First Semester Courses in MSc-Biotechnology 2023-2024

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APPROVED SYLLABUS

ST. XAVIER'S COLLEGE-AUTONOMOUS MUMBAI-400 001

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#.MSc. Part I. Biotechnology Semester I **Course Code: PSBTY6001CR1**

Name of the course: Biomolecular Studies
Credits: 4 (Theory 3 – Total 45hr and Practical 1 Total 30hr)

Course Objectives:

1. To develop an understanding of biomolecules, supra-molecular assemblies, and their functional dynamics.
2. To develop a holistic understanding of how the structural and functional aspects of biomolecules superimpose cellular locations and modulate physiological functions.
3. Explore the relationship between biomolecular dysfunction and human health conditions.
4. Explain enzyme-substrate interactions, active site specificity, and factors influencing enzyme activity.
5. Gain proficiency in computational techniques for analyzing and characterizing biological molecules through available data.

Course Outcomes (COs):

Course Title and Code	**Biomolecular Studies**	**PSBTY6001CR1**	
CO No.	**Course Outcomes** *On completion of the course, the student will be able to*	**PSOs Addressed**	**Cognitive Level**
CO-1	Understand the architecture of structural levels of proteins and DNA	PSO-1,3,6	U, E
CO-2	Apply fundamental knowledge in biomolecular properties on their purification and in designing strategies for the same.	PSO- 1,2,3,6,7	Ap
CO-3	Understand the interaction on DNA and protein and apply the concept in its function and purification	PSO 1,3,6	U, A
CO-4	Demonstrate the understanding of biomolecular organization in cellular membranes	PSO-1,3,6	U
CO-5	Demonstrate the understanding of enzymology and enzyme kinetics	PSO-1,3,6	U, Ap
CO-6	Apply computational tools for analyzing biological molecules and communicating the data in a meaningful manner. Evaluate current research and advancements in the field of biological molecules.	PSO- 2, 3, 4,6	U, Ap

CONTENT

Unit 1: Conformation of Biomolecules — 15 lectures

- Different forms of DNA, - A/B/C/Z and RL form of double helical DNA, Triple Helix, Linking number, Supercoiling, Topoisomerases, DNA Packaging: Nucleosomes and Chromatin.
- Protein stability, Quaternary structure – (Haemoglobin) subunit interaction, symmetry, subunit composition determination.
- Structural levels of proteins, methods of determining protein sequence, intramolecular interactions
- Protein folding and Misfolding: The different pathways of protein folding and its co-relationship with protein stability, Molecular chaperons. Effects of misfolding protein on human diseases; unfolded protein response.
- RNA World: Types of RNA and their structural conformations

Unit 2: Bio-Membranes — 15 lectures

Bio-membranes: Membrane Structure Composition and Architecture of membrane: glycolipids, lipid types and the lipid bilayer, membrane proteins (integral and peripheral), conformation of membrane proteins, the association of membrane proteins in the lipid bilayer, Hydropathy index.

- Membrane Dynamics- lipid movements, flippase, FRAP, Lipid raft, Membrane fusion, Membrane Channels, Ion pumps & Transporters, Primary and Secondary active transport (P, F, ABC, symporter, and antiporter), Membrane Potential, Diffusion coefficient.

- Membrane transporter Kinetics: Symporters, Uniporters, antiporters, High affinity Vs Low Affinity nutrient Uptake: GLUT1,3, 4 vs GLUT2-Implications for drug design Macro Vs Micronutrient transporters in plants and animals: Implications for Bioengineering. Intracellular membrane transport: Transport of molecules between nucleus and cytosol, Endoplasmic reticulum, Transport across mitochondria and chloroplast.

Unit 3: Enzymology — 15 lectures

- Enzyme catalysis – general principles of catalysis; enzyme activity and efficiency; Biocatalysis: Relevance of enzymes in metabolic regulation, activation, inhibition, and covalent modification; Isozymes; the role of covalent modification in enzymatic activity; zymogens
- Enzyme Kinetics: Mono-substrate enzyme kinetics, Michaelis-Menten kinetics, Lineweaver burke Plots, Dixon Plots, Concepts of enzyme affinity Km/Vm, Enzyme Inhibition: Competitive, Non-Competitive and Uncompetitive Inhibitors, Enzyme inhibitors in drug design. Allosteric Enzymes, Multi substrate Enzyme kinetics: Sequential and Ping Pong Mechanism, Cleland plots.

Practical Component: Computational Tools for Studying Biomolecules **30 hours**

- Computational tools for studying Biomolecules.
- Retrieval of protein, nucleotide, and protein structural data for analysis
- Protein sequence analysis
- DNA and RNA structural study

List of Recommended Reference Books

- Amit Kessel and Ner Ben Tal, Introduction to proteins (2011), CRC Press, Taylor & Francis Group
- Gromiha, M. M. (2010). Protein bioinformatics: from sequence to function. academic press.
- Nelson, D. L., Lehninger, A. L., & Cox, M. M. (2008). *Lehninger principles of biochemistry*. Macmillan.
- Bonner, P., & Bonner, P. L. (2007). Protein purification. Taylor & Francis.
- Berg, J. M., Tymoczko, J. L., & Stryer, L. (2007). Biochemistry (Loose-Leaf). Macmillan.
- Donald Voet and Judith Voet. Biochemistry 3rd Ed, John Wiley and sons, Inc publisher, 2004
- Arthur M Lesk, (1998) Introduction to Protein Science Architecture, Function and Genomics, Oxford publishers,
- Robert K. Scopes, Protein Purification, Springer Science, 1982,

Evaluation (Core Theory): Total marks per course -150

I. Formative Assessment 'for' Learning (continuous internal assessment - CIA to improve learning).
CIA- 40 marks
CIA 1: Written test -20 marks
CIA 2: Assignment -20 marks

II. Summative Assessment 'of' Learning (focus on outcomes, quantitative data for outcomes of instruction).
End Semester Examination – 60 marks
One question from each unit for 20 marks, with internal choice.

