

**Core Course-IV**

| COURSE CODE | MICROBIOLOGY | Total Lec.:30 |
|---|---|---|
| **BT20M104** | | **2 – 0 – 0** |
| **Learning Objectives** | • The objectives of this course are to introduce the students to the field of microbiology with special emphasis on microbial diversity, morphology, physiology and nutrition.<br>• Methods for control of microbes and host-microbe interactions. | |
| **Pre-requisites** | None. | |

| UNIT | CONTENT | HOURS |
|---|---|---|
| **I** | Microbial Characteristics: Introduction to microbiology and microbes, history & scope of microbiology, morphology, structure, growth and nutrition of bacteria, bacterial growth curve, bacterial culture methods; bacterial genetics: mutation and recombination in bacteria, plasmids, transformation, transduction and conjugation; antimicrobial resistance. | 4 |
| **II** | Microbial Diversity :Microbial taxonomy and the evolution of diversity, classification of microorganisms, criteria for classification; classification of bacteria; Cyanobacteria, acetic acid bacteria, Pseudomonads, lactic and propionic acid bacteria, endospore forming bacteria, Mycobacteria and Mycoplasma. Archaea: Halophiles, Methanogens, Hyperthermophilicarchae, Thermoplasm; eukarya: algae, fungi, slime molds and protozoa; extremophiles and unculturable microbes. | 4 |
| **III** | Control of Microorganisms:Sterilization, disinfection and antisepsis: physical and chemical methods for control of microorganisms, antibiotics, antiviral and antifungal drugs, biological control of microorganisms. | 4 |
| **IV** | Virology: Virus and bacteriophages, general properties of viruses, viral structure, taxonomy of virus, viral replication, cultivation and identification of viruses; sub-viral particles – viroids and prions. | 8 |
| **V** | Host-Microbes Interaction:Host-pathogen interaction, ecological impacts of microbes; symbiosis (Nitrogen fixation and ruminant symbiosis); microbes and nutrient cycles; microbial communication system; bacterial quorum sensing; microbial fuel cells; prebiotics and probiotics | 10 |

| **Course Outcomes as per Bloom's Taxonomy** | |
|---|---|
| **CO1** | Student will be able to **identify**[2]the major categories of microorganisms and analyze their classification, diversity, and ubiquity. |
| **CO2** | Student will be able to**identify**[2]and demonstrate the structural, physiological, and genetic similarities |
| **CO3** | They will be able to **identify**[2]and demonstrate how to control microbial growth. |
| **CO4** | They will be able to**demonstrate**[3] and evaluate the interactions between microbes, hosts and environment |
| **CO5** | They will be able to**differentiate**[2] of the major categories of microorganisms |
| **Text Books:** | • J Pelczar, E C S Chan and N R Krieg, Microbiology,5th edition,1993, McGraw Hill M Book Company<br>• GJ Tortora, B R Funke and C L Case, Microbiology: An Introduction, 9th edition, 2008, Pearson Education.<br>• C P Baveja, Textbook of Microbiology. 6thedition, 2019, Arya Publication.<br>• D K Maheshwari, S Chand, Text Book of Microbiology.6thedition, 2013. |
| **Reference Books:** | • J Cappucino and N Sherman, Microbiology: A Laboratory Manual. 9th edition, 2010, Pearson Education Limited.<br>• J M Wiley, L M Sherwood and C J Woolverton, Prescott'sMicrobiology. 9th edition 2013, McGraw Hill International.<br>• R M Atlas, Principles of Microbiology, 2nd edition, 1997, W M T Brown Publishers.<br>• R Y Stanier, J L Ingraham, M L Wheelis and P R Painter, General Microbiology. 5th edition, 2005, McMillan |

**Core Course-V**

| COURSE CODE | GENETICS | Total Lec.:30 |
|---|---|---|
| **BT20M105** | | **2– 0 – 0** |
| **Learning Objectives** | • The objectives of this course are to take the students through the basics of genetics and classical genetics encompassing prokaryotic/phage genetics to yeast and higher eukaryotic domains.<br>• With knowledge of classical concepts of Mendelian genetics across these life-forms, the students will be exposed to the concepts of population genetics, quantitative genetics encompassing complex traits, clinical genetics and genetics of evolution. | |
| **Pre-requisites** | None | |

| UNIT | CONTENT | HOURS |
|---|---|---|
| **I** | Genetics of Bacteria and Bacteriophages: Concept of a gene in pre-DNA era; mapping of genes in bacterial and phage chromosomes by classical genetic crosses; fine structure analysis of a gene; genetic complementation and other genetic crosses using phenotypic markers; phenotype to genotype connectivity prior to DNA-based understanding of a gene. | 4 |
| **II** | Yeast Genetics, meiotic crosses, tetrad analyses, non-Mendelian and Mendelian ratios, gene conversion, models of genetic recombination, yeast mating type switch; dominant and recessive genes/mutations, suppressor or modifier screens, complementation groups, transposon mutagenesis, synthetic lethality, genetic epistasis.. | 4 |
| **III** | Genetics as a model of higher Eukaryotes: Monohybrid &dihybrid crosses, back-crosses, test-crosses, analyses of autosomal and sex linkages, screening of mutations based on phenotypes and mapping the same, hypomorphy, genetic mosaics, genetic epistasis in the context of developmental mechanisms. Laws of segregation in plant crosses, inbreeding, selfing, heterosis, maintenance of genetic purity, gene pyramiding | 8 |
| **IV** | Population Genetics & Genetics of Evolution:Introduction to the elements of population genetics: genetic variation, genetic drift, neutral evolution; mutation selection, balancing selection, Fishers theorem, Hardy-Weinberg equilibrium, linkage disequilibrium; in-breeding depression & mating systems; population bottlenecks, migrations, Bayesian statistics; adaptive landscape, spatial variation & genetic fitness. | 8 |
| **V** | Quantitative Genetics of complex traits (QTLs) :Complex traits, mapping QTLs, yeast genomics to understand biology of QTLs. | 6 |

| **Course Outcomes as per Bloom's Taxonomy** | |
|---|---|
| **CO1** | Students will be able to **describe**[2]the fundamental molecular principles of genetics. |
| **CO2** | Students will be able to**understand**[2]the relationship between phenotype and genotype in human genetic traits. |
| **CO3** | They will be able to **describe**[2]the basics of genetic mapping. |
| **CO4** | Students will be able to**understand**[2]how gene expression is regulated. |
| **CO5** | Students will be able to**understand**[2]principles of population genetics. |
| **Text Books:** | • G M Cooper, R E Hausman, The Cell: a Molecular Approach 6th edition, 2013,Sunderland.<br>• J Hardin, G Bertoni,Becker's World ofthe Cell 8th edition, L J Kleinsmith&W. M Becker, 2012, Benjamin Cummings. |
| **Reference Books:** | • B Alberts, B Johnson, A Lewis, J Raff, M Roberts, P Walter, Lewins Gene VI 2008, New York: Garland Science.<br>• H F Lodish,Molecular Cell Biology 8th edition, 2016, New York W H Freeman. |

**Discipline Specific Electives I**

| COURSE CODE | MICROBIAL GENETICS | Total Lec.:45 |
|---|---|---|
| **BT20M106** | | **3 – 0 – 0** |
| **Learning Objectives:** | • This course enables student to understand fundamental principles of Microbial genetics.<br>• Concepts of gene transfer in microbes<br>• Mutational analysis.<br>• Genetic analysis. | |
| **Pre-requisites:** | **None** | |

| UNIT | CONTENT | HOURS |
|---|---|---|
| **I** | Genetic analysis of bacteria: Importance and uses of mutation analysis. Inheritance in bacteria, types of mutations, spontaneous and induced mutagenesis, isolating mutants, selecting mutants, mutant enrichment. Reversions versus suppression. Complementation tests, recombination tests and gene replacements. Cloning genes by complementation. Cloning genes by marker rescue. | 10 |
| **II** | Gene transfer and mapping by conjugation: Basis of fertility in bacteria. Self transmissable and mobilizable plasmids. Molecular mechanism of gene transfer by conjugation – genes and proteins involved. Regulation of gene transfer by conjugation. Hfr strains. Mapping bacterial genomes using Hfr strains. Chromosomal DNA transfer by plasmids – by integrated plasmids, by chromosome mobilization and by creation of prime factors. Transfer systems in gram positive bacteria. Ti plasmid transfer system and its application in creating transgenics. | 10 |
| **III** | Lytic bacteriophages: Lytic development cycle using phages T4 and T7 as models. Regulation of expression of genes in phage T4 – transcriptional activators, anti-termination, a new sigma factor and replication-coupled transcription. Regulation of gene expression in phage T7 – a phage-encoded RNA polymerase. Replication of T4 versus T7 phages – recent advances. Replication and packaging of filamentous phages M13 and f1 – recent advances. Genetic analysis of phages – complementation and recombination tests with phages. Genetic experiments with the rII genes of phage T4. Deciphering the genetic code using rII mutants. Constructing phage genetic linkage maps using two-factor and three factor crosses. | 10 |
| **IV** | Gene transfer by transformation and transduction: Natural transformation and competence. Molecular basis of natural transformation – DNA uptake competence systems in gram positive and gram negative bacteria. Regulation of competence in B.subtilis. Importance of natural transformation. Artificially induced competence. Generalized versus specialized transduction - T4 and lambda phage. Mapping bacterial genes by transduction. | 10 |
| **V** | Lambda phage – gene and promoter organization. Lambda lytic cyle – regulation of gene expression – very early, early and late genes. Establishment and maintenance of lysogeny. Transposons: Discovery of transposition. Classes of bacterial transposons. Regulation of transposition activity. Effects of transposition in bacteria. Genetic requirements for transposition. | 5 |

| **Course Outcomes as per Bloom's Taxonomy** | |
|---|---|
| **CO 1** | Students will be able to **understand**[2] genetic mutations and analysis of mutation |
| **CO 2** | Students will be able to **understand**[2] the types of gene transfer and of regulation and mis-regulation |
| **CO 3** | They will be able to critically **evaluate**[4] gene transfer mechanisms. |
| **CO 4** | They will **Know**[2] the scope of flow of genetic information. |
| **CO 5** | Students will be able to apply **acquired** to **design**[6] experiments to manipulate cellular and molecular processes |
| **Text Books:** | • J Pelczar, E C S Chan and N R Krieg, Microbiology. 5th edition,1993, McGraw Hill M Book Company<br>• GJ Tortora, BR Funke and CL Case, Microbiology: An Introduction. 9th edition, 2008, Pearson Education.<br>• C P Baveja, Textbook of Microbiology. 6th edition, 2019, Arya Publication. |

