1. **SC INDUSTRIAL BIOTECHNOLOGY**
2. Programme Outcome
3. Programme Specific Outcome
4. Highlights of the Revamped Curriculum:
5. Value additions in the Revamped Curriculum:

# Credit Distribution and Structure of Course

# Template for Semester

# Model Syllabus

1. Elective Courses (ED from other Department Experts)

# Skill Development Courses

1. Institution-Industry-Interaction

|  |  |
| --- | --- |
| **SEM - I****SEMESTER - 2** **SEMESTER - 4** **SEMESTER - 5** **SEMESTER 6**  | **MICROBIOLOGY**Commercial Production of MicroorganismsMicroorganisms & Agriculture Products from MicroorganismsBioremediationPrinciples of Microbial growthBioreactor / FermenterTechnology of Microbial cell maintenance Downstream processing**ENZYME TECHNOLOGY** Enzyme technologyBiological fuel generation Biotechnology in specific medical & industrial applications**GENETIC ENGINEERING** Introduction and Tools for Genetic Engineering Different Types of VectorDifferent Types Of PCR Techniquesc DNA AnalysisGene Silencing and Genome Editing Technologies**BIOPROCESS TECHNOLOGY** Introduction to Engineering Calculation Bioreactor Types and operation controlBioreactor Design Reactor engineeringApplications**IMMUNOLOGY** Immunology- fundamental concepts and anatomy of the immune system Immune responses generated by B and T lymphocytes Antigen-antibody interactions Vaccinology**BASICS OF INDUSTRIAL BIOTECHNOLOGY**Introduction to Industrial Bio processProduction of Primary MetabolitesProduction of Secondary MetabolitesProduction of Enzyme and Other Bio productsProduction of Modern Biotechnology products**DOWNSTREAM PROCESSING** Screening and Design Purification StrategiesLow-Resolution Protein Purification MethodsProtein Purification and Characterization Large Scale Protein PurificationAnimal Based ProductsPlant Based ProductsMicrobial Based Products **ANALYTICAL TECHNIQUES** Principles and application of SpectrophotometryChromatographic techniquesElectrophoresisMethods for measuring nucleic acid and protein interactions**BIOCHEMISTRY**Organisation of BiomoleculesLipidsAminoacidsIUB Classification and nomenclature of enzymes **BIOINFORMATICS** Biological Database Sequence Alingment and Database SearchingPhylogenetic AnalysisStructural BiologyClassification and Compare of 3 D StructureApplication in Drug DesignAnalysis of Micro assay DataBiological AlgorithmsSystem Biology**CELL BIOLOGY** **An overview of cell and cell organelles****Cytoskeleton and cell movement**Microscopic**Cell signaling, cell Cycle, cell death and renewal** **STATISTICS** Introduction Descriptive Statics Probability and Distribution Correlation and Regression AnalysisStatistical Hypothesis Testing Tests of Significance Experimental DesignsFERMENTATION TECHNOLOGYIndustrial VisitReaction EngineeringProcess InitializationReactor EngineeringBioprocess Scale upCommercial Product ProcessingProcess Technology Bio ConversionsBio safety And Bio security **BIOETHICS** Philosophy And Theories Of BioethicsHistory, Religion And BioethicsEpidermiology And BiostatisticsLaws And Global Health Ethics , Public Health PolicyResearch EthicsFunctions of clinical ethics committee**PROJECT**  |

**B.SC INDUSTRIAL BIOTECHNOLOGY SYLLABUS**

**SEMESTER - I**

**UNIT - I**

**MICROBIOLOGY**

**Commercial Production of Microorganisms** – Industrial Fermenters, Single-cell Protein. **Bioconversions** – Biomining and bioleaching of ores (Use of thermophilic microorganisms in industrial microbiology Bio-gas, Bio-leaching, Bio-diesel. **Microorganisms & Agriculture** – Microorganisms in Agricultural Waste water treatment, Vermiculture, Microbial pesticides.

 **Products from Microorganisms** – Metabolites, Enzymes, Antibiotics.

**Bioremediation** – Petroleum prospecting and formation of oil spills,, Wastewater treatment, chemical degradation, heavy Metals.

**Principles of Microbial growth** – introduction, the ways of growing microorganisms, ways to increase yield of microbes, Batch, fed-batch and continuous cultures (definition and kinetics).

**Bioreactor / Fermenter** – types & operation of Bioreactors, physico-chemical standards used in bioreactors, limitations of bioreactors, stages of fermentation processes, Media design for fermentation processes, Solid substrate fermentation, Fermenters (Stirred tank, bubble columns, airlift. Bioreactors, Static, Submerged and agitated fermentation), advantages & disadvantages of solid substrate & liquid fermentations.