Evaluation of (Practical) – Total marks Practical Course - 50 marks

CIA- 20marks

End Semester Practical Examination – 30 marks.

Eg: Template for the Core course End Semester examination in Semester I for the Core course

UNITS	KNOWLEDGE	UNDERSTANDING	APPLICATION and ANALYSES	TOTAL MARKS- Per unit
1	7	7	6	20
2	7	7	6	20
3	7	7	6	20
-TOTAL - Per objective	21	21	18	60
% WEIGHTAGE	35	35	30	100%

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#.MSc. Part I. Biotechnology Semester I **Course Code: PSBTY6002CR1**

Name of the course: Fundamentals in Molecular Biology
Credits: 4 (Theory 3 – Total 45hr and Practical 1 Total 30hr)

Course Objectives:

1. This course will introduce the students to the concept of genes, gene cistron relationship in prokaryotes and eukaryotes and other regulatory elements involved in molecular process.
2. This course will provide in-depth knowledge of the central dogma of biology and its regulation.
3. The core objective is to provide in-depth insight on non -coding RNA synthesis and its role in gene expression.
4. The course will also help in developing an understanding of regulatory mechanisms governing genome activity in prokaryotes and eukaryotes.
5. This course will introduce concepts of population genetics across various life forms.

Course Outcomes (CO)

Course Title and Code	**Fundamentals of Molecular biology** **PSBTY6002CR1**		
CO No.	**Course Outcomes** *On completion of the course, the student will be able to*	**PSOs Addressed**	**Cognitive Level**
CO-1	Understand DNA is a genetic material through classical molecular experiments, concept of gene and its regulatory elements	PSO-1,6	U, A
CO-2	Elucidate the transfer of information from DNA to RNA to protein	PSO-1,6	U, Ap
CO-3	Understand the mechanism of differential gene expression in prokaryotes and eukaryotes	PSO-1,6,	U, A, An
CO-4	Describe the consequences of DNA damage due to mutations and DNA -repair systems.	PSO-1,6	U, Ap
CO-5	Describe the fundamental molecular principles of genetics	PSO-1,6	U, Ap

CO-6	Describe the concept of gene regulation, gene silencing and epigenetics and its application	PSO-1,3,6,7	U, Ap, An

CONTENT

Unit 1: DNA: The Hereditary Material **15 lectures**

Classical Molecular Biology Experiments: Miescher's 'nuclein' theory, Griffith's experiment, Avery, McCarty and Macleod's experiment, Chargaff's ratio, Meselson, and Stahl's semi-conservative replication.

- DNA Replication (prokaryotes and eukaryotes): replication origin, replication fork, fidelity of replication, DNA Polymerase, and regulation of replication process
- DNA damage and repair mechanisms
- DNA recombination mechanisms

Unit 2: The Central Dogma- Flow of Genetic Information **15 lectures**

- Chromosomal location of genes, Structure of a gene: Prokaryotes Vs Eukaryotes: ORF, Promoter, Transcription Start Site, Ribosomal Binding Site, Transcription factors.
- DNA-Protein interactions during Transcription initiation and regulation of transcription initiation
- Synthesis of eukaryotic mRNAs by RNA polymerase II, rho factor mediated termination – antitermination.
- RNA processing: Processing of Pre-RNA, splicing, RNA editing, mRNA transport, Degradation of mRNAs.
- 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
- Basic mechanisms of RNA to Protein conversion: Prokaryotes vs Eukaryotes, Translation Inhibition
- Post-translational Processing
- Processing by proteolytic cleavage
- Processing by chemical modification
- Protein Degradation

Unit3: Regulation of Gene Expression: Regulatory Elements and RNAs **15 lectures**

- Regulation in prokaryotes- negative and positive regulation: lac and trp operon riboswitches, antisense RNA
- Regulation in Eukaryotes: Transcription complex, 3-D interactions of the genome for regulation of gene expression.
    - Genome rearrangements, Gene silencing by modification of histones and DNA methylation

- Transcriptional activators, Co-activators; repressors, enhancers, and insulator
- Post transcriptional regulation: Regulation through RNA interference.
- Concept of Epigenetics

- Regulation of Genome activity: Yeast genetics: yeast mating type switch; dominant and recessive genes/mutations, suppressor or modifier screens, transposon mutagenesis, synthetic lethality, genetic epistasis.
- Concepts of Population Genetics: Gene Pool-Genotypic frequency-allelic frequency-Hardy Weinberg Law-Factors affecting allelic frequency, Speciation

Practical Component: Essential Techniques in Molecular Biology **30 hours**

- Extraction of Genomic DNA from Bacteria, Yeast, Plant, human samples (Cheek cells, Blood)
- Quantification of nucleic acids using UV
- Separation of nucleic acids using Agarose Gel Electrophoresis
- Isolation of RNA from yeast/ E. coli
- Computational tools for understanding Gene anatomy.