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|---|---|
| | • D K Maheshwari, S Chand, Text Book of Microbiology.6th edition, 2013. |
| **Reference Books:** | • J Cappucino and N Sherman, Microbiology: A Laboratory Manual. 9th edition, 2010, Pearson Education Limited.<br>• J M Wiley, L M Sherwood and Woolverton, C J Prescott's, Microbiology. 9th edition 2013, McGraw Hill International.<br>• R M Atlas, Principles of Microbiology. 2nd edition, 1997, W M T Brown Publishers.<br>• R Y Stanier, J L Ingraham, M L Wheelis, and P R Painter, General Microbiology. 5th edition, 2005, McMillan<br>• H F Lodish, Molecular Cell Biology 8th edition, 2016, New York: W.H. Freeman.<br>• J EKrebs, B Lewin, S T Kilpatrick, Goldstein, Lewin's Genes XI, 2014, Sudbury: Jones and Bartlett. |

**Practical Paper**

| COURSE CODE | LAB I | Practicals:60 |
|---|---|---|
| **BT20M108** | | **2** |
| | 1. Preparing various stock solutions and working solutions that will be needed.<br>2. To prepare an Acetic-Na Acetate Buffer and validate the Henderson-Hasselbachequation.<br>3. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law.<br>4. Titration of Amino Acids and separation of aliphatic, aromatic and polar aminoacids by thin layer chromatography.<br>5. Effect of colchicine on cell division.<br>6. Genomic DNA Extraction.<br>7. Agarose gel electrophoresis.<br>8. Plasmid DNA isolation and DNA quantitation.<br>9. Restriction Enzyme digestion of plasmid DNA.<br>10. 16 s rRNA Polymerase Chain Reaction and analysis by agarose gel electrophoresis. | |

| COURSE CODE | LAB II | Practicals:60 |
|---|---|---|
| **BT20M109** | | **2** |
| | 1. Sterilization, disinfection and safety in microbiological laboratory.<br>2. Preparation of media for cultivation of bacteria.<br>3. Isolation of bacteria in pure culture by streak plate method.<br>4. Study of colony and growth characteristics of some common bacteria: Bacillus, E. coli, Staphylococcus, Streptococcus, etc.<br>5. Preparation of bacterial smear and Grams staining.<br>6. Enumeration of bacteria: standard plate count.<br>7. Antimicrobial sensitivity test and demonstration of drug resistance.<br>8. Maintenance of stock cultures: slants, stabs and glycerol stock cultures.<br>9. Determination of Minimum Inhibitory Concentration (MIC).<br>10. Isolation and identification of bacteria from soil/water samples Isolation of Pure culture of Bacteria.<br>11. Effect of UV radiations, pH, disinfectants, chemicals and heavy metal ions on Microbes.<br>12. Biochemical Characterization of bacteria. | |

## Project Based Learning I

| COURSE CODE | PROJECT BASED LEARNING |
|---|---|
| **PB20B101** | |
| **Learning Objectives:** | • Integrating the knowledge and skills of various courses on the basis of multidisciplinary projects.<br>• Develop the skill of critical thinking and evaluation.<br>• To develop 21st century success skills such as critical thinking, problem solving, communication, collaboration and creativity/innovation among the students.<br>• To enhance deep understanding of academic, personal and social development in students.<br>• Employ the specialized vocabularies and methodologies. |
| **General Guidelines:** | • PBL will be an integral part of UG/PG Programs at different levels.<br>• Each semester offering PBL will provide a separate Course Code, two credits will be allotted to it.<br>• Faculty will be assigned as mentor to a group of 30 students minimum by HoS.<br>• Faculty mentor will have 4 hours/week to conduct PBL for assigned students.<br>• Student will select a topic of their choice from syllabus of any course offered in respective Semester (in-lines with sustainable development goals).<br>• Student may work as a team maximum 3 or minimum 2 members for single topic.<br>• For MSE, student's performance will be assessed by panel of 2 experts either from other Department/school, or from same department/school based on chosen topic. This will be comprised of a presentation by student followed by viva-voce. It will be evaluated for 30 marks.<br>• 20 marks would be allotted for continuous performance assessment by concerned guide/mentor.<br>• For ESE, student will need to submit a project report in prescribed format, duly signed by concerned guide/mentor and head of the school. The report should be comprised of following components:<br>1. Introduction<br>2. Review of literature<br>3. Methodology<br>4. Result and Discussion<br>5. Conclusion and Project Outcomes<br>6. References<br>• In ESE, viva-voce of students will be conducted on the basis of report, by one external and one internal faculty which is of 50 Marks.<br>Student will need to submit three copies for<br>1. Concerned School<br>2. Central Library<br>3. Self.<br>The integrity of the report should be maintained by student. Any malpractice will not be entertained.<br>• Writing Ethics to be followed by student, a limit of 10 % plagiarism is permissible. Plagiarism report is to be attached along with the report.<br>• Project could be a case study/ analytical work /field work/ experimental work/ programming or as per the suitability of the program. |

# Syllabus
# SEMESTER II

**Core Course-I**

| COURSE CODE | IMMUNOLOGY | Total Lec.:60 |
|---|---|---|
| **BT20M201** | | **4– 0-0** |
| **Learning Objectives** | • The objectives of this course are to make students learn about the structural features of the components of the immune system as well as their function.<br>• The major emphasis of this course will be on the development of the immune system and mechanisms by which our body elicit the immune response.<br>• This will be imperative for the students as it will help them to think like an immunologist and predict about the nature of immune response that develops against bacterial, viral or parasitic infection, and prove it by designing new experiment. | |
| **Pre-requisites:** | None. | |
| **UNIT** | **CONTENT** | **HOURS** |
| **I** | Immunology fundamental concepts and anatomy of the immune system.Components of innate and acquired immunity; phagocytosis; complement and inflammatory responses; pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP); innate immune response; mucosal immunity; antigens - immunogens, haptens; Major Histocompatibility Complex - MHC genes, MHC and immune responsiveness and disease susceptibility. | 10 |
| **II** | Immune responses generated by B and T lymphocytes. Immunoglobulins - basic structure, classes & subclasses of immunoglobulins, antigenic determinants; multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; principles of cellsignaling; basis of self & non self-discrimination; kinetics of immune response, memory; B cell maturation, activation and differentiation; generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; functional T Cell subsets; cell-mediated immune responses, ADCC; cytokines-properties, receptors and therapeutic uses; antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; cell-cell co-operation, Hapten-carrier system. | 10 |
| **III** | Antigen-antibody interactions Precipitation, agglutination and complement mediated immune reactions; advanced immunological techniques - RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence, flow cytometry and immunoelectron microscopy; surface plasmon resonance, biosenor assays for assessing ligand –receptor interaction, CMI techniques- lymph proliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays, apoptosis, microarrays, transgenic mice, gene knock outs. | 10 |
| **IV** | Vaccinology: Active and passive immunization; live, killed, attenuated, subunit vaccines; vaccine technology- role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines; antibody genes and antibody engineering- chimeric, hybrid monoclonal antibodies; catalytic antibodies and generation of immunoglobulin gene libraries, idiotypic vaccines and marker vaccines, viral-like particles (VLPs), dendritic cell based vaccines, vaccine against cancer, T cell based vaccine, edible vaccine and therapeutic vaccine. | 8 |
| **V** | Clinical Immunology: Immunity to infection : bacteria, viral, fungal and parasitic infections (with examples from each group); hypersensitivity – Type I-IV; autoimmunity; types of autoimmune diseases; mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; treatment of autoimmune diseases; transplantation – immunological basis of graft rejection; clinical transplantation and immunosuppressive therapy; tumor immunology – tumor antigens; immune response to tumors and tumorevasion of the immune system, cancer immunotherapy; immunodeficiency - | 22 |

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|---|---|---|
| | primary immune deficiencies, acquired or secondary immune deficiencies, autoimmune disorder, anaphylactic shock, immunesenescence, immune exhaustion in chronic viral infection, immune tolerance, NK cells in chronic viral infection and malignancy.Immunogenetics. Major histocompatibility complex genes and their role in autoimmune and infectious diseases, HLA typing, human major histocompatibility complex (MHC), Complement genes of the human major histocompatibility complex: implication for linkage disequilibrium and disease associations, genetic studies of rheumatoid arthritis, systemic lupus erythematosus and multiple sclerosis, genetics of human immunoglobulin, immune genetics of spontaneous control of HIV, KIR complex. | |
| **Course Outcomes as per Bloom's Taxonomy** | | |
| **CO1** | Students will be able to**evaluate**[2]the usefulness of immunology in different pharmaceutical companies | |
| **CO2** | They will be able to **identify**[2]the proper research lab working in the area of their own interests. | |
| **CO3** | Students will be able to**apply**[5] their knowledge and design immunological experiments to demonstrate immunological process | |
| **CO4** | Students will be able to**understand**[2]the kind of immune responses in the setting of infection (viral or bacterial) by looking at cytokine profile. | |
| **CO5** | They will be able to **communicate**[3]the principles, theories, problems and research results associated with questions that lie within the immunological framework to specialists and laymen orally and in writing. | |
| **Text Books:** | • T Kindt, R Goldsby, B Osborne, B& J Kuby, Kubyimmunology, 2006, New York: W H Freeman.<br>• J Brostoff, J K Seaddin, D Male, D & I M Roitt ,Clinical immunology, 2002 , London: Gower Medical Pub. | |
| **Reference Books:** | • K Murphy, P Travers, M Walport, C Janeway ,Janeway'simmunobiology, 2012, New York: Garland Science.<br>• W E Paul, Fundamental immunology, 1993, New York: Raven Press.<br>• J WGoding, Monoclonal antibodies: Principles and practice, 1986, London: Academic Press.<br>• P Parham, the Immune System2005, New York: Garland Science. | |

**Core Course-II**

| COURSE CODE | BIOINFORMATICS | Total Lec.:60 |
|---|---|---|
| BT20M202 | | 4 – 0 – 0 |
| Learning Objectives | • The objectives of this course are to provide students with the theory and practical experience of the use of common computational tools and databases<br>• This knowledge facilitates investigation of molecular biology and evolution-related concepts. | |
| Pre-requisites: | Nil. | |

| UNIT | CONTENT | HOURS |
|---|---|---|
| I | Bioinformatics basics: Computers in biology and medicine; Introduction to Unixand Linux systems and basic commands; Database concepts; Protein and nucleic acid databases; Structural databases; Biological XML DTD's; pattern matching algorithm basics; databases and search tools: biological background for sequence analysis, Identification of protein sequence from DNA sequence; searching of databases similar sequence; NCBI; publicly available tools; resources at EBI; resources on web; data base mining tools. | 10 |
| II | DNA sequence analysis: gene bank sequence database; submitting DNA sequences todatabases and database searching; sequence alignment; pairwise alignment techniques;motif discovery and gene prediction; local structural variants of DNA, their relevance in molecular level processes, and their identification; assembly of data from genome sequencing. | 10 |
| III | Multiple sequence analysis; multiple sequence alignment; flexible sequence similarity searching with the FASTA3 program package; use of CLUSTALW and CLUSTALX for multiple sequence alignment; submitting DNA protein sequence to databases: where and how to submit, SEQUIN, genome centres; submitting aligned sets of sequences, updating submitted sequences, methods of phylogenetic analysis: | 15 |
| IV | Protein modelling: introduction; force field methods; energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; mapping propertiesonto surfaces; fitting monomers; RMS fit of conformers; assigning secondary structures; sequence alignment- methods, evaluation, scoring; protein completion: backbone construction and side chain addition; small peptide methodology; software accessibility; building peptides; protein displays; substructure manipulations, annealing. | 10 |
| V | Protein structure prediction: protein folding and model generation; secondary structure prediction; analyzing secondary structures; protein loop searching; loop generating methods; homology modelling: potential applications, description, methodology, homologous sequence identification; align structures, align model sequence; construction of variable and conserved regions; threading techniques; topology fingerprint approach for prediction; evaluation of alternate models; structure prediction on a mysterysequence; structure aided sequence techniques of structure prediction; structural profiles, alignment algorithms, mutation tables, prediction, validation, sequence based methods of structure prediction, prediction using inverse folding, fold prediction; significance analysis, scoring techniques, sequence-sequence scoring; protein function prediction;elements of in-silico drug design;Virtual library: Searching PubMed, current content,science citation index and current awareness services, electronic journals, grants and funding information. | 15 |

