ACHARYA NAGARJUNA UNIVERSITY

A State Government University, Accredited with "A" Grade by NAAC

Nagarjuna Nagar - 522 510, Guntur, Andhra Pradesh, India.

M.Sc. BIOTECHNOLOGY

SYLLABUS

2022 - 2023 onwards

UNIVERSITY COLLEGE OF SCIENCES

PROGRAM CODE:

ANUCS04


ACHARYA NAGARJUNA UNIVERSITY
సత్యం సర్వం ప్రతిష్ఠితమ్

ABOUT UNIVERSITY

ACHARYA NAGARJUNA UNIVERSITY (ANU)

- A Brief Profile

Acharya Nagarjuna University, a State University established in 1976, has been constantly striving towards achieving progress and expansion during its existence for over four decades, in terms of introducing new courses in the University Colleges, affiliated colleges and professional colleges. Spread over 300 acres of land on the National High Way (NH-16) between Vijayawada and Guntur of Andhra Pradesh, the University is one of the front ranking and fastest expanding Universities in the state of Andhra Pradesh. The University was inaugurated on 11th September, 1976 by the then President of India, Sri Fakruddin Ali Ahmed and celebrated its Silver Jubilee in 2001. The National Assessment and Accreditation Council (NAAC) awarded "A" grade to Acharya Nagarjuna University and also has achieved 108 International ranks, 39 National ranks UI Green Metrics rankings and many more It is named after Acharya Nagarjuna – one of the most brilliant preceptors and philosophers, whose depth of thought, clarity of perception and spiritual insight were such that even after centuries, he is a source of inspiration to a vast number of people in many countries. The University is fortunate to be situated on the very soil where he was born and lived, a soil made more sacred by the aspiration for light and a state of whole someness by generations of students. With campus student strength of over 5000, the University offers instruction for higher learning in 68 UG & PG programs and guidance for the award of M.Phil. and Ph.D. in 48 disciplines spread over six campus colleges and one PG campus at Ongole. It also offers 160 UG programs in 440 affiliated colleges in the regions of Guntur and Prakasam Districts. It has a Centre for Distance Education offering 87 UG & PG programs. Characterized by its heterogeneous students and faculty hailing from different parts of the state and the country, the University provides most hospitable environment for pursuing Higher Learning and Research. Its aim is to remain connected academically at the forefront of all higher educational institutions. The University provides an excellent infrastructure and on- Campus facilities such as University Library with over one lakh books & 350 journals; Computer Centre; University Scientific Instrumentation Centre; Central Research Laboratory with Ultra-modern Equipment; Well-equipped Departmental Laboratories; Career Guidance and Placement Cell; Health Centre; Sports Facilities with Indoor & Outdoor Stadiums and Multipurpose Gym; Sports Hostel; Separate hostels for Boys, Girls, Research Scholars and International Students; Pariksha Bhavan (Examinations Building); Computers to all faculty members; Wi-Fi connectivity to all Departments and Hostels; Canteen, Student Centre & Fast-food Centre; Faculty Club; Dr. H.H. Deichmann & Dr. S.John David Auditorium cum Seminar Hall; Post office; Telecom Centre; State Bank of India; Andhra Bank; Energy Park; Silver Jubilee Park; Fish ponds; internet center; xerox center; cooperative stores; Water harvesting structures.

VISION, MISSION & OBJECTIVES OF THE UNIVERSITY

ACHARYA NAGARJUNA UNIVERSITY

VISION

To generate sources of knowledge that dispels ignorance and establishes truth through teaching, learning and research.

MISSION

To promote a bank of human talent in diversified faculties – Commerce & Management Studies, Education, Engineering & Technology, Humanities, Law, Natural Sciences, Pharmacy, Physical Education & Sports Sciences, Physical Sciences and Social Sciences that would become an investment for a prosperous society.

OBJECTIVES

- To inspire and encourage all who would seek knowledge through higher education and research.
- To provide quality instruction and research for the advancement of science and technology.
- To promote teaching and research studies in disciplines of societal relevance.
- To bridge the gap between theory and practice of the principles of higher education.
- To develop human talent necessary for the industry.
- To open up avenues of higher education and research through non-formal means.
- To invite and implement collaborations with other institutes of higher learning on a continuous basis for mutual academic progress.
- To motivate and orient each academic department/centre to strive for and to sustain advanced levels of teaching and research so that the university emerges as an ideal institute of higher learning.
- To focus specially on the studies involving rural economy, justifying its existence in the rural setting.

VISION

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MISSION OF THE COLLEGE

ACHARYA NAGARJUNA UNIVERSITY

UNIVERSITY COLLEGE OF SCIENCES

VISION OF THE COLLEGE:

University College of Sciences envisages to be a good team of people with scientific temperament, research bent and a flair for Teaching & Learning for the betterment of the Community, Society, State and the Country at large.

MISSION OF THE COLLEGE:

The College intends to incubate and nurture the Leaders, Mentors, Educators and researchers who can transform the country and contribute to advances in science while addressing the challenges faced by the society for the betterment of human life.

VISION & MISSION OF THE DEPARTMENT

ACHARYA NAGARJUNA UNIVERSITY
UNIVERSITY COLLEGE OF SCIENCES
DEPARTMENT OF BIOTECHNOLOGY
M.Sc. BIOTECHNOLOGY

VISION OF THE DEPARTMENT:

The vision of a Department of Biotechnology has specific goals and objectives. The department motto is to advance the understanding and application of biotechnology for the benefit of society. This may involve conducting innovative research to uncover new knowledge about biological processes, developing new technologies and products for various industries, and training and educating the next generation of biotechnology professionals.

DEPARTMENT OF BIOTECHNOLOGY'S VISION INCLUDES:

1) Advancing the frontiers of biotechnology through cutting-edge research in areas such as genomics, proteomics, and synthetic biology
2) Developing new biotechnology products and processes for industries such as healthcare, agriculture, and energy
3) Collaborating with other academic institutions, industry partners, and government agencies to address major societal challenges such as global health and sustainability
4) Educating and training students to become leaders in the field of biotechnology and promoting diversity and inclusion in the biotech workforce
5) Fostering an entrepreneurial spirit and supporting the creation of biotechnology startups and spin-off companies that can translate research into real-world applications.

Overall, a department of biotechnology's vision should aim to leverage the power of biotechnology to make a positive impact on the world.

MISSION OF THE DEPARTMENT:

The mission of a Department of Biotechnology is to promote the understanding and application of biotechnology to improve the well-being of society.

Biotechnology's mission could include:

1) Conducting research to advance the knowledge of biological processes and developing new technologies and applications based on that research
2) Educating and training the next generation of biotechnology professionals and promoting diversity and inclusivity in the field
3) Collaborating with other academic institutions, industry partners, and government agencies to address societal challenges such as improving human health, enhancing food security, and promoting sustainability
4) Translating research findings into practical solutions that can benefit society, such as new therapeutics, agricultural products, or industrial processes
5) Promoting ethical and responsible use of biotechnology and ensuring safety and security in biotech research and applications
6) Fostering an innovative and entrepreneurial culture that encourages the development of new biotech startups and spin-off companies.

Overall, a biotechnology's mission is employing biotechnology to make a positive impact on society while advancing the frontiers of scientific knowledge.

ACHARYA NAGARJUNA UNIVERSITY
UNIVERSITY COLLEGE OF SCIENCES
DEPARTMENT OF BIOTECHNOLOGY
M.Sc. BIOTECHNOLOGY

PROGRAMME SPECIFIC OUTCOMES (PSO's):

Programme specific Outcomes (PSOs) are broad statements that describe the expected accomplishments of graduates of a particular academic program in their professional career and life. The PSOs for M.Sc Biotechnology students are:

1. To educate students with a strong foundation in fundamental concepts in biotechnology, including molecular biology, genetics, biochemistry, and microbiology, among others, enabling them to apply these principles to solve complex problems in biotechnology.
2. To apply knowledge and skills in the advanced laboratory techniques and methods used in biotechnology research and development, enabling students to carry out independent research and development work in biotechnology.
3. To train students with skills in the application of bioinformatics and computational tools for the analysis and interpretation of biological data.
4. To prepare students for careers in academia, industry, and government, and to develop the skills necessary to succeed in biotechnology fields.
5. To develop professional development, including the ability to critically evaluate scientific literature and stay current with developments in Biotechnology field.

These PSOs are developed with the aim of providing students with a comprehensive understanding of the field of biotechnology and to prepare them for a successful career in the industry. The achievement of these PSOs is assessed through various methods, including assessments of student performance, research projects, and practical exercises.

PROGRAMME OUTCOME (PO's):

Programme Outcomes (POs) are specific statements that describe what a student is expected to know, understand, or be able to do upon successful completion of a program. The POs for M.Sc Biotechnology students are:

1. Apply knowledge of fundamental concepts in biotechnology, including molecular biology, genetics, biochemistry, and microbiology, among others, to solve complex problems in biotechnology.
2. Understanding and conducting experiments, analyze data, and interpret results using advanced laboratory techniques and methods used in biotechnology research and development.

3. Applying bioinformatics and computational tools for the analysis and interpretation of biological data.
4. Explaining the ethical, legal, and social responsibility associated with biotechnology research and development, and communicates effectively with peers and stakeholders.
5. Applying multidisciplinary teams, including teams of scientists, engineers, and business professionals, to address complex challenges in biotechnology research and development.
6. Understanding the scientific manuscripts, and effectively communicate scientific findings to a range of audiences.
7. Understanding scientific literature, stays current with developments in the field, and applies critical thinking skills to solve problems in biotechnology research and development.
8. Applying biotechnology knowledge and skills to address real-world problems and challenges, and develop innovative solutions.
9. Applying professional and personal development, including the ability to adapt to new technologies and trends in biotechnology research and development.
10. Organizing the professional training in biotechnology or related fields, or transition into a biotechnology-related career.

These POs are designed to provide M.Sc Biotechnology students with the knowledge, skills, and competencies necessary to succeed in a variety of biotechnology-related careers. The achievement of these POs is assessed through various methods, including examinations, laboratory reports, research projects, and presentations.

STRUCTURE

ACHARYA NAGARJUNA UNIVERSITY

UNIVERSITY COLLEGE OF SCIENCES

DEPARTMENT OF BIOTECHNOLOGY

M.Sc. BIOTECHNOLOGY

TWO YEAR M.SC. COURSE IN BIOTECHNOLOGY (2022-2023) COURSE STRUCTURE AND EXAMINATION SCHEME

SEMESTER-I

S. No.	Components of Study	Title of the Course	Title of the Paper	No. of Credits	Internal Assessment Marks	Semester end Examinations Marks	Total Marks	No. of hours/week
1.	**Mandatory Core**	**MBT1.1(22)**	Chemistry of Biomolecules	4	30	70	100	5
2		**MBT1.2(22)**	Cell Biology	4	30	70	100	5
3.	**Compulsory Foundation**	**MBT1.3 (a) (22)**	Bioanalytical Methods & Biostatistics	4	30	70	100	5
4	**Elective Foundation**	**MBT1.4 (a) (22)**	Genetics	4	30	70	100	5
		MBT1.4 (b) (22)	Environmental Biotechnology					
		MBT1.4 (c) (22)	Food Technology					
5.	**Practical-I**	**MBTP1.1 (22)**	Cell Biology & Biomolecules	4	30	70	100	6
6.	**Practical-II**	**MBTP1.2 (22)**	Genetics & Biostatistics	4	30	70	100	6
TOTAL				**24**	**180**	**420**	**600**	

SEMESTER-II

S. No.	Components of Study	Title of the Course	Title of the Paper	No. of Credits	Internal Assessment Marks	Semester end Examinations Marks	Total Marks	No. of hours/week
1.	**Mandatory Core**	**MBT 2.1(22)**	Biochemistry	4	30	70	100	5
		MBT 2.2(22)	Microbiology	4	30	70	100	5
2	**Compulsory Foundation**	**MBT 2.3 (a) (22)**	Molecular Biophysics & Enzymology	4	30	70	100	5
3	**Compulsory Foundation**	**MBT 2.4 (a) (22)**	Immunology	4	30	70	100	5
		MBT2.4 (b) (22)	Bioprocess Validation & current Good manufacturing Practices (cGMP)					
		MBT2.4 (c)(22)	Nanotechnology					
5.	**Practical-I**	**MBTP 2.1 (22)**	Microbiology & Immunology	4	30	70	100	6
6.	**Practical-II**	**MBTP 2.2 (22)**	Biochemistry & Enzymology	4	30	70	100	6
	Skill Development Course			4	00	00	00	00
	TOTAL			**28**	**180**	**420**	**600**	
Elective Foundation–Choose one paper								

SEMESTER -III

S. No.	Components of Study	Title of the Course	Title of the Paper	No. of Credits	Internal Assessment Marks	Semester end Examinations Marks	Total Marks	No. of hours/week
1.	**Mandatory Core**	**MBT 3.1(22)**	Molecular Biology	4	30	70	100	5
		MBT 3.2(22)	Protein Engineering	4	30	70	100	5
2	**Elective –I**	**MBT 3.3 (a) (22)**	Genetic Engineering	4	30	70	100	5
		MBT 3.3 (b) (22)	Nano-chemistry					
		MBT 3.3 (c) (22)	Bioreactor Designing					
3	**Elective –II**	**MBT 3.4 (a) (22)**	Bioinformatics	4	30	70	100	5
		MBT 3.4 (b) (22)	Bioethics, Bio-safety. IPR and Patent Laws					
		MBT 3.4 (c) (22)	Virology					
4	**Practical-I**	**MBTP 3.1 (22)**	Molecular Biology& Protein Engineering	4	30	70	100	6
5	**Practical-II**	**MBTP 3.2 (22)**	Genetic Engineering & Bioinformatics	4	30	70	100	6
	Skill Development Course			4	00	00	00	0
	TOTAL			**28**	**180**	**420**	**600**	
Elective-I: Choose one paper & Elective-II: Choose one paper.								

SEMESTER -IV

S. No.	Components of Study	Title of the Course	Title of the Paper	No. of Credits	Internal Assessment Marks	Semester end Examinations Marks	Total Marks	No. of hours/week
1.	**Mandatory Core**	**MBT 4.1(22)**	Plant Biotechnology	4	30	70	100	5
2		**MBT 4.2(22)**	Animal Biotechnology	4	30	70	100	5
3	**Elective –I**	**MBT 4.3 (a) (22)**	Biochemical Engineering	4	30	70	100	5
		MBT 4.3 (b) (22)	Nano informatics & Chemiinformatics					
		MBT 4.3 (c) (22)	Medical Biotechnology					
4	**Elective –II**	**MBT 4.4 (a) (22)**	Bioinformatics	4	30	70	100	5
		MBT 4.4 (b) (22)	Tools in Biotechnology					
		MBT 4.4 (c) (22)	Pharmaceutical Biotechnology					
5	**Practical-I**	**MBTP 4.1 (22)**	Plant & Animal Tissue Culture	4	30	70	100	6
6	**Practical-II**	**MBT 4.2 (22)**	Fermentation Technology	4	30	70	100	6
	Project Work			4	-	100	100	-
	TOTAL			**28**	**180**	**520**	**600**	
Elective-I: Choose one paper & Elective-II: Choose one paper.								

FIRST SEMESTER

ACHARYA NAGARJUNA UNIVERSITY

UNIVERSITY COLLEGE OF SCIENCES

DEPARTMENT OF BIOTECHNOLOGY

M.Sc. BIOTECHNOLOGY

SEMESTER-I

MBT-1.1. (22): CHEMISTRY OF BIOMOLECULES

Credits: 4

Unit I:

Thermodynamics: Basic concepts of heat, work and energy. Molecular interpretation of energy changes, First law of Themodynamics. Enthalpy and thermochemistry. Entropy and second law of Thermodynamics. Concept of free energy. Gibbs free energy G, Distinctions between G and G^o.

Unit II:

Chemical equilibrium: Equilibrium and non-equilibrium reactions. The relationship between G^o, Equilibrium constant and standard state. Measurement of changes in standard free energy, Oxidation - reduction potentials in biological processes, Relationship between equilibrium constants, G and redox potentials.