List of Recommended Reference Books

- Griffiths, Anthony J.F., Wessler, Susan R., Lewontin, Richard C. & Gelbart, William M.: An introduction to genetic analysis. (8th Ed.) New York. W.H. Freeman and Company, 2005. 0-7167-4939-4--(575.1GRI)
- Lodish, Harvey F.; Berk, Arnold; Kaiser, Chris A. & Krieger, Monty: Molecular cell biology. (7th ed.) New York. W.H. Freeman and Company, 2013. 978-1-4641-0981-2--(574.87Lod)
- Snustad, D. Peter & Simmons, Michael J.: Principles of genetics. (5th ed.) Hoboken. John Wiley & Sons, Inc., 2010. 0-470-39842-5--(575.1Snu/Sim)
- Brown, T.A.: Genomes 3. New York. Garland Science Publishing, 2007. 0-8153-4138-5--(575.1Bro)
- Watson, James D., Baker, Tania A., Bell, Stephen P. & Gann, Alexander: Molecular biology of the gene. (6thed.) New York. Pearson Education Inc., 2008. 0-321-50781-9--(574.88Wat)
- Alberts, Bruce, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, and Peter Walter: Molecular Biology of the cell (6th Ed) Garland Science Publishing., 2015
- Lewis (2010) – Human genetics: concepts and applications, 9th Ed, Tata McGraw- Hill Publishing
- Daniel L. Hartl, Principles of Population Genetics, 4th Ed
- Geoffrey M. Cooper and Robert E. Hausma: The Cell: A Molecular Approach, 6th Ed

Evaluation (Core Theory): Total marks per course -150

I. Formative Assessment 'for' Learning (continuous internal assessment - CIA to improve learning).
CIA- 40 marks
CIA 1: Written test -20 marks
CIA 2: Assignment -20 marks

II. Summative Assessment 'of' Learning (focus on outcomes, quantitative data for outcomes of instruction).
End Semester Examination – 60 marks
One question from each unit for 20 marks, with internal choice.

Evaluation of (Practical) – Total marks Practical Course - 50 marks

CIA- 20marks

End Semester Practical Examination – 30 marks.

Eg: Template for the Core course End Semester examination in Semester I for the Core course

UNITS	KNOWLEDGE	UNDERSTANDING	APPLICATION and ANALYSES	TOTAL MARKS- Per unit
1	7	8	5	20
2	7	8	5	20
3	5	8	7	20
-TOTAL - Per objective	19	24	17	60
% WEIGHTAGE	31.67%	40%	28.33%	100%

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#.MSc. Part I. Biotechnology Semester I **Course Code: PSBTY6003CR1**

Name of the course: Molecular Immunology
Credits: 2 (Theory – Total 30hr)

Course Objectives:

1. To understand the fundamental concepts of immunology, including the immune system's roles in defense against pathogens, tissue repair, and immune surveillance.
2. To stimulate the learner to explore the cellular and molecular mechanisms underlying immune recognition, activation, and regulation, including antigen presentation and receptor-ligand interactions.
3. To understand the innate immune system's mechanisms of pathogen recognition, phagocytosis, inflammation, and cytokine signaling, the principles of adaptive immune responses, antibody production, and cell-mediated immunity.
4. To analyze the dynamic interactions between the immune system and various pathogens, such as bacteria, viruses, and parasites.
5. To familiarize learners with laboratory techniques used in immunology, such as flow cytometry, ELISA, Western blotting, and immunohistochemistry and the latest advancements in immunology research and its role in diagnostics and therapeutics.

Course Outcomes (CO)

Course Title and Code	**Molecular Immunology**	**PSBTY6003CR1**	
CO No.	**Course Outcomes** *On completion of the course , the student will be able to*	**PSOs Addressed**	**Cognitive Level**
CO-1	Demonstrate basic knowledge of the organization and function of the immune system.	PSO-1,5,6,7,8	U, Ap
CO-2	Differentiate the mechanisms that lead to beneficial immune responses and immune disorders.	PSO-1,5,6,7,8	U, Ap,
CO-3	Apply key immunologic concepts and methods to diagnose immune disorders.	PSO-1,5,6,7,8	U, Ap, An
CO-4	Explain strategies for manipulating the immune system for therapy	PSO-1,5,6,7,8	A , Ap,An
CO-5	Apply the knowledge of Antigen- Antibody interaction in the field of diagnostics and therapeutics	PSO-1,5,6,7,8	Ap, An
CO-6	Analyze immunology-based case studies.	PSO-1,4,7	C, An,

CONTENT

Unit 1: Fundamentals in Immunology — 15 lectures

- Overview of the immune system, Organs and Cells involved, Innate and acquired immunity and their components
- PAMPs, and Membrane-associated receptors (Pattern recognition, TLRs, NLRs),
- Complement System, Inflammatory responses, Phagocytosis
- Antigens-Immunogens and Haptens & Antibodies: fine structure and superfamily: Synthesis, assembly, and secretion of Immunoglobulins
- Immunogenetics: MHC genes-organisation and inheritance, Multigene organization of Ig gene, Variable region gene rearrangement and generation of antibody diversity, Class switching among the constant region ,
- Antigen processing and presentation: Presentation of peptide and non-peptide antigens
- Cytokines and their role in immune responses.