**Course Outcomes as per Bloom's Taxonomy**

| | |
|---|---|
| CO1 | Students will **develop**[2]an understanding of the basic theory of these computational tools. |
| CO2 | They will gain working **knowledge**[2] of these computational tools and methods. |

| | |
|---|---|
| **CO3** | Students will appreciate their relevance for **investigating**[4]specific contemporary biological questions. |
| **CO4** | Students will be able tocritically **analyze**[4] and **interpret** the results of their study. |
| **CO5** | Students will be able to**analyze**[4], interpret, and present methodology and results from primary literature in the discipline. |
| **Text Books:** | • A M Lesk,Introduction to bioinformatics, 2002, Oxford University Press.<br>• D W Mount, Bioinformatics: Sequence and genome analysis, 2001, NY Cold Spring Harbor Laboratory Press.<br>• P E Bourne, G U Jenny, Structural bioinformatics, 2009, Wiley-Blackwell.<br>• A M Lesk, Introduction to protein science: Architecture, function, and genomics,2004, Oxford University Press. |
| **Reference Books:** | • A D Baxevanis, B F Ouellette, Bioinformatics: A practical guide to the analysis of genes and proteins, 2001, New York: Wiley-Interscience.<br>• J Pevsner, Bioinformatics and functional genomics, 2015, Wiley-Blackwell. |

**Core Course-III**

| COURSE CODE | GENETIC ENGINEERING | Total Lec.:60 |
|---|---|---|
| **BT20M203** | | **4 – 0 – 0** |
| **Learning Objectives** | • The objectives of this course are to teach students with various approaches to conducting genetic engineering that they can apply to their future career in biological research as well as in biotechnology industries<br>• Genetic engineering is a technology that has been developed based on our fundamental understanding of the principles of molecular biology and this is reflected in the contents of this course.<br>• This technology has revolutionized the way modern biological research is done and has impacted mankind with a number of biological products and processes | |
| **Pre-requisites:** | Nil. | |

| UNIT | CONTENT | HOURS |
|---|---|---|
| **I** | Impact of genetic engineering in modern society; general requirements for performing a genetic engineering experiment; restriction endonucleases and methylases; DNA ligase,Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase;cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing; labellingof DNA: nick translation, random priming, radioactive and non-radioactive probes,hybridization techniques: northern, southern, south-western and far-western and colonyhybridization, fluorescence *in situ* hybridization. | 10 |
| **II** | Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors, hagemids;Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosomevectors (YACs; BACs); Principles for maximizing gene expression expressionvectors;pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag *etc.*;Intein-based vectors; Inclusion bodies; methodologies to reduce formation of inclusionbodies; mammalian expression and replicating vectors; Baculovirus and *Pichia*vectorssystem, plant based vectors, Ti and Ri as vectors, yeast vectors, shuttle vectors. | 10 |
| **III** | Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases;types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, touchdownPCR, hot start PCR, colony PCR, asymmetric PCR, cloning of PCR products;T-vectors; proof reading enzymes; PCR based site specific mutagenesis; PCR inmolecular diagnostics; viral and bacterial detection; sequencing methods; enzymaticDNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNAsequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP,DGGE, RFLP. | 10 |
| **IV** | Insertion of foreign DNA into host cells; transformation, electroporation, transfection;construction of libraries; isolation of mRNA and total RNA; reverse transcriptase andcDNA synthesis; cDNA and genomic libraries; construction of microarrays – genomicarrays, cDNA arrays and oligo arrays; study of protein-DNA interactions: electrophoreticmobility shift assay; DNasefoot-printing; methyl interference assay, chromatin immune precipitation; protein-protein interactions using yeast two-hybrid system;phage display. | 15 |
| **V** | Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene-knockouts and gene therapy; creation of transgenic plants; debate over GM crops;introduction to methods of genetic manipulation in different model systems *e.g.* fruit flies(*Drosophila*), worms (*C. elegans*), frogs | 15 |

| | | |
|---|---|---|
| | (*Xenopus*), fish (zebra fish) and chick; Transgenicsgene replacement; gene targeting; creation of transgenic and knock-out mice; diseasemodel; introduction to genome editing by CRISPR-CAS with specific emphasis onChinese and American clinical trials. | |
| **Course Outcomes as per Bloom's Taxonomy** | | |
| **CO1** | Given the impact of genetic engineering in modern society, the students should be endowed with strong theoretical **knowledge**[2]of this technology. | |
| **CO2** | Students will be able to**understand**[2] basics of Molecular Biology. | |
| **CO3** | With the practical knowledge molecular biology & genetic engineering, the students should be able to **set-up**[5]experiments related to biological research. | |
| **CO4** | Students will be able to**comprehend**[5] the skills required to do experimental cloning. | |
| **CO5** | Students will be able to**design**[5]experiments using advanced tools of selecting vectors for cloning; sequencing analysis, PCR, expression of cloned products. | |
| **Text Books:** | • R W Primrose, S B Twyman, Principles of gene manipulation: An introduction to genetic engineering, 2001, Oxford: Blackwell Scientific Publications.<br>• T A Brown, Genomes 3rd edition, 2006, New York: Garland Science Pub.<br>• Selected papers from scientific journals, particularly Nature & Science.<br>• Technical Literature from Stratagene, Promega, Novagen, New England Biolabetc. | |
| **Reference Books:** | • M R Green, J Sambrook, Molecular cloning: A laboratory manual, 2012, NY: Cold Spring Harbor Laboratory Press. | |

**Core Course-IV**

| COURSE CODE | GENOMICS AND PROTEOMICS | Total Lec.:30 |
|---|---|---|
| **BT20M204** | | **2 – 0 – 0** |
| **Learning objectives** | • The objectives of this course are to introduce the students to define genomics and proteomics.<br>• To understand whole genome sequencing and correlate with big data.<br>• Explain different applications of genomics and proteomics. | |
| **Pre-requisites:** | **None** | |
| **UNIT** | **CONTENT** | **HOURS** |
| **I** | Brief overview of prokaryotic and eukaryotic genome organization; extra-chromosomal DNA: bacterial plasmids, mitochondria and chloroplast. Genomes: Size, physical structure, genome analysis, gene duplication. | 4 |
| **II** | Genetic and physical maps,markers for genetic mapping; methods and techniques used for gene mapping, physical mapping, linkage analysis. Tools for studying DNA/genes: Enzymes for DNA manipulation, molecular cloning, DNA libraries, fluorescent in situ hybridization (FISH), denaturing gradient gel electrophoresis (DGGE).somatic cell hybridization, radiation hybrid maps, *in situ* hybridization, comparative gene mapping.. | 8 |
| **III** | Human Genome Project, genome sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from the web. | 2 |
| **IV** | Mapping of genome: Molecular markers as tools for mapping, restriction fragment length polymorphism (RFLP), randomly amplified polymorphic DNA (RAPD), simple sequence length polymorphism (SSCP), amplified fragment length polymorphism (AFLP). | 6 |
| **V** | Functional genomics: entire genome expression analysis-microarrays, expressed sequence tags (ESTs), serial analysis of gene expression (SAGE), single nucleotide polymorphism(SNP).Transcriptome analysis for identification and functional annotation of gene, Contig assembly, chromosome walking and characterization of chromosomes, mining functional genes in genome, gene function- forward and reverse genetics, gene ethics; protein- protein and protein-DNA interactions; protein chips and functional proteomics; clinicaland biomedical applications of proteomics; introduction to metabolomics, lipidomics, metagenomics and systems biology. | 10 |
| **Course Outcomes as per Bloom's Taxonomy** | | |
| **CO1** | Students will **learn**[2] about transition elements and their properties in detail. | |
| **CO2** | They will **know**[2] the coordination chemistry and different bonding theories. | |
| **CO3** | They will gain the **knowledge**[2] about the kinetic theory of gases in detail. | |
| **CO4** | They will **know**[2] the surface tension, viscocity and other properties of liquids as well as details of solids. | |
| **CO5** | They will **learn**[2] the concept of chemical kinetics and will learn about the factors that affect the rate of a chemical reaction. | |
| **Text Books:** | • S B Primrose, R M Twyman, Principles of gene manipulation and genomics, 2006 Malden, MA: Blackwell Pub.<br>• A M Campbell& L J Heyer, Discovering genomics, proteomics, and bioinformatics, 2003, San Francisco: Benjamin Cummings. | |
| **Reference Books:** | • Liebler, D. C. (2002). Introduction to proteomics: Tools for the new biology. Totowa, NJ: Humana Press | |