Unit III:

Acids, Bases, Buffers, Physiologically important buffers, pH, Osmotic and Colligative properties, Activity coefficient of solutions, Structure and biological significance of mono, di, oligo and polysaccharides. Sugar derivatives, Glycoproteins, Blood group polysaccharides, Lectins

Unit IV: Structure properties and significance of simple and compound lipids including sterols. Fat and water soluble vitamins,alkaloids. Structure and biological significance of amino acids, peptides and proteins.

Unit V:

Structure and biological significance of nucleosides. Nucleotides and nucleic acids. Effect of environmental factors (pH, temperature, salt concentration) on biomolecular structure and activity. Native and denatured structures, cross links, linear and circular polynucleotide molecules.

REFERENCE BOOKS:

1) Lehninger Principles of Biochemistry,4th edition, Nelson, David L. , Cox, Michael M. 2005, W.H. Freeman, Madison avenue, Newyork.
2) Experimental Biochemistry 3rd edition, Switzer, Robert L., Garrity, Liam F. 1999, W.H. Freeman, Madison avenue, New york.

3) Biochemistry, Berg M.J, Tymoczko J.L, Stryer L., 5th edition, W.H. Freeman, Madison avenue, New york.
4) Harper's Biochemistry, Murray R.K, Granner D.K , Mayes P.A and Rodwell V.W 26th edition, 2003 Mc graw-Hill professional publishers, New Delhi.
5) D Voet, J.G. Voet, and C.W. Pratt. Fundamentals of Biochemistry. New York: John Wiley & Sons, 1999.

LEARNING OBJECTIVES: The learning objectives of the Chemistry of Biomolecules

LO 1	Understand the basic concepts of biochemistry, including the structure and function of biomolecules such as carbohydrates, lipids, nucleic acids, and proteins
LO 2	Explain the fundamental principles of enzyme catalysis and kinetics, and apply this knowledge to the study of biochemical reactions**.**
LO 3	To Explain the scientific literature related to the chemistry of biomolecules, and communicate scientific findings effectively in written and oral formats
LO 4	Develop critical thinking skills necessary for designing and conducting experiments related to the chemistry of biomolecules**.**
LO 5	Apply the principles of the chemistry of biomolecules to solve problems in biotechnology research and development

These learning objectives are designed to provide M.Sc Biotechnology students with a comprehensive understanding of the chemistry of biomolecules and their role in biological systems. The course will prepare students for further studies in biotechnology, as well as careers in biotech-related fields.

COURSE OUTCOMES: The course outcomes for a Chemistry of Biomolecules course may include:

CO 1	Understanding the chemical structures of biomolecules such as carbohydrates, lipids, nucleic acids, and proteins.
CO 2	Educating the scientific literature related to the chemistry of biomolecules, and communicating scientific findings effectively in written and oral formats
CO 3	Applying critical thinking skills necessary for designing and conducting experiments related to the chemistry of biomolecules
CO 4	Applying the principles of the chemistry of biomolecules to solve problems in biotechnology research and development
CO 5	Applying the skills in data analysis and interpretation in the context of biomolecular research

These course outcomes will help students develop a thorough understanding of the chemical properties and functions of biomolecules in living systems. This knowledge will be useful for students pursuing careers in biotechnology research, medicine, and related fields, as well as for those interested in graduate study in biochemistry, biophysics, or related disciplines.

CO-PO MAPPING TABLE:

CO /PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	2	3	2	3	2	2	3	3	3	2	3	2	2	3
CO2	3	2	3	2	3	2	2	3	3	3	2	3	2	2	3
CO3	3	2	3	2	3	2	2	3	3	3	2	3	2	2	3
CO4	3	2	3	2	3	2	2	3	3	3	2	3	2	2	3
CO5	3	2	3	2	3	2	2	3	3	3	2	3	2	2	3

MBT-1.2. (22): CELL BIOLOGY

Credits: 4

Unit I:

Diversity of cell size and shape, Ultrastructure, Cell theory, Cell isolation, Cell disruption, Centrifugation for separation of cell contents, Biochemical methods for the identification of Cell organelles (Marker enzymes) Ultra structure, Composition and functions of organelles in eukaryotes. Nucleus, Endoplasmic reticulum, Mitochondria, Chloroplast, Golgi complex, Ribosomes, Lysosomes and Microbodies (Peroxisomes and Glyoxysomes) Vacuoles, Gap junctions and Plasmodesmata.

Unit II:

Structure and chemical composition of membranes, symmetry of membrane, membrane fluidity, membrane transport, Donnan membrane equilibrium, Ion transport across the membrane and tonoplast. Pumps, channels and carriers, Na^+ - K^+ pumps. Na^+ - H^+ - ATPases, Uniport, symport and antiport. Structure - function relationship of anion (chloride) and cation (Potassium) transport, Water channels, Glucose transport.

Unit III:

Structure and organization of prokaryotic DNA, Eukaryotic DNA organization, Nucleoproteins, Chromatin fibers, Centriosome, Euchromatin and Heterochromatin, Satellite DNA. structure, function, Genome organization of Chloroplasts and Mitochondria, Regulation of chloroplast and mitochondrial genes.

Unit IV:

Cytoskeleton - Structure of actin filaments, microtubules and intermediate filaments, Microtubules,Actin binding proteins, Functions of cytoplasmic microtubules, Assembly of microtubules, Mitotic spindle and its formation.

.Unit V: Cell cycle – Phases of cell cycle, experimental systems in cell cycle research, regulation of cell cycle, Cell Division, amitosis,binary fission mitosis and meiosis,; Programmed cell death, Genes and proteins associated with Apoptosis, Necrosis uncontrolled cell division.

REFERENCE BOOKS:

1) Molecular Cell Biology, 5th edition by Harvey Lodish, Arnold Berk, Paul Matsudaira, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, Lawrence Zipursky, and James Darnell.W.H. Freeman publishers, Madison avenue, New york.
2) The Cell: A Molecular Approach, 4th edition, Geoffrey M. Cooper and Robert E. Hausman, 2006, *ASM Press and Sinauer Associates, Inc.*

3) De robertis E.D.P and E.M.F Derobertis Cell and molecular biology 8th ed, 1996, Warley publishers, New Delhi.
4) Cell and Molecular Biology: Concepts and Experiments, 4th edition, Gerald Karp, Wiley Publishers, New York
5) Alberts B, Johnson A, Lewis J.Raff M, Roberts K and Walter P.,Molecular cell biology of the cell 4th ed, 2002, Garland Science publishers , New york.

LEARNING OBJECTIVES: The learning objectives of a Cell Biology course for M.Sc Biotechnology students may include:

LO 1	Understanding the basic structure and functions of cells, including organelles and the cytoskeleton Understanding the principles of cell signaling, including receptor-ligand interactions, signal transduction pathways, and gene expression regulation
LO 2	Familiarizing with the molecular mechanisms involved in cell division, growth, differentiation, and death Understanding the principles of membrane transport, including diffusion, osmosis, and active transport.
LO 3	Familiarizing with the methods used in cell biology research, including microscopy, cell culture, and genetic engineering techniques. Understanding the role of cell biology in disease processes, including cancer, genetic disorders, and infectious diseases
LO 4	Developing critical thinking skills necessary for designing and conducting experiments related to cell biology Understanding the ethical and regulatory issues related to cell biology research
LO 5	Developing critical thinking skills necessary for designing and conducting experiments related to cell biology. Applying the principles of cell biology to solve problems in biotechnology research and development

These learning objectives will provide students with a strong foundation in the fundamental principles of cell biology and their applications in biotechnology research and development. This knowledge will be essential for students pursuing careers in biotechnology research, medicine, and related fields, as well as for those interested in graduate study in cell biology, molecular biology, or related disciplines.

COURSE OUTCOMES: The course outcomes of a Cell Biology course for M.Sc. Biotechnology students may include:

CO 1	Understanding the basic structure and functions of cells, including organelles and the cytoskeleton.

CO 2	Explain the principles of cell signaling, including receptor-ligand interactions, signal transduction pathways, and gene expression regulation.
CO 3	Apply the methods used in cell biology research, including microscopy, cell culture, and genetic engineering techniques.
CO 4	Understanding the principles of cell biology to solve problems in biotechnology research and development.
CO 5	Understanding and interpreting data in the context of cell biology research

By the end of the course, students should be able to understand the fundamental principles of cell biology and their applications in biotechnology research and development. They should be able to apply their knowledge to solve problems related to cell biology, and to analyze and interpret data in the context of cell biology research. They should also be able to evaluate the ethical and regulatory issues related to cell biology research, and to design and conduct experiments related to cell biology using critical thinking skills. The course outcomes will prepare students for careers in biotechnology research, medicine, and related fields, as well as for graduate study in cell biology, molecular biology, or related disciplines.

CO-PO MAPPING TABLE:

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	2	2	3	2	3	2	2	3	3	2	2	3	2	2	2
CO2	2	2	3	2	3	2	2	3	3	2	2	3	2	2	3
CO3	3	3	3	3	3	3	3	3	3	3	2	3	2	2	3
CO4	2	3	2	3	2	2	2	3	2	2	2	3	2	2	3
CO5	2	3	3	2	3	2	2	3	3	2	2	3	2	2	3

MBT-1.3. (22): BIOANALYTICAL METHODS AND BIOSTATISTICS

Credits: 4

Unit I:-

Centrifugation - Principles of centrifugation, concept of RCF, different types of instruments and rotors used, preparative, differential and density gradient centrifugation, analytical ultracentrifuge; Chromatography Principles of partition chromatography, paper and thin layer chromatography, ion exchange chromatography, Gel permeation chromatography, Gas liquid and High pressure liquid chromatography

Unit II:

Spectroscopy Basic concepts of spectroscopy, visible and UV spectroscopy. Laws of photometry. Beer - Lamberts law; Principles and applications of colorimetry, flourimetry, atomic absorption spectrophotometry; Basic Principles and applications of UV, IR, ESR, NMR and mass spectroscopy, Use of CD and ORD techniques.

Unit III:

Microscopy - Basics of phase contrast, polarization, fluorescence and electron microscopy; Electrophoresis – Principles of electrophoretic separation, zonal and continuous electrophoresis, Different types of electrophoresis – paper, cellulose acetate/nitrate, gel and capillary electrophoresis, use of native and denaturing gels, isoelectric focussing and two dimensional gel electrophoresis, Pulse field gel electrophoresis.

Unit IV:

Radioactivity - Principles of scintillation counting, GM Counters; Applications of isotopes, isotope dilution technique; Autoradiography, turnover studies, precursor-product relationship, production of Radio-labelled biomolecules; Radiation hazards and methods for containment and prevention.

Unit V:

Biostatistics - Measurement of central tendency (Mean, Median and Mode) and Dispersion (Range, standard error, Standard deviation, Mean deviation, Quartile deviation); Probability and distribution (Binomial, Poisson, Hyper Geometric, Normal); Population and Sample, Testing - Applications of t, F, Chi^2, ANOVA; Nonparametric tests -Sign test, Media test, Run test, kolmogrov test.

REFERENCE BOOKS:

1) Pattabhi V. and Gautham N. Biophysics, 1st ed, 2005, Narosa publishing house, New Delhi.
2) Manz A, Pamme. N. Lossifidis. D, Bioanalytical Chemistry 1^{st}ed, 2004, Pmperial College press, London.

3) Upadhyay, Upadhyay and Nath, Biophysical chemistry, 5th edition, 2002, Himalya publishing house, New Delhi
4) Pagano M. and Gauvreau K., Principles of Biostatistics, Duxbury Thomson learning.
5) Wilson, K. and Walker, JM, 5th edition, Principles and Techniques of Practical Biochemistry, Cambridge University Press, New York, USA.

LEARNING OBJECTIVES: The learning objectives of a Bioanalytical Methods and Biostatistics course for M.Sc. Biotechnology students may include:

LO 1	Understand the basic principles of bioanalytical methods and their applications in biotechnology research and development. Analyze the principles of statistical analysis and experimental design in biological research.
LO 2	Apply different types of bioanalytical techniques such as chromatography, spectroscopy, electrophoresis, and immunoassays in laboratory experiments. Analyze the data generated from bioanalytical experiments using statistical tools and software.
LO 3	Understand the principles of method validation and quality control in bioanalytical methods. Evaluate the significance of experimental results in the context of biotechnology research and development.
LO 4	Develop effective laboratory and experimental protocols to address specific biological questions. Evaluate the ethical and regulatory issues related to the use of bioanalytical methods in biotechnology research.
LO 5	Communicate scientific findings and experimental protocols effectively through written and oral reports. Work effectively in a team to design and conduct bioanalytical experiments and analyze the results.

By the end of the course, students should be able to understand the principles of bioanalytical methods and biostatistics, and their applications in biotechnology research and development. They should be able to apply different types of bioanalytical techniques to laboratory experiments and analyze the data generated from these experiments using statistical tools and software. They should be able to develop effective laboratory protocols and communicate their findings effectively through written and oral reports. They should also be able to evaluate the ethical and regulatory issues related to the use of bioanalytical methods in biotechnology research and work effectively in a team to design and conduct experiments. The course objectives will prepare students for careers in biotechnology research and development, as well as for graduate study in biotechnology, bioanalytical methods, or related disciplines.

COURSE OUTCOMES: Course outcomes for the subject of Bioanalytical Methods and Biostatistics for M.Sc. Biotechnology course may include:

CO 1	Understanding of the basic principles and concepts of bioanalytical methods, including chromatography, electrophoresis, and spectrophotometry.
CO 2	Applying knowledge of the principles of statistics and their application to biological data. Applying proficiency in using statistical software to analyze biological data and draw meaningful conclusions.
CO 3	Understanding of the ethical and regulatory aspects of bioanalytical methods and data analysis.
CO 4	Development of critical thinking and problem-solving skills in the context of bioanalytical methods and biostatistics.
CO 5	Explaining the latest developments in bioanalytical methods and biostatistics through literature review and discussion.

CO-PO MAPPING TABLE:

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	2	3	2	3	2	2	3	3	2	2	3	2	2	3
CO2	3	3	3	2	3	2	2	3	3	3	3	3	2	2	3
CO3	3	2	3	2	3	2	2	3	3	2	2	3	2	2	3
CO4	3	3	3	2	3	2	2	3	3	3	3	3	2	2	3

MBT-1.4. (A) (22): GENETICS

Credits: 4

Unit I:

Mendelian Genetics - Mendelian inheritance in plants and humans; Dominance and recessivity, chromosomal basis of heredity; Sex linked inheritance, Multiple alleles, Gene interactions, Lethal genes, Genotypes and phenotypes.

Unit II:

Linkage, crossing over and recombination; Site specific recombination; Transposable elements; Structure and Molecular basis of AC-DS transposition in maize, "P" element of Drosophila and hybrid dysgenesis, Yeast "T_7" elements, Retroposans.

Unit III:

Gene and chromosomal mutations; Mutagenesis - Spontaneous and induced (Chemical and physical) mutations; Natural and induction of mutations, point mutations, frameshift mutations, auxotrophic conditional and suppressor mutations, impact of mutations; Chromosomal aberrations - rearrangements and ploidy levels.

Unit IV:

One gene - one enzyme hypothesis . Fine structure of r II locus in T_4 phage, Gene fine structure and over lapping genes (φX174); Concepts of cistron, muton and recon; Organization of DNA on chromosome, DNA as genetic material, RNA as genetic material, eg.TMV; Origin and evolution of gene, Biological clock in Drosophila.

Unit V:

In born errors of metabolism and their genetic orgin - genetic heterozygosity. Modulation of somatic genome - transplantation; DNA polymorphism; Quantitative trait loci (QTL) markers; gene mapping, Physical methods for gene mapping - Heteroduplex analysis, Human genome mapping and advantages. Somatic cell fusion and somatic cell genetics for mapping genetic defects in humans.

REFERENCE BOOKS:

1) Pierce, Benjamin Transmission and Population Genetics 2nd edition 2006, W.H. Freeman Madison avenue,Newyork.
2) Griffiths, Anthony JF. , Wessler, Susan R. , Lewontin, Richard C. , Gelbart, William M. , Suzuki, David T. , Miller, Jeffrey H.
3) An Introduction to Genetic Analysis 8/e, 2005, W.H. Freeman ,Madison avenue,Newyork.
4) Pierce, Benjamin Genetics (A Conceptual Approach) 2/e, 2005, W.H. Freeman Madison avenue, Newyork.
5) Principles of Genetics, 8th edition, Eldon J. Gardner, D. Peter Snustad, Michael J. Simmons, John Wiley & Sons, USA
6) Grenetics, Stickberger,3rd ed,1999, Prentice hall of India,New Delhi.

