SIES COLLEGE OF ARTS,SCIENCE AND COMMERCE
Sion (West), Mumbai – 400022
(Autonomous)

Faculty: Science

Program: M.Sc.

Subject: BIOTECHNOLOGY

Academic Year: 2023 – 2024

M.Sc. Program

Credit Based Semester and Grading Syllabi approved by Board of Studies in Biotechnology to be brought into effect from June 2023.

PREAMBLE

Biotechnology, broadly defined, includes any technique that uses living organisms, or parts of such organisms, to make or modify products, to improve plants or animals, or to develop microorganisms for specific use. The interdisciplinary nature of biotechnology integrates living systems including animal, plant and microbes and their studies from molecular biology to cell biology, from biochemistry to biophysics, from genetic engineering to stem cell research, from bioinformatics to genomics-proteomics, from environmental biology to biodiversity, from microbiology to bioprocess engineering, from bioremediation to material transformation and so on.

Biotechnology is the science of today and tomorrow. It has applications in all major service sectors. i.e. health, agriculture, industry, environment etc. Biotechnology as an application science has taken firm footing in many countries, abroad where a number of transgenic crops, genetically modified food and recombinant therapeutic molecules for human and animal health are available in the market. Biotechnology as a science of service to human society is yet to make inroads in India

With the advent of the World Wide Web in the early nineties and its subsequent growth, the latest research trends have become accessible from drawing rooms across the globe. This acted as a positive feedback mechanism in increasing the pace of research in all fields including Chemical Engineering and Bio-technology. This was the motivation for an in depth analysis of what is actually required for today's technology. It is also important to take advantage of the freely available software to enhance the quality and quantity of material that can be covered in the class room.

This restructured syllabus is therefore intended to combine the principles of physical, chemical and biological sciences along with developing advanced technology. The postgraduate curriculum is prepared to impart primarily basic knowledge of the respective subject from all possible aspects. In addition, students will be trained to apply this knowledge particularly in day-to-day applications of biotechnology and hence get a flavor of research

PROGRAM OUTCOMES

The expected graduate attributes are directed towards the following:

- Applying the knowledge of various courses learned under the program to break down complex problems to simple components by designing processes for problem solving
- Utilizing the acquired contextual knowledge in an interdisciplinary framework. Integrating research-based knowledge and research-based methods involving problem definition, analysis and interpretation of data followed by its consolidation to arrive at valid conclusions
- Facilitating to write and document effectively; make crisp presentations and reports and convey the message/ instructions/findings clearly
- Equipping to select, create and apply the appropriate tools and techniques through electronic media for the purpose of understanding and analyzing data and drawing inference keeping in mind its limitations and disadvantages
- Understanding the need for sustainable development and concern for environmental issues
- Applying the acquired contextual knowledge in assessing public health and safety; addressing gender, ethnic and environmental issues in addition to performing with decisive responsibility.

PROGRAM SPECIFIC OUTCOMES

The program has been designed to expose the students to the latest developments in the areas of diagnostics, therapeutic techniques and instrumentation. This program is aimed at empowering students for a career in research and also to provide trained manpower for the fast-growing Biotech companies.

A Postgraduate student upon completion of this program is expected to gain the following attributes:

- Competence for research and innovation in the field of Biotechnology
- Design and execute experiments applying the concepts learnt and thereby being able to translate theoretical knowledge to practical knowledge
- Prepare, plan and execute a research project independently.
- Critically evaluate and interpret results

Semester I

Course Type	Course Title	Credits	Lectures (Hrs.)/ week
Major 1	Biochemistry I	4	4
Major 2	Molecular Biology I	4	4
Major 1 Practical	Biochemistry I practical	2	
Major 2 Practical	Molecular Biology I practical	2	
Major	IPR	2	2
Elective	Biochemical and Biophysical Techniques	3	3
Elective Practical	Biochemical and Biophysical Techniques Practical	1	
Research Methodology	Research Methodology	4	4
Total		**22**	