Unit 2: Clinical Immunology and Immunodiagnostics — 15 lectures

- Hypersensitivity and Autoimmune disorder: overview, diseases pathology, role of immune system in pathogenesis
- Immune response to infectious agents: Bacteria, Virus, Parasites, and Fungi
- Transplantation immunology: Basis of Graft rejection, clinical manifestation of graft rejection, Immune tolerance, Immunosuppressive therapy, and clinical transplantation
- Immunodiagnostics: Ag-Ab interaction assays for understanding immune biology, and diagnostics (ELISA, Flow cytometry, RIA, Immunoprecipitation, Immunofluorescence - cytochemistry, and histochemistry)

List of Recommended Reference Books

- Abbas, Abul K. & Lichtman, Andrew H.: Cellular and molecular immunology. (5th Ed.) Philadelphia. W.B. Saunders Company, 2003. 0-7216-0008-5--(616.079ABB/LIC)
- Elgert, Klaus D.: Immunology: Understanding the immune system. (2nd edition) Hoboken. John Wiley & Sons, Inc., 2009. 978-0-470-08157-0--(616.079Elg)
- Kuby, Janis: Immunology. (7th ed.) New York. W.H. Freeman and Company, 2013. 978-1-4641-3784-6--(616.079Kub)
- Tizard, Ian R.: Immunology: an introduction. (4th Ed.) Singapore. Thomson Asia Pte Ltd., 2004. 981-243-516-6--(616.079TIZ)
- Janeway, Charles A., Jr.; Murphy, Kenneth & Weaver, Casey: Immunobiology. (9th ed.) New York. Garland Science, 2017. 978-0-8153-4551-0--(616.079Jan)

- Male, David; Brostoff, Jonathan; Roth, David B. & Roitt, Ivan M.: Immunology. (8th ed.) Amsterdam. Elsevier Ltd., 2013. 978-0-7020-4548-6--(616.079Roi)
- Recent trends – research articles.

Evaluation total marks per course - 50

I. Formative Assessment 'for' Learning (continuous internal assessment - CIA to improve learning).
CIA- 20 marks
CIA 1: Written test -10 marks
CIA 2: Assignment -10 marks

II. Summative Assessment 'of' Learning (focus on outcomes, quantitative data for outcomes of instruction).
End Semester Examination – 30 marks
One question from each unit for 15 marks, with internal choice.

Eg: Template for the Core course End Semester examination in Semester I for the Core course

UNITS	KNOWLEDGE	UNDERSTANDING	APPLICATION and ANALYSES	TOTAL MARKS- Per unit
1	5	5	5	15
2	5	5	5	15
-TOTAL - Per objective	10	10	10	30
% WEIGHTAGE	33.33	33.33	33.33	100%

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#.MSc. Part I. Biotechnology Semester I **Course Code: PSBTY6004CR1**

Name of the course: Essential Techniques in Biotechnology - Lab Course

Credits : 4 (Total 120hrs)

Course Objectives:

- The course is designed to teach students the utility of a set of experimental methods in biotechnology in a problem-oriented manner.
- This course will introduce the students to basic laboratory skills, good laboratory practices and different techniques commonly used in biotechnology experimentation.
- It will also orient students to learn the basic techniques of separation, quantification, purification, and characterisation of proteins and enzyme assays.

Course Outcomes (CO)

Course Title and Code	**Essential Techniques in Biotechnology - Lab Course**	**PSBTY6004CR1**	
CO No.	**Course Outcomes** ***On completion of the course , the student will be able to***	**PSOs Addressed**	**Cognitive Level**
CO-1	Be competent to utilise basic laboratory instruments and understand the principle of measurements using those instruments with experiments in biotechnology.	PSO-2,3,7	U,Ap
CO-2	Acquire technical competence in a range of biotechnology and computational techniques and will be able to utilise basic biotechnological experiments to answer research queries.	PSO-2,3,4,7	U,Ap, E
CO-3	Acquire practical skills which will enable to follow written standard laboratory methods and achieve expected outcomes. Plan and execute experiments and analyse the data obtained	PSO-2,3,4,7	U, C,A, Ap, E
CO-4	Will learn the best practice for recording experimental procedures and outcomes in a lab record book in an ethical manner.	PSO-2,3,4,7	Ap, An

CO-5	Carry out laboratory techniques alone or in a group with others safely and efficiently.	PSO-2,3,4,7,8	Ap,
CO-6	Read scientific literature and utilize various modalities of scientific communication effectively.	PSO-2,3,4,7,8	E, C

CONTENT

1. Introduction to good laboratory practices
2. Calibration techniques for common instruments
    a. Calibration of instruments: pHmeter, analytical balance, UV-spectrophotometer, colorimeter
    b. Calibration of apparatus used for measuring: glass pipettes, auto pipettes and measuring cylinders
    c. Validation: Autoclave, Laminar air flow
3. Preparation of solutions and Buffers
    a. Preparing various stock solutions and working solutions that will be needed for the course.
    b. Preparation an Acetic-Na Acetate Buffer and validate the Henderson-Hasselbach equation
4. Microbial techniques:
    a. Isolation and Identification of microorganisms
    b. Growth curve of microorganisms
    c. Anti-microbial assay
    d. Sterility testing of products
5. Immunological techniques:
    a. Isoagglutination titre study
    b. Single Radial Immunodiffusion
    c. Dot-ELISA/ Antibody/ antigen capture ELISA
    d. Western Blot Technique
    e. Flow Cytometry (Lab visit)
6. Protein Quantification, Separation and Purification techniques
    a. Biuret assay
    b. Bradford's assay
    c. Folin-Lowry assay
    d. UV-Quantification
    e. Polyacrylamide gel electrophoresis (native and SDS)
    f. Staining techniques
    g. Agarose Gel electrophoresis for proteins
    h. Protein Precipitation
    i. Ion exchange Chromatography