**Core Course- V**

| COURSE CODE | MOLECULAR DIAGNOSTICS | Total Lec.:30 |
|---|---|---|
| **BT20M205** | | **2 – 0 – 0** |
| **Learning objectives** | • The objectives of this course are to sensitize the students about the recent advances in molecular biology and various facets of molecular medicine<br>• alter many aspects of modern medicine including the pre- or post-natal analysis of genetic diseases and<br>• Identification of individuals predisposed to disease ranging from common cold to cancer | |
| **Pre-requisites:** | None | |
| **UNIT** | **CONTENT** | **HOURS** |
| **I** | Genome Biology in Health & Disease DNA, RNA, Protein: An overview; chromosomal structure & mutations; DNA polymorphism: human identity; clinical variability and genetically determined adverse reactions to drugs. | 5 |
| **II** | Genome: Resolution, Detection & Analysis PCR: Real-time; ARMS; Multiplex; ISH; FISH; ISA; RFLP; DHPLC; DGGE; CSCE; SSCP; Nucleic acid sequencing: new generations of automated sequencers; Microarray chips; EST; SAGE; microarray data normalization & analysis; molecular markers: 16S rRNA typing; Diagnostic proteomics: SELDI-TOF MS; Bioinformatics data acquisition & analysis. | 10 |
| **III** | Diagnostic Metabolomics Metabolite profile for biomarker detection in the body fluids/tissues under various metabolic disorders by making use of LCMS & NMR technological platforms. | 6 |
| **IV** | Detection & Identity of Microbial Diseases Direct detection & identification of pathogenic-organisms that are slow growing or currently lacking a system of invitro cultivation as well as genotypic markers of microbial resistance to specific antibiotics. | 4 |
| **V** | Detection of Inherited Diseases Exemplified by two inherited diseases for which molecular diagnosis has provided a dramatic improvement of quality of medical care: - Fragile X Syndrome: Paradigm of the new mutational mechanism of the unstable triplet repeats, von-HippelLindau disease: recent acquisition in the growing number of familial cancer syndromes. Quality Assurance & Control Quality oversight; regulations and approved testing. | 5 |
| **Course Outcomes as per Bloom's Taxonomy** | | |
| **CO 1** | Students will **learn**[2] about Health and disease. | |
| **CO 2** | They will **know**[2] basics of techniques of diagnostics | |
| **CO 3** | Students will be able to**usage**[3]of available online resources of diagnostics | |
| **CO 4** | Students will be able tocomputational data **analysis**[4] in disease biology | |
| **CO 5** | Students will be able to**analyze**[2] big Data | |
| **Text Books:** | • R J Brooker, Genetics: Analysis & principles, 2009, NY: McGraw-Hill.<br>• B R Glick, J J Pasternak &C L Patten, Molecular biotechnology: Principles and applications of recombinant DNA, 2010, Washington, DC: ASM Press. | |
| **Reference Books:** | • A M Campbell, L J Heyer Discovering Genomics, Proteomics, and Bioinformatics, 2006, San Francisco: Benjamin Cummings.<br>• W B Coleman, G J Tsongalis, Molecular diagnostics: For the clinical laboratorian, 1997, Totowa, NJ: Humana Press. | |

**Practical Papers**

| COURSE CODE | LAB III | Practicals.:60 |
|---|---|---|
| **BT20M208** | | **2** |
| | 1. To access scientific data from Literature data bases (PUBMED, LITDB, Medline)<br>2. To access nucleic acid databases for retrieval of gene sequence.<br>3. To access protein databases for retrieval of amino acid sequence of target protein.<br>4. To perform pair wise sequence alignment using Dot matrix.<br>5. To perform multiple sequence alignment using BLAST.<br>6. To perform multiple sequence alignment using CLUSTAL-W and to find conserved sequences using JAL view.<br>7. To prepare Phylogenetic tree and Cladogram using CLUSTAL-W.<br>8. 3D protein structure prediction and structure refinement using Swiss-PDB viewer Double diffusion, Immuno-electrophoresis and Radial Immuno diffusion.<br>9. SDS-PAGE, Immunoblotting, Dot blot assays.<br>10. Blood smear identification of leucocytes by Giemsa stain.<br>11. Separation of leucocytes by dextran method.<br>12. Demonstration of Phagocytosis of latex beads.<br>13. Separation of mononuclear cells by Ficoll-Hypaque.<br>14. Immunodiagnostics using commercial kits. | |

| COURSE CODE | LAB IV | Practicals:60 |
|---|---|---|
| **BT20M209** | | **2** |
| 1. | 1. Plasmid extraction, vector and Insert Ligation.<br>2. Preparation of competent cells.<br>3. Transformation of *E.coli*with standard plasmids, Calculation of transformation efficiency.<br>4. Confirmation of the insert by Colony PCR and Restriction mapping.<br>5. Expression of recombinant protein, concept of soluble proteins and inclusion body formation in *E.coli*, SDS-PAGE analysis.<br>6. Single Nucleotide Polymorphism in health and disease. | |

## Project Based Learning II

| COURSE CODE | PROJECT BASED LEARNING |
|---|---|
| **PB20B201** | |
| **Learning Objectives:** | • Integrating the knowledge and skills of various courses on the basis of multidisciplinary projects.<br>• Develop the skill of critical thinking and evaluation.<br>• To develop 21st century success skills such as critical thinking, problem solving, communication, collaboration and creativity/innovation among the students.<br>• To enhance deep understanding of academic, personal and social development in students.<br>• Employ the specialized vocabularies and methodologies. |
| **General Guidelines:** | • PBL will be an integral part of UG/PG Programs at different levels.<br>• Each semester offering PBL will provide a separate Course Code, two credits will be allotted to it.<br>• Faculty will be assigned as mentor to a group of 30 students minimum by HoS.<br>• Faculty mentor will have 4 hours/week to conduct PBL for assigned students.<br>• Student will select a topic of their choice from syllabus of any course offered in respective Semester (in-lines with sustainable development goals).<br>• Student may work as a team maximum 3 or minimum 2 members for single topic.<br>• For MSE, student's performance will be assessed by panel of 2 experts either from other Department/school, or from same department/school based on chosen topic. This will be comprised of a presentation by student followed by viva-voce. It will be evaluated for 30 marks.<br>• 20 marks would be allotted for continuous performance assessment by concerned guide/mentor.<br>• For ESE, student will need to submit a project report in prescribed format, duly signed by concerned guide/mentor and head of the school. The report should be comprised of following components:<br>1. Introduction<br>2. Review of literature<br>3. Methodology<br>4. Result and Discussion<br>5. Conclusion and Project Outcomes<br>6. References<br>• In ESE, viva-voce of students will be conducted on the basis of report, by one external and one internal faculty which is of 50 Marks.<br>Student will need to submit three copies for<br>1. Concerned School<br>2. Central Library<br>3. Self.<br>The integrity of the report should be maintained by student. Any malpractice will not be entertained.<br>• Writing Ethics to be followed by student, a limit of 10 % plagiarism is permissible. Plagiarism report is to be attached along with the report.<br>• Project could be a case study/ analytical work /field work/ experimental work/ programming or as per the suitability of the program. |

**Discipline Specific Electives II**

| COURSE CODE | MICROBIAL ENZYME TECHNOLOGY | Total Lec.45 |
|---|---|---|
| **BT20M206** | | **3– 0– 0** |
| **Learning Objectives** | • This course provides the theory and knowledge relevant to the enzymology principles including fundamental properties of enzymes, enzyme catalytic mechanisms and enzyme kinetics.<br>• Techniques employed in enzymes purification and characterization is also emphasized in this course. Students will also be introduced to the theory as well as applications of enzyme technology in food, medical, and household industries.<br>• Finally this course serves to provide an awareness of the current and possible future applications of enzyme technologies.<br>• This course also emphasizes on the development of attitude and capability of the students to work in a group and gather information on the related field for lifelong learning. | |
| **Pre-requisites:** | Microbiology/Microbial Physiology and Metabolism | |
| **UNIT** | **CONTENT** | **HOURS** |
| **I** | Extraction and purification of microbial enzymes: Importance of enzyme purification, different sources of enzymes. Extracellular and intracellular enzymes. Physical and Chemical methods used for cell disintegration. Enzyme fractionation by precipitation (using Temperature, salt, solvent, pH, etc.), liquid-liquid extraction, ionic exchange, gel chromatography, affinity chromatography and other special purification methods. Enzyme crystallization techniques. Criteria of purity of enzymes. Pitfalls in working with pure enzymes. | 10 |
| **II** | Enzyme inhibition and Co-factors:Irreversible, reversible, competitive, non-competitive and un-competitive inhibition with suitable examples and their kinetic studies.Allosteric inhibition, types of allosteric inhibition and their significance in metabolic regulation & their kinetic study.Vitamins and their co-enzymes: structure and functions with suitable examples Metallo-enzymes and Metal ions as co-factors and enzyme activators | 15 |
| **III** | Immobilization of microbial enzymes: Methods viz. adsorption, covalent bonding, entrapment & membrane confinement and their analytical, therapeutic & industrial applications. Properties of immobilized enzymes. | 10 |
| **IV** | Enzyme Engineering: Chemical modification and site-directed mutagenesis to study the structure-function relationship of industrially important enzymes. | 5 |
| **V** | Microbial enzyme in textile, leather, wood industries and detergents. Enzyme in clinical diagnostics. Enzyme sensors for clinical processes and environmental analyses. Enzyme as therapeutic agents. | 5 |
| **Course Outcomes as per Bloom's Taxonomy** | | |
| **CO1** | Students will be able to**distinguish**[2]the fundamentals of enzyme properties, nomenclatures, characteristics and mechanism. | |
| **CO2** | Students will be able to**apply**[4] biochemical calculation for enzyme kinetics. | |
| **CO3** | They will be able to **compare**[3]methods for production, purification, characterization and immobilization of enzymes. | |
| **CO4** | Students will be able to**discuss**[5]various application of enzymes that can benefit human life. | |
| **CO5** | Students will be able to**discover**[2] the current and future trends of applying enzyme technology for the commercialization purpose of biotechnological products. | |
| **Text Books:** | • J Pelczar, E C S Chan and N R Krieg, Microbiology. 5th edition, 1993, McGraw Hill M Book Company.<br>• GJ Tortora, BR Funke and CL Case, Microbiology: An Introduction, 9th edition, 2008, Pearson Education.<br>• C P Baveja, Textbook of Microbiology, 6$^{th}$edition, 2019, Arya Publication. | |

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| | • D K Maheshwari, S Chand, Text Book of Microbiology, 6th edition, 2013. |
| **Reference Books:** | • J Cappucino and N Sherman, Microbiology: A Laboratory Manual. 9th edition, 2010, Pearson Education Limited.<br>• J M Wiley, L M Sherwood and Woolverton, C J Prescott's, Microbiology. 9th edition 2013, McGraw Hill International.<br>• R M Atlas, Principles of Microbiology. 2nd edition, 1997, W M T Brown Publishers.<br>• R Y Stanier, J L Ingraham, M L Wheelis, and P R Painter, General Microbiology. 5th edition, 2005, McMillan.<br>• H F Lodish,Molecular Cell Biology 8th edition, 2016, New York: W.H. Freeman.<br>• J EKrebs, B Lewin, S T Kilpatrick, Goldstein, Lewin's Genes XI, 2014, Sudbury: Jones and Bartlett. |