Semester II

Course Type	Course Title	Credits	Lectures (Hrs.)/ week
Major 1	Immunology I	4	4
Major 2	Molecular Biology II	4	4
Major 1 Practical	Immunology I practical	2	
Major 2 Practical	Molecular Biology II practical	2	
Major	Regulatory affairs	2	2
Elective	Bioprocess technology	3	3
Elective Practical	Bioprocess technology practical	1	
OJT	OJT	4	4
Total		**22**	

SEMESTER 1

COURSE CODE	TITLE	CREDITS	LECTURES
	BIOCHEMISTRY I	**4**	**60**
Course Outcomes	On successful completion of the course the learner is expected to demonstrate and explain the understanding of		
Unit I	**DNA topology** DNA topology: Different forms of DNA – A, B, C, Z and RL form of double helical DNA, triple helix. Nucleic acid binding proteins – Leucine zipper, zinc finger, OB fold, B- barrel, helix turn-helix, helix -loop -helix. Linking number, supercoiling, Topoisomerases.	**1**	**15**
Unit II	**Metabolism** Lipid metabolism: Phospholipids, Cerebrosides and Gangliosides; Alzheimer's disease; Steroid hormones, lipid storage diseases Biosynthesis of purines and pyrimidines with regulation, disorders of Nucleic acid metabolism. Biosynthesis of essential amino acids. Disorders of amino acid metabolism Glycosaminoglycans- Heparin, Chondroitin sulphate, Hyaluronic acid Glycoproteins & Glycolipids, Acidic sugars – ascorbic, glucuronic acid.	**1**	**15**
Unit III	**Membrane Dynamics** Membrane dynamics and transport of solutes across the membrane; States of bilayer lipids, Trans-bilayer Movement of Lipids, Flip-flop diffusion. Measurement of lateral diffusion rates of lipids by fluorescence recovery after photobleaching (FRAP). Hop diffusion of individual lipid molecules; Caveolins and cadherins; Membrane Fusion; Transporter classification system channel (Na+ channel of neurons) and ligand (acetylcholine) mediated transport with examples. ABC transporters and Ionophores, Diseases associated with Defective Ion Channels	**1**	**15**
Unit IV	**Enzymology** Enzyme classification, kinetics, Bisubstrate reaction, stable state kinetics, enzyme inhibitions, examples of enzymatic reaction – chymotrypsin, induced fit hypothesis, Catalytic antibodies, Ribozymes Regulatory enzymes and their mode of action and covalent modification of enzymes. Enzyme immobilization techniques, Enzyme biosensors.Basics of	**1**	**15**

	Enzyme engineering (Rational protein design and directed evolution).		

COURSE CODE	TITLE	CREDITS	LECTURES /WEEK
	MOLECULAR BIOLOGY I	**4**	**60**
Course Outcomes	On successful completion of the course, the student will understand the basic concepts of … Learner will be skilled in…..		
Unit I	**Gene evolution and the human genome** Human mitochondrial genome, content of the human nuclear genome: cis-trans regulatory elements, Introns, pseudogenes, non-coding RNA genes, tandemly repeated DNA, interspersed genome-wide repeats, Mobile genetic elements, Transposable elements in bacteria (Insertion elements, Transposons, Bacteriophage Mu) and eukaryotes (Plant transposable elements, Yeast transposable element, Drosophila transposable elements, Human retrotransposons) Genome evolution - Acquisition of New Genes by gene duplication: causes of gene duplication, whole genome duplication, smaller duplication, rearrangement of existing genes, Acquisition of New Genes from other species	**1**	**15**
Unit II	**Mapping techniques** Genetic Mapping: DNA markers for genetic mapping, Physical Mapping: Restriction Mapping, Fluorescent in situ hybridization (FISH), Sequence tagged site (STS) mapping, Next Gen sequencing, Human genome project	**1**	**15**
Unit III	**Transcription** Transcription in prokaryotes and eukaryotes, Types of RNA polymerases, Transcription in cell organelles, RNA processing in eukaryotes, Synthesis of eukaryotic mRNAs by RNA polymerase II, Intron splicing. Synthesis and processing of Non-coding RNAs: Transcript elongation and termination by RNA polymerases I and III, Introns in eukaryotic pre-rRNA and pre-tRNA. Processing of Pre RNA. Degradation of mRNAs	**1**	**15**
Unit IV	**Regulation of gene expression** Regulatory proteins: Activators, Enhancers, Insulators, Regulation of Transcription in Prokaryotes: Allostery,	**1**	**15**

	action at distance, DNA looping, cooperative binding, Examples: *lac* genes, NtrC & MerR, araBAD operon, regulation of bacteriophage **λ**, Eukaryotic Gene Regulation: Eukaryotic regulators, Recruitment of protein complexes to genes by activator, Signal integration and Combinatorial control, Transcriptional repressors & its mechanism, Signal transduction and control of transcriptional regulators		