LEARNING OBJECTIVES: The learning objectives of genetics for M.Sc Biotechnology students may include

LO 1	Understanding the fundamental concepts of genetics, including the structure and function of genes, genetic variation, and inheritance patterns. Knowledge of the techniques used to study genetics, such as genetic mapping, genome sequencing, and genetic engineering.
LO 2	Familiarity with the molecular mechanisms of DNA replication, transcription, and translation. Ability to analyze and interpret genetic data using bioinformatics tools and databases.
LO 3	Knowledge of the ethical, legal, and social issues surrounding genetics and genetic technologies. Ability to analyze and interpret genetic data using bioinformatics tools and databases.
LO 4	Development of critical thinking and problem-solving skills in the context of genetics research.
LO 5	Ability to communicate scientific results and findings effectively through written reports and oral presentations. Exposure to the latest developments in genetics research through literature review and discussion.

COURSE OUTCOMES: The course outcomes of genetics for students pursuing a master's degree in biotechnology may include:

CO 1	Deep understanding of the principles and concepts of genetics, including the structure and function of genes, genetic variation, and inheritance patterns.
CO 2	Demonstrate a deep understanding of the principles and concepts of genetics, including the structure and function of genes, genetic variation, and inheritance patterns.
CO 3	Understanding of the molecular mechanisms of DNA replication, transcription, and translation, and the ability to explain how these processes are regulated and controlled.
CO 4	Understanding of the ethical, legal, and social issues surrounding genetics and genetic technologies, and the ability to engage in thoughtful and informed discussions about these issues.
CO 5	Development of critical thinking and problem-solving skills in the context of genetics research, including the ability to develop and test hypotheses, and the ability to integrate and synthesize information from multiple sources.

CO-PO MAPPING TABLE:

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	2	3	2	2	3	3	2	2	3	2	2	3
CO2	2	2	3	2	3	2	2	3	3	2	2	3	2	2	3
CO3	3	2	3	2	3	2	2	3	3	2	2	3	2	2	3
CO4	3	2	3	2	3	2	2	3	3	2	2	3	2	2	3
CO5	2	2	3	2	3	2	2	3	3	2	2	3	2	2	3

MBT-1.4. (B) (22): ENVIRONMENTAL BIOTECHNOLOGY

Credits: 4

Unit I:

Principles of Ecology, Water and terrestrial ecosystems, Bio-geo chemical cycles - Carbon, Oxygen, Nitrogen, Sulphur and Phosporus cycles. Role of microbes in bio-geochemical cycles.

Unit II:

Inorganic and Organic pollutants of air, land and water; maintenance of standards, Environmental monitoring. Detection, treatment and prevention of pollution. Dose response curves and tolerance limits. Environmental monitoring, Biological indicators

Unit III:

Biocides, Four stage alternatives, Refuse disposal - Treatment methods, case studies and effluent from distillery, tannery, pharmaceuticals, fertilizers, pulp and paper industry.

Unit IV: Waste water management - Aerobic and anaerobic treatment, primary, secondary and tertiary treatment of municipal wastes, Eutrophication, Solid waste management

Unit V: Bioremediation, Bioaugmentation, Biodegradation of recalcitrant compounds and the role of genetically engineered microbes and genetically modified organisms in the environmental management. Bioplastics and Biocompatible materials

LEARNING OBJECTIVES: Environmental biotechnology, learning objectives typically include:

LO 1	For students pursuing a master's degree in environmental biotechnology, the learning objectives typically include: Developing an in-depth understanding of the principles of environmental biotechnology, including the roles of microorganisms in bioremediation, the design of bioreactors, and the use of molecular biology tools in environmental biotechnology research.
LO 2	Gaining expertise in the various environmental biotechnologies used to address environmental problems, including bioremediation, bioaugmentation, phytoremediation, and biostimulation. Developing the skills necessary to design and conduct experiments in environmental biotechnology, including experimental design, statistical analysis, and interpretation of results.
LO 3	Learning to critically evaluate scientific literature in environmental biotechnology and to develop independent research projects in the field. Developing the ability to communicate scientific findings effectively to both scientific and lay audiences, through written reports and oral presentations.
LO 4	Gaining an understanding of the ethical and social implications of environmental biotechnology, including the regulation of biotechnology research, biosafety, and public perception.

LO 5	Building professional skills, such as project management, teamwork, and leadership, to prepare for careers in industry, government, or academia. Becoming familiar with emerging trends and technologies in environmental biotechnology, such as nanobiotechnology, synthetic biology, and systems biology, to stay current with the latest developments in the field

COURSE OUTCOMES: The course outcome of Environmental biotechnology:

CO 1	Knowledge and understanding of the principles of environmental biotechnology, including the roles of microorganisms in bioremediation, the design of bioreactors, and the use of molecular biology tools in environmental biotechnology research.
CO 2	Applying skills necessary to design and conduct experiments in environmental biotechnology, including experimental design, statistical analysis, and interpretation of results.
CO 3	Understanding of the ethical and social implications of environmental biotechnology, including the regulation of biotechnology research, biosafety, and public perception.
CO 4	Applying professional skills, such as project management, teamwork, and leadership, to prepare for careers in industry, government, or academia.
CO 5	Explaining emerging trends and technologies in environmental biotechnology, such as nanobiotechnology, synthetic biology, and systems biology, to stay current with the latest developments in the field.

Overall, the outcome of an environmental biotechnology course is to equip students with the knowledge, skills, and expertise necessary to address environmental problems through the application of biotechnology. Graduates of environmental biotechnology courses are prepared for careers in a variety of fields, including environmental engineering, bioremediation, environmental consulting, and biotechnology research and development.

CO-PO MAPPING TABLE:

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	3	2	2	2	2	3	3	2	2	3	2	2	3
CO2	3	2	3	2	3	2	2	3	3	2	2	3	2	2	3
CO3	2	2	3	2	2	2	2	3	3	2	2	3	2	2	3
CO4	3	2	3	2	3	2	2	3	3	2	2	3	2	2	3
CO5	2	2	3	2	2	2	2	3	3	2	2	3	2	2	3

MBT-1.4 (C) (22): FOOD BIOTECHNOLOGY

Credits: 4

Unit I:

Dairy processing and product sanitation - Introduction, Characteristics of dairy products, cleaning equipment for dairy facilities. Sea food processing and product sanitation – Introduction, sources of contamination, seafood plants and cleaning principles. Fruit and Vegetable processing and product sanitation – Introduction, Prevention of contamination, cleaning systems for processing plants.

Unit II:

Fermented and Microbial foods – Introduction to Yeast and Lactic acid and fermentation. Fermented milk – Yoghurt, Cheese and other fermented milks. Fermented vegetables – Olives, Cucumbers, Sauerkraut and Kimchi. Fermented meat and fish. Mould Fermentation – Temich, Soya sauce, Rice wine and Mycoprotein.

Unit III:

Methods for microbial examination of foods – Indicator organisms, Direct examination. Enumeration methods – Plate counts, Most probable number counts, Alternative methods – Dye reduction tests, Electrical methods, ATP determination, rapid methods for detection of specific organisms and toxins – Immunological methods, DNA/RNA methodology. Biochemical methods. Enzyme analysis, Vitamin and mineral analysis.

Unit IV:

Evaluation of food quality - Physical methods, Chemical methods, and instruments used. Sensory evaluation, Methods for conducting sensory tests, texture and color measurements, Food plant sanitation, Food legislation, Different standards pertaining to India, PFA, FPO, MFPO, Agmark. Standards in world, ISO, FDA

Unit V:

Food preservation – Different food processing methods, High temperature, Pasteurization, Sterilization, Cold storage, Chill temperature, Freezing, Drying, Concentration, Chemical preservation, Radiation and novel methods like high pressure, microwave, dielectric methods

LEARNING OBJECTIVES: For students pursuing a master's degree in biotechnology, the learning objectives of the subject of Food Biotechnology generally include

LO 1	Developing an understanding of the principles of food biotechnology, including genetic modification of crops, food safety and quality, and the use of enzymes in food processing
LO 2	Gaining knowledge of the various biotechnological tools and techniques used in food biotechnology research, including genetic engineering, protein engineering, and metabolomics. Understanding the regulatory framework governing the use of biotechnology in food production, including the role of the FDA and other regulatory bodies.

LO 3	Gaining expertise in the application of biotechnology in food production, including the development of functional foods, bioprocessing of food ingredients, and fermentation technology. Developing critical thinking and problem-solving skills through case studies and real-world examples of food biotechnology applications.
LO 4	Gaining an appreciation for the interdisciplinary nature of food biotechnology, including its links to other fields such as food science, microbiology, and bioprocess engineering. Developing skills in project management, data analysis, and scientific communication, including the ability to write scientific reports and present research findings to scientific and lay audiences.
LO 5	Becoming familiar with emerging trends and technologies in food biotechnology, such as nanobiotechnology, gene editing, and synthetic biology, to stay current with the latest developments in the field.

Overall, the learning objectives of Food Biotechnology for students pursuing a master's degree in biotechnology are to equip them with the knowledge, skills, and expertise necessary to apply biotechnology in the production of safe, nutritious, and sustainable food products. Graduates of food biotechnology programs are prepared for careers in the food and beverage industry, biotechnology research and development, regulatory agencies, and academia.

COURSE OUTCOMES: The course outcomes of Food biotechnology outcomes include

CO 1	Understanding the principles of biotechnology and their application to food production.
CO 2	Understanding of the regulation and ethical issues surrounding the use of biotechnology in food production
CO 3	Understanding of food safety and quality control measures in biotechnology-based food production.
CO 4	Development of critical thinking and problem-solving skills through case studies and hands-on laboratory work.
CO 5	Developing communication and presentation skills to communicate scientific findings effectively to scientific and non-scientific audiences.

Overall, the course outcomes of Food Biotechnology aim to provide students with a comprehensive understanding of the principles and applications of biotechnology in food production. Graduates of Food Biotechnology programs should be prepared for careers in the food and beverage industry, biotechnology research and development, regulatory agencies, and academia, with the ability to apply biotechnology to address food-related challenges and improve food production processes.

CO-PO MAPPING TABLE:

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO2	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO3	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO4	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3
CO5	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3

PRACTICAL-I:

MBTP 1.1. (22): CELL BIOLOGY AND BIOMOLECULES

Credits - 4

CELL BIOLOGY

1) Determination of tonocity of blood cells.
2) Localization of nucleus and cell organelles by differential staining
3) Study of nucleus in leukocyte cells.
4) Location of proteins by amidoblack-b and bromophenol blue
5) Location of lipids by Sudan black –b
6) Demonstration of selective permeability of plasma membrane (Determination of Osmoscope by potato and egg membrane)
7) Localization of Lysosomes in blood cells
8) Isolation and estimation of starch from potato/rice
9) The effect of detergents and other membrane active reagents on theviability of erythrocyte membrane
10) Localization of proteins by Bromophenol blue and Amido black B
11) Microscopic observation of plant and animal cells and different tissues
12) Fractionation of cell organelles (Chloroplasts and mitochondria) by centrifugation
13) Preparation of tissue (Animal and plant) blocks in wax
14) Microtomy (Tissue section cutting) and preparation of slides, staining and fixation for observation under microscope.

BIOMOLECULES

1) Qualitative Reactions of carbohydrates, amino acids, lipids and amino acids
2) Paper chromatography- Separation of carbohydrates and amino acids
3) Thin layer chromatography - Separation of carbohydrates and amino acids
4) Isolation and analysis of casein from milk
5) Titration curve of amino acids and calibration of p^k and p^i values
6) Determination of absorption maxima of β-carotene or flower pigments
7) Separation of nucleic acids by submerged gel electrophoresis
8) Analysis of normal and abnormal constituents of urine
9) Separation of proteins by SDS-PAGE and documentation of gels
10) Quantification and Absorption spectra of nucleic acids
11) Mutarotation of glucose
12) Isolation and assay of glycogen from liver
13) Isolation of phopholipids from egg yolk

PRACTICAL-II:

MBT 1.2. (22): GENETICS AND BIOSTATISTICS

Credits - 4

GENETICS

1) Study of different phases of mitosis in onion root tips and meiosis in Allium cepa flower buds
2) Karyotyping in Allium or Drosophila
3) Determination of multiple allele frequencies of leaf scars in Trifolium
4) Demonstration of Bar bodies in the buccal epithelial cells
5) Problems and assignments in Mendilian genetics
6) Determination of linkage and calculation of recombination frequencies (maize/Drosophila)
7) Chromosome preparations in Leukocytes
8) Induction of chromosomal aberrations by chemical mutagenesis in Allium (or any plant)
9) Bacterial Conjugation
10) Isolation of auxotrophic mutants (plants or insects)

BIOSTATISTICS

1) Determination of Mean, Median and Mode.
2) Computation of Quartile Deviation and Standard deviation.
3) Large sample test for means.
4) Large sample test for standard deviations.
5) Large sample test for Proportions.
6) Small sample test for means.
7) F- test for two variances.
8) Chi-square test for independence of attributes.
9) Run test.
10) Sign test.
11) Median test.
12) Computation of Karl Pearson's coefficient of correlation.
13) Computation of Rank coefficient of correlation.

SECOND SEMESTER

DEPARTMENT OF BIOTECHNOLOGY

M.Sc. BIOTECHNOLOGY

SEMESTER-II

MBT-2.1. (22): BIOCHEMISTRY

Credits: 4

Unit I:

Basic concepts of metabolism. Diversity of metabolic processes in microorganisms, plants and animals; Autotrophs and heterotrophs; Glycolysis, Gluconeogenesis and Glycogen metabolism, coricycle,Citric acid cycle, Electron transport system and oxidative phosphorylation, Pentose phosphate pathway ,

Unit II:

Biochemistry of photosynthesis, C_3, C_4 andCAM pathways, photosynthetic electron transport and Photophosphorylation, Photorespiration; Secondary metabolic processes and their regulation (Ex. Antibiotic synthesis).

Unit III: Fatty acid metabolism Triglycerols as energy storages, degradation of fatty acids, synthesis of fatty acids, formation of ketone bodies, cholesterol metabolism, regulation of fatty acid metabolism. Synthesis of Eicosinoids, Glyoxalate cycle in plants.

Unit IV: Protein and amino acid metabolism, Conversion of nitrogen to NH_4 by microorganisms, utilization of ammonia in higher organisms. Regulation of amino acid biosynthesis. Amino acids as precursors of variety of biomolecules. Degradation of amino acids, urea cycle, linkage between urea cycle and citric acid cycle. Biosynthesis of heme, Chlorophyll and Porphyrins.

Unit V: Nucleotide metabolism-Biosynthesis of purines, Pyrimidines; Biosynthesis of deoxyribonucleotides, Catabolism of purines and pyrimidines; Integration of carbohydrate, lipid and protein metabolism. Major metabolic pathways and control sites, key Junctions, metabolic process of major organs, Hormonal regulation of fuel metabolism, metabolic adaptation.

REFERENCE BOOKS:

1) Nelson, David L., Cox, Michael M. Lehninger Principles of Biochemistry 4/e, 2005, W.H. Freeman ,Madison avenue, New York.
2) Berg Jeremy M. , Tymoczko, John L. , Stryer, Lubert Biochemistry 5/e, 2002, W.H. Freeman, Madison avenue, New york
3) Switzer, Robert L. Garrity, Liam F. Experimental Biochemistry 3/e, 1999, W.H. Freeman, Madison avenue, New york.
4) Biochemistry Campbell K.M and Farrel O.S 5ed 2005,Thomson brooks and Cole.
5) Biochemistry, Berg M.J, Tymoczko J.L, Stryer L., 5ed 2002, W.H. Freeman ,Madison avenue, New york.