j. Gel filtration
k. Affinity Chromatography

7. Enzyme assays: crude enzyme preparation and kinetic studies.

List of Recommended Reference Books

1. Rodney Boyer, Biochemistry Laboratory (2nd Ed, 2012), Pearson's Publication
2. Sheppler J and Cassin P, Biotechnology explorations (2000), ASM Press
3. Segel, Irwin H.: Biochemical calculations: how to solve mathematical problems in general biochemistry. (2nd Ed.) Singapore. John Wiley & Sons (Asia) Pte. Ltd., 2004. 9812-53-149-1--(574.1920151SEG)
4. Wilson, Keith & Walker, John: Principles and techniques of biochemistry and molecular biology. [ed. by] (7th ed.) Cambridge. Cambridge University Press, 2010 (2013). 978-0-521-73167-6--(574.19285Wil/Wal)
5. Online resources
6. Relevant SOPs from USP and IP

Evaluation (Core Practical): Total marks per course - 150

I. Formative Assessment 'for' Learning (continuous internal assessment - CIA to improve learning).
CIA- 60 marks
Continous experiment based evaluation along with Lab record book assessment

II. Summative Assessment 'of' Learning (focus on outcomes, quantitative data for outcomes of instruction).
End Semester Examination – 90 marks
Experiment based, Quiz and Viva voce

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Syllabus

Second Semester Courses in

MSc-Biotechnology

2023-2024

Contents:

APPROVED SYLLABUS

ST. XAVIER'S COLLEGE-AUTONOMOUS MUMBAI-400 001

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#.MSc. Part I. Biotechnology Semester II **Course Code: PSBTY6005CR1**

Name of the course: Bioinformatics and Computational Biology
Credits: 4 (Theory 3 – Total 45hr and Practical 1 Total 30hr)

Course Objectives:

1. The course aims to equip students with the necessary knowledge and skills to effectively apply computational techniques in the field of biology.
2. This course is designed to provide theory and practical experience of the use of computational tools and databases to investigate molecular biology and evolution related concepts.
3. This course will help learners to explore techniques for mining large biological datasets and develop skills in data visualization and interpretation.
4. Acquire basic programming skills in relevant languages for data analysis.
5. Apply computational techniques to analyze DNA, RNA, and protein sequences and structure data.
6. Analyze gene expression data using computational methods to study transcriptional patterns and interaction networks.

Course Outcomes (CO)

Course Title and Code	**Bioinformatics and Computational Biology**	**PSBTY6005CR1**	
CO No.	**Course Outcomes** ***On completion of the course, the student will be able to***	**PSOs Addressed**	**Cognitive Level**
CO-1	Demonstrate understanding of the fundamental concepts, principles and applications of bioinformatics and computational biology.	PSO-1,2,3,6,7	U, An, Ap
CO-2	Effectively use biological databases to retrieve relevant biological information and apply bioinformatics tools to analyze biological sequences, structures, pathways, and omics data.	PSO- 3,4,6,7	U, An, Ap
CO-3	Apply algorithmic concepts to solve bioinformatics problems and implement bioinformatics tasks using programming languages like Python or R.	PSO-3,4,7	U, An, Ap

CO-4	Adhere to best practices for data privacy and security.	PSO-2,3,4,7	U, An, Ap
CO-5	Apply computational approaches to address complex biological questions, Evaluate and interpret bioinformatics results critically, considering the limitations and potential sources of error.	PSO-2,3,4,6,7	U, An, Ap
CO-6	Develop a foundation for continued self-learning in the rapidly evolving field of bioinformatics and computational biology.	PSO-2,3,4,7,8	U, An, Ap

CONTENT

Unit 1: Introduction to Programming and Biological Databases — 15 lectures

- Bioinformatics basics: Computers in biology and medicine.
- Introduction to Unix and Linux systems and basic commands.
- Introduction to R programming - Basic Syntaxes, data structure and types in R, operators, and functions
- Introduction to SQL
- Biological databases -
    - concepts,
    - classification
    - Information retrieval from biological databases
    - data annotation and curation
    - Biological database management system

Unit 2: Biological Sequence and Structure Analysis — 15 lectures

- Biological sequence alignment - types, algorithms, tools for alignment
- Molecular phylogenetics
- Protein structure and function analysis
    - Protein 3 D structure prediction, mutational analysis
    - DNA structure analysis
- Coding and non-coding RNA analysis
- Gene prediction and Promoter and Regulatory Element Prediction

Unit 3: Omics Data Analysis — 15 lectures

- Genomic data analysis: WGS, functional genomics, Comparative genomics, Metagenomics, and applications
- Metabolomics concepts and resources

- Protein-protein interaction analysis – Network analysis Cytoscape, resources for PPI/ Gene interaction study
- Gene ontologies and importance
- Post translational modification analysis.

Practical component: Bioinformatics Data Analysis **30 hours**

- Exercises based on programming.
- Practical based on sequence alignment - BLAST, MSA
- Editing of Biological sequence alignment
- Data curation for biological database construction
- Population genomics and phylogenetics based exercises.
- Protein sequence and structure analysis
- Protein – Protein interactions, Immuno-bioinformatics, Gene Network analysis
- Structure and functional genomics-based exercise.