COURSE CODE	**TITLE**	**CREDITS**	**LECTURES**
	BIOCHEMISTRY I – PRACTICAL	**2**	
	1. Isolation of starch from potato and its estimation by Anthrone method. 2. Estimation of Protein by Bradford's method. 3. Purification of protein by ammonium sulfate fractionation, dialyze and separate using PAGE 4. Study of protein complexes using SDS-PAGE and visualization using silver staining. 5. Determination of Lactate Dehydrogenase (LDH) Activity in Blood Serum. 6. Extraction of lipids (Essential oils) from the plant materials using clevenger apparatus. 7. Saponification value of oils. 8. Isolation of cholesterol and lecithin from egg yolks. 9. Study of effect of inhibitors on Enzyme activity 10. Study of Km and Vmax. 11. Titration curve of amino acids		

COURSE CODE	TITLE	CREDITS	LECTURES
	MOLECULAR BIOLOGY I – PRACTICAL	**2**	
	1. Extraction of genomic DNA from a. bacteria b. blood 2. Perform transformation of bacteria 3. Expression of recombinant protein 4. Restriction digestion 5. Ligation 6. Induction of β-Galactosidase in *E. coli* (and effect of inducers) 7. Problems on gene mapping and restriction mapping 8. RFLP analysis		

COURSE CODE	TITLE	CREDITS	LECTURES /WEEK
	INTELLECTUAL PROPERTY RIGHTS	**2**	**30**
Course Outcomes	On successful completion of the course, the student will understand the basic concepts of … Learner will be skilled in…..		
Unit I	**Introduction to IPR** Introduction to intellectual property; types of IP: patents, trademarks, trade secrets, copyright & related rights, industrial design, geographical indications, Biodiversity importance and legislation, International convention and treaties; plant variety protection and farmers rights act, traditional knowledge.	**1**	**15**
Unit II	**Basics of Patent** Eligibility criteria, concept of novelty, concept of inventive step; Patentable and Non-patentable inventions in India and abroad. Patenting systems. Process of Patenting, Types of patent applications, Patent Search, Rights of the patent holder, Assignment and licensing of patents and patent Infringement, case studies. Patent Agent. Biotechnological Inventions as Patentable Subject Matter, Patentability of Biotechnology Inventions in India, Statutory Provisions Regarding Biotechnological Inventions Under the Current Patent Act 1970 (as Amended 2005).	**1**	**15**

COURSE CODE	TITLE	CREDITS	LECTURES
ELECTIVE	**BIOCHEMICAL AND BIOPHYSICAL TECHNIQUES**	**3**	**45**
Course Outcomes	On successful completion of the course, the student will understand the basic concepts of … Learner will be skilled in…..		
Unit I	**Microscopic techniques** Confocal microscopy, Scanning Probe microscope, AFM, cryotomy scanning and transmission microscopes, different fixation and staining techniques for EM, freeze-etch and freeze- fracture methods for EM, image processing methods in microscopy, single cell imaging. Environmental	**1**	**15**

	SEM and its advantages, Immunoelectron microscopy.		
Unit II	**Spectroscopy**: Introduction and principle of: fluorescence spectroscopy, Light scattering spectroscopy, Luminometry, circular dichroism, NMR and ESR spectroscopy, Molecular structure determination using X-ray diffraction, X ray crystallography and NMR, Molecular analysis using light scattering, IR, Atomic absorption Spectroscopy.	**1**	**15**
Unit III	**Other techniques:** Introduction, principle and analysis using HPTLC, Capillary electrophoresis, Gel free electrophoresis, Types of PCR, mass spectrometry and LC-MS, GCMS, In–situ gene expression techniques; Microarrays, Flow cytometry. Introduction to cell imaging techniques.	**1**	**15**

COURSE CODE	TITLE	CREDITS	LECTURES
ELECTIVE	**BIOCHEMICAL AND BIOPHYSICAL TECHNIQUES - PRACTICALS**	**1**	
	1. Polymerase Chain Reaction 2. Separation of pigments using column chromatography 3. Viscosity of Proteins 4. Demonstration and interpretation of NMR, HPLC, GC readouts. 5. Separation of sugars using TLC. 6. Use of affinity chromatography for purification of antibodies from serum. 7. Technique based - Paper presentation.		