6) Harper'sBiochemistry ,Murray R.K, Granner D.K , Mayes P.A and Rodwell V.W 26ed 2003 Mc graw-Hill professional publishers, New Delhi.
7) Voiet D. and Voiet J.G., Biochemistry, 2nd ed ,1995, John Wiley publications, New york

LEARNING OBJECTIVES: For students pursuing a degree in Biochemistry, the learning objectives of the subject generally include:

LO 1	Understanding the fundamental principles of biochemistry, including the chemistry of biological molecules such as proteins, carbohydrates, lipids, and nucleic acids. Gaining knowledge of the various metabolic pathways that occur within cells, including glycolysis, the citric acid cycle, and oxidative phosphorylation.
LO 2	Understanding the regulation of metabolic pathways and the role of enzymes in catalyzing biochemical reactions. Understanding the molecular basis of genetic information and DNA replication, transcription, and translation.
LO 3	Understanding the structure and function of biomolecules, such as enzymes, receptors, and transporters, and their interactions with ligands. Gaining knowledge of biochemical techniques and methods used in biochemistry research, including protein purification, chromatography, and spectroscopy.
LO 4	Developing critical thinking and problem-solving skills through case studies and real-world examples of biochemical processes.
LO 5	Gaining an appreciation for the interdisciplinary nature of biochemistry, including its links to other fields such as molecular biology, genetics, and medicine. Developing skills in data analysis, scientific writing, and communication, including the ability to write scientific reports and present research findings to scientific and lay audiences.

Overall, the learning objectives of Biochemistry aim to equip students with a comprehensive understanding of the chemical processes occurring in living organisms, and how they are regulated and coordinated. Graduates of Biochemistry programs are prepared for careers in the biotechnology and pharmaceutical industries, academia, and research institutions.

COURSE OUTCOMES:

The course outcomes of Biochemistry for Master's students may vary depending on the specific program and institution offering the course. However, some common course outcomes of Biochemistry for Master's students include

CO 1	Understanding knowledge of the metabolic pathways involved in energy production, biosynthesis, and degradation of biomolecules, and the regulatory mechanisms that control these pathways.
CO 2	Understanding of the role of biochemistry in disease states and the development of therapeutic agents.
CO 3	Development of critical thinking and problem-solving skills through case studies, research projects, and data analysis
CO 4	Development of critical thinking and problem-solving skills through case studies, research projects, and data analysis.
CO 5	Developing skills in scientific writing and communication, including the ability to write scientific papers and grant proposals and to present research findings to scientific and non-scientific audiences.

Overall, the course outcomes of Biochemistry for Master's students aim to prepare them for careers in biotechnology and pharmaceutical industries, academia, research institutions, and government agencies. Graduates of Biochemistry programs are expected to have a thorough understanding of the principles and applications of biochemistry, as well as the skills necessary to address complex biochemical problems and contribute to the development of new technologies and therapies.

CO-PO MAPPING TABLE:

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO2	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO3	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO4	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3
CO5	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3

MBT-2.2. (22): MICROBIOLOGY

Credits: 4

Unit I:

Introduction to microbiology - Scope and history. Broad classification of bacteria - Ultrastructure of capsule, envelope, flagella, pili. Mesosomes. Virus-Classification, morphology and composition in general, Bacteriophage φx174, Cynophage and retroviruses. Prions, viroids, virusoids.

Unit II:

Nutritional requirements of bacteria; Essentials of microbial nutrition. Phototrophs, chemotrophs,and heterotrophs; Pure and enrichment culture methods; Microbial growth kin amitosis and binary fission etics, Batch and continuous cultures; Chemostats and turbidostats; Chemical control amitosis and binary fission of microbial growth; Methods of sterilization of media. Isolation, cultivation and identification of bacteria; Selective culture methods.

Unit III:

General characteristics of Chemolithotrophs, photosynthetic bacteria, archebacteria, methanogens, fermentative and sulfur reducing bacteria, Mycoplasma and Rickettsiae. General features of Fungi and algae. Role of microbes in carbon, sulphur and nitrogen cycle in nature. General features and importance of mycorrhiza.

Unit IV:

Modes of gene transfer in bacteria – Transformation, Transduction, Conjugation, recombination in bacteria; Lytic cycle – Phage multiplication; Lysogeny - Life cycle of Lamda; Nitrogen cycle, Nitrogenase enzyme catalysis; Genetics of nitrogen fixation, Nif gene structure and regulation; Methods of controlling microbes and pathogens, HIV transmission and control, Tuberculosis, Bacculovirus and Influenza virus.

Unit V:

Industrial microbiology – Brief outline and type of reactions, in fermentation, fermentative production of alcohol, lactic acid and butyric acid; Production of acetic acid (vinegar), citric acid, and gluconic acid; Fermentative production of amino acids (Glutamic acid, Aspartic acid, Lysine, Phenylalanine, Histidine). Production of vitamins (Rboflavin, vitamin B_{12} and Carotenoids). Polysaccharides (Xanthans, Dextrans, Pullulans and Alginates) and enzymes (Proteases, Pectinases, Lipases, Cellulases). Tissue culture and its applications in agriculture, horticulture and industry.

REFERENCE BOOKS:

1) Prescott L.M. Harley J.P Klein D.A Microbiology,6thed, 2004, Mcgra-hill publishers, New Delhi

2) Brooks G.F, Butel J.S., Morse S.A., Medical microbiology, 23rd ed , 2004,McGra-Hill Professionals, USA
3) Johnson A.G., Ziegler. R.J Microbiology and Immunology,4th ed , 2002, Lippincott Williams & Wilkins publishers, Baltimore.
4) Microbiology, 5th edition, Pelczar, Michael J, Krieg, Noel R.; Jr.; Chan, E. C, McGraw-Hill publishers.
5) Principles of Microbiology, Atlas, RM, 2nd edition, W.M.C. Brown Publishers, Dubuque.

LEARNING OBJECTIVES: For postgraduate students pursuing Biotechnology, the learning objectives of the subject Microbiology generally include:

LO 1	Understanding the fundamental principles of microbiology, including the classification, structure, and function of microorganisms.
LO 2	Understanding the mechanisms of microbial growth, replication, and adaptation, including the role of horizontal gene transfer, plasmids, and mobile genetic elements.
LO 3	Understanding the principles of microbial pathogenesis, including the mechanisms of host-microbe interactions, virulence factors, and the immune response to infection.
LO 4	Developing skills in laboratory techniques for microbiological research, including culturing, isolation, and identification of microorganisms, as well as molecular techniques such as PCR and DNA sequencing.
LO 5	Understanding the role of microorganisms in biotechnology, including microbial fermentation, industrial microbiology, and microbial bioremediation**.**

Overall, the learning objectives of Microbiology for postgraduate students aim to equip them with a comprehensive understanding of the diversity, physiology, and applications of microorganisms, as well as the skills necessary to address complex microbiological problems and contribute to the development of new technologies and therapies. Graduates of Microbiology programs are prepared for careers in biotechnology and pharmaceutical industries, academia, research institutions, and government agencies.

COURSE OUTCOMES:

The course outcomes of Microbiology for Master's students in Biotechnology include:

CO 1	Understanding of the principles of microbial genetics, including genetic engineering, gene regulation, and the use of recombinant DNA technology in biotechnology.

CO 2	Understanding of microbial interactions in natural and engineered systems, including microbial communities, biofilms, and microbial consortia relevant to biotechnology.
CO 3	Development of critical thinking and problem-solving skills through case studies, research projects, and data analysis
CO 4	Developing scientific writing and communication, including the ability to write scientific papers and grant proposals and to present research findings to scientific and non-scientific audiences.
CO 5	Understanding of ethical issues related to microbial biotechnology, including biosafety, biosecurity, and intellectual property.

Overall, the course outcomes of Microbiology for Master's students in Biotechnology aim to prepare them for careers in biotechnology and pharmaceutical industries, academia, research institutions, and government agencies. Graduates of Microbiology programs in Biotechnology are expected to have a thorough understanding of the principles and applications of microbiology in biotechnology, as well as the skills necessary to address complex microbiological problems and contribute to the development of new biotechnological products and processes.

CO-PO MAPPING TABLE:

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO2	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO3	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO4	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3
CO5	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3

MBT-2.3 (22): MOLECULAR BIOPHYSICS AND ENZYMOLOGY

Credits: 4

Unit I: Interactions in biological systems - Intra and intercellular forces, electrostatic interactions, hydrogen bonding ,Vander wall interactions, hydrophobic interactions and disulphide bridges; Role of water and weak interactions.

Unit II: Prediction of primary, secondary and tertiary structure of proteins by X-ray crystallography, CD, ORD, ESR and NMR. Multiple equlibrium -Titration of proteins, scatchard plot, protein folding unfolding equilibrium, denaturation of proteins and nucleic acids, effect of solvent conditions and temperature on the thermodyanamics of protein folding - Kinetics of folding and unfolding; Phenomenon of self assembly and its biophysical basis.

Unit III: Basic concepts of Enzymology – Classification of enzymes, nomenclature and general properties of enzymes; Formation, of enzyme-substrate complex and experimental evidences Diffusion and the rate of encounter of enzyme with substrate; Methods of isolation and purification of enzymes; Isozymes; Enzyme activation - zymogens, Multienzyme complexes and multi functional enzymes.

Unit IV: Enzyme Kinetics - Kinetics of enzyme-catalyzed reactions, Michaelis-Menten equation, Significance of Km, Vmax and Kcat ,effect of pH, temperature, Substrate and enzyme concentrations on the rate of enzyme catalyzed reactions, Turnover numbers, Enzyme inhibition

Unit V: Identification of binding and catalytic sites of enzymes, Allosteric and multiple site enzymes, cooperativity, Hill equation, Sigmoidal kinetics, MWC and KNF models, study of ATcaseas a typical allosteric enzyme. The cage effect and rotation of molecules.

REFERENCE BOOKS:

1) Introduction to Biophysics, Tyszynski J.A, Kurzynki.M, First edition , 2003, CRC Press, Florida.
2) Essentials of Biophysics, 1st edition, Narayanan. K , 2005, New age publishers, New Delhi.
3) Biophysics, 4th Edition, Glaser .R, 2001, Springer, Newyork.
4) Jackson. M.B , Molecular & Cellular Biophysics, First edition, 2006 , Cambridge University Press.
5) Understanding of Enzymes, Fourth edition,Trevor Palmer, 2003, Cambridge University Press, New york
6) Creighton,T.E., Proteins Structure and molecular properties, 2nd edition, 1993, W H freeman publishers, Madison avenue, Newyork.

LEARNING OBJECTIVES: For postgraduate students pursuing a degree in Biotechnology, the learning objectives of the subject of Molecular Biophysics and Enzymology generally include:

LO 1	Understanding the principles of molecular biophysics, including the structure and function of biomolecules such as proteins, nucleic acids, and lipids. Familiarity with the techniques used to study the structure and function of biomolecules, including X-ray crystallography, nuclear magnetic resonance (NMR) spectroscopy, and mass spectrometry.
LO 2	Understanding the principles of enzymology, including enzyme kinetics, regulation, and mechanisms of catalysis. Familiarity with the techniques used to study enzymatic reactions, including spectrophotometry, chromatography, and isothermal titration calorimetry (ITC).
LO 3	Knowledge of the role of enzymes in biotechnology and biocatalysis, including industrial applications of enzymes in food processing, pharmaceuticals, and biofuels. Understanding of the role of protein-ligand interactions in molecular recognition and drug design, including the principles of drug discovery and design.
LO 4	Developing skills in laboratory techniques for molecular biophysics and enzymology research, including protein expression, purification, and characterization. Developing critical thinking and problem-solving skills through case studies and real-world examples of molecular biophysics and enzymology.
LO 5	Gaining an appreciation for the interdisciplinary nature of molecular biophysics and enzymology, including its links to other fields such as biochemistry, biophysics, and structural biology. Developing skills in data analysis, scientific writing, and communication, including the ability to write scientific reports and present research findings to scientific and lay audiences.

Overall, the learning objectives of Molecular Biophysics and Enzymology for postgraduate students in Biotechnology aim to equip them with a comprehensive understanding of the principles and techniques of molecular biophysics and enzymology, as well as the skills necessary to address complex problems in biotechnology and biocatalysis. Graduates of this program are prepared for careers in biotechnology and pharmaceutical industries, academia, research institutions, and government agencies.

COURSE OUTCOMES: The course outcomes of the subject of Molecular Biophysics and Enzymology for postgraduate students in Biotechnology may vary depending on the specific program and institution offering the course. However, some common course outcomes of Molecular Biophysics and Enzymology for postgraduate students in Biotechnology include:

CO 1	Comprehensive understanding of the principles and techniques of molecular biophysics and enzymology, including the structure and function of biomolecules such as proteins, nucleic acids, and lipids, enzyme kinetics, regulation, and mechanisms of catalysis.
CO 2	Knowledge of the role of enzymes in biotechnology and biocatalysis, including industrial applications of enzymes in food processing, pharmaceuticals, and biofuels.

CO 3	Understanding of the role of protein-ligand interactions in molecular recognition and drug design, including the principles of drug discovery and design.
CO 4	Development of critical thinking and problem-solving skills through case studies and real-world examples of molecular biophysics and enzymology.
CO 5	Development of skills in data analysis, scientific writing, and communication, including the ability to write scientific reports and present research findings to scientific and lay audiences.

Overall, the course outcomes of Molecular Biophysics and Enzymology for postgraduate students in Biotechnology aim to prepare them for careers in biotechnology and pharmaceutical industries, academia, research institutions, and government agencies. Graduates of this program are expected to have a thorough understanding of the principles and applications of molecular biophysics and enzymology, as well as the skills necessary to address complex problems in biotechnology and biocatalysis.

CO-PO MAPPING TABLE:

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO2	2	1	2	1	3	2	2	2	3	2	2	2	2	2	3
CO3	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO4	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3
CO5	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3

MBT-2.4. (A) (22): IMMUNOLOGY

Credits: 4

Unit I:

The lymphoid system - Common characteristics of the lymphoid system. Primary and secondary lymphoid Organs, characteristics of cells involved in the immune response; Adaptive and innate immunity, Humoral and cell mediated immunity. Structure and physiology of the immune cells, B-lymphocytes, T-lymphocytes; Humoral and Cell mediated immunity.

Unit II:

Antibodies - Classes and sub-classes of Ig, structure, properties and activity of various antibodies; Immunoglobulin genes and Antibody diversity, Mechanism of generation of antibody diversity, avidity and affinity of antibodies. Antigens – Immunogenicity, antigenicity, properties of immunogenicity, determinent groups of epitopes. Synthetic peptides and immune response to peptides

Unit III:

Immunodiagnostics, Antigen - antibody interactions, precipitation and agglutination reactions, Immunoelectrophoresis; Direct and indirect immunof1uorescence. FACS, ELISA and immunobloting. Hybridoma technology. Immunodiagnostics and immunotherapy using monoclonal antibodies.

Unit IV:

The immune response system - Cell cooperation in the immune response, activation of T cells and B cells and other cells involved in immune response to virus bacteria and parasites; Interferons, chemotactic and colony stimulating factors. Major histo compatibility complex - Structure and function of MHC. Molecules other than antibodies which recognize antigens, MHC restriction by helper and cytotoxic T-cells, the T cell receptor, binding of peptides with MHC, antigen presentation.

Unit V:

Cytokines; Basic biology of Interleukins, complement components and pathways of activation; Tumor immnunology - Tumor associated antigens, immune response to tumor antigens. Basis and types of autoimmunity and hypersensitivity. Vaccines, routes of administration, immunoprophylaxis, designing and production of vaccines, viral and recombinant vaccines

REFERENCE BOOKS:

1) KindtThomas J. ,Osborne, Barbara A., Goldsby, Richard A. Kuby Immunology 6/e, 2006, W.H. Freeman, Madison avenue, New york
2) Immunobiology, 6th edition, Charles A. Janeway, Garland Science Publishers.

3) Cellular and Molecular Immunology, 5th edition, Abul K. Abbas and Andrew H. Lichtman. Elsevier publications
4) Immunology, Immunopathology and Immunity, Stewart Sell, Edward E M, 6 ed,2001 ASM press, Washington
5) Roitt's Essential Immunology Roitt I.M and Delves P.J, 10th edition, 2001, Blackwell publishers.