 **Technology of Microbial cell maintenance** – steps to maintain microbial culture in an aseptic & sterile environment (how to inoculate, preserve & maintain), Strain preservation, maintenance and strain improvement by mutation of gene transfer processes

 **Downstream processing** – extraction, separation, concentration, recovery & purification, operations (Insulin, Vitamins, Metabolites), Industrial production of Ethyl alcohol, Acetic Acid (Vinegar), Citric acid, lactic acid, α-amylase, protease penicillin, tetracycline and vitamin B12, with reference to easily available raw materials, Production of herbal drugs. .

**UNIT - II**

**ENZYME TECHNOLOGY**

**Enzyme technology**

 Nature of enzymes, application of enzymes, limitations of microbial cells used as catalysts in fermentation, multi-enzyme reactors, genetic engineering & protein engineering of enzymes, cloning strategy for enzymes, technology of enzyme production, use of immobilized cells and enzymes (Ca-alginate beads, polyacrylamide), industrial applications of immobilized enzymes.

**Biological fuel generation**

Photosynthesis, sources of biomass, ethanol from biomass, methane from biomass, hydrogen, microbial recovery of petroleum.

**Biotechnology in specific medical & industrial applications**

Retting of jute, microbial process for immunization (Production of monoclonal antibodies), Deterioration of paper, textiles, painted surfaces and their prevention, Biofilms, microbial biopolymers, biosurfactants, Microbial culture selection with high yield potential.

**UNIT - III**

**GENETIC ENGINEERING**

**UNIT - I**

**INTRODUCTION AND TOOLS FOR GENETIC ENGINEERING**

Impact of genetic engineering in modern society ; general requirements for performing a genetic engineering experiments ; restriction endonuclease and methylase ; DNA ligase , Klenow enzyme , T 4 DNA polymerase , poly nucleotide kinase , alkaline phosphatase ; cohesive and blunt end lingation , linkers , adaptors ; homo-polymer tailing ; labeling of DNA ; nick translation , random priming , radioactive and no - radioactive probes ,hybridization techniques ; northern , southern , south - western and far - western and colony hybridization , fluorescence in situ hybridization.

**UNIT - II**

**DIFFERENT TYPES OF VECTOR**

Plasmids, bacteriophages, M13mp vectors ; PUC 19 and p Blue-script vectors , phagemids ; Lambda vector; Insertion and Replacement vectors ; cosmids; Artificial chromosomes vectors (YACs; BACs); principle for maximizing gene expression vectors , p Mal ; GST ; pET - based vector, protein purification , His- tag , GST - tag ; MBP - tag etc. Intein based vectors ; inclusion bodies , methodologies to reduce formation of inclusion bodies ; mammalian expression and replicating vectors , Baulovirus and pichia vectors system , plant based vectors , Ti and Ri as vectors , yeast vectors, shuttle vectors

**UNIT- III**

**DIFFERENT TYPES OF PCR TECHNIQUES**

Principle of PCR : primer design , fidelity of thermostable enzyme , DNA polymerases ; types of PCR - multiplex , nested , reverse transcription PCR , real time PCR , touchdown PCR Hot star PCR , colony PCR , asymmetric PCR , cloning of PCR products ; TA cloning vectors ; proof reading enzymes , PCR based site specific mutagenesis; PCR in molecular diagnostics ; viral and bacterial detection, sequencing methods, enzymatic DNA sequencing ; chemical sequencing of DNA ; automated DNA sequencing ; RNA sequencing , chemical synthesis of oligonucleotides, mutation detection : SSCP, DGGE , RFLP

**UNIT - IV**

**c DNA ANALYSIS**

 Insertion of foreign DNA into host cells, transformation , electroporation , transfection , construction of libraries , isolation of mRNA and total RNA ; reverse transcriptase and c DNA synthesis , c DNA and genome libraries ; construction of micro-arrays - genomic array c DNA array and oligo arrays ; study of protein - DNA interaction ; electrophoretic mobility shift assay ; DNA ase foot printing ; methyl interference assay , chromatin immunoprecipitation ; protein - protein interaction using yeast two - hybrid system ; phage display.

**UNIT - V**

**GENE SILENCING AND GENOME EDITING TECHNOLOGIES**

Gene silencing techniques ; introduction to si RNA technology ; Micro RNA ; construction of siRNA vectors, principle and application of gene silencing ; gene knockout and gene therapy , creation of transgenic plant ; debate over GM crops ; introduction to method of genetic manipulation in different model system e.g. fruit flies (Drosophila ), worms (C. elegans ), frogs (Xenopus ), fish ( Zebra fish ) and chick; Transgenics - gene replacement ; gene targeting ; creation of transgenic and knock out mice , disease model ; introduction to genome editing by CRISPR - CAS with specific emphasis on Chinese and American clinical traits ; cloning genome targets into CRISPR /Cas9 plasmid, electroporation of Cas9 plasmid into cells ; purification of DNA from Cas9 treated cells and evaluation of Cas9 gene editing in-vitro synthesis of single guide RNA (sgRNA), using Cas9/sgRNA complexes to test for activity on DNA substrate ; evaluate Cas 9 activities by T 7E1 assay and DNA sequence analysis ; Application of CRISPR /cas9 technology. Application gene therapy/gene editing - antiviral strategies , cancer immunotherapy , hematologic disorder ; liver - targeted gene editing, neuromusclar disorder , ocular disorder etc ., examples of Chinese and American clinical trials .