COURSE CODE	TITLE	CREDITS	LECTURES
	RESEARCH METHODOLOGY	**4**	**60**
Course Outcomes	On successful completion of the course, the student will understand the basic concepts of … Learner will be skilled in…..		
Unit I	**Foundations of Research:** Meaning, Objectives, Motivation, Utility. Concept of theory, empiricism, deductive and inductive theory. Characteristics of scientific method – Understanding the language of research – Concept, Construct, Definition, Variable. Research and its types The research process: Problem Identification & Formulation – Research Question – Investigation Question –Measurement Issues – Hypothesis – Qualities of a good Hypothesis –Null Hypothesis & Alternative Hypothesis. Hypothesis Testing – Logic & Importance	**1**	**15**
Unit II	Research Design: Concept and Importance in Research – Features of a good research design, The functions of a research design, The theory of causality and the research design, Study designs in quantitative and qualitative research Data Collection : Data and its types, Selecting a method of data collection Data Analysis: Data Preparation – Univariate analysis (frequency tables, bar charts, pie charts, percentages), Bivariate analysis – Cross tabulations and Chi-square test including testing hypothesis of association.	**1**	**15**
Unit III	**Sampling -** The concept of sampling, Sampling terminology, Principles of sampling, Factors affecting the inferences drawn from a sample, Aims in selecting a sample. Concepts of Statistical Population, Sample, Sampling Frame, Sampling Error, Sample Size, Non-Response. Characteristics of a good sample. Probability Sample – Simple Random Sample, Systematic Sample, Stratified Random Sample & Multi-stage sampling. Determining size of the sample– Practical considerations in sampling and sample size.	**1**	**15**
Unit IV	Research proposal and its contents, Types of research paper, Layout of a Research Paper, Reviewing the		

	literature, Methods to search required information effectively, Reference Management Software like Zotero/Mendeley, Software for paper formatting like LaTeX/MS Office. Journals in Life Science, Impact factor of Journals, When and where to publish? Ethical issues related to publishing, Plagiarism and Self-Plagiarism, Software for detection of Plagiarism.	**1**	**15**

SEMESTER II

COURSE CODE	TITLE	CREDITS	LECTURES
	IMMUNOLOGY I	**4**	**60**
Course Outcomes	On successful completion of the course, the student will understand the basic concepts of … Learner will be skilled in…..		
Unit I	**Understanding the Immune system** Mechanisms of Innate immune system (pattern recognition receptors, complement system, ADCC) and Adaptive immune system (cells involved, Antigen recognition by B cells and T cells, Effector mechanisms) Cytokines: Properties, Classification, Receptors, Signaling, Cytokine secretion by TH1 and TH2, Cytokine related diseases, Cytokine expression.	**1**	**15**
Unit II	**Humoral Immunity** B cell development: development in Bone marrow, B cell lineages (B1 and B2), Negative regulation of B cells, T dependent and independent responses, Generation of Antibody Diversity: Germ line and Somatic theory, Dreyer and Bennett model, Tonegawa's Bombshell experiment Multigene organization of Ig gene, Variable gene rearrangements, Generation of antibody diversity, Synthesis, assembly, and secretion of immunoglobulins, Antibody engineering, Chimeric antibodies.	**1**	**15**
Unit III	**Cell mediated immunity** T cell Development: Early thymocyte development, positive and negative selection, Differentiation, maturation, Apoptosis. Transplantation: Basis of Graft rejection, clinical manifestation of graft rejection; immunosuppressive therapy; immune tolerance; clinical transplantation. Cancer immunology: Malignant transformation of cells, Cancer induction, Tumor Antigens, Immunosurveillance, tumor evasion, Cancer immunotherapy.	**1**	**15**
Unit IV	**Diseases of the immune system** Hypersensitivity: Classification and types Primary immunodeficiencies: Combined immunodeficiency (Reticular dysgenesis, SCID, BLS, DiGeorge syndrome, Wiskott-Aldrich syndrome, Hyper IgM, Job syndrome), B-cell immunodeficiency (CVID, X linked agammaglobulinemia), Disruption of	**1**	**15**