LEARNING OBJECTIVES: For postgraduate students pursuing a degree in Biotechnology, the learning objectives of the subject of Immunology generally include:

LO 1	Understanding the basics of the immune system, including the components of the innate and adaptive immune system, and the differences between humoral and cellular immune responses. Familiarity with the techniques used to study the immune system, including ELISA, flow cytometry, and microscopy.
LO 2	Knowledge of the molecular and cellular mechanisms of immune responses, including antigen recognition, T and B cell activation, and cytokine signaling. Understanding the role of immunology in disease processes, including autoimmune diseases, allergies, and immunodeficiencies.
LO 3	Knowledge of the principles and applications of immunotherapy, including the use of monoclonal antibodies, vaccines, and gene therapies. Familiarity with the techniques used in immunological research, including cell culture, animal models, and genetic engineering.
LO 4	Developing skills in data analysis and interpretation, including the use of statistical methods to analyze immunological data. Developing critical thinking and problem-solving skills through case studies and real-world examples of immunological research.
LO 5	Gaining an appreciation for the interdisciplinary nature of immunology, including its links to other fields such as microbiology, genetics, and biochemistry. Developing skills in scientific writing and communication, including the ability to write scientific reports and present research findings to scientific and lay audiences.

Overall, the learning objectives of Immunology for postgraduate students in Biotechnology aim to equip them with a comprehensive understanding of the principles and techniques of immunology, as well as the skills necessary to address complex problems in immunological research and biotechnology. Graduates of this program are prepared for careers in biotechnology and pharmaceutical industries, academia, research institutions, and government agencies, working on the development of novel immunotherapies, vaccines, and diagnostic tools.

COURSE OUTCOMES: The course outcomes of the subject of Immunology for M.Sc Biotechnology students may vary depending on the specific program and institution offering the course. However, some common course outcomes of Immunology for M.Sc Biotechnology students include:

CO 1	Comprehensive understanding of the immune system, including the components of the innate and adaptive immune system, and the differences between humoral and cellular immune responses.
CO 2	Understanding the role of immunology in disease processes, including autoimmune diseases, allergies, and immunodeficiencies.
CO 3	Developing skills in data analysis and interpretation, including the use of statistical methods to analyze immunological data.
CO 4	Developing critical thinking and problem-solving skills through case studies and real-world examples of immunological research.
CO 5	Developing skills in scientific writing and communication, including the ability to write scientific reports and present research findings to scientific and lay audiences.

Overall, the course outcomes of Immunology for M.Sc Biotechnology students aim to prepare them for careers in biotechnology and pharmaceutical industries, academia, research institutions, and government agencies. Graduates of this program are expected to have a thorough understanding of the principles and applications of immunology, as well as the skills necessary to address complex problems in immunological research and biotechnology. They may also pursue further education in immunology, such as a Ph.D. or medical degree.

CO-PO MAPPING TABLE:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO2	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO3	3	2	3	2	2	2	2	2	3	2	2	2	2	2	3
CO4	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3
CO5	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3

MBT-2.4. (B) (22): BIOPROCESS VALIDATION AND CURRENT GOOD MANUFACTURING PRACTICES (CGMP)

Credits: 4

Unit I:

Introduction to cGMPs and the FDA. cGMPs and Quality Systems Management: GMP as a concept. Biosafety and containment: Biosafety, classification, area design, biosafety levels, inactivation and disposal of biological materials. Occupational hazards and preventive measures.

Unit II:

Instruments and equipment validation: Validation of autoclaves, dry heat sterilizers, washing devices, incubators, fermentors, analytical instruments.

Unit III:

Area validation: Classification of clean rooms, air handling units, pressure gradients, particle counts, colony forming units, air changes and linear air velocity.

Unit IV:

Process validation: Clean area operations, washing, drying, sterilization, filling, sealing, critical process variables, cause and effect of process deviations, production protocols, standard operating procedures and validation protocols and in-hose standards.

Unit V:

Regulatory affairs: Introduction of new drug and regulatory clearances from DBT, DCG (I), phase I, phase II and phase III, clinical studies. Genetic engineering approval committee. Environmental impact assessment, safety, efficacy of candidate drug. National control authority.

LEARNING OBJECTIVES: For students pursuing a course in Biotechnology and the subject Bioprocess Validation and Current Good Manufacturing Practices (cGMP), the learning objectives may include:

LO 1	Understanding the importance of cGMP in the biotechnology industry, including the regulatory requirements and guidelines for manufacturing biologics and pharmaceuticals. Familiarity with the various stages of bioprocess development and validation, including process design, process qualification, and continued process verification.
LO 2	Knowledge of the principles and techniques used for cleaning validation, equipment qualification, and facility design. Understanding the principles and importance of risk assessment in bioprocess validation, including the identification and mitigation of potential risks in biomanufacturing processes.

LO 3	Familiarity with the various analytical methods used for product characterization, including assays for purity, potency, and identity. Understanding the principles and techniques used for process monitoring and control, including statistical process control and data analysis.
LO 4	Developing skills in the design and execution of validation studies, including the preparation of protocols and reports. Developing critical thinking and problem-solving skills through case studies and real-world examples of bioprocess validation.
LO 5	Gaining an appreciation for the interdisciplinary nature of bioprocess validation, including its links to other fields such as microbiology, biochemistry, and engineering. Developing skills in scientific writing and communication, including the ability to write validation reports and present validation findings to scientific and lay audiences.

Overall, the learning objectives of Bioprocess Validation and cGMP aim to prepare students for careers in the biotechnology and pharmaceutical industries, where compliance with cGMP regulations and the validation of bioprocesses are critical components of drug development and manufacturing. Graduates of this program are expected to have a thorough understanding of the principles and applications of bioprocess validation and cGMP, as well as the skills necessary to address complex problems in bioprocess validation and manufacturing. They may also pursue further education in regulatory affairs or quality control, or work in academia, research institutions, or government agencies.

COURSE OUTCOMES: The course outcomes for a subject on Bioprocess Validation and Current Good Manufacturing Practices (cGMP) for students studying biotechnology may include the following:

CO 1	Understanding the principles of cGMP and the regulatory requirements for manufacturing biologics and pharmaceuticals.
CO 2	Understanding the principles and importance of risk assessment in bioprocess validation, including the identification and mitigation of potential risks in biomanufacturing processes
CO 3	Understanding the principles and techniques used for process monitoring and control, including statistical process control and data analysis
CO 4	Developing skills in the design and execution of validation studies, including the preparation of protocols and reports.
CO 5	Developing critical thinking and problem-solving skills through case studies and real-world examples of bioprocess validation.

Upon completion of this course, students should be able to apply the principles and techniques of bioprocess validation and cGMP to real-world manufacturing processes. They should have a thorough understanding of the regulatory requirements for manufacturing biologics and pharmaceuticals, and be able to design and execute validation studies to ensure the safety and efficacy of these products. Graduates of this program may pursue careers in the biotechnology and pharmaceutical industries, or further education in regulatory affairs or quality control. They may also work in academia, research institutions, or government agencies.

CO-PO MAPPING TABLE:

CO /PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	3	2	3	2	2	3	3	2	2	2	2	2	3
CO2	2	2	3	2	3	2	2	2	3	2	2	2	2	2	3
CO3	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO4	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3
CO5	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3

MBT-2.4. (C) (22): NANOTECHNOLOGY

Credits: 4

Unit I

Introduction to Quantum and Statistical Physics: Electrons as waves, wave mechanics, Schrödinger equation and particle in a box, Heisenberg's Uncertainty Principle, Introduction to the operator formalism-bas, kets, expectation values, Spin and exclusion principle, Boltzmann distribution, indistinguishable particles, Fermi-Dirac and Bose-Einstein distributions.

Unit II

Background and history of Nano-world: Emergence of Nano science refence to Feynman and Drexler; Role of particle size, Spatial and temportal scale; Concept of confinement, strong and weak confinement with suitable example; Development of quantum structure, Basic concept of quantum well, quantum wire and quantum dots. Finite size Zero, One and Two Dimensional Nanostructures, Concept ofsurcace and Interfacial Energies.

Unit III

Energy Bonds and Gaps of semiconductors, Effective masses Fermi Surfaces Localized particles: Donars, Acceptors and deep Traps, Mobility, Excitons. Intramolecular and interfacial forces in organic, biological and aqueous systems, meso scale themodynamics-Vander wall, Electostatic, double layer acid base, depletion inertactios.

Unit IV

Classification of Nanomaterails

Inorganic nanomaterials: carbon nanotubes and cones, nanofols and nonporous, zeolites minerals, silicate minerals, montmorillonite and Laponite;

Organic nanomaterials: dendrimers, micelles, liposomes, block copolymers,

Bionanomaterials : Biomimtric, bioceramic and nanotherapeutics; nano materials for molecular eletronics and optoelectronics.

Unit V

Molecular & Nano Electronics, Semiconductors, Transition from crystal technology to nanotechnology. Tiny motors, Gyroscope and accelerometer. Nano particle embedded wrinkle resistant cloth, Transparent Zinc Oxide sun screens. Biosynthesis, Nanoscale Processes in the environment. Nanoscale structures, Novel phenomena and Quantum control and quantum computing. Single electron transistors, Quantum dots, Qunatum wires and RTT.

REFERENCE BOOKS:

1) Solid Sate Physics by Pillai: Wiley Eastern Ltd.
2) Introduction to Solid State Physics 7th edition by Kittel: John Wiley & Sons (Asia) Pvt. Ltd.
3) Introduction to Nanotechnology by Charles P. Pooler Jr & Frank J.Owens. Wiley India Pvt. Ltd.

4) Nanotechnology and Nano electronics materials, devise and measurement Techniques by WR Fahrner- Springer.
5) Encyclopedia of Nano technology by M. Balakrishna Rao and K.Krishna Reddy, Vol I to X.

LEARNING OBJECTIVES: The learning objectives for a subject on nanotechnology for postgraduate Biotechnology students may include:

LO 1	Understanding the fundamentals of nanotechnology, including the physical and chemical properties of nanoparticles, and their potential applications in biotechnology. Familiarity with the methods used for synthesis, characterization, and manipulation of nanoparticles, including nanoscale imaging and spectroscopy techniques.
LO 2	Knowledge of the principles and techniques of nanotoxicology, including the potential risks and hazards associated with exposure to nanoparticles, and the methods used for evaluating their safety. Familiarity with the various applications of nanotechnology in biotechnology, including drug delivery, biosensors, tissue engineering, and nanomedicine.
LO 3	Understanding the ethical and societal implications of nanotechnology, including issues related to privacy, security, and the responsible development and use of nanotechnology.
LO 4	Developing critical thinking and problem-solving skills through case studies and real-world examples of nanotechnology in biotechnology.
LO 5	Developing skills in scientific writing and communication, including the ability to write research proposals, scientific articles, and presentations on nanotechnology.

Upon completion of this course, students should be able to apply the principles and techniques of nanotechnology to real-world problems in biotechnology. They should have a thorough understanding of the potential applications of nanotechnology in drug discovery, biosensors, and other areas of biotechnology, and be able to critically evaluate the risks and benefits of these technologies. Graduates of this program may pursue careers in the biotechnology and pharmaceutical industries, or further education in nanotechnology research or regulatory affairs. They may also work in academia, research institutions, or government agencies.

COURSE OUTCOMES: The course outcomes for a subject on nanotechnology for M.Sc Biotechnology students may include:

CO 1	Understanding the fundamental principles of nanotechnology, including the properties and behavior of nanoparticles, their synthesis, and manipulation techniques.
CO 2	Understanding the potential applications of nanotechnology in biotechnology, including drug delivery, biosensors, tissue engineering, and nanomedicine.
CO 3	Understanding the ethical and societal implications of nanotechnology, including issues related to privacy, security, and the responsible development and use of nanotechnology.
CO 4	Developing critical thinking and problem-solving skills through case studies and real-world examples of nanotechnology in biotechnology.
CO 5	Understanding the interdisciplinary nature of nanotechnology, including its links to other fields such as biology, chemistry, physics, and engineering.

Upon completion of this course, students should have a broad understanding of the principles and techniques of nanotechnology and their potential applications in biotechnology. They should be able to evaluate the risks and benefits of nanotechnology, design and execute experiments to characterize nanoparticles, and apply nanotechnology in drug discovery, biosensors, and other areas of biotechnology. Graduates of this program may pursue careers in the biotechnology and pharmaceutical industries, or further education in nanotechnology research or regulatory affairs. They may also work in academia, research institutions, or government agencies.

CO-PO MAPPING TABLE:

CO /PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	**2**	**2**	**2**	**2**	**3**	**2**	**2**	**2**	**3**	**2**	**2**	**2**	**2**	**2**	**3**
CO2	**2**	**2**	**2**	**2**	**3**	**2**	**2**	**2**	**3**	**2**	**2**	**2**	**2**	**2**	**3**
CO3	**2**	**2**	**2**	**2**	**3**	**2**	**2**	**2**	**3**	**2**	**2**	**2**	**2**	**2**	**3**
CO4	**3**	**2**	**3**	**2**	**3**	**2**	**2**	**3**	**3**	**2**	**2**	**2**	**2**	**2**	**3**
CO5	**2**	**2**	**3**	**2**	**3**	**2**	**2**	**3**	**3**	**2**	**2**	**2**	**2**	**2**	**3**

PRACTICAL – I

MBTP- 2.1. (22): MICROBIOLOGY AND IMMUNOLOGY

Credits 04

MICROBIOLOGY

1) Staining techniques - Preparation of staining reagent, Simple staining, Negative staining, Grams staining, Spore staining
2) Isolation of microorganisms - Serial dilution technique (Isolation of bacteria from soil),
3) Fungal isolation from air, Isolation of *Rhizobium* from root nodules, T.S. of root nodule, Observation of bacterioids
4) Pure culture techniques - Spread plate method, Streak plate method, Pour plate method
5) Identification of microbes
6) Biochemical characterization of Microbes-IMVIC test, Qualitative tests for the enzyme production and extra cellular compounds
7) Determination of different phases of growth curve in a batch culture
8) Effect of physical factors on microbial growth – Temperature, pH, Salt concentration,
9) UV radiation, Antibiotic sensitivity test, Minimum inhibitory concentration,
10) Bacteriological examination of milk, Phage titration
11) Cell spore counting by Haemocytometer
12) Preparation of Replica Plates of bacteria
13) Preparation of competent cells of bacteria

IMMUNOLOGY

1) ABO and Rh blood typing
2) Electrophoretic study of Serum proteins
3) Preparation of immunoglobulin of serum
4) Rapid serological diagnostics of syphilis
5) Widal test
6) Ouchterlony double Immuno diffusion technique
7) Differential Leucocyte count
8) Agglutination Inhibition test (Pregnancy test)
9) Determination of cross reactivity
10) Mancini technique
11) Immunoelectrophhoresis
12) Radial immunodiffusion
13) Rocket immuno electrophoresis
14) Counter current Immunoelectrophoresis
15) ELISA – Quantitative and Quantitative

PRACTICAL –II

MBTP 2.2. (22): BIOCHEMISTRY AND ENZYMOLOGY

Credits 04

BIOCHEMISTRY

1) Estimation of maltose by 3,5 dinitrosalysilic acid
2) Estimation of reducing sugars by Nelson and Somogyi method
3) Estimation of total sugars by Anthrone method
4) Determination of molar extinction co efficient of p- Nitrophenol
5) Quantitative measurement of amino acids and proteins by Spectrphotometric methods
6) Isolation and estimation of Cholesterol
7) Estimation of Ascorbic acid by Colorimetry
8) Estimation of inorganic phosphorous by Fiske and Subbarao method
9) Estimation of Urea by Diphenyl amine method
10) Estimation of Creatinine by Jaffees method
11) Estimation of Calcium by Clark and Collip method
12) Purification of proteins – Ammonium sulfate fractionation, Dialysis, Column
13) Chromatography and Freeze drying

ENZYMOLOGY

1) Assay of amylase activity from seedlings of rice or mungbean
2) Determination of optimum pH of an enzyme
3) Effect of time of incubation on enzyme activity
4) Effect of substrate concentration on enzyme activity
5) Effect of temperature on enzyme activity
6) Production of amylase from bacteria/potato/sweet potato
7) Assay of protease activity
8) Effect of inhibitors on enzyme activity
9) Determination of Km and Vmax of an Enzyme (Amylase)
10) Determination of enzyme activity of Urease and malate dehydrogenase or catalase or peroxidase using UV-VIS Spectrophotometer.