**Discipline Specific Elective II**

| COURSE CODE | R PROGRAMMING | Total Lec.:30 |
|---|---|---|
| **BT20M207** | | **2– 0– 0** |
| **Learning Objectives:** | • This course will develop ability to write R code script.<br>• Use (fundamental) commands in R for data manipulation, statistical tests, and plotting graphs and diagrams<br>• Finally this course serves to provide an awareness of the current and possible future applications of Programming.<br>• Ability to understand commands, solve problems and analyze data. | |
| **Pre-requisites:** | Basics understanding of computers | |

| UNIT | CONTENT | HOURS |
|---|---|---|
| **I** | Introduction to R programming, how to run R, R sessions and functions, basics of Rstudio , variables, data types, vectors, conclusion, advanced data structures, data frames, lists, matrices, arrays, classes. | 5 |
| **II** | Getting data into R, understanding basic type data in R, R operators, box plots, scatter plots and boxand-whisker plots together. | 10 |
| **III** | Graphics, creating graphs, the workhorse of R base graphics, plot () function – customizing graphs, saving graphs to files. | 5 |
| **IV** | Basic math, introduction to statistical analysis in R, measures of central tendency,histogram. | 5 |
| **V** | Probability, distributions, normal distribution- binomial distribution- poisson distributions. Correlation and covariance, t-tests,-anova. | 5 |

| **Course Outcomes as per Bloom's Taxonomy** | |
|---|---|
| **CO1** | Students will be able to**interpret**[5] simple R scripts. |
| **CO2** | Students will be able toexpress R programming language concepts and **apply**[3] in analytical projects. |
| **CO3** | They will be able to describe and **summarize**[2] basic statistics used in data analysis. |
| **CO4** | They will be able to **define**[1] suitable data analysis workflows and **evaluate**[5] the main variables in the experimental design of a project. |
| **CO5** | They will be able to**discover**[4] the current and future trends of applying R programming for the analysis of data. |
| **Text Books:** | • Peter Dalgaard, Introductory Statistics with R. Springer, 2nd edition, 2008, ISBN 978-0-387-79053-4.<br>• John Maindonald and John Braun, Data Analysis and Graphics Using R. Cambridge University Press, Cambridge, 2nd edition, 2007 ISBN 978-0-521-86116-8. |
| **Reference Books:** | • Alain F. Zuur, Elena N. Ieno, and Erik Meesters, A Beginner's Guide to R. Use R. Springer, 2009. ISBN: 978-0387-93836-3.<br>• Brian Everitt and TorstenHothorn, A Handbook of Statistical Analyses Using R. Chapman & Hall/CRC, Boca Raton, FL, 2006. ISBN 1-584-88539-4. |

# Syllabus
# SEMESTER III

**Core Paper-I**

| COURSE CODE | BIOPROCESS ENGINEERING & TECHNOLOGY | Total Lec:60 |
|---|---|---|
| BT20B301 | | 4– 0 – 0 |
| Learning Objectives: | • The objective of this course is to educate students about the fundamental concepts of bioprocess technology and its related applications.<br>• Prepare students to meet the challenges of the new and emerging areas of bioprocess industry. | |
| Pre-requisites: | Elementary Biology | |
| UNIT | CONTENT | HOURS |
| I | Basic principles of biochemical engineering, isolation, screening and maintenance of industrially important microbes, microbial growth and death kinetics, strain improvement for increased yield and other desirable characteristics. | 10 |
| II | Bioreactor Design and Analysis, Batch and continuous fermenters, modifying batch and continuous reactors,chemostat with recycle, multistage chemostat systems, fed-batch operations; conventional fermentation v/s biotransformations, immobilized cell systems; large scale animal and plant cell cultivation,fermentation economics, upstream processing, media formulation and optimization, sterilization, aeration, agitation and heat transfer in bioprocess, scale up and scale down, measurement and control of bioprocess parameters. | 10 |
| III | Downstream Processing and Product Recovery, Separation of insoluble products - filtration, centrifugation, sedimentation, flocculation, Cell disruption,separation of soluble products, liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis, final purification, drying, crystallization, storage and packaging. | 10 |
| IV | Applications of enzyme technology in food processing, Mechanism of enzyme function and reactions in process techniques, enzymatic bioconversions e.g. starch and sugar conversion processes, high-fructose corn syrup, interesterifiedfat,hydrolyzed protein etc. and their downstream processing, baking by amylases, deoxygenation and desugaring by glucoses oxidase, beer mashing and chill proofing, cheese making by proteases and various other enzyme catalytic actions in food processing. | 15 |
| V | Applications of Microbial Technology in food process operations and production, biofuels and bio refinery, Fermented foods and beverages, food ingredients and additives prepared by fermentation and their purification, fermentation as a method of preparing and preserving foods, microbes and their use in pickling, producing colours and flavours, alcoholic beverages and other products, process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products,bacteriocins from lactic acid bacteria – production and applications in food preservation, biofuels and bio refinery. | 15 |
| **Course Outcomes as per Bloom's Taxonomy** | | |
| CO1 | Student will be able to **identify**[1] role of microorganisms in industries. | |
| CO2 | They will **understand**[2] the **design** and operations of various fermenters. | |
| CO3 | They will be able to**illustrate**[2]fundamental principles for basic methods in production technique for bio-based products. | |
| CO4 | They will be able to **analyse**[4] yield and production rates in a biological production process, and also **interpret** data. | |
| CO5 | They will be able to **critically**[5]analyze any bioprocess from an economics/market point of | |

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| | view. |
| **Text Books:** | • M.L Shuler, F.Kargi,Bioprocess Engineering: Basic Concepts, 2002, Upper Saddle River, NJ Prentice Hall.<br>• M. El-Mansi, C.F Bryce, Fermentation Microbiology and Biotechnology, 2007, BocaRatonCRC/Taylor & Francis. |
| **Reference Books:** | • P.F Stanbury, A. Whitaker, Principles of Fermentation Technology, 1997, OxfordPergamon Press.<br>• Pauline M. Doran, Bioprocess Engineering Principles Second Edition, 2013, Science Direct.<br>• H.W Blanch, D.S Clark, Biochemical Engineering, 1997, New York M. Dekker.<br>• J.E Bailey, D.F Ollis, Biochemical Engineering Fundamentals, 1986, New York: McGraw-Hill. |

**Core Paper-II**

| COURSE CODE | CRITICAL ANALYSIS OF CLASSICAL PAPERS | Total Lec:60 |
|---|---|---|
| **BT20B302** | | **4– 0 – 0** |
| **Learning Objectives:** | • The objectives of this course are to familiarize the students with classic literature to make them appreciate how ground-breaking discoveries were made without, necessarily, use of high-end technologies. | |
| **Pre-requisites:** | Elementary Biology | |
| **UNIT** | **CONTENT** | **HOURS** |
| | **How does the Course Module work?** Students may be divided groups and each group may be responsible for one paper. Each week there may be a 1.5 hour presentation cum discussion for each of the papers. At the end of the semester each student will be asked to write a mini-review (2-3 pages long) on any of the sixteen papers, other than the one he/she presented/discussed.<br>A list of sixteen classic papers and some suggested reference materials: | |
| **I** | **Molecular Biology**<br>1) Studies on the chemical nature of the substance inducing transformation of Pneumococcal types: Induction of transformation by a deoxyribonucleic acid fraction isolated from Pneumococcus type III.<br>Avery OT, Macleod CM, McCarty M.; J Exp Med. 1944 Feb 1; 79(2):137-58.<br>**Note: This paper demonstrates that DNA is the transforming Principle originally described by Fredrick Griffith.**<br>2) Independent functions of viral protein and nucleic acid in growth of bacteriophage<br>Hershey AD and Chase M.; J Gen Physiol. 1952 May; 36(1):39-56.<br>**Note: This paper demonstrates that DNA, and not protein, component of phages enter bacterial cells.**<br>3 Molecular structure of nucleic acids; a structure for deoxyribose nucleic acid Watson JD and Crick FH; Nature. 1953 Apr 25;171(4356):737-8<br>**Note: In this one page paper Watson and Crick first described the structure of DNA double helix Study help - Watson_Crick_Nature_1953_annotated** | 12 |
| **II** | 1) Transposable mating type genes in Saccharomyces cerevisiae<br>James Hicks, Jeffrey N. Strathern& Amar J.S. Klar; Nature 282, 478483, 1979**Note: This paper provided evidence for „cassette hypothesis" of yeast mating type switches i.e. interconversion of mating types in yeast (S. cerevisiae)occurs by DNA rearrangement.**<br>2)Messelson and Stahl experiment demonstrating semi-conservative replication of DNA.<br>Meselson M and Stahl FW.; ProcNatlAcadSci U S A. 1958 Jul 15;44(7):67182<br>**Note: The experiment demonstrating semi-conservative mode of DNA replication is referred to as "the most beautiful experiment in biology"**<br>3) In vivo alteration of telomere sequences and senescence caused by mutated Tetrahymena telomerase RNAs<br>Guo-Liang Yu, John D. Bradley, Laura D. Attardi& Elizabeth H. Blackburn; Nature 344, 126-132, 1990.<br>**Note: This paper demonstrates that the telomerase contains the template for** | 12 |

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| | **telomere synthesis.** | |
| **III** | **Cell Biology**<br>1) A protein-conducting channel in the endoplasmic reticulum.<br>Simon SM AND Blobel G.; Cell. 1991 May 3; 65(3):371-80.<br>**Note: This paper demonstrates the existence of a protein conducting channel Study help - A brief history of Signal Hypothesis.**<br>2) Identification of 23 complementation groups required for post-translational events in the yeast secretory pathway.<br>Novick P, Field C, Schekman R.; Cell. 1980 Aug;21(1):205-15<br>**Note: In this ground breaking paper Randy Schekman's group used a mutagenesis screen for fast sedimenting yeast mutants to identify genes involved in cell secretion.**<br>3) A yeast mutant defective at an early stage in import of secretory protein precursors into the endoplasmic reticulum.<br>Deshaies RJ and Schekman R.; J Cell Biol. 1987 Aug;105(2):633-45.<br>**Note: Using another yeast mutation screen Schekman lab identifies Sec61, a component of ER protein Conducting Channel (PCC)**<br>**Suggested reference paper - A biochemical assay for identification of PCC.**<br>4) Reconstitution of the Transport of Protein between Successive Compartments of the Golgi.<br>Balch WE, Dunphy WG, Braell WA, Rothman JE.; Cell. 1984 Dec;39(2 Pt 1):405-16<br>**Note: This paper describes setting up of an in vitro reconstituted system for transport between golgi stacks which eventually paved the way for identification of most of the molecular players involved in these steps including NSF, SNAP etc.** | 12 |
| **IV** | 1) A complete immunoglobulin gene is created by somatic recombination. Brack C, Hirama M, Lenhard-Schuller R, Tonegawa S.; Cell. 1978 Sep;15(1):1-14<br>**Note: This study demonstrates DNA level molecular details of somatic rearrangement of immunoglobulin gene sequences leading to the generation of functionally competent antibody generating gene following recombination.**<br>2) A novel multigene family may encode odorant receptors: a molecular basis for odor recognition.<br>Buck L and Axel R; Cell. 1991 Apr 5;65(1):175-87<br>**Note: This paper suggests that different chemical odorants associate with different cell-specific expression of a transmembrane receptor in Drosophila olfactory epithelium where a large family of odorat receptors is expressed.**<br>**3**) Kinesin walks hand-over-handYildiz A, Tomishige M, Vale RD, Selvin PR.; Science. 2004 Jan 30; 303(5658):676-8.<br>**Note: This paper shows that kinesin motor works as a two-headed dimericmotor walking hand-over-hand rather than like an inchworm on microtubule tract using the energy of ATP hydrolysis.** | 12 |
| **V** | **Developmental Biology/ Genetics**<br>1) Mutations affecting segment number and polarity in Drosophila.<br>Christiane Nusslein-Volhard and Eric Weischaus; Nature 287, 795-801, | 12 |