	immune regulation (APECED, IPEX), Disruption in innate immunity (LAD, CGD, CHS) Autoimmunity: Organ Specific and Systemic autoimmune diseases		

COURSE CODE	TITLE	CREDITS	LECTURES
	MOLECULAR BIOLOGY II	**4**	**60**
Course Outcomes	On successful completion of the course, the student will understand the basic concepts of … Learner will be skilled in…..		
Unit I	**Translation** Translation in Prokaryotes and Eukaryotes, Inhibitors of translation, Post translational modification:Protein folding, Processing by proteolytic cleavage, Processing by chemical modification and Inteins splicing. Protein targeting and degradation.	**1**	**15**
Unit II	**Histone modification & Genome activity** Chromatin & Nucleosome, Histone & histone variants, Gene silencing by Histone modification, Nucleosome remodeling, Regulatory RNAs in Prokaryotes: sRNAs, Riboswitches, CRISPRs, Regulatory RNAs in eukaryotes: miRNA, siRNA, long non-coding RNAs & their role. Regulation of Genome Activity During Development: Sporulation in *Bacillus*, Vulva development in *Caenorhabditis elegans*, Development in *Drosophila melanogaster*	**1**	**15**
Unit III	**Model organisms** *Saccharomyces cerevisiae*- Genome, existence of haploid and diploid cells, facilitating genetic analysis, generating mutations in yeast. *Arabidopsis*- genome life cycle, ease of transformation epigenetics, response to environment. *Mus musculus*- mouse embryonic development and stem cells, ease of introduction of foreign DNA, epigenetic inheritance.	**1**	**15**
Unit IV	**DNA Vectors** DNA cloning with single-stranded DNA vectors: M13 phages cloning vector, Specialist purpose vectors: M13 based vector for ssDNA, Expression vectors - Vectors for making RNA probes, vectors for maximizing protein synthesis, vectors to facilitate protein purification, vectors to promote protein solubilization, vectors to promote protein export, Gateway system, combination vectors-	**1**	**15**

	LITMUS, Pin-point series vectors, BACs, Phage P1 derived vectors & PACs. Cloning in *S.cerevisiae*: YEPs, YRPs, YCPs, YACs, Retrovirus – like vectors, Expression of cloned genes, Specialist vectors & Yeast surface display		

COURSE CODE	TITLE	CREDITS	LECTURES
	IMMUNOLOGY I - PRACTICAL	**2**	
Course Outcomes	On successful completion of the course, the student will understand the basic concepts of … Learner will be skilled in…..		
	1. DOT-ELISA 2. Quantification of antigen using Single Radial Immuno-Diffusion. 3. Immuno-diffusion and immune-electrophoresis 4. Serum electrophoresis 5. Western Blotting 6. Demonstration of HLA typing. 7. In-vitro demonstration of phagocytosis and calculating phagocytic index. 8. Latex bead agglutination / precipitation test for detection of rheumatoid factor (RF) 9. Separation of lymphocytes on Ficoll-Histopaque, viability count.		