List of Recommended Reference Books

- Jonathan Pevsner (2009) Bioinformatics and Functional Genomics. 2nd edition, John Wiley and Sons, New Jersey.
- Arthur M. Lesk (2005) Introduction to Bioinformatics, 2nd edition Oxford University Press
- Jian Xiong (2006), Essential Bioinformatics, 1st edition, Cambridge university press,
- Su, C. (2006). Bioinformatics: A Practical Guide to the Analysis of Genes & Proteins, (third edition). Edited by Andreas D. Baxevanis and BF Francis Ouellette New York: John Wiley & Sons; ISBN: 0471 478784; 540pp.; 2004.
- David Mount (2004) Bioinformatics: Sequence and Genome Analysis. 2nd edition, Cold Spring Harbor Laboratory Press, New York.
- Andreas D. Baxevanis and B. F. Francis Ouellette (2001) Bioinformatics A Practical Guide to the Analysis of Genes and Proteins. 2ndedition, A John Wiley & Sons, Inc., Publication
- Teresa K. Attwood and D. J. Parry Smith (1999) Introduction to Bioinformatics. 1stedition, Pearson Education Limited, England

Evaluation (Core Theory): Total marks per course -150

I. Formative Assessment 'for' Learning (continuous internal assessment - CIA to improve learning).
CIA- 40 marks
CIA 1: Written test -20 marks
CIA 2: Assignment -20 marks

II. Summative Assessment 'of' Learning (focus on outcomes, quantitative data for outcomes of instruction).
End Semester Examination – 60 marks

One question from each unit for 20 marks, with internal choice.

Evaluation of (Practical) – Total marks Practical Course - 50 marks

CIA- 20marks

End Semester Practical Examination – 30 marks.

Eg: Template for the Core course End Semester examination in Semester II for the Core course

UNITS	KNOWLEDGE	UNDERSTANDING	APPLICATION and ANALYSES	TOTAL MARKS- Per unit
1	4	6	10	20
2	4	6	10	20
3	4	6	10	20
-TOTAL - Per objective	12	18	30	60
% WEIGHTAGE	20	30	50	100%

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#MSc. Part I. Biotechnology Semester II **Course Code: PSBTY6006CR1**

Name of the course: Genetic Engineering and Functional Genomics
Credits: 4 (Theory 3 – Total 45hr and Practical 1 Total 30hr)

Course Objectives:

1. This course aims to provide students with a comprehensive understanding of the principles, techniques, and applications of genetic engineering and functional genomics.
2. The course is designed for developing a technical understanding of genetic engineering tools and methodologies in biotechnology applications.
3. The span of the course deals with recombinant DNA technology, its evolution with technological advancements and its expansion with respect to contemporary knowledge of biological organisms.
4. This course will introduce the students to the basic techniques for recombinant DNA technology.

Course Outcomes (COs)

Course Title	**GENETIC ENGINEERING AND FUNCTIONAL GENOMICS** **PSBTY6006CR1**		
CO No.	**Course Outcomes** ***On completion of the course, the student will be able to***	**PSOs Addressed**	**Cognitive Level**
CO-1	Understand principles of genetic engineering and its applications in the field of biotechnology.	PSO-1,3,6,7	U, An
CO-2	Devise broad research methodologies by utilizing genetic engineering techniques and related bioinformatics tools.	PSO-2,3,6,7	U, An, Ap
CO-3	Describe the principles of genome editing using various tools	PSO-4,6,7	U, An, Ap
CO-4	Understand functional genomics data, including microarray and RNA sequencing results, to understand gene expression patterns and regulatory networks.	PSO-2,3,6,7	An, Ap, E

CO-5	Demonstrate the ability to perform molecular biology techniques to construct recombinant DNA molecules and expression vectors.	PSO-1,2,3,6,7	U, Ap, An, E
CO-6	Demonstarte acquired knowledge and skills to design, plan and execute independent research projects, adept at troubleshooting in the realm of genetic engineering or functional genomics.Showcase a profound understanding of laboratory safety protocols, encompassing appropriate management of hazardous materials and waste disposal.	P,SO-1, 2,3,4, 6,7	An, Ap, E

CONTENT

Unit 1: Genomes and Genome Mapping — 15 lectures

- A brief overview of prokaryotic and eukaryotic genome organization; extra-chromosomal DNA: bacterial plasmids, mitochondria, and chloroplast
- Model organisms: *S. cerevisiae, C. elegans, D. melanogaster, M. musculus, D. rerio*
- Genome mapping: molecular markers; physical mapping methods (sequencing, RM, STS), cytogenetic techniques, somatic cell hybridization, radiation hybrid maps, in situ hybridization, comparative gene mapping
- Methods of genome analysis: Polymorphisms in DNA sequence, Next Generation Sequencing technologies, Whole Genome Assembly and challenges, Sequencing of large genomes
- Genome sequencing projects: Human Genome Project, genome sequencing projects for microbes, plants, and animals

Unit 2: Genome Analysis — 15 lectures

- Comparative genomics: Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing, SNPs; use of genomes to understand the evolution of eukaryotes, track emerging diseases and design new drugs; determining gene location in the genome sequence.
- Functional genomics - Transcriptome analysis for identification and functional annotation of the gene, Contig assembly, chromosome walking and characterization of chromosomes, mining functional genes in a genome, gene function- forward and reverse genetics.
- Genomics and medicine

Unit 3: Gene Editing: Tools and Techniques **15 lectures**

- Cloning tools:
    - Enzymes: Properties and applications of DNA Modifying Enzymes: Host controlled restriction modification system (Type I-IV restriction endonucleases) DNA polymerases, Ligases.
    - Vectors: Insertional vectors, replacement vectors, cosmids, phasmids, phagemids, in-vitro packaging; High-cloning capacity vectors (Virus based single stranded DNA vectors: Expression vectors, Vectors for making RNA probes., YAC, BAC, Mammalian expression vectors
    - Tools for cloning and expression in prokaryotic and eukaryotic systems: Marker and reporter genes; positive and negative selection; insertional inactivation, adapters, linkers, directional cloning
    - PCR techniques: semi-quantitative and quantitative RT-PCRs
- Gene silencing and genome editing technologies: Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts, genome editing using enzymes.