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| | 1980.**Note: This single mutagenesis screen identified majority of the developmentally important genes not only in flies but in other metazoans as well.**<br>2) Information for the dorsal--ventral pattern of the Drosophila embryo is stored as maternal mRNA.<br>Anderson KV and Nüsslein-Volhard C; Nature. 1984 Sep 2026; 311(5983):223-7.<br>**Note: This landmark paper demonstrated that early dorsal-ventral pattern information is stored as maternal mRNA in flies and devised the method of identifying genes encoding such genes.**<br>3) Hedgehog signalling in the mouse requires intraflagellar transport proteins Huangfu D, Liu A, Rakeman AS, Murcia NS, Niswander L, Anderson KV.; Nature. 2003 Nov 6;426(6962):83-7<br>**Note: One of the architects of original fly mutagenesis screens conducted a mouse mutagenes screen which identified a gene Kif3a as a major component of hedgehog signaling pathway. Eventually this discovery revolutionizes our understanding of mechanisms of action of signaling pathways by demonstrating central role of cillia in it.**<br>Suggested Reference paper - Design and execution of a embryonic lethal mutation screen in mouse. | |
| **Course Outcomes as per Bloom's Taxonomy** | | |
| **CO1** | Students will be able to **evaluate**[5] hypothesis. | |
| **CO2** | They will develop **understanding**[2] of scientific literature. | |
| **CO3** | They will be able to **critically**[5]analyzeground-breaking discoveries. | |
| **CO4** | They will be able to**compose critical/analytical**[5]essays and papers using primary texts as evidence. | |
| **CO5** | They will be able topresent projects and **analyses**[5] orally. | |

**Core Paper-III**

| COURSE CODE | PLANT AND ANIMAL BIOTECHNOLOGY | Total Lec:60 |
|---|---|---|
| **BT20B303** | | **4 – 0 – 0** |
| **Learning Objectives:** | • The objectives of this course is to introduce students to the principles, practices and application of animal biotechnology, plant tissue culture, plant and animal genomics, genetic transformation and molecular breeding of plants and animals. | |
| **Pre-requisites:** | Elementary Biology | |
| **UNIT** | **CONTENT** | **HOURS** |
| **I** | Introduction Plant tissue culture, historical perspective, totipotency, organogenesis, Somatic embryogenesis, establishment of cultures – callus culture, cell suspension culture, media preparation – nutrients and plant hormones, sterilization techniques, applications of tissue culture – micropropagation,somaclonalvariation,androgenesis and its applications in genetics and plant breeding,germplasm conservation and cryopreservation, synthetic seed production; protoplast culture and somatic hybridization - protoplast isolation, culture and usage, somatic hybridization - methods and applications,cybrids and somatic cell genetics, plant cell cultures for secondary metabolite production. | 15 |
| **II** | Animal cell culture, brief history of animal cell culture, cell culture media and reagents, culture of mammalian cells, tissues and organs; primary culture, secondary culture, continuous cell lines, suspension cultures, application of animal cell culture for virus isolation and in vitro testing of drugs, testing of toxicity of environmental pollutants in cell culture, application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins. | 10 |
| **III** | Plant Genetic Manipulation Genetic engineering, Agrobacterium-plant interaction; virulence, Ti and Ri plasmids; opines and their significance, T-DNA transfer, disarmed Ti plasmid, Genetic transformation - Agrobacterium-mediated gene delivery,cointegrate and binary vectors and their utility, direct gene transfer - PEG-mediated, electroporation, particle bombardment and alternative methods, screenable and selectable markers,characterization of transgenics, chloroplast transformation, marker-free methodologies, advanced methodologies - cisgenesis, intragenesis and genome editing, molecular pharming - concept of plants as biofactories, production of industrial enzymes and pharmaceutically important compounds. | 10 |
| **IV** | Animal Reproductive Biotechnology and Vaccinology, Animal reproductive biotechnology, structure of sperms and ovum, cryopreservation of sperms and ova of livestock, artificial insemination, super ovulation, embryo recovery and in vitro fertilization, culture of embryos, cryopreservation of embryos, embryo transfer technology, transgenic manipulation of animal embryos, applications of transgenic animal technology, animal cloning - basic concept, cloning for conservation for conservation endangered species. Vaccinology, history of development of vaccines, introduction to the concept of vaccines, conventional methods of animal vaccine production, recombinant approaches to vaccine production, modern vaccines. | 15 |
| **V** | Plant and Animal Genomics Overview of genomics – definition, complexity and classification, need for genomics level analysis; methods of analyzing genome at various levels – DNA, RNA, protein, metabolites and phenotype, genome projects and bioinformatics resources for genome research – databases, overview | 10 |

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| | of forward and reverse genetics for assigning function for genes. | |
| **Course Outcomes as per Bloom's Taxonomy** | | |
| **CO1** | Students will have an enhanced **understanding[2]** and appreciation of animal and plant biotechnology. | |
| **CO2** | Students should be able to gain knowledge of fundamental **experiments[4]**in animal and plant biotechnology. | |
| **CO3** | They will be able to **describe[1]** the applications of animal and plant biotechnology. | |
| **CO4** | They will **know[1]** the scope ofanimal and plant biotechnology. | |
| **CO5** | Students are able to **summarize[4]** different aspects of animal and plant biotechnology. | |
| **Text Books:** | • H.S Chawla, Introduction to Plant Biotechnology, 2000, Enfield, NH: Science.<br>• M.K Razdan,Introductionto Plant Tissue Culture, 2003, Enfield, NH: Science.<br>• S. Umesha, Plant Biotechnology, 2013, the Energy and Resources.<br>• T.A Brown, Gene Cloning and DNA Analysis: An introduction, 2006, Oxford: Blackwell Pub.<br>• I. Gordon, Reproductive Techniques in Farm Animals, 2005, Oxford: CAB International. | |
| **Reference Books:** | • A. Slater, N.W Scott, and M.R Fowler, Plant Biotechnology: The genetic manipulation of plants, 2008, Oxford University Press.<br>• A.K. Rathore, Plant and Animal Biotechnology, 2019, Narendra publishing house.<br>• R. Portner, Animal Cell Biotechnology: Methods and Protocols, 2007, NJ: Humana Press.<br>• S.B Primrose, R.M Twyman, Principles of Gene Manipulation and Genomics, 2006, MA: Blackwell Pub. | |

**Core Paper-IV**

| COURSE CODE | BIO-ENTREPRENEURSHIP | Total Lec:30 |
|---|---|---|
| BT20M304 | | 2 – 0 – 0 |
| Learning Objectives: | • The objectives of this course are to teach students about concepts of entrepreneurship including identifying a winning business opportunity, gathering funding and launching a business, growing and nurturing the organization and harvesting the rewards. | |
| Pre-requisites: | None | |
| **UNIT** | **CONTENT** | **HOURS** |
| **I** | Basics of Bio entrepreneurship, Importance of entrepreneurship, advantages of being entrepreneur, freedom to operate, introduction to bio entrepreneurship, biotechnology in a global scale, Scope in bio entrepreneurship, types of bio-industries – biopharma, bioagri, bio services and bio industrial, innovation types, out of box thinking, skills for successful entrepreneur creativity, leadership, managerial, team building, decision making; opportunities for bio entrepreneurship- entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Start-up& Make in India), patent landscape, IP protection & commercialization strategies. | 10 |
| **II** | Accounting and Finance Business plan preparation; business feasibility analysis by SWOT, socio-economic costs benefit analysis, funds/support from Government agencies like MSME/banks and private agencies like venture capitalists/angel investors for bio entrepreneurship, business plan proposal for virtual start-up company, statutory and legal requirements for starting a company/venture, basics in accounting practices, concepts of balance sheet, profit and loss statement, double entry bookkeeping, collaborations & partnerships, information technology for business administration and expansion. | 5 |
| **III** | Business Strategy, Entry and exit strategy, pricing strategy, negotiations with financiers, bankers, government and law enforcement authorities, dispute resolution skills, external environment/ changes, avoiding/managing crisis, broader vision–global thinking, mergers & acquisitions. | 5 |
| **IV** | Marketing ,Market conditions, segments, prediction of market changes, identifying needs of customers, Market linkages, branding issues, developing distribution channels – franchising, policies, promotion, advertising, branding and market linkages for virtual start-up company. | 5 |
| **V** | Knowledge Centre and R&D Knowledge centres e.g., in universities, innovation centres, research institutions (public & private) and business incubators, R&D for technology development and up gradation, assessment of technology development, managing technology transfer, industry visits to successful bio-enterprises, regulations for transfer of foreign technologies, quality control; technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GLP, GCP, GMP). | 5 |
| **Course Outcomes as per Bloom's Taxonomy** | | |
| **CO1** | Student will be able to **develop**[3] managerial qualities and competencies of an entrepreneur with knowledge of biology. | |
| **CO2** | They will **acquaint**[2]themselves with the challenges of starting a new venture and the process of setting up a business. | |
| **CO3** | They will **build**[3] essential skills and creativity needed to build teams and work in and with them. | |
| **CO4** | They will **know**[2] the essential procedure and funding avenues for setting up a biosciences business. | |
| **CO5** | They will **learn**[2]about the various government initiatives and accordingly plan for his business. | |

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| **Text Books:** | • C.D Shimasaki, Biotechnology entrepreneurship: Starting, managing, and leading biotech companies. Amsterdam, 2014, Elsevier.<br>• J.F Jordan, Innovation, Commercialization, and Start-Ups in Life Sciences, 2014, London: CRC Press.<br>• V. Desai, the Dynamics of Entrepreneurial Development and Management, 2009, New Delhi: Himalaya Pub. House. |
| **Reference Books:** | • D.J Adams, J.C Sparrow, Enterprise for life scientists: Developing innovation and entrepreneurship in the biosciences, 2008, Bloxham: Scion.<br>• A. Onetti, A, A. Zucchella, Business modeling for life science and biotech companies: Creating value and competitive advantage with the milestone bridge, 2016, Routledge. |