**RECOMMENDED TEXTBOOK AND REFERENCE :**

1. Old , R.W. , Primrose, S.B., &Twyman, R.M. (2001).Principles of gene Manipulation and Genomics, 7th Edition: Oxford : Blackwell Scientific Publications.
2. FGreen , M.R., & Sambrook, J. (2012). Molecular cloning : a Laboratory Manual. Cold spring Harbor, NY : Cold spring Harbor Laboratory Press.
3. Brown , T.A. (2006). Genomes (3rd ed.). New york ; Garland Science Pub .
4. Selected papers from Scientific Journals, particularly Nature & science .
5. Technical Literature from Stratagene, Promega , Novagen, New England Biolabs .

**SEMESTER - 2**

**BIOPROCESS TECHNOLOGY**

 **UNIT I**

**Introduction to Engineering Calculation**

Introduction to engineering calculations; unit conversion, measurement conventions, Errors in Data and Calculations, Presentation of Experimental Data, Data Analysis, General Procedures For Plotting Data, Process Flow Diagrams.

**UNIT II.**

**Bioreactor Types and operation control**

 Batch reactors, fed-batch reactors, CSTR reactors, various types of bioreactors for microbial, animal , plant cell culture, fluidized bed reactor, bubble column, air lift fermenter, packed bed, trickle bed etc. parallel and series bioreactor. Impellers, stirrer, glands and bearings, packed gland seal, mechanical seal, magnetic drives, baffles, different types of spargers, computer based advance controllers for bioreactors.

**UNIT III.**

**Bioreactor Design**

Introduction, general design information, design of bioreactors, basic function of a bioreactor design, mass and energy balance, materials of construction for bioprocess plant, mechanical design of process equipment, utilities for biotechnology production plants.

**UNIT IV.**

**Reactor engineering** Ideal reactors, concept of holding and space time, performance equations for single reactors; multiple reactor systems, design of multiple reactors: kinetics of series and parallel reaction, residence time distributions (RTD), exit age distribution, recycle reactors, recycle ratio for auto catalytic reactions.

**UNIT V.**

**Applications** Process technology for the production of cell biomass and some primary metabolites, e.g. ethanol, acetone-butanol, citric acid, dextran and amino acids. Microbial production of industrial enzymes glucose isomerase, cellulase & lipases. Applications of bioconversion, transformation of steroids and sterols. Transformation of non-steroidal compounds, antibiotics and pesticides. Bioenergy-fuel from biomass, production and economics of biofuels. Metal recovery and microbial desulfurization of coal.

**Text / Reference Books:**

1. Comprehensive Biotechnology Vol. 1- 4: M.Y. Young (Eds.), PergamonPress.
2. Biotechnology: A Text Book of Industrial Microbiology: T.D. Brock, Smaeur Associates,1990.
3. Industrial Microbiology: L.E. Casida, Willey Eastern Ltd., 1989.
4. Industrial Microbiology: Prescott & Dunn, CBS Publishers, 1987.
5. Bioprocess Technology- fundamentals and applications, S O Enfors & L Hagstrom (1992),RIT, Stockholm.
6. Biotechnology, Economic & Social Aspects: E.J. Dasilva, C Rutledge & A Sasson, Cambridge Univ. Press, Cambridge.
7. Biotechnology - a handbook of industrial microbiology: W. Crueger and A. Crueger.
8. Microbial Biotechnology: Channarayaappa, University press, Hyderabd, 2003
9. Biochemical engineering by Aiba, Humphrey and Mells, Academic press.
10. Bioprocess engineering principles by Pauline M. Doran, Academic Press.
11. Biochemical Engineering by H.W. Blanch and D.S. Clark, MarcelDekker. 12. Bioseparations Science and Engineering by Roger. H. Harrison., Oxford Universitypress. 13.Applied instrumentation in the Process Industries,Vols I,II,III Andrew W G., Gulf Publishing Company. 14.Bioseparations-Downstream processing for Biotechnology by Paul. A. Belter, E.L.Cussler and Wei-Shou Hu., John Wiley and sons

**UNIT - II**

**IMMUNOLOGY**

**Unit I**

**Immunology- fundamental concepts and anatomy of the immune system**

Components of innate and acquired immunity; Phagocytosis; Complement and

Inflammatory responses; Haematopoesis; Organs and cells of the immune system

primary and secondary lymphoid organs; Lymphatic system; Lymphocyte circulation;

Lymphocyte homing; Mucosal and Cutaneous associated Lymphoid tissue.