THIRD SEMESTER

DEPARTMENT OF BIOTECHNOLOGY

M.Sc. BIOTECHNOLOGY

MBT-3.1 (22): MOLECULAR BIOLOGY

Credits: 4

Unit I: Watson Crick model of DNA; Genome organization with specific reference to prokaryotic and eukaryotic genomes; Genome size, C-Value paradox; Replication of DNA, semiconservative replication, Messelson and Stahl's experiments; Models of replication of circular and linear DNA, DNA polymerases, Termination of replication.

Unit II: Repair of DNA, Excision repair and mismatch repair, Rec gene and its role in DNA repair and SOS repair; Transcription - Synthesis and structural features of mRNA, hnRNA, rRNA, tRNA; Post transcriptional modifications.

Unit III: Deciphering the Genetic code, Functional genomics and reverse genetics, translation-initiation, elongation and termination, Post translational modifications, Protein stability, Degradation and N-end rule, Non-ribosomal pathway of protein synthesis, inhibitor of protein synthesis.

Unit IV: Regulation of gene expression; Clustered genes and the operon concepts - Negative and positive control of the Lac Operon, Dual promoters in the gal operon, trp operon, arabinose operon, Control of gene expression by Sigma factor and post transcriptional control, Absolute control by antisense RNAs; Enhancers, Upstream controlling elements, Helix turn helix, Zinc finger motif's, Leucine zippers. Homeotic genes.

Unit V: Oncogenes, protooncogenes and oncogenes; Mechanism of activation of oncogenes, Tumour suppressor genes, Role of phosphatases, kinases and signal transduction pathways in cell signaling

REFERENCE BOOKS:

1) Genes VII, Lewin B, OxfordUniversity Press
2) Molecular Biology of the Gene, Fifth Edition, James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick, Benjamin Cummings
3) Young and Paul Exploring Genomes ,2003, W.H. Freeman, Madison avenue, New york
4) Glick B.R and Pasternak .J.J Molecular Biotechnology 3rd ed 2003, American Society microbiology, New York.

LEARNING OBJECTIVES: The learning objectives for a subject on Molecular Biology for PG Biotechnology students may include:

LO 1	Understanding the fundamental concepts of molecular biology, including the structure and function of nucleic acids, DNA replication, transcription, translation, and gene regulation. Familiarity with the techniques used in molecular biology, including DNA sequencing, PCR, gene cloning, and genetic engineering.

LO 2	Understanding the applications of molecular biology in biotechnology, including gene therapy, genetic engineering, and bioproduction of proteins. Knowledge of the role of molecular biology in disease diagnosis and treatment, including molecular diagnostics and personalized medicine.
LO 3	Understanding the ethical and societal implications of molecular biology, including issues related to genetic testing, genetic counseling, and genetic privacy.
LO 4	Developing critical thinking and problem-solving skills through case studies and real-world examples of molecular biology in biotechnology.
LO 5	Developing skills in scientific writing and communication, including the ability to write research proposals, scientific articles, and presentations on molecular biology.

Upon completion of this course, students should be able to apply the principles and techniques of molecular biology to real-world problems in biotechnology. They should have a thorough understanding of the potential applications of molecular biology in gene therapy, genetic engineering, and bioproduction of proteins. Graduates of this program may pursue careers in the biotechnology and pharmaceutical industries, or further education in molecular biology research or regulatory affairs. They may also work in academia, research institutions, or government agencies.

COURSE OUTCOMES: The course outcome for the subject of Molecular Biology studied as part of a Biotechnology program may include:

CO 1	Understanding the molecular basis of life processes and the role of molecular biology in biotechnology.
CO 2	Developing skills in genetic engineering, including the design and construction of recombinant DNA molecules.
CO 3	Understanding the applications of molecular biology in biotechnology, including bioproduction of recombinant proteins, gene therapy, and genetic engineering of crops and animals.
CO 4	Acquiring knowledge of the ethical and social implications of molecular biology in biotechnology, including issues related to genetic privacy, patenting, and biosecurity.
CO 5	Developing skills in scientific writing and communication, including the ability to write research proposals, scientific articles, and presentations on molecular biology in biotechnology.

Upon completion of this course, students should be able to apply the principles and techniques of molecular biology to real-world problems in biotechnology. They should have a thorough understanding of the potential applications of molecular biology in bioproduction, gene therapy, and genetic engineering of crops and animals. Graduates of this program may

pursue careers in the biotechnology and pharmaceutical industries, or further education in molecular biology research or regulatory affairs. They may also work in academia, research institutions, or government agencies.

CO-PO MAPPING TABLE:

CO /PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO2	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3
CO3	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO4	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3
CO5	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3

MBT-3.2 (22): PROTEIN ENGINEERING

Credits: 4

Unit I: Strategies for the design and construction of novel proteins. Conformation of proteins in general, Effect of amino acids on structure of proteins, Energy status of a protein molecule, Structure function relations of enzymes and proteins.

Unit II: Use of Polyarginine - tailing in protein purification; Increased protein stability and enhanced specific activity of enzymes; Altering the kinetic properties and pH dependence of enzymes; In vitro chemical modifications, Immobilization of enzymes.

Unit III: Random versus site directed mutagenesis, Modification of restriction sites, Linker insertion, Cassete mutagenesis; Mutagenesis and PCR, Use of synthetic genes; Applications of site directed mutagenesis.

Unit IV: The art of expression: sites and strategies for the expression of heterologus proteins using Escherichia coli, methods for recombinant protein expression in saccharomyces servisiae. Post translational modification for the expressed proteins.

Unit V: Biosensors - The role of transducer and its applicability to biosensing, electrochemical, temperature and optical transducers, Biocatalysts and their availabi1ity and applicabi1ity to biosensing; Role of antibodies in biosensing; Direct and indirect immunoassay using biosensing devices; Applications of biosensors in medicine, food industry and environmental monitoring. Principles and applications of Nanotechnology

REFERENCE BOOKS:

1) Walker M.J., and Raply R. Molecular biology and biotechnology 4th ed,2000,Panima publishers,New Delhi.,
2) Jeffery W.Kelly, applications of enzyme Biotechnoloy 9th ed, 1991, Plenum Press,Newyork.
3) Watson, James , Gilman, Michael , Witkowski, Jan , Zoller, Mark Recombinant DNA 2/e, 1992, W.H. Freeman, Madison avenue, New york
4) Brown T.A . Genomes, 2nd ed, 2002 , Taylor and Francis publishers, New York
5) Primrose S.B, Twyman R.m., and Old R.w., Principles of gene manipulations, 6th ed, 2002, Blackwell publishers, Oxford.
6) Enzyme Technology, 1990, Martin Chaplin and Christopher Bucke, Cambridge University Press

LEARNING OBJECTIVES: The learning objectives for a course on Protein Engineering in a Biotechnology program may include:

LO 1	Understanding the structure, function, and properties of proteins, including their biological roles and interactions. Familiarity with the techniques used in protein engineering, including mutagenesis, directed evolution, and rational design.

LO 2	Understanding the principles of protein folding, stability, and dynamics, and how they relate to protein engineering. Developing skills in the design and optimization of protein functions, such as enzymatic activity, binding specificity, and stability.
LO 3	Knowledge of the applications of protein engineering in biotechnology, including the production of recombinant proteins, biocatalysis, and drug discovery. Developing skills in experimental design, data analysis, and interpretation of results in protein engineering research.
LO 4	Developing critical thinking and problem-solving skills through case studies and real-world examples of protein engineering in biotechnology.
LO 5	Developing skills in scientific writing and communication, including the ability to write research proposals, scientific articles, and presentations on protein engineering in biotechnology.

Upon completion of this course, students should be able to apply the principles and techniques of protein engineering to real-world problems in biotechnology. They should have a thorough understanding of the potential applications of protein engineering in biocatalysis, drug discovery, and the production of recombinant proteins. Graduates of this program may pursue careers in the biotechnology and pharmaceutical industries, research institutions, or government agencies. They may also work in academia, teaching and researching protein engineering in biotechnology.

COURSE OUTCOMES: The course outcome for the subject of protein engineering for PG students in biotechnology could be:

CO 1	Understanding the structure, function, and properties of proteins, including their biological roles and interactions.
CO 2	Understanding the principles of protein folding, stability, and dynamics, and how they relate to protein engineering.
CO 3	Developing skills in experimental design, data analysis, and interpretation of results in protein engineering research.
CO 4	Developing critical thinking and problem-solving skills through case studies and real-world examples of protein engineering in biotechnology.
CO 5	Developing skills in scientific writing and communication, including the ability to write research proposals, scientific articles, and presentations on protein engineering in biotechnology.

Upon completion of this course, students should be able to apply the principles and techniques of protein engineering to real-world problems in biotechnology. They should have

a thorough understanding of the potential applications of protein engineering in biocatalysis, drug discovery, and the production of recombinant proteins. Graduates of this program may pursue careers in the biotechnology and pharmaceutical industries, research institutions, or government agencies. They may also work in academia, teaching and researching protein engineering in biotechnology.

CO-PO MAPPING TABLE:

CO /PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	2	2	2	2	3	2	2	2	2	2	3
CO2	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO3	3	2	3	2	2	3	2	3	2	2	2	2	2	2	3
CO4	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3
CO5	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3

MBT-3.3 (A) (22): GENETIC ENGINEERING

Credits: 4

Unit I: Isolation and purification of DNA and RNA; Host controlled restriction modification. Classification of restriction enzymes and isoschizomers; DNA methylation enzymes and modification of restriction sites; Enzymes used in molecular cloning; Polymerases, ligases, phosphatases, kinases and nucleases; Advanced Molecular biology techniques, Electrophoresis and Blotting techniques.

Unit II: Cloning vehicles - Plasmid, Bacteriophage, Cosmid, Yeast shuttle and Viral vectors; Construction of genomic and cDNA libraries; Strategies for the construction of genomic and cDNA libraries and advantages of cDNA libraries.

Unit III: Methods of gene cloning, Complementation technique; polymerase chain reaction technique, RFLP, RAPD, Transposon tagging and Map based cloning; Organization of cloned insert; size, mapping of restriction sites, sub-cloning and location of segment of interest.

Unit IV: Methods of gene sequencing – Maxam - Gilberts and Sanger's dideoxy chain termination methods; Identification and expression of cloned genes based on genetic, immunochemical and blotting methods; Factors influencing expression of cloned genes, Use of computers for sequence analysis; Chemical synthesis of DNA (Oligos); In vitro amplification of DNA; Methods of gene transfer in fungi, yeast and higher plants using microinjection, microprojectile bombardment (gene gun method, Electroporation and Agrobacterium mediated transformation

Unit V: Production of transgenic plants; Use of reporter genes; Methods of transfection and production of transgenic fish, pigs, goats, sheep, mice and plants; Somatic cell gene therapy; Application of recombinant DNA technology in cattle improvement; Application of recombinant DNA technology in medicine, agriculture and industry, Selection methods and problems associated with expression of foreign DNA in animal cells.

REFERENCE BOOKS:

1) Nicholl D.S.T Introduction to genetic engineering, 2nd ed 2002 , University of Cambridge, U.K.
2) Winnacker E.L.,Genes to Clones,1sted , 2003, Panima publishing corporation, New Delhi.
3) Watson, James , Gilman, Michael , Witkowski, Jan , Zoller, Mark Recombinant DNA 2/e, 1992, W.H. Freeman, Madison avenue, New York
4) Brown T.A. Genomes ,2ed, 2002, Taylor and Francis publishers, New York
5) Gilbert, Scott F. Tyler, Anna ,Zackin, Emily Bioethics and the New Embryology (Springboards for Debate) 2005, W.H. Freeman , Madison avenue, New York
6) Molecular Cloning: A Laboratory Manual (3-Volume Set) 3rd edition, Joseph Sambrook and David W. Russell, Cold Spring Harbor Laboratory Press

LEARNING OBJECTIVES: The learning objectives of the subject of genetic engineering in biotechnology are:

LO 1	Understanding the fundamental principles of genetic engineering, including gene cloning, DNA sequencing, and gene editing.
LO 2	Developing knowledge of genetic tools and techniques, including restriction enzymes, plasmids, polymerase chain reaction (PCR).
LO 3	Understanding the fundamental principles of genetic engineering, including gene cloning, DNA sequencing.
LO 4	Understanding the applications of genetic engineering in biotechnology, including the production of recombinant proteins, genetic modification of crops, and gene therapy.
LO 5	Understanding the regulatory and safety issues related to genetic engineering in biotechnology.

Upon completion of this course, students should be able to apply the principles and techniques of genetic engineering to real-world problems in biotechnology. They should have a thorough understanding of the potential applications of genetic engineering in biotechnology and an ability to evaluate ethical, social, and environmental implications of genetic engineering. Graduates of this program may pursue careers in the biotechnology and pharmaceutical industries, research institutions, or government agencies. They may also work in academia, teaching and researching genetic engineering in biotechnology.

COURSE OUTCOMES: By the end of a course on Genetic Engineering in Biotechnology, students should be able to:

CO 1	Understanding the molecular tools and techniques used in genetic engineering, such as restriction enzymes, DNA ligase, PCR, and gene cloning.
CO 2	Applying principles of genetic engineering and its applications, including the production of recombinant proteins, genetic modification of crops.
CO 3	Knowing the ethical, social, and legal issues surrounding genetic engineering and its applications.
CO 4	Understanding genetic engineering experiments and draw conclusions based on the results.
CO 5	Applying scientific concepts related to genetic engineering, both orally and in writing, using appropriate scientific language and referencing relevant scientific literature.

Overall, the course should equip students with a comprehensive understanding of the concepts, techniques, and applications of genetic engineering, as well as the ability to think critically about the ethical and societal implications of genetic engineering research and development.

CO-PO MAPPING TABLE:

CO /PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO2	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO3	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO4	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3
CO5	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3

MBT-3.3 (B) (22): NANOCHEMISTRY

Credits: 4

Unit I: Novel physical chemistry related to nanoparticles such as colloids and clusters: different equilibrium structures, quantum effects, conductivity and enhanced catalytic activity compared to the same materials in the macroscopic state.

Unit II: Exploitation of self-assembly and self-organization to design functional structures in 1D, 2D or 3D structures. Examples to emphasize on self-assembled monolayers.

Role of polymers in lithography resists, as well as self-organization of more complicated polymer architectures such as block copolymers and polymer brushes.

Unit III: Nanomaterials (Nanoparticles, nanoclusters, quantum dots synthesis): Preparation and Characterization: "Top-Down" and "Bottom-Up" approaches of nanomaterial (nanoparticles, nanoclusters and quantum dots) synthesis: Top-down techniques

Unit IV: Photolithography, other optical lithography (EUV, X-Ray, LIL), particle-beam lithographies (e-beam, FIB, shadow mask evaporation), probe lithographies, Bottom-up techniques: self-assembly, self-assembled monolayers, directed assembly, layer-by-layer assembly.

Unit V: Pattern replication techniques: soft lithography, nanoimprint lithography. Pattern transfer and enhancement techniques: dry etching, wet etching, pattern growth techniques (polymerization, directed assembly). Combination of Top-Down and Bottom-up techniques: current state-of-the-art.

REFERENCE BOOKS:

1) Ozin, Geoffrey A., Arsenault, André C., Cademartiri, Ludovico A Chemical Approach to Nanomaterials 2nd ed., 2009, 820 p, Springer Publications.
2) Jonathan W. Steed, David R. Turner, Karl WallaceCore Concepts in Supramolecular Chemistry and Nanochemistry 2007, Wiley Publications.
3) Geoffrey A. Ozin, Andre C. Arsenault Nanochemistry A Chemical Approach to Nanomaterials, 2007, Black Well Publications.

LEARNING OBJECTIVES: The primary learning objectives of a course in Nanochemistry may include:

LO 1	Understanding the basic principles of nanoscale science, including size-dependent properties, quantum mechanics, and surface chemistry.
LO 2	Understanding the properties and applications of nanomaterials, including nanoparticles, nanotubes, and nanowires, and their synthesis and characterization.
LO 3	Understanding the role of intermolecular forces, self-assembly, and molecular recognition in the design and synthesis of functional nanomaterials.
LO 4	Understanding the principles of nanotechnology and its applications in various fields, including electronics, energy, medicine, and catalysis.
LO 5	Understanding the environmental, health, and safety concerns associated with the production and use of nanomaterials and Developing laboratory skills for the synthesis, characterization, and analysis of nanomaterials.