**Discipline Specific Elective III**

| COURSE CODE | INTELLECTUAL PROPERTY RIGHTS, BIOSAFETY AND BIOETHICS | Total Lec:45 |
|---|---|---|
| BT20M307 | | 2 – 0 – 0 |
| Learning Objectives: | • To provide basic knowledge on intellectual property rights and their implications in biological research and product development.<br>• To learn biosafety and risk assessment of products derived from biotechnology and regulation of such products.<br>• To understand ethical issues in biological research. | |
| Pre-requisites: | None | |

| UNIT | CONTENT | HOURS |
|---|---|---|
| I | Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; introduction to history of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; concept of „prior art": invention in context of "prior art"; patent databases - country-wise patent searches (USPTO, EPO, India); analysis and report formation. | 5 |
| II | Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application; role of a Country Patent Office; filing of a patent application; precautions before patenting-disclosure/non-disclosure - patent application- forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications; PCT and conventional patent applications; international patenting-requirement, procedures and costs; financial assistance for patenting-introduction to existing schemes; publication of patents gazette of India, status in Europe and US; patent infringement- meaning, scope, litigation, case studies and examples; commercialization of patented innovations; licensing – outright sale, licensing, royalty; patenting by research students and scientists-university/organizational rules in India and abroad, collaborative research - backward and forward IP; benefit/credit sharing among parties/community, commercial (financial) and non-commercial incentives. | 10 |
| III | Biosafety and Biosecurity - introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs; principles of safety assessment of transgenic plants – sequential steps in risk assessment; concepts of familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation – protection goals, compilation of relevant information, risk characterization and development of analysis plan; risk assessment of transgenic crops vs cisgenic plants or products derived from RNAi, genome editing tools. | 5 |
| IV | International regulations – Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; Draft bill of Biotechnology Regulatory authority of India - containments – biosafety levels and category of rDNA experiments; field trails – biosafety research trials – standard operating procedures - guidelines of state governments; GM labeling – Food Safety and Standards Authority of India (FSSAI). | 5 |

| | | |
|---|---|---|
| **V** | Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. Bioethics in research – cloning and stem cell research, Human and animal experimentation, animal rights/welfare, Agricultural biotechnology - Genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations - Protection of environment and biodiversity – biopiracy | 5 |
| **Course Outcomes as per Bloom's Taxonomy** | | |
| **CO1** | Students will **understand[2]** different types of intellectual property rights in general and protection of products derived from biotechnology research. | |
| **CO2** | They will be able to **analyze[4]**issues related to application and obtaining patents. | |
| **CO3** | They will **understand[2]**ethical aspects related to biological, biomedical, health care and biotechnology research. | |
| **CO4** | They will **gain knowledge[2]** of biosafety and risk **assessment** of products derived from recombinant DNA research. | |
| **CO5** | They willbe able to **explain[5] the** environment release of genetically modified organisms, national and international regulations. | |
| **Text Books:** | • P. Ganguli, Intellectual property rights: Unleashing the knowledge economy, 2001, New Delhi: Tata McGraw-Hill Pub.<br>• H. Kuhse, Bioethics: An anthology, 2010, Malden, MA: Blackwell. | |
| **Reference Books:** | • World Intellectual Property Organisation. http://www.wipo.int<br>• International Union for the Protection of New Varieties of Plants. http://www.upov.int<br>• National Portal of India. http://www.archive.india.gov.in<br>• National Biodiversity Authority. http://www.nbaindia.org<br>• Complete Reference to Intellectual Property Rights Laws. (2007). Snow White Publication Oct.<br>• Office of the Controler General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India. http://www.ipindia.nic.in/<br>• Recombinant DNA Safety Guidelines, 1990, Department of Biotechnology, Ministry of Science and Technology, Govt. of India. Retrieved from http://www.envfor.nic.in/divisions/csurv/geac/annex-5.pdf | |

**Discipline Specific Elective III**

| COURSE CODE | ENVIRONMENTALBIOTECHNOLOGY | Total Lec.: 45 |
|---|---|---|
| **BT20M308** | | **3-0-0** |
| **Learning Objectives** | • To understand the concept and techniques used inenvironmental biotechnology.<br>• To understand the role/ application of microbes in environmental biotechnology. | |
| **Pre-requisite** | None. | |
| **UNIT** | **CONTENT** | **HOURS** |
| **I** | Environmental Biotechnology: Role of environmental biotechnology, scope for use, market for environmental biotechnology, modalities and local influences, integrated approach in environmental biotechnology; immobilisation, degradation or monitoring of pollutants from a biological origin, metabolic pathways of particular relevance to environmental biotechnology. | 8 |
| **II** | Fermentation in environmental biotechnology: Importance of fermentation in environmental biotechnology types of bioreactor, design of bioreactor; microbial growth kinetics and yield constants; kinetics; types of fermentation: batch, continuous and fed-batch system; batch culture and kinetics; continuous culture – types, multistage systems, feedback systems; comparison of batch and continuous culture – biomass productivity, metabolite productivity, continuous culture and biomass productivity, fed-batch culture – types and applications strain improvement: methods of strain improvement in fermentation, chemical and molecular methods of strain improvement, Random and site direct methods of mutagenesis; use of molecular biology for the development of strain to be utilised for fermentation examples with respect to environmental biotechnology. | 10 |
| **III** | Environmental monitoring: Definition and environmental monitoring process; sampling– land (site) sampling, water sampling, air sampling, analysis– physical, chemical and biological analysis methods and process, use of microbial population for environmental monitoring– recombinant DNA technology and proteomics monitoring pollution; bio-indicators; biomarkers – biochemical indicators, immunochemistry, genetic indicators; toxicity testing using biological material– example algae, luminescent organisms, molecular biology biomarkers; biosensors– mechanism, principle and working environment impact assessment: EIA complete process, importance of EIA. | 9 |
| **IV** | Solid Waste Management: Sources, generation, classification & composition of solid wastes. solid waste management methods- sanitary land filling, recycling, composting, vermin-composting, incineration, energy recovery from organic waste, solid waste management plan, waste minimization technologies, hazardous waste management, sources & classification, physicochemical properties, hazardous waste control & treatment, hospital waste management, hazardous waste management & handling rules, 1989 & 2000 (amendments); disaster management, fly ash generation & utilization, primary, secondary & tertiary & advance treatment of various effluents. | 9 |
| **V** | Environmental Toxicology: Toxic chemicals in the environment - air, water & their effects, pesticides in water, biochemicals aspects of arsenic, cadmium, lead mercury, carbon monoxide, ozone and PAN pesticide, toxic substance, biotransformation of xenobiotics detoxification, carcinogens in air, chemical carcinogenicity, mechanism of carcinogenicity, environmental carcinogenicity testing, insecticides, MIC effects, concept of major, trace and Rare Earth Element (REE)- possible effects of imbalance of some trace elements, biogeochemical factors in environmental health. Epidemiological issues: goiter, fluorosis, arsenic poisoning. | 9 |
| **Course Outcomes as per Bloom's Taxonomy** | | |

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|---|---|
| **CO1** | The students will be able to **recall**[1] the concepts of environmental biotechnology. |
| **CO2** | The students will **understand**[2] the 12 principles of bioreactor. |
| **CO3** | They will be able to **apply**[3] the concept of biotechnology in environmental monitoring. |
| **CO4** | They will **develop**[3] the awareness for solid waste management. |
| **CO5** | Students will be able to **analyse**[4]toxic chemicals from the environment. |
| **Text Books:** | • Textbook of Environmental Biotechnology, by Pradipta Kumar Mohapatra, Dreamtech Press, 2020, ISBN-10 : 9389633052.<br>• Manahan, S.E. 1997. Environmental Science and Technology. Lewis, New York.<br>• Textbook of Environmental Biotechnology by Vipin Kumar Er. Pramod Kumar And Er. Vipin Kumar, Woodhead Publishing, 2019, pp- 304, ISBN 9789385059384.<br>• Environmental Biotechnology, Monika Jain, CBS Publishers and Distributers. |
| **Reference Books:** | • Metcalf and Eddy (Eds). 2003, Wastewater Engineering: Treatment and Reuse,Tata McGraw-Hill, New Delhi.<br>• Nelson, G.C. 2001. Genetically Modified Organisms in Agriculture: Economicsand Politics. Academic Press.<br>• Evans, G.M. and Furlong J.C. 2003. Environmental Biotechnology: Theory andApplication. John Wiley and Sons.<br>• Thomas, J.A. and Fuchs, R. 2002. Biotechnology and Safety Assessment.Academic Press.<br>• Wang L.K. Hung Y.T. nad Shammas N.K.(Eds). 2006. AdvancedPhysicochemical Treatment Processes. Springer-Verlag New York, LLC |

**Practical**

| COURSE CODE | LAB V | Practicals:60 |
|---|---|---|
| **BT20M309** | | **4** |

**1) Basic Microbiology techniques**

a) Scale up from frozen vial to agar plate to shake flask culture. b) Instrumentation: Microplate reader, spectrophotometer, microscopy. c) Isolation of microorganisms from soil samples.

**2) Experimental set-up**

a) Assembly of bioreactor and sterilization. b) Growth kinetics. c) Substrate and product inhibitions. d) Measurement of residual substrates.

**3) Data Analysis**

a) Introduction to Metabolic Flux Analysis (MFA).

**4) Fermentation**

a) Batch. b) Fed-batch. c) Continuous.

**5) Unit operations**

a) Microfiltrations: Separation of cells from broth. b) Bioseparations: Various chromatographies and extractions.

**6) Bioanalytics**

a) Analytical techniques like HPLC, FPLC, GC, GC-MS etc. for measurement of amounts of products/substrates.