(MALT&CALT); Mucosal Immunity; Antigens - immunogens, haptens; Major

Histocompatibility Complex - MHC genes, MHC and immune responsiveness and

disease susceptibility, HLA typing.

**Unit II**

**Immune responses generated by B and T lymphocytes**

Immunoglobulins-basic structure, classes and subclasses of immunoglobulins, antigenic determinants; Multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; Principles of cell signaling; Immunological 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; Cellmediated 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.

**Unit 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 plasma resonance, Biosenor assays for assessing ligand –receptor interaction, CMI techniqueslymphoproliferation assay, Mixed lymphocyte reaction, Cell Cytotoxicity assays, Apoptotosis, Microarrays, Transgenic mice, Gene knock outs.

**Unit IV**

**Vaccinology**

Active and passive immunization; Live, killed, attenuated, sub unit 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 and hybrid monoclonal

antibodies; Catalytic antibodies and generation of immunoglobulin gene libraries. **References**

1. William E. Paul, Fundamental Immunology, Wolters Kluwer/ Lippincott

Williams & Wilkins.

2. Stephen K Wikel, The Immunology Host-Ectoparasitic arthropod relationships.

Cabinternational.

3. Herman N. Eisen, MD, General Immunology. J.B. Lippincott Company. F.M.

Burnet, Immonology. W.H. Freeman and company

1. Jack G. Chirikjian, Plant Biotechnology, Animal cell culture Immunobiotechnology. Jones and Bartlett Publisher

**UNIT - III**

**BASICS OF INDUSTRIAL BIOTECHNOLOGY**

**UNIT – I :**

 **INTRODUCTION TO INDUSTRIAL BIOPROCESS**

Biotechnology: Scope and importance, Commercial potential of Biotechnology in India. Historical overview of industrial fermentation process -traditional and modern Biotechnology. Industrial Fermentation- microorganisms, mode of operation, fermentation processes-pictorial representation

**UNIT – II :**

 **PRODUCTION OF PRIMARY METABOLITES**

A brief outline of processes for the production of some commercially important organic acids (citric acid, lactic acid & acetic acid); amino acids (glutamic acid & tryptophan) and alcohols (ethanol & butanol)

**UNIT – III :**

**PRODUCTION OF SECONDARY METABOLITES**

Production processes for various classes of secondary metabolites: antibiotics: (penicillin streptomycin & erythromycin), vitamins (Vit B12 and Vit B2) and steroid biotransformation.

**UNIT – IV :**

**PRODUCTION OF ENZYMES AND OTHER BIOPRODUCTS**

Production of industrial enzymes (proteases & amylases), Production of biopesticide, Biofertilizers, biopreservative (Nisin), biopolymers (xanthan gum & PHB), cheese, SCP.

**UNIT – V :**

**PRODUCTION OF MODERN BIOTECHNOLOGY PRODUCTS**

Production of recombinant proteins having therapeutic and diagnostic applications (insulin, human growth hormone), Production of recombinant vaccines (Hepatitis B vaccine, cholera vaccine), production of monoclonal antibodies.

**TEXT BOOKS:**

1. Lee, S.Y., Nielsen, J. and Stephanopoulos, G., “Industrial Biotechnology: Products and Processes”, John Wiley & Sons, 2016.
2. Waites, M.J., Morgan,N.L., Rockey,J.S., Higton, G., “Industrial Microbiology: An Introduction” Blackwell, 2001.
3. Cruger, W., Cruger, A., “A Textbook of Industrial Microbiology”, Panima Publishing Corporation, 2nd Edition, 2005.

**SEMESTER -3**

**UNIT - I**

**DOWNSTREAM PROCESSING**

**UNIT - I**

**SCREENING AND DESIGN PURIFICATION STRATEGIES**

 Overview of down - stream processing ; Establishment of deign space for bio-pharmaceutical process, High - through out process development , Media selection in ion - exchange chromatography in single micro-plate , high - throughput screening of dye - ligand for chromatography.

**UNIT -II**

**LOW -RESOLUTION PROTEIN PURIFICATION METHODS**

 Aqueous two phase partitioning system , A platform for isolation of process related impurities from therapeutics proteins , Simultaneous purification refolding of protein by affinity precipitation and macro (Affinity ligand )- facilitate three- phase partitioning bacterial cytoplasm and periplasm , immunoglobulin purification by caprylic acid ; Filtration , Chromatography (comparison),rationale of choosing between quality and cost of different products .