Practical component: Molecular Biology Techniques **30 hours**

1. Creation of genomic library: Isolation of genomic DNA and Plasmid DNA, Restriction Digestion, Ligation and Transformation
2. Expression of recombinant proteins
3. PCR amplification of 16srRNA
4. RFLP analysis
5. Preparation of glycerol stocks

List of Recommended Reference Books

- Lewin, Benjamin; Krebs, Jocelyn E.; Goldstein, Elliott S. & Kilpatrick, Stephen T.: Genes XI. New Delhi. Jones and Bartlett India Pvt. Ltd., 2015. 978-93-80853-71-0--(575.1Lew)
- Glick, Bernard R., Pasternak, Jack J. & Patten, Cheryl L.: Molecular biotechnology: principles and applications of recombinant DNA. (4th ed.) Washington, D.C. ASM Press, 2010. 1-55581-498-4--(660.6Gli)
- Cooper, Geoffrey M. & Hausman, Robert E.: The cell: a molecular approach. (6th ed.) Sunderland. Sinauer Associates, Inc., 2013. 978-0-87893-964-0--(574.87Coo/Hua)
- Primrose, S.B. & Twyman, R.M.: Principles of gene manipulation and genomics. (7th ed.) Malden. Blackwell Publishing, 2006. 1-4051-3544-3--(575.1Pri/Twy)

- Sambrook, Joseph & Russell, David W.: Molecular cloning: a laboratory manual. [Vol.1-3] (3rd Ed.) Cold Spring Harbor. Cold Spring Harbor Laboratory Press, 2001. 0-87969-577-3--(574.873224SAM/RUS)
- Brown, T.A.: Gene cloning and DNA analysis: an introduction. (7th ed.) Chichester. John Wiley & Sons Ltd., 2016. 978-1-119-07256-0--(574.873282Bro)
- Watson, James D., Baker, Tania A., Bell, Stephen P. & Gann, Alexander: Molecular biology of the gene. (6th ed.) New York. Pearson Education Inc., 2008. 0-321-50781-9--(574.88Wat)
- Molecular Cloning: Laboratory Manual Vol I, 2001, Joseph Sambrook, David William Russel, CHL Press
- Relevant current research articles

Evaluation (Core Theory): Total marks per course -150

I. Formative Assessment 'for' Learning (continuous internal assessment - CIA to improve learning).
CIA- 40 marks
CIA 1: Written test -20 marks
CIA 2: Assignment -20marks

II. Summative Assessment 'of' Learning (focus on outcomes, quantitative data for outcomes of instruction).
End Semester Examination – 60 marks
One question from each unit for 20 marks, with internal choice.

Evaluation of (Practical) – Total marks Practical Course - 50 marks

CIA- 20marks
End Semester Practical Examination – 30 marks.

Eg: Template for the Core course End Semester examination in Semester II for the Core course

UNITS	KNOWLEDGE	UNDERSTANDING	APPLICATION and ANALYSES	TOTAL MARKS- Per unit
1	6	8	4	20
2	6	8	4	20
3	6	9	8	20
-TOTAL - Per objective	18	26	16	60
% WEIGHTAGE	30%	43.33	26.67	100%

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#.MSc. Part I. Biotechnology Semester II **Course Code: PSBTY6007CR1**

Name of the course: Animal Cell Technology
Credits: 4 (Theory 3 – Total 45hr and Practical 1 Total 30hr)

Course Objectives:

1. The course will provide an overarching view of concepts in cell development. It will also illustrate the potential of animal cells, organ engineering, and genetic engineering in therapeutics.
2. The course aims to provide students with a comprehensive understanding of the principles, techniques, and applications of working with animal cells in biotechnological and research contexts.
3. The course will introduce learners to basic techniques in animal cell culture and give insights into *in vitro* cellular growth and behavior, and its application to various biotechnological processes.

Course Outcomes (CO)

Course Title and Code	**Animal cell technology**	**PSBTY6007CR1**	
CO No.	**Course Outcomes** ***On completion of the course, the student will be able to***	**PSOs Addressed**	**Cognitive Level**
CO-1	Understand the the basic principles of cell culture, including cell types, growth requirements, and culture techniques and foundational concepts and applications of stem cells,and regenerative medicine	PSO-1,3,4,6,7	U, An , Ap
CO-2	Explain the core principles of tissue engineering and scaffold-based approaches for creating functional tissue constructs and analyze the importance of biomaterials and scaffold design in tissue engineering.	PSO-1,3,4,6,7	U, An, Ap
CO-3	Describe advanced techniques like 3D bioprinting, evaluate the potential and limitations of these techniques in creating complex tissue structures and applications of cell lines in tissue engineering, regenerative medicine, drug testing and production of recombinant proteins for therapy.	PSO-1,3,4,6,7	U,An, Ap, E

CO-4	Analyze case studies of stem cell-based therapies, tissue engineering applications and biopharmaceutical production using cell lines.	PSO-1,3,4,6,7	An, Ap, E
CO-5	Perform basic cell culture techniques required for cell line development, maintenance, authentication, and preservation. Design, Plan and execute well-controlled experiments to address specific research questions., Analyze experimental results, maintain accurate and organized records of protocols, apply critical thinking skills to troubleshoot challenges that arise during cell culture-based experiments. Demonstrate a strong awareness of laboratory safety protocols, including proper handling of hazardous materials and waste disposal.	PSO-1,2, 3,4,6,7	An, Ap