COURSE CODE	TITLE	CREDITS	LECTURES
	MOLECULAR BIOLOGY II	**2**	
Course Outcomes	On successful completion of the course, the student will understand the basic concepts of … Learner will be skilled in…..		
	1. Mutagenesis 2. AMES test		

	3. Conjugation 4. Detection of GMO using PCR 5. Plasmid DNA extraction and detection using agarose gel electrophoresis 6. Elution of extracted plasmid from Agarose gel and quantification 7. Characterization of DNA by Spectrophotometric Assay and Melting Temperature (Tm)		

COURSE CODE	TITLE	CREDITS	LECTURES
	REGULATORY AFFAIRS	**2**	**30**
Course Outcomes	On successful completion of the course, the student will understand the basic concepts of … Learner will be skilled in…..		
Unit I	The Concepts of innovator and generic drugs, drug development process. Basic ICH Requirement and ICH topics. Basic regulatory framework with respect to Regulated and Non-regulated market practices and procedures. Regulatory Approval Process Approval processes and timelines involved in Investigational New Drug (IND), New Drug Application (NDA), Abbreviated New Drug Application (ANDA). Changes to an approved NDA / ANDA. Regulatory authorities and agencies Overview of regulatory authorities of India, United States, European Union, Australia, Japan, Canada (Organization structure and types of applications). Registration of Indian drug product in overseas market Procedure for export of pharmaceutical products, Technical documentation, Drug Master Files (DMF)	**1**	**15**
Unit II	Common Technical Document (CTD), electronic Common Technical 163 Document (eCTD), ASEAN Common Technical Document (ACTD)research. CTD-Module 1, 2, 3, 4, 5 (including QOS, quality design concept and bioequivalence). Clinical trials Developing clinical trial protocols, Institutional Review Board / Independent Ethics committee - formation and working procedures, Informed consent process and procedures, GCP, obligations of Investigators, sponsors	**1**	**15**

	& Monitors, Managing and Monitoring clinical trials, Pharmacovigilance - safety monitoring in clinical trials.		

COURSE CODE	TITLE	CREDITS	LECTURES
ELECTIVE	**BIOPROCESS TECHNOLOGY**	**3**	**45**
Course Outcomes	On successful completion of the course, the student will understand the basic concepts of … Learner will be skilled in…..		
UNIT I	**Fermentation** Strain improvement for increased yield and other desirable characteristics; Upstream processing: Media formulation; Sterilization, Bioreactor designs; classification of fermenters: Batch, fed batch and continuous; Solid state, surface and submerged fermentation; Conventional fermentation v/s biotransformation; Basics of bioreactor kinetics and mathematical equations regarding bioreactors, scale-up and aeration of bioreactors in detail, Kinetics of microbial growth, substrate utilization and product formation (Batch, Fed- Batch and continuous processes), Scale up concepts with respect to fermenter design and product formation, Gas exchange and mass transfer: O2 transfer, critical oxygen concentration, determining the oxygen uptake rate.	**1**	**15**
UNIT II	**Applications of enzymes and microbes in fermentation** Mechanism of enzyme function and reactions in process techniques; Enzymic bioconversions e.g. starch and sugar conversion processes; High-Fructose Corn Syrup; Interesterified fat; Hydrolyzed protein etc. and their downstream processing; baking by amylases, deoxygenation and desugaring by glucose oxidase, beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing. Microbes and their use in pickling, producing colours and flavours, alcoholic beverages and acids; 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**.**	**1**	**15**

UNIT III	**Food processing** Fermented foods and beverages; Food ingredients and additives prepared by fermentation and their purification; Fermentation as a method of preparing and preserving foods; Food Processing: Ambient-temperature processing, heat processing and processing by removal of heat. Post processing operations: Coating or enrobing, packaging and storage.	**1**	**15**

COURSE CODE	TITLE	CREDITS	LECTURES
ELECTIVE	**BIOPROCESS TECHNOLOGY PRACTICAL**	**1**	
Course Outcomes	On successful completion of the course, the student will understand the basic concepts of … Learner will be skilled in…..		
	1. Demonstration of Plackett-Burman design for formulation of fermentation media. 2. Pigment production and isolation from a microbial source (yeast, fungi or bacteria). 3. Study of enzyme activity of cellulase. 4. Immobilization of yeast cells and determination of its invertase activity. 5. Detection of different food enzymes by simple tests (amylase, catalase, invertase, papain, pectinase, pepsin). 6. Study of pickling process (sauerkraut / pickled cucumbers) with respect to physical, chemical / biochemical and biological changes occurring during the pickling process.		

COURSE CODE	TITLE	CREDITS	LECTURES
OJT	**OJT**	**4**	

EVALUATION SCHEME

33 to 50% continuous internal evaluation and remaining at the end of each semester.

References

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