**UNIT -III**

**PROTEIN PURIFICATION AND CHARACTERIZATION**

 Introduction , initial recovery of proteins , removal of whole cells and cell debris , concentrations and primary purification , protein inactivation and stabilization , protein characterization .

**UNIT - IV**

**LARGE SCALE PROTEIN PURIFICATION**

 Some general principle , range and medical significance of impurities potentially present in proteins based therapeutic products , labeling and packing of finished products .

**UNIT- V**

**ANIMAL BASED PRODUCTS**

General DSP, Case studies of : monoclonal antibodies ; Tissue Plasminogen activator, insulin, erythropoietin.

**UNIT- VI**

**PLANT BASED PRODUCTS**

General DSP, Case studies of : shikonin , Protein extract from Seed material and green tissues.

**UNIT- VII**

**MICROBIAL BASED PRODUCTS**

General DSP, Case studies of : lipase , cellulose, amylase, horse radish per oxidase , subtilisin, ethanol, citric acid , xanthan gum.

**RECOMMENDED TEXTBOOKS AND REFERENCES :**

1. Nikolaos . E . Labrous (2014), Protein Downstream Processing : Design Development and application of high and low Resolution Methods in Molecular Biology , Spinger protocols, Human Press.
2. Gary Walsh , (2002), Proteins : Biochemistry and Biotechnology , 2 nd Editions , Wiley Blackwell.

**UNIT - II**

**ANALYTICAL TECHNIQUES**

**Unit - I**

Principles and application of Spectrophotometry (UV-Visible spectrophotometry),

Titrimetry, Gravimetry, Colourimetry, NMR, ESR, Microscopy-phase, light and

flourscence microscopes, Scanning and Transmission electron microscopes.

**Unit - II**

Chromatographic techniques (Paper chromatography, thin layer chromatography, ion

exchange chromatography, Column chromatography), Atomic absorption

spectrophotometry, cytophotometry and flow cytometry, Fixation and staining, Principles and techniques of nucleic acid hybridization and Cot curves, Principle of biophysical method used for analysis of biopolymer structure, Hydrodynamics methods, Plasma emission spectorocopy.

**Unit - III**

Electrophoresis, solid and liquid scintillation, X-ray florescence, X-ray diffraction. Flame photomtery, Gas-liquid chromatography, High pressure liquid chromatography - auto radiography, Ultracentrifugation.

**Unit- IV**

Methods for measuring nucleic acid and protein interactions, DNA finger printing

Molecular markers RFLP, AFLP, RAPD, Sequencing of proteins and nucleic acids,

southern, northern, western blotting techniques, PCR polymerase chain reaction.

**References :**

1. Principles of Biophysical chemistry - Uppadahay -Uppadahay - and Nath.

2. Analytical Techniques - S.K. Sahani

**UNIT - IIII**

**BIOCHEMISTRY**

**Unit - I**

Organisation of Biomolecules, Buffers, Principle and biological application of diffusion osmosis, viscosity and Donnan membrane equilibrium. Carbohydrates : structure and classification of carbohydrates, metabolism of carbohydrates : glycoysis, TCA ycle HMP pathways.

**Unit - 2**

Lipids : Classification, structure and nomenclature of lipids, Biological significance of lipids, physico- chemical properties of fattyacids and triacyl glycerol.

**Unit - 3**

Aminoacids : classification, structure and nomenclature of aminoacids, physico-chemical properties of aminoacids. proteins: confirmation of proteins and polypeptides secondary, tertiary and quartenary and domain structure of proteins, denaturation of proteins and Ramchandran plots.

**Unit- 4**

IUB Classification and nomenclature of enzymes, general properties of enzymes, enzyme kineticsMichaelis Menten equations, Coenzymes - structure and biological fucntion of coenzymes A, TPP, FMN, FAD, NAD and lipoic acid, structure of purine and pyrimidine bases, nucleosides and nucleotides. Primary structure of nucleic acid, Three dimensional structure of t- RNA.

**References :**

1. Principles of Biochemistry Lehninger.

**SEMESTER - 4**

 **BIOINFORMATICS**

**UNIT - I**

**BIOLOGICAL DATABASE**

Introduction , primary &secondary database , Sequence file formats, Introduction to structure , Proteins Data Bank (PDb), Molecular Modelling Database (MMDb ), structure file formats, Visualizing structural information , Database of structure viewers , collection of sequence , sequence annotation , sequence description .

**UNIT -II**

**SEQUENCE ALIGNMENT AND DATABASE SEARCHING :**

 Evolutionary basis of sequence alignment , Optimal alignment methods, Substitution scores & gap penalties , statistical significant of alignments , Database similarly searching ., FASTA, BLAST, Low complexity regions , Repetitive elements , Multiple Sequence Alignments : Progressive alignments methods, Motifs and patterns , Clustral, Muscle, Scoring matrices , Distance matrices .