CONTENT

Unit 1: Biology of Cell Development and Stem Cell Biology **15 lectures**

- Cell differentiation into cell types and organization into specialized tissues, cell motility and migration.
- Embryonic development stages [fertilization, post fertilization, Implantation]
- Establishment of germ layers and their fate
- Immune response to developing embryo.
- Stemness, types of stem cells: ES, Adult, IPSCs, Cancer stem cells
- Molecular basis of pluripotency, Properties- Self-renewal and Differentiation. Regulation of stem cells (cell cycle, gene expression and miRNA). Cross talk between miRNAs and epigenetic regulators during stem cell differentiation
- Characterisation of stem cells: Identification of stem cells using specific markers. Isolation of stem cells -Fluorescence based cell sorting.
- Culture and genetic manipulation of stem cells.
- Applications of stem cells in therapeutics

Unit 2: Animal Cell Culture **15 lectures**

- Biology of cultured cells, Transformation, immortalization, and Differentiation
- Primary Culture and development of cell lines – normal and tumor
- Characterisation of cells in culture and maintenance of cells in culture: subculture, contamination, and cryopreservation
- 3-D culture: organ culture, histiotypic culture, and organotypic culture
- Scale up in cell culture (types of bioreactors for suspension and monolayer cultures and process control)
- *In vitro* testing (cytotoxicity)

Unit 3: Advances in Animal Cell Technology **15 lectures**

- Tissue Engineering
    - Fundamentals of tissue engineering: Growth Factors, morphogens, Extracellular Matrix, Cell adhesion and migration, Inflammatory and Immune responses to tissue engineered devices.
    - Biomaterials: Polymeric scaffolds, Calcium Phosphate Ceramics, Biomimetic materials
    - Applications of tissue engineering (grafts, clean meat)
    - Introduction of 3-D organ printing, organ on chip
- Methods of transfection of cell lines and Cell line models in biomedical research
- Animal models in biomedical research, transgenesis in animal models
- Therapeutic peptides/ Biosimilars- Production methodology and purification
    - Insulin, Tissue plasminogen activator, Interleukins, Interferon – alpha, Erythropoietin
    - Vaccines
    - Monoclonal antibodies (Antibody engineering)

Practical component- Techniques in Animal Cell Culture **30 hours**

1. General aseptic techniques and preparation for ACC
2. Media preparation for ACC
3. Primary culture using embryo tissues.
4. Subculture of cell lines
5. Karyotyping and G- Banding using human blood cells.
6. Cytotoxicity Testing assays

List of Recommended Reference Books

- Lodish, Harvey F.; Berk, Arnold; Kaiser, Chris A. & Krieger, Monty: Molecular cell biology. (7th ed.) New York. W.H. Freeman and Company, 2013. 978-1-4641-0981-2--(574.87Lod)
- Alberts, Bruce, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, and Peter Walter: Molecular Biology of the cell (6th Ed) Garland Science Publishing., 2015
- Bernard R. Glick, Jack J. Pasternak, Cheryl L. Patten. (2010) Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press.
- Daan J. A. Crommelin, Robert D. Sindelar. (2002) Pharmaceutical Biotechnology: An Introduction for Pharmacists and Pharmaceutical Scientists. Taylor & Francis.

- Gary Stein and Maria B *et al.* (2011) Human Stem Cell Technology and Biology. Wiley Blackwell.
- Inderbir Singh & GP Pal. (2007) Human Embryology. MacMillan Publishers.
- Kaushik Deb and Satish Totey. (2009) Stem Cells Basics and Applications. Tata McGraw Hill.
- Freshney, R. Ian: Culture of animal cells: a manual of basic technique and specialized applications. (6th ed.) Hoboken. John Wiley & Sons, Inc., 2010. 978-0-470-52812-9--(591.0724Fre)
- R. Ian Freshney, Glyn N. Stacey, Jonathan M. Auerbach. (2007) Culture of Human Stem Cells. John Wiley & Sons
- Robert Lanza, Robert Langer, Joseph P. Vacanti. (2011) Principles of Tissue Engineering. Academic Press.
- Scott F Gilbert. (2000) Developmental Biology, 6th edition. Sinauer Associates.
- Thomas W. Sadler. (2009) Langman's Medical Embryology. Lippincott Williams & Wilkins.
- Relevant research and review articles

Evaluation (Core Theory): Total marks per course -150

I. Formative Assessment 'for' Learning (continuous internal assessment - CIA to improve learning).

CIA- 40 marks

CIA 1: Written test -20 marks

CIA 2: Assignment -20 marks

II. Summative Assessment 'of' Learning (focus on outcomes, quantitative data for outcomes of instruction).

End Semester Examination – 60 marks

One question from each unit for 20 marks, with internal choice.

Evaluation of (Practical) – Total marks Practical Course - 50 marks

CIA- 20marks

End Semester Practical Examination – 30 marks.

Eg: Template for the Core course End Semester examination in Semester II for the Core course

Units	Knowledge	Understanding	Application & Analyses	Total Marks-Per Unit
1	6	7	7	20
2	6	7	7	20
3	6	7	7	20
-TOTAL - Per objective	18	21	21	60
% WEIGHTAGE	30	35	35	100%

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