COURSE OUTCOMES: Upon completing a Biotechnology course with subject Nanochemistry, students should be able to:

CO 1	Explain the basic principles of nanoscale science and the properties of nanomaterials, including their synthesis and characterization
CO 2	Understanding the applications of nanotechnology in various fields, including electronics, energy, medicine, and catalysis.
CO 3	Understand the environmental, health, and safety concerns associated with the production and use of nanomaterials
CO 4	Analyzing and optimizing nanomaterials for specific applications using critical thinking and problem-solving skills.
CO 5	Understanding the laboratory experiments for the synthesis, characterization, and analysis of nanomaterials

Overall, a course Biotechnology withNanochemistryas one of the subject should equip students with a comprehensive understanding of the principles and applications of nanotechnology, as well as the practical skills needed for research and development in the field.

CO-PO MAPPING TABLE:

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO2	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO3	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO4	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3
CO5	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3

MBT-3.3 (C) (22): BIOREACTOR DESIGNING

Credits: 4

Unit I: Definition of bioreactor, basic principles of bioreactor. Factors affecting bioreactor design. Classification of bioreactors and their configurations. Analysis of batch, continuous, fed batch and semi-continuous bioreactors.

Unit II: Bioreactor design. Bioreactor instrumentation and control. Aseptic operation of bioreactors and ancillary equipment. Mechanical design of bioreactors and its components. Design of bioreactors using Monod growth kinetics: Batch, CSTF, CSTF with recycle, CSTFs in series. Plug flow reactors (PFTF), Fed-batch reactors.

Unit III: Design of CSTR and PFTR for enzyme-based conversions - Simple Michaelis-Menten and substrate-inhibited kinetics. Design of batch and continuous sterilization equipments. Oxygen mass transfer andHeat transfer in Bioreactors.Estimation of cooling coil length in fermenter design.

Unit IV: Kinetics of single particles containing immobilized enzymes-Liquid phase diffusions limitation. Microbial flocs and films. Measurement of flocculation and floc size. Performance characteristics of fermenters containing microbial flocs.

Unit V: Modelling Principles: Bioreactor modelling and stability analysis. Fundamentals of Modelling. Modelling of Enzyme Kinetics. Simple Microbial Kinetics. Structured Kinetic Models. Bioreactor Modelling. General balances for Tank-type Biological Reactors.

LEARNING OBJECTIVES: The primary learning objectives of a course Biotechnology with Bioreactor Designing as one of the subject include:

LO 1	Understanding the principles and concepts of bioreactors and their role in bioprocessing.
LO 2	Understanding the design and operation of bioreactors for different types of microbial and cell cultures, including batch, fed-batch, and continuous culture systems.
LO 3	Understanding the principles of scale-up and scale-down in bioreactor design, including the effects of mixing, mass transfer, and shear stress on cell growth and product formation.
LO 4	Understanding the principles of reactor kinetics and its applications in the design and operation of bioreactors and understanding the principles of downstream processing and the integration of bioreactor systems with other process units.

LO 5	Developing problem-solving skills for designing and optimizing bioreactor systems for specific applications. Developing laboratory skills for the operation and monitoring of bioreactor systems.

Overall, a course in Bioreactor Designing aims to provide students with a solid foundation in the principles and applications of bioreactor systems for bioprocessing, as well as the practical skills needed for research and development in the field.

COURSE OUTCOMES: Upon completing a course in Bioreactor Designing in Biotechnology, students should be able to:

CO 1	Understanding the principles of bioreactor design and operation for different types of microbial and cell cultures, including batch, fed-batch, and continuous culture systems.
CO 2	Explaining the effects of mixing, mass transfer, and shear stress on cell growth and product formation in bioreactors
CO 3	Understand the principles of scale-up and scale-down in bioreactor design, including the use of modeling and simulation tools.
CO 4	Analyze the effects of mixing, mass transfer, and shear stress on cell growth and product formation in bioreactors.
CO 5	Understand the principles of scale-up and scale-down in bioreactor design, including the use of modeling and simulation tools.

Overall, a course in Bioreactor Designing in Biotechnology should equip students with a comprehensive understanding of the principles and applications of bioreactor systems for bioprocessing, as well as the practical skills needed for research and development in the field.

CO-PO MAPPING TABLE:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO2	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO3	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO4	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3
CO5	2	2	3	2	3	2	2	3	3	2	2	2	2	2	3

MBT-3.4 (A) (22): BIOINFORMATICS

Credits: 4

Unit I: Biology in the Computer age, information processing challenges in Biotechnology, Introduction and Scope of Bioinformatics, Biological Database Classification : Sequence, Structure and Integrated Databases.

Unit II: Introduction to Windows, Basics of M.S. Office and Internet, Introduction to Web Searching, Searching the databases, Deposition of Data into Databases, Introduction to Languages, Programming with C.

Unit III: Sequence formats, Sequence Analysis, Gap Penalty and scoring Matrices, Pair wise sequence alignment, Multiple Sequence Alignment, Phylogenetic Analysis.

Unit IV: Protein Structure Databases and Visualization Tools, Protein Classification, Protein Structure Prediction, Methods of Structure Production for Known Folds and for Unknown Folds, Protein Function Prediction.

Unit V: Introduction to Genomics and Proteomics, Genomic Databanks, metabolic Data banks, Analysis of Genomic and proteomic Sequences. Tools for the Genomic and Proteomic Analysis.

REFERENCE BOOKS:

1) Jambeck P, Gibas .C Developing Bioinformatics Computer Skills first edition2001 O'Reilly, Sebastapol,
2) David W Mount, Bioinformatics, 2004,second edition,CSHL Press, New York
3) Primrose S.B, TwymanR.m., and Old R.w., Principles of gene manipulations, 6th ed, 2002, Blackwell publishers, Oxford.
4) James Tisdall, Beginning Perl for Bioinformatics, 2001, first edition, O'Reilly, Sebastapol,
5) JinXiong, Essential Bioinformatics, 2006, first edition, Cambridge University Press, New York
6) Ingvar Eidhammer, Inge Jonassen, William R. Taylor, Protein Bioinformatics, 2004, First edition, John Wiley and Sons, England
7) Mark Yandell, Ian Korf, Joseph Bedell, BLAST, 2003, First edition O'Reilly , Sebastapol,

LEARNING OBJECTIVES: The learning objectives of the subject bioinformatics can vary depending on the level of study, but some common goals may include:

LO 1	Understanding the fundamental concepts and techniques of bioinformatics, such as sequence analysis, molecular modeling, and data mining.
LO 2	Developing practical skills in using bioinformatics tools and software, such as BLAST, ClustalW, and R.

LO 3	Learning to critically evaluate and interpret bioinformatics results and data
LO 4	Applying bioinformatics approaches to solve biological problems and answer research questions, such as identifying potential drug targets, predicting protein-protein interactions, and reconstructing evolutionary relationships
LO 5	Understanding the ethical and legal issues surrounding the use of bioinformatics, such as data privacy and ownership, intellectual property, and biosecurity

Overall, the goal of studying bioinformatics is to integrate biological knowledge and computational techniques to advance our understanding of life processes and solve important scientific problems.

COURSE OUTCOMES: A biotechnology course on bioinformatics may cover a variety of topics and involve different types of coursework. The possible coursework for a bioinformatics course in biotechnology could include:

CO 1	Understanding the gene expression, comparative genomics, and protein structure prediction.
CO 2	Understanding bioinformatics tools such as BLAST, Clustal W, and multiple sequence alignment software.
CO 3	Explaining the Genome annotation: Assignments that involve predicting the function of genes and their products using bioinformatics tools such as gene prediction software, functional annotation databases, and pathway analysis tools.
CO 4	Extending the assignments that involve predicting the 3D structure of proteins or other biomolecules using bioinformatics tools such as homology modeling, molecular docking, and molecular dynamics simulations
CO 5	Extending assignments that involve working with large-scale datasets, such as transcriptomic or proteomic data, and using bioinformatics tools such as statistical analysis software and machine learning algorithms to extract meaningful insights.

Overall, a biotechnology course in bioinformatics is likely to involve a combination of theoretical and practical coursework, with a focus on developing both knowledge and skills in using bioinformatics to address important biological questions.

REGENERATE RESPONSE

CO-PO MAPPING TABLE:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO2	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO3	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO4	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3
CO5	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3

MBT-3.4 (B) (22): BIOETHICS, BIO-SAFETY, IPR AND PATENT LAWS

Credits: 4

UNIT - I: Intellectual property rights - Definition - types -patents - copy rights-trademarks: essential requirements for IPR, procedures of filing patents-provisional and complete specifications-Pan-Cooperation treaty (PCT)-application: GATT and IPR: WTO Act - Global and Indian Biodiversity Act Indian Patent Act and their revised versions.

UNIT - II: Legal and Ethical aspects of Biotechnology -Prenatal diagnosis - Genetic screening - Surrogate mothers and exploitation of women - designing of plants and animals-gene therapy - cloning - Manipulation of human genome -Technology transfer.

UNIT - III: Social and Moral aspects of Biotechnology -Biotechnology and International trade - Privatisation and patenting of Biotechnology products - Role of Government, Industries and society in promoting, accepting and regulating the rDNA research.

UNIT – IV: Environmental and Health aspects of Biotechnology - Generally engineered organisms - Introduction of novel species and natural equilibrium - Environmental security and safety - Precautionary measures - Genetically modified foods - health safety.

Unit- V: Patent Filing, types of patents and World Trade Organization's (WTO) TRIPS Agreement, Anti-patent initiatives, Benefits of patents

REFERENCE BOOKS:

1) Gene cloning – Brown.
2) Concepts in Biotechnology- Balasubramanyam.D.
3) Basic Biotechnology - Colin Rotledge and Kristainsen.

LEARNING OBJECTIVES: The learning objectives of the subject Bioethics, Bio-safety, IPR (Intellectual Property Rights), and Patent Laws are as follows

LO 1	The objective of the bioethics component is to familiarize students with ethical issues in biotechnology research, such as animal experimentation, stem cell research, genetic testing, and biobanking.
LO 2	The learning objectives include developing an understanding of the ethical principles involved in biotechnology research, analyzing case studies that involve ethical issues, and exploring the ethical implications of emerging biotechnologies
LO 3	The objective of the biosafety component is to ensure that students understand the principles of laboratory safety and are familiar with the regulations governing biotechnology research. The learning objectives include developing an understanding of the basic principles of biosafety, including risk assessment, hazard identification, and control measures, as well as the regulations governing biotechnology research, such as the NIH Guidelines for Research Involving Recombinant DNA Molecules.
LO 4	The objective of the IPR and patent laws component is to familiarize students with the basic principles of intellectual property law and their application to biotechnology research.

LO 5	The learning objectives include developing an understanding of the different types of intellectual property, such as patents, copyrights, and trademarks, as well as the legal framework governing biotechnology research, such as the Bayh-Dole Act and the TRIPS Agreement.

Overall, the learning objectives of the subject Bioethics, Biosafety, IPR, and Patent Laws are to provide students with a comprehensive understanding of the ethical, safety, and legal issues that arise in biotechnology research, and to prepare them to navigate these issues in their future careers in the biotechnology industry or academia.

COURSE OUTCOMES: The course outcome for a biotechnology course that covers Bioethics, Bio-safety, IPR, and Patent Laws may include the following:

CO 1	Demonstrate an understanding of ethical principles in biotechnology research: Students should be able to analyze case studies and ethical dilemmas in biotechnology research, and apply ethical principles such as respect for autonomy, beneficence, non-maleficence, and justice to address these issues.
CO 2	Understand and implement biosafety measures in the laboratory: Students should be able to identify and evaluate potential hazards in biotechnology research, and develop and implement appropriate control measures to mitigate risks and ensure laboratory safety.
CO 3	Understand the legal framework for biotechnology research: Students should be familiar with the regulations and laws governing biotechnology research, including intellectual property laws and patent laws, and understand how to navigate these legal frameworks to protect intellectual property and promote innovation.
CO 4	Develop critical thinking and communication skills: Students should be able to critically evaluate ethical, safety, and legal issues in biotechnology research, and effectively communicate their findings and recommendations to diverse audiences, including scientists, policymakers, and the general public.
CO 5	Understand the social and cultural implications of biotechnology: Students should be able to analyze the social and cultural implications of biotechnology research, including issues related to access, equity, and justice, and develop strategies to promote responsible and sustainable biotechnology innovation.

Overall, the course outcome for a biotechnology course that covers Bioethics, Bio-safety, IPR, and Patent Laws is to prepare students to navigate the complex ethical, safety, and legal issues that arise in biotechnology research, and to promote responsible and sustainable biotechnology innovation.

CO-PO MAPPING TABLE:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO2	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO3	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO4	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3
CO5	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3

MBT-3.4 (C) (22): VIROLOGY

Credits: 4

UNIT I- Brief outline of discovery of viruses; properties of viruses; Morphology of viruses- Structure, Capsid architecture; envelopes and peplomers Chemistry of viruses- viral proteins, genome – structure and types. Study of sub-viral agents – Brief account of diseases caused by viroids – PSTV, Cadangcadang; Prions- Scrape, Cruetzfeldjakob; Satellite viruses, Satellite RNA's.

UNIT II General methods of cultivation of viruses-in embryonated eggs, experimental animals and cell cultures, monolayer cultures, cell lines. General methods of purification of viruses. Serological methods for detection of viruseshaemagglutination& HAI, immunoflourescense, ELISA, PCR and RIA. Infectivity assay – plaque method. Ultra structure and life cycles of bacteriophages- M13, Mu, T4 & lambda.

UNIT III Taxonomy of plant viruses, Symptoms of diseases caused by plant viruses (morphological, physiological, and histological), Ultra structure and life cycles of TMV and CaMV, Transmission of plant viruses – mechanical and biological (vector and non vector), Basic control measures of plant diseases- vector and chemical control. General account of viruses of Cyanobacteria, algae and fungi.

UNIT IV Taxonomy of human viruses, Ultra structure and brief account on life cycles of RNA viruses- Polio, Influenza and HIV; Ultra structure and brief account on life cycles of DNA viruses-

Unit- V: Vaccina, Adenovirus, SV40. Viral vaccines- Types, preparation and production of vaccines. New generation vaccinesgenetic recombinant vaccines. General account on interferons and antiviral drugs.

REFERENCE BOOKS:

1) DIMMOCK NJ, PRIMROSE SB (1994). Introduction to Modern Virology IV Edition, Blackwell Scientific publications. Oxford.
2) MORAG, C and TIMBURY M (1994). Medical Virology, Churchill livingstone,
3) CONRAT HF, KIMBALL PC and LEVY JA (1994). Virology-III ed. Englewoood cliff, New Jersey.
4) MATHEWS, RE (1992). Functionals of plant Virology, Academic Press, San Diego.
5) TOPLEY and WILLIAMS (1995). Text book on Principles of Bacteriology, Virology and Immunology, Edward Arnold, London.
6) WILLIAM HAYES (1985), The genetics of bacteria and Their viruses, black well Scientific publishers, London.
7) DAVID GA WALKEY (1985). Applied Plant Virology. William Heinemann Ltd, London.

LEARNING OBJECTIVES: The learning objectives of the subject Virology are as follows:

LO 1	Understand the basic structure and replication of viruses: The objective of this component is to provide students with a basic understanding of the structure and replication cycle of viruses. Students should be able to identify the major components of viruses, including the viral genome, capsid, and envelope, and understand the process of viral replication.
LO 2	Identify different types of viruses and their pathogenesis: The objective of this component is to familiarize students with different types of viruses, including RNA viruses, DNA viruses, retroviruses, and prions, and understand the mechanisms by which viruses cause disease.
LO 3	Develop an understanding of host-virus interactions: The objective of this component is to provide students with an understanding of how viruses interact with host cells, including viral entry, replication, and evasion of the host immune response.
LO 4	Understand the principles of viral diagnosis and treatment: The objective of this component is to familiarize students with the different methods for detecting and diagnosing viral infections, including serological and molecular methods, as well as the principles of antiviral treatment and vaccine development.
LO 5	Develop critical thinking and research skills: The objective of this component is to develop students' ability to critically evaluate primary literature in virology, design and execute experiments to address specific research questions in virology, and effectively communicate scientific findings to diverse audiences.