**UNIT -III**

**PHYLOGENETIC ANALYSIS :**

 Alignments , tree building and tree evaluation , Comparison and application of Unweighted Pair Group Method with Arithmetic Mean (UPGAMA), Neighbouring Joining (NJ), Maximum Parsimony (MP) , Maximum Like hood (ML ) methods , Bootstrapping , Jacknife , software for Phylogenetic analysis . DNA bar coding : Methods tools and database for bar coding across all species , Applications and limitations of bar coding , Consortium for Bar coding of Life (CBOL ) recommendation , Bar coding of Life Database (BOLD)

**UNIT -IV**

**STRUCTURAL BIOLOGY**

1. D structure visualization and simulation , Basic concepts in molecular modeling different types of computer representation of molecules ; External coordinated and Internal Coordinates, Molecular Mechanisms, Force field etc. Secondary structure elucidation using Peptide bond, phi, psi and chi torsion angles , Ramachandran map, anatomy of proteins - Hierarchical organization of protein structure - like CATH (Class, architecture , topology , homology ), SXOP (structural classification of proteins ), FSSP (families of structurally similar proteins )

**UNIT - V**

**CLASSIFICATIONH AND COMPARE OF 3 D STRUCTURE**

DNA & RNA secondary and tertiary structure , t- RNA tertiary structure ; protein secondary structure prediction : Algorithms viz Chou Fasman , GOR method Tertiary structure prediction : Fundamentals of the ,methods for 3 D structure prediction (sequence similarity/ identity of proteins of known structure , fundamentals of the method for 3D structure prediction (sequence similarity / identity of target proteins of known structure , fundamental principle of protein folding etc ) Homology/ comparative modeling , fold recognition , threading approaches and lab initio structure prediction methods; CASP (Critical Assesment of protein Structure Prediction ); Computational design of promoters , proteins enzymes .

**UNIT - VI**

**APPLICATION IN DRUG DESIGN :**

 Chemical database like NCI/PUBCHEM ; Fundamentals of Receptors - ligands interactions; Structure based drug design : Identification and Analysis of Binding sites and viral screening ; ligand based drug design : Structure Activity Relationship - QSARs & Pharmacophore ; In silco prediction of drug activity and ADMET .

**UNIT - VII**

**ANALYSIS OF MICROASSAY DATA** :

Designing of oligo probes ; Image processing and normalization ; Micro-array data variability (measurements ad quantification ); Analysis of differentially expressed genes , Experimental designs

**UNIT VIII**

**BIOLOGICAL ALGORITHMS :**

 Comparison with computer algorithms, string structures , Introduction to programming in computational biology through C / Perl / Java .

**UNIT IX**

**SYSTEM BIOLOGY :**

 System - level understanding of biological system , use and integration of data from transcriptomics , proteomics and metabolomics ; concepts in glycomices , interactomics and fluxomics .

**RECOMMENDED TEXTBOOK AND REFERENCES :**

1. A.D.Baxevanis and B.F.F .Outlette (Eds ). (2002), Bio-informatics : a Practical Guide to the Analysis of Gene and Proteins , John Wiley and Sons .
2. D.W. Mount (2001), Bio-informatics : Sequence and Genome Analysis , Cold Spring Harbour Laboratory Press.
3. Jones &Peuzer , (2004) ; Introduction to Bio-informtics Algorithms , Anc Books, India.
4. Dov Stekel , (2003); Microarray Bio-informatics ; Cambridge University Press.
5. Web - resource and suggested reviews/ research papers.

**UNIT - II**

**CELL BIOLOGY**

**Unit I**

**An overview of cell and cell organelles:**
Prokaryotic and eukaryotic cells, cell size and shape, molecules of cell, cell membranes and cell proteins., transport across nuclear envelope, The endoplasmic reticulum, golgi apparatus, lysosomes, mitochondria, chloroplast, peroxisomes.

Nuclear Envelope- structure of nuclear pore complex, nuclear lamina Chromatin: molecular organization, nucleolus and rRNA processing.