# Syllabus
# Semester IV

**Discipline Specific Elective IV**

| COURSE CODE | NANOBIOTECHNOLOGY | Total Lec.: 45 |
|---|---|---|
| **BT20M401** | | **4-0-0** |
| **Learning Objectives** | • To understand the concept of nanobiotechnology.<br>• To understand the application of nano materials in various biotechnology. | |
| **Pre-requisite** | None | |
| **UNIT** | **CONTENT** | **HOURS** |
| **I** | Introduction to Nanobiotechnology: History of nanotechnology and its emergence, concept of nanobiotechnology, types of nanoparticles and their properties: quantum dots, polymeric nanoparticles, metal nanoparticles, metal oxide nanoparticles, dendrimers, composites. | 5 |
| **II** | Methods for synthesis of Nanomaterials: Physical, chemical, biological methods: chemical precipitation and coprecipitation, polyol, and borohydrate reduction methods, Sol-Gel synthesis; microemulsions synthesis, hydrothermal, solvothermal synthesis methods, microwave assisted synthesis; sonochemical assisted synthesis, core-shell nanostructure, organic-inorganic hybrid nanocomposites, quantum dot (QDs) synthesis, microbial/plant mediated nanoparticle production: overview and concept of microbial/plant mediated nano-particle production; methods of microbial/plant mediated nano-particle production. | 10 |
| **III** | Unit- III, Physiochemical characterization of Nanomaterials: Optical (UV-Vis/Fluorescence), X-ray diffraction, imaging and size (Electron microscopy-TEM, SEM; light scattering- DLS, NTA; zeta potential) | 10 |
| **IV** | Applications of Nanomaterials: Proteins, lipids, RNA and DNA; protein targeting - small molecule/nanomaterial - protein interactions; nanomaterial-cell interactions-manifestations of surface modification (polyvalency). nanomaterials and diagnostics/drug delivery and therapeutics: peptide/DNA coupled nanoparticles; lipid nanoparticles for drug delivery; inorganic nanoparticles for drug delivery; metal/metal oxide nanoparticles (antibacterial/antifungal/antiviral activities); anisotropic and magnetic particles (Hyperthermia). MRI, imaging surface modified nanoparticles; MEMS/NEMS based on Nanomaterials; applications of nanobiotechnology: nanomedicines, nanoparticles for diagnostics and imaging, food science (food processing, food packaging, detection of pathogens), nanosensors, nanotechnology for water remediation and purification | 15 |
| **V** | Concerns of Nanomaterials/Nanobiotechnology: Fate of nanomaterials, environmental and health impact of nanomaterials, genotoxicity and cytotoxicity evaluation of nanomaterials, ecotoxicology | 5 |
| **Course Outcomes as per Bloom's Taxonomy** | | |
| **CO1** | Students will be able to **develop**[3]concept of nanobiotechnology. | |
| **CO2** | They will **learn**[1] about physicochemical characterization of nanomaterials. | |
| **CO3** | They will be able to **design**[6]protocols of nanomaterials production. | |
| **CO4** | They will be able to **define**[5]usage of nanomaterials in food science. | |
| **CO5** | They will learn to **create**[3]nanomaterials from microbial source. | |
| Text Books: | • Nanotechnology by Rishabh Anand, 1st edition, Khanna Publishers, 2020, pp- 276, ISBN: 9788194538066.<br>• Nanotechnology, 2ed: The Science of Small by M.A. Shah, K.A. Shah, Wiley Publication, pp- 22, ISBN: 9788126579976.<br>• Nanotechnology by Ratner, 2003, Pearson Education, pp 208, ISBN-10: 9788177587432. | |

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|---|---|
| Reference Books: | • Microbial Nanotechnology by Mahendra Rai, Patrycja Golińska, 1st edition, CRC Press, 2020, ISBN 9780367226763.<br>• The Chemistry of Nanomaterials: Synthesis, Properties and Applications, 2 Volume Set C. N. R. Rao (Editor), Achim Müller (Editor), Anthony K. Cheetham (Editor), 2004. Wiley Publisher.<br>• Nanobiotechnology: Concepts, Applications and Perspectives, Christof M. Niemeyer (Editor), Chad A. Mirkin (Editor) , Wiley Publishers, April 2004.<br>• Nanotechnology: A Gentle Introduction to Next Big Idea, Mark Ratner and Daniel Ratner, Low Price edition, Third Impression, Pearson Education.<br>• Nanoparticles: From theory to applications – G. Schmidt, Wiley Weinheim , 2004<br>• Nanochemistry: A Chemical Approach to Nanomaterials – Royal Society of Chemistry, Cambridge UK 2005. |

**Discipline Specific Elective IV**

| COURSE CODE | PHARMACEUTICAL AND DRUG DESIGNING | Total Lec.: 45 |
|---|---|---|
| **BT20M403** | | **4-0-0** |
| **Learning Objectives** | • To understand the concept of pharmaceutical biotechnology.<br>• To understand the process of drug designing and development. | |
| **Pre-requisite** | None. | |
| **UNIT** | **CONTENT** | **HOURS** |
| **I** | Introduction: Introduction to pharmaceutical biotechnology and drug discovery, drug targets: structure and functions; physiochemical properties of drugs; drugs from natural sources. pharmacodynamics, pharmacokinetics and drug metabolism, drug tolerance & intolerance, drug allergy, drug induced side effects with examples. Screening and isolation of bioactive compounds, role of regulatory authorities in drug approvals. The food and drug administration (FDA), investigational new drug application, new drug application; European regulations national regulatory, authorities, European medicines agency and the new EU drug approval system, centralized procedure, mutual, Indian drug regulations, & pharmacopeia, Market issues of drug patenting and licensing in pharma industry. | 10 |
| **II** | Drug action and Resistance: Mechanism of action of anti-diabetic, anticancer, anti-inflammatory and antibiotics (any two drugs of each), mechanisms of drug resistance to antibiotics and anticancer drugs with examples, MDR, XDR or PDR, assay of drug potency- bioassay and immunoassay. | 5 |
| **III** | Process of Drug Development: Target identification and validation, pre-clinical studies-toxicity (cytotoxicity, genotoxicity, reproductive toxicity, carcinogenicity, mutagenicity, and other tests), animal models for in vivo activity of drugs testing, clinical trials: Phase I, II, III and IV. | 5 |
| **IV** | Biopharmaceuticals: Introduction and scope of biopharmaceutical industry, biotherapeutics: various categories of therapeutics like vitamins, antibiotics, hormones, enzymes, hematopoietic growth factors and coagulation factors, interferon's and cytokines for anti-infective and cancer therapy, biopharmaceuticals manufacturing: overview of upstream & downstream processing, production of biopharmaceuticals using synthetic biology approach (eg. Artemisinin). | 10 |
| **V** | Computer aided drug design (CADD): Introduction to CADD, Identification drug targets using molecular modeling, combinatorial libraries and high-throughput screening (HTS), Methods of drug designing: Structure based drug design, Molecular docking: Types and principles, Semi-flexible docking, Flexible docking; Ligand and protein preparation, Macromolecule and ligand optimization, Analysis of docking results and validation with known information. Use of Small-molecule libraries, Natural compound libraries for virtual high throughput screenings. Commonly used docking software. Ligand based drug design Quantitative structure activity relationships; Introduction to chemical descriptors like 2D, 3D and Group-based pharmacophore modelling, pharmacophore-based screenings of compound library, analysis and experimental validation. Concept of quantitative drug design using quantitative structure-activity relationship models (QSAR models), types of molecular modelling for proteins. | 15 |
| **Course Outcomes as per Bloom's Taxonomy** | | |
| **CO1** | Students will be able to **develop**[3]understanding in pharmaceutical biotechnology | |
| **CO2** | They will **learn**[1] about drug resistance. | |
| **CO3** | They will be able to **do** *in silico* drug **design**[6] using molecular modelling. | |
| **CO4** | They will be able to **define**[5]processes involved in drug manufacturing. | |

| **CO5** | They will learn to **create**[3]biopharmaceuticals using synthetic biology approach. |
|---|---|
| Text Books: | • Vyas and Dixit Pharmaceutical Biotechnology, 1 st CBS Publisher New Delhi, 1991<br>• P. K. Gupta, Elements Of Biotechnology, Rastogi Publication, 10 th edition, 2004<br>• S.S. Purohit, Biotechnology Fundamentals and Applications Student edition Agrobios Publisher;2002<br>• K. Sambamurthy, Ashutosh Kar, Pharmaceutical Biotechnology, 2nd edition New AGE International (LP) Limited, 2007. |
| Reference Books: | • Olive Kaiser ,Rainer Muller, Pharmaceutical Biotechnology: Drug Discovery and Clinical Application, Wiley VCH publisher, 2004<br>• Hermann Dugas, Bioorganic Chemistry: A chemical Approach to Enzyme action by Springer New York, 1999.<br>• Kerns, E.H.; Di, L. Drug-Like Properties: Concepts, Structure Design andMethods:from ADME to Toxicity Optimization, Academic Press, Oxford, 2008<br>• M. E. Wolff, John Wiley & Sons Burger's Medicinal Chemistry and Drug Discovery, 7th Edition, Vol. 1-6. Principles and Practice, edited by: New York, 2010.<br>• Foye's Principles of Medicinal Chemistry, 7th Edition, edited by T.L. Lemke, D. A.Williams, V. F. Roche, and S.W. Zito, Williams and Wilkins: Philadelphia, 2013.<br>• Edward C. Olson, Christoffersen Editor, Ralph E. Computer-assisted drug design / 2009, American Chemical Society.<br>• Martin YC, Marcel Deckker Quantitative Drug Design - A Critical Introduction by Inc. New York.<br>• Veerapandian, "Structure Based Drug Design". Taylor and Francis, 1997. 13. Drug Design, V.M. Kulkarni, K.G. Bothara, Nirali Prakashan<br>• Graham L. Patrick An Introduction to Medicinal Chemistry, ,Oxford University Press1995.<br>• Richard B. Silverman The Organic Chemistry of Drug Design & Drug Action, , Elsevier Academic Press, 2014.<br>• Natanya Civjan, Chemical Biology: Approaches to Drug Discovery and Development to Targeting Disease, Edited by Wiley (2012).<br>• Biology For Engineers 2019 Edition by SINGAL R, CBS Publishers and Distributors |

## Project Based Learning III

| COURSE CODE | PROJECT BASED LEARNING |
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| **PB20B301** | |
| **Learning Objectives:** | • Integrating the knowledge and skills of various courses on the basis of multidisciplinary projects.<br>• Develop the skill of critical thinking and evaluation.<br>• To develop 21st century success skills such as critical thinking, problem solving, communication, collaboration and creativity/innovation among the students.<br>• To enhance deep understanding of academic, personal and social development in students.<br>• Employ the specialized vocabularies and methodologies. |
| **General Guidelines:** | • PBL will be an integral part of UG/PG Programs at different levels.<br>• Each semester offering PBL will provide a separate Course Code, two credits will be allotted to it.<br>• Faculty will be assigned as mentor to a group of 30 students minimum by HoS.<br>• Faculty mentor will have 4 hours/week to conduct PBL for assigned students.<br>• Student will select a topic of their choice from syllabus of any course offered in respective Semester (in-lines with sustainable development goals).<br>• Student may work as a team maximum 3 or minimum 2 members for single topic.<br>• For MSE, student's performance will be assessed by panel of 2 experts either from other Department/school, or from same department/school based on chosen topic. This will be comprised of a presentation by student followed by viva-voce. It will be evaluated for 30 marks.<br>• 20 marks would be allotted for continuous performance assessment by concerned guide/mentor.<br>• For ESE, student will need to submit a project report in prescribed format, duly signed by concerned guide/mentor and head of the school. The report should be comprised of following components:<br>1. Introduction<br>2. Review of literature<br>3. Methodology<br>4. Result and Discussion<br>5. Conclusion and Project Outcomes<br>6. References<br>• In ESE, viva-voce of students will be conducted on the basis of report, by one external and one internal faculty which is of 50 Marks.<br>Student will need to submit three copies for<br>1. Concerned School<br>2. Central Library<br>3. Self.<br>The integrity of the report should be maintained by student. Any malpractice will not be entertained.<br>• Writing Ethics to be followed by student, a limit of 10 % plagiarism is permissible. Plagiarism report is to be attached along with the report.<br>• Project could be a case study/ analytical work /field work/ experimental work/ programming or as per the suitability of the program. |