**UNI T- II**

**Cytoskeleton and cell movement:**
Structure and organization of actin filaments; actin, myosin and cell movement; intermediate filaments; microtubules. Mechanism of vesicular transport. Endocytosis. Bacterial and Eukaryotic Cell Wall; The plasma membrane structure; Transport of small molecules,the extracellular matrix and cell matrix interactions; cell-cell interactions

**UNIT - III**

**Microscopic**

-Principles of Light microscopy; Phase contrast microscopy; Confocal microscopy; Electron microscopy (EM)- scanning EM and scanning transmission EM (STEM); Fluorescence microscopy. Analytical- Flow cytometry- flurochromes, fluorescent probe and working principle; Spectrophotometry; Mass spectrometry; X-ray diffraction analysis.Separation-Sub-cellular fractionation- differential and density gradient centrifugation; Chromatography- paper, thin-layer, gel-filtration, ion-exchange,affinity and High-Performance Liquid Chromatography (HPLC)

**UNIT - IV**

**Cell signaling, cell Cycle, cell death and renewal:**
Signaling molecules and their receptor; functions of cell surface receptors;**Cancer and mutation:**Development and Causes of Cancer, Tumor Viruses, Oncogenes, Tumor Suppressor genes, Mutation, types of mutation Intracellular signal transduction pathway; signaling networks. Eukaryotic Cell Cycle, Regulation of Cell cycle progression, Events of Mitotic Phase, Meiosis and Fertilization. Programmed Cell Death, Stem Cells and Maintenance of adult tissues, Embryonic Stem Cells and Therapeutic cloning Cancer Treatment- molecular approach.

**Suggested readings:**

1. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology.
3. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
4. Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. V
5. Edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
6. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.

**UNIT - III**

**STATISTICS**

**UNIT - I**

**INTRODUCTION**

Types of biological data (ordinal scale , nominal scale, continuous and discrete data), frequency distribution and graphical representation (bar graph, histogram , box plot and frequency polygon ), cumulative frequency distribution , populations, samples, simple random , stratified and systematic sampling .

**UNIT - II**

**DESCRIPTIVE STATISTICS**

Measures of location , properties of Arthmetic Mean , medium , mode , range , Properties of Variance and Standard Deviation , Coefficient of Variation , Grouped Data, Graphic Methods , Obtaining Descriptive Statistics on Computer , case study.

**UNIT - III**

**PROBABILITY AND DISTRIBUTION :**

Introduction to probability and laws of probability , random events , events - exhaustive , mutually exclusive and equally likely (with simple exercise ), definition and properties of binomial distribution , Poisson distribution and normal distribution .

**UNIT - IV**

**CORRELATION AND REGRESSION ANALYSIS :**

Correlation , covariance, calculation of covariance and correlation , correlation coefficient from un grouped data person’s Rank Correlation Coefficient , scatter and dot diagram , general concepts of regression, Fitting Regression lines , regression coefficient, properties of Regression coefficients , standard error of estimates.

**UNIT - V**

 **STATISTICAL HYPOTHESIS TESTING :**

 Making assumption , Null and alternative hypothesis , error hypothesis testing , confidence interval , one - tailed and two -tailed testing decision making .

**UNIT - VI**

**TESTS OF SIGNIFICANCE**

Steps n testing statistical significance , selection and computation of test of significance and interpretation of results, sampling, distribution of mean and standard error, large sample tests (test for an assumed mean and equality of two population means with known S.D.), z- test; small sample test (t-Test for an assumed mean and equality of means of two population when sample observation are independent ); Parametric and Non parametric test (Mann - Whitney test ); paired and unpaired t- test ;chi square test.

**UNIT - VII**

**EXPERIMENTAL DESIGNS**

Introduction to study design; Longitudinal , cross- sectional , retrospective and prospective study , Principle of experimental design , Randomized block , and sample factorial design , Analysis of variance (ANOVA) and its analysis of RBD , introduction to meta - analysis and systematic review , ethics in statistics.

**RECOMMENDED TEXTBOOKS AND REFERENCE :**

1. Jaype Brothers, (2011), Methods in bio-statistics for medical students and Research workers (English ) , 7th Edition
2. Norman T.J. Bailey , (1995), statistical Methods in biology , 3rd Edition , Cambridge University press.
3. P.N. Arora and P.K. Malhan , (2006), Bio-statics , 2nd Edition , Himalaya publishing House
4. Jerold Zar , Bio statistical Analysis , 4th Edition , Pearson Education .
5. Bio-statistics : A Foundation for analysis in the Health Science , 7 th Edition , Wiley.
6. ML Samuels , JA Witmer (2003) Statistics for the life science , 3rd edition . prentice Hall.

**SEMESTER - 5**

**UNIT - I**

**INDUSTRIAL VISIT**

**UNIT - II**

**FERMENTATION TECHNOLOGY**

**REACTION ENGINERRING :**

Homologous reaction Basic reaction theory, calculation of reaction rates , general reaction kinetics for biological system , yields in cell culture , cell growth kinetics , production kinetics , kinetics of cell death ; Continuous stirred tank reactor as a tool for calculating kinetics parameters for growth and production formation ; Concept of maintenance and calculation of maintenance coefficient.

**UNIT - III**

**PROCESS INITIALIZATION :**

Types of sterilization , thermal death kinetics of microorganisms; Heat sterilization of liquid medium in batch and continuous mode ; Air sterilization ; Inoculum development ; Various types of fermentation , submerged and solid state fermentation , aerobic and anaerobic fermentation ; Overview of bio synthetic mechanism ; Metabolic stoichiometry.

**UNIT - IV**

**REACTOR ENGINEERING**

 Bioreactor configurations practical consideration for bioreactor construction, monitoring and control of bioreactors, ideal reactor operations, batch operation of a mixed reactor .

**UNIT - V**

**BIOPROCESS SCALE UP**

Heat and mass transfer issues in bioreactors, Estimation of KLa , Scale up with constant parameter like oxygen transfer rate , mixing, shear stress,f low regime, Reactor volume , etc. Scale up method by currently used rules -of - thumb viz. Constant P/V, kLa, Various approaches to scale up including regime analysis and scale down ; Analysis of alternate bioreactor configuration including cell -cycle , air lift and immobilized - cell bioreactors, Problems on scale - up method .

**UNIT - VI**

**COMMERCIAL PRODUCT PROCESSING**

 Bulk organs (ethanol ), Biomass (Bakers yeast ), Organic acids (Citric acid ), Amino acids (L- Lysine ), Microbial Transformation (steroids), Antibiotics (Penicillin ), Extra Cellular Polysaccharides (Xantham Gum ) , Nucleotide (5- GMP ), vitamins (B12) ,Pigments (Shikonim )

**UNIT - VI I**

**PROCESS TECHNOLOGY**

 Production of cell biomass and some primary metabolites , e. g. ethanol , acetone - butanol, citric acid , dextran and amino acids ; Microbial production of industrial enzymes - glucose isomerase , cellulase & lipases.

**UNIT - VIII**

**BIOCONVERSIONS**

 Applications of bio-conversions , transformation of steroids ; Transformation of non - steroidal compounds, antibiotics and pesticides ; Bio-energy fuel from biomass, production and economic of bio-fuel

**UNIT - IX**

**BIOSAFETY AND BIOSECURITY**

 Biological Risk Assessment , Laboratory Bio-safety Level 1 to 4 , Animal Bio-safety for Recombinant research , Bio-security , development of bio-security program , Containment for bio-hazards.

**RECOMMENDED TEXTBOOKS AND REFERENCES:**

1. M.L.Schuler, F. Kargi & M. DeLisa , (2017), Bio-process Engineering - Basic Concepts , 3rd Ed., Prentice Hall.
2. Pauline M. Doran, (2012), Bio-process Engineering Principles, 2 ndEdition Academic Pres.
3. C.Ratledge &B. Kristiansen, (2008). Basic Biotechnology, 3rd Ed., Cambridge University Press.
4. Peter F. Stanbury, Stephen J. Hall & A. Whitaker, (2007), Principles of fermentation Technology , Elsevier India Pvt Ltd.

**UNIT - III**

**BIOETHICS**

**UNIT - I**

**PHILOSOPHY AND THEORIES OF BIOETHICS**

Consequentialism : Mils Utilitarianism ; Deontology : Kantian Ethics ; Virtue Ethics : Aristotle ‘s moral theory ; Social contract theories : John Rawls theory ;Moral relativism ;Principlism

**UNIT - II**

**HISTORY, RELIGION AND BIOETHICS**

Ancient civilization and the develoment of ethics - Indian , Chinese, Greek ; The development of ethics after the World Wars; Modern research ethics , codes guidliness, regulations; Development of clinical ethics

**Role of religion in ethics**

1. Islam , Hinduism, Christianity, Jewish

**Culture and bioethics**

1. Indian culture and its influence . African ethics , Western civilizations

**UNIT - III**

**EPIDERMIOLOGY AND BIOSTATISTICS**

Design and carry out an epidemiological studies ; Reliability and validity of instruments (tests) from data provided ; Relevant measures of association and potential impact ; Evaluate critically journal articles (adequacy of the design , potential source of statistical and non- statistical errors and validity of conclusions)

**UNIT - IV**

**LAWS AND GLOBAL HEALTH ETHICS , PUBLIC HEALTH POLICY**

Indian law and its implication on clinical medicine and Research ; Display in health , health care and access to health ; Disparity in resource allocation for health , Macro, meso and micro levels ; Research in developing countries ; Public health policy and resource allocation ; Ethical Analysis of policies

**UNIT - V**

**RESEARCH ETHICS**

IRB and its function ; Ethical issues in clinical research ;Vulnerable population

Risk and benefits ; Authorship ; Human protectionism ; Contemporary issue in research ethics

**UNIT - VI**

Functions of clinical ethics committee; Ethical issues at the end of life ; Ethical issues at the beginning of life ; Reproductive medicine and ethics ; Contemporary issue in bioethics; Resource allocation; Euthanasia; Professionalism

**SEMESTER 6**

**PROJECT**