Overall, the learning objectives of the subject Virology are to provide students with a comprehensive understanding of the basic principles of virology, including viral structure, replication, pathogenesis, and host-virus interactions, and to develop critical thinking and research skills to advance our understanding of viruses and their role in human health and disease.

COURSE OUTCOMES: The course outcomes for a biotechnology course that covers Virology may include the following:

CO 1	Demonstrate an understanding of the basic principles of virology: Students should be able to describe the structure and replication cycle of viruses, identify different types of viruses and their pathogenesis, and understand the mechanisms of host-virus interactions.
CO 2	Understanding and interpret scientific literature in virology: Students should be able to critically evaluate primary literature in virology, identify gaps in knowledge, and design and execute experiments to address specific research questions in virology.
CO 3	Develop laboratory skills in virology: Students should be able to apply laboratory techniques, such as cell culture, viral isolation and identification, and molecular methods for viral detection, to advance our understanding of viruses and their role in human health and disease.

CO 4	Understand the practical applications of virology: Students should be able to understand the principles of antiviral treatment and vaccine development, and apply this knowledge to the development of new therapies and vaccines for viral infections.
CO 5	Develop effective communication skills: Students should be able to effectively communicate scientific findings in virology to diverse audiences, including scientists, clinicians, policymakers, and the general public.

Overall, the course outcomes for a biotechnology course that covers Virology is to provide students with a comprehensive understanding of the basic principles of virology, develop laboratory skills in virology, and prepare them for careers in virology research, biotechnology industry, or public health.

CO-PO MAPPING TABLE:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO2	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO3	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO4	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3
CO5	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3

PRACTICAL-I:

MBTP- 3.1. (22): MOLECULAR BIOLOGY AND PROTEIN ENGINEERING

Credits :04

MOLECULAR BIOLOGY

1) Effect of UV radiations on the growth of microorganisms.
2) Determination of absorption maxima of DNA and RNA and their quantification
3) Isolation of plasmid DNA from bacteria
4) Isolation of genomic DNA from *E.coli*
5) Isolation of DNA from sheep liver
6) Isolation of DNA from plant leaves (Rice or Tobacco or any other plant)
7) Transformation of bacteria using a plasmid and screening of colonies fortransformants
8) Isolation of RNA from yeast or Rice or any other plant
9) Purity analysis of the Nucleic acids
10) Development of RAPD or AFLP markers in different species of cotton or Brinjal using PCR technique
11) Screening of gene libraries using colony hybridization technique
12) Thermal denaturation of DNA, correlation of Tm on base composition of DNA
13) Determination of phosphorous in nucleic acids

PROTEIN ENGINEERING

1) Immobilization of an enzyme (Amylase or Invertase)
2) Assay of immobilized enzyme (Amylase or Invertase)
3) Demonstration of cassette mutagenesis
4) Modification of restriction endonuclease site
5) Immobilization of yeast cells using entrapment method
6) To test the expression of an enzyme activity using a Western Blotting technique
7) Equation for substrate consumption in an immobilized cell reactor.
8) Affinity purification of Histidine Tagged proteins
9) Expression of Eukaryotic protein in a prokaryotic system
10) Inclusion body purification and refolding of proteins

PRACTICAL-II:

MBTP 3.2. (22): GENETIC ENGINEERING & BIOINFORMATICS

Credits: 04

GENETIC ENGINEERING

1) Transformation in Bacteria using plasmid
2) To test the integration of DNA in a transgenic system using a Southern Blotting technique
3) To test the expression of a gene in a transgenic system using a Northen Blotting technique
4) Restriction digestion of DNA and its electrophoretic separation
5) Ligation of DNA molecules and their testing using electrophoresis
6) Activity of DNAase and RNAse on DNA and RNA
7) Amplification of DNA using Polymerase Chain Reaction (PCR)
8) Cloning and expression of Green Fluorescent Protein in Bacteria or Plants
9) DNA sequencing – Sanger's method (manual sequencers are available atreasonable prices)
10) Construction of restriction maps (Assignments)

BIOINFORMATICS

1) Accessing of Biological Databases such as NCBI and EMBI or DDBJ onnc^{+} (Sequence retrievals from DNA or GenBank and Protein Data bases)
2) Sequence identification and sequence format
3) Sequence analysis
4) Pair wise sequence alignment
5) Multiple sequence alignment (Clustal) (Local and Global Alignment)
6) Protein structure visualization using RASMOL, cn3d
7) MMDB and analysis of structure with cn3d
8) Secondary structure prediction of proteins using n n-predict
9) Secondary structure prediction by PSIPRED
10) Primer designing using the software
11) Phylogenetic analysis of genes or proteins and construction of dendrograms.

FOURTH SEMESTER

DEPARTMENT OF BIOTECHNOLOGY

M.Sc. BIOTECHNOLOGY

MBT-4.1. (22): PLANT BIOTECHNOLOGY

Credits: 4

Unit I: Tissue culture media preparation and sterilization procedures; Role of plant hormones in tissue and cell culture. Initiation and maintenance of callus and suspension cultures; Growth of callus/suspension, Packed cell volume, Bergman's plating technique and single cell clones.

Unit II: Organogenesis, Embryogenesis and Synthetic seeds; Methods of Invitro micro propagation; Transfer and establishment of whole plants in the soil; Meristem culture and production of virus free plants.

Unit III:; Anther and pollen culture, production of haploids and homozygous diploid plants, Production of Triploids - endosperm culture; Embryo culture, Protoplast isolation. culture and fusion; Selection of hybrids, symmetric and asymmetric hybrids, cybrids.

Unit IV: Somaclonal variations and crop improvement In vitro selection of mutants, Auxotrophic mutants, Autotrophic mutants, Resistant mutants; Cryopreservation and germplasm conservation. Germplasm storage and establishment of gene banks.

Unit V: Production of pharmaceutically and industrially important compounds from cultured cells, Biotransformations of important compounds such as digitonin;.. Tissue culture and its biotechnological applications in agriculture, horticulture and industry;

REFERENCE BOOKS:

1) Bhojwani. S.S. RazdanM.K.Plant tissue culture theory and practice, 2nded , 1985, Elseiver publishers, Amsterdam, Netherlands.
2) Razdan M. K., An introduction to plant tissue culture, 1st ed, 2000, Oxford and IBH Publishing house, New Delhi.
3) Jha T.B., Ghosh B., plant tissue culture ,1st ed .2005, University press, pvt , New Delhi.
4) Kalyankumar De, Plant tissue culture , 1st ed, 2004, New central book agency, kolkata

LEARNING OBJECTIVES: Plant biotechnology is a field of study that deals with the application of scientific and engineering principles to the processing of plants for human benefit. The learning objectives of plant biotechnology include:

LO 1	**Understanding:** Students of plant biotechnology should have a good grasp of the biology of plants, including their structure, physiology, genetics, and evolution.
LO 2	**Give an insight of the k**nowledge of genetic engineering: Plant biotechnology involves the use of genetic engineering to modify the genetic makeup of plants. Students should have a thorough understanding of the principles and techniques of genetic engineering, such as gene cloning, transformation, and genome editing.
LO 3	Understanding plant tissue culture: Plant tissue culture involves the aseptic culture of plant cells, tissues, or organs in vitro. Students should be familiar with the principles and techniques of plant tissue culture, including media preparation, sterilization, culture initiation, and maintenance.

LO 4	Understanding plant biochemistry: Plant biotechnology also involves the study of plant biochemistry, including the biosynthesis and metabolism of plant secondary metabolites, such as alkaloids, flavonoids, and terpenoids. Students should have a basic knowledge of plant biochemistry, including the structure and function of enzymes and metabolic pathways**.**
LO 5	Knowledge of plant breeding: Plant biotechnology plays an important role in plant breeding, including the development of new cultivars with improved traits such as yield, disease resistance, and nutritional quality. Students should be familiar with the principles and techniques of plant breeding, including hybridization, selection, and genetic analysis.

Overall, the learning objectives of plant biotechnology aim to provide students with a comprehensive understanding of the principles and techniques involved in the manipulation of plant cells, tissues, and genes, and their applications in agriculture, medicine, and industry.

COURSE OUTCOMES: The course outcomes of plant biotechnology are:

CO 1	Understanding of plant biology, including plant structure, physiology, genetics, and evolution.
CO 2	Explaining the principles and techniques of genetic engineering, including gene cloning, transformation, and genome editing, and their applications in plant biotechnology.
CO 3	Students will be able to perform plant tissue culture techniques, including media preparation, sterilization, culture initiation, and maintenance.
CO 4	Students will be able to design and conduct plant transformation experiments, including selection of suitable transformation methods, preparation of transformation vectors, and optimization of transformation conditions.
CO 5	Students will be able to apply the principles and techniques of plant breeding, including hybridization, selection, and genetic analysis, to develop new cultivars with improved traits such as yield, disease resistance, and nutritional quality.

Overall, the course outcomes of plant biotechnology aim to provide students with the knowledge and skills to apply scientific and engineering principles to the processing of plants for human benefit. Graduates of plant biotechnology programs can pursue careers in agricultural biotechnology, pharmaceuticals, biofuels, and other related industries. They can also work in academic research institutions, government agencies, or non-profit organizations focused on plant biotechnology.

CO-PO MAPPING TABLE:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO2	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO3	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO4	4	2	3	2	3	2	2	3	3	2	2	2	2	2	3
CO5	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3

MBT4.2 (22): ANIMAL BIOTECHNOLOGY

Credits: 4

Unit I: Biology of cells in culture, Brief outline of the chemical, physical and metabolic functions of different constituents of culture medium. Adaptation of mammalian cells to growth in serum free and protein free media. Establishment of primary and secondary cell lines Maintenance and preservation of cultures

Unit II: Cell line authentication – species verification, tests for contamination, Testing for intra species cross contamination;. Concept of growth, measuring parameters of growth, Basic techniques and types of mammalian cell cultures; Monolayer cultures, suspension cultures, Immobilized cultures, Micro carrier culture and its applications

Unit III: Cytotoxicity and Viability assay. Cell synchronization, and cell transformation. Tissue engineering; Organ and histotypic culture; Assisted reproductive technology, *In vitro* fertilization and ebryo transfer in humans and cattles and its applications.

Unit IV: Stem cell culture technology-different types of stem cells, unique properties of stem cells identification of embryonic stem cells, and potential applications of stem cells, Transgenic technology and gene knockout technology Applications of animal cell culture.

Unit V: Pest management using juvenile hormone analogs, Biotechnology of silk worms. Gene manipulations in fresh water and marine fish and prawns, ploidy manipulations to enhance growth in fish and prawns. Bioreactors for animal cell culture. Mammalian cell products, Viral vaccines produced from animal cell cultures. Ethical issues

REFERENCE BOOKS:

1) Freshney I.R, Culture of Animal cells ,4th ed,2005, Wiley- lispublishers, USA.
2) Gilbert, Scott F. , Tyler, Anna , Zackin, Emily Bioethics and the New Embryology (Springboards for Debate) 2005, W.H. Freeman. Madison avenue, New york
3) Holland A. and Johnsonn A. Animal Biotechnology and ethics 1st ed ,1998 Springers, 1sted New york.
4) Animal cell bioitechnology 1sted, Jenkins N, Humana press,1999, New jersey.
5) Dunham R.A, Aquaculture and fisheries biotechnology 1st ed., 2004, CABI publishers, Cambridge, USA.
6) Helgason C.D., Miller C.L. Basic cell culture protocols, 3rded, 2005, Humana press, New Jersey.

LEARNING OBJECTIVES: Animal biotechnology is the use of scientific and engineering principles to process animals for human benefit. The learning objectives of animal biotechnology include:

LO 1	Understanding animal biology: Students of animal biotechnology should have a good grasp of the biology, anatomy, physiology, genetics, and evolution of animals

LO 2	Knowledge of genetic engineering: Animal biotechnology involves the use of genetic engineering to modify the genetic makeup of animals. Students should have a thorough understanding of the principles and techniques of genetic engineering, such as gene cloning, transformation, and genome editing.
LO 3	Understanding animal cell culture: Animal cell culture involves the aseptic culture of animal cells in vitro. Students should be familiar with the principles and techniques of animal cell culture, including media preparation, sterilization, culture initiation, and maintenance.
LO 4	Understanding animal biopharmaceuticals: Animal biotechnology also involves the production of biopharmaceuticals using animal cells, tissues, or organs. Students should have a basic knowledge of animal biopharmaceuticals, including the production process, purification techniques, and quality control.
LO 5	Ethical considerations: Animal biotechnology also raises ethical issues, such as animal welfare, the potential risks to human health, and the environmental impact of genetically modified animals. Students should be aware of these ethical considerations and be able to engage in informed debates about them.

Overall, the learning objectives of animal biotechnology aim to provide students with a comprehensive understanding of the principles and techniques involved in the manipulation of animal cells, tissues, and genes, and their applications in medicine, agriculture, and industry.

COURSE OUTCOMES: The course outcomes of animal biotechnology are**:**

CO 1	Understand and discuss and differentiate the basic structure and function of cell components in prokaryotes and eukaryotes cells.
CO 2	Explaining Stem Cell Biology, Animal Cell Culture, Genomics and Proteomics, Drug Design, Genetic Engineering and Bioinformatics.
CO 3	To Understand advanced streams like Stem Cell Biology, Animal Cell Culture, Genomics and Proteomics, Drug Design, Genetic Engineering and Bioinformatics.
CO 4	To understand principles of animal culture, media preparation
CO 5	To explain Invitro fertilization and embryo transfer technology.

Overall, the course outcomes of animal biotechnology aim to provide students with the knowledge and skills to apply scientific and engineering principles to the processing of animals for human benefit. Graduates of animal biotechnology programs can pursue careers in animal biotechnology, animal breeding, pharmaceuticals, biotech, and other related industries. They can also work in academic research institutions, government agencies, or non-profit organizations focused on animal biotechnology**.**

CO-PO MAPPING TABLE:

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO2	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO3	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO4	2	2	3	2	3	2	2	3	3	2	2	2	2	2	3
CO5	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3

MBT4.3 (A) (22): BIOCHEMICAL ENGINEERING

Credits: 4

Unit I: Introduction to Biochemical Engineering. Role of the Biochemical engineer. Units and dimensions. Concepts of dimensionless numbers. Flow sheets. Material and energy balances. Basic biochemical engineering calculations. Stoichiometry. Biological rate equations for cell growth, death, lysis, endogeneous metabolism, maintenance energy, product formation and substrate uptake. Principles of sterilisation of media and air.

Unit II: Fermentation broth rheology. Fluid flow and mixing. Newton's law of Viscosity. Momentum transfer. Non-newtonian fluids. Flow patterns in agitaed vessels with aeration and without aeration. Determination of aerated and unaerated power Consumption both for Newtonian and non-Newtonian cultivation broths. Gas hold-up and power input to stirred and gas-agitated bioreactors. Bioreactor configurations and scale-up and scale-down of bioreactor systems.

Unit III: Oxygen requirements of microbial cultures. Oxygen mass transfer fundamentals, Oxygen transfer and oxygen demand. Oxygen transfer by aeration and agitation. Determination of oxygen transfer coefficient by various methods including sulfite oxidation, dynamic gassing out and oxygen balance methods. Factors affecting oxygen transfer coefficient. Correlation for volumetric oxygen mass transfer coefficient. Heat transfer requirements of microbial cultivations including correlations for the determination of heat transfer coefficients.

Unit IV: Introduction to factors affecting bioreactor design. Description of a typical aseptic bioreactor. Bioreactor operation. Bioreactor configurations: Modelling of microbial activity in batch, fed-batch and continuous processes. Cell recycle in a bioreactor. Analysis of various kinds of bioreactors employed in Biotech Industry.

Unit V: Overview of methods for online and offline monitoring of bioreactors. Bioprocess measurements: physical and chemical measurements. Introduction to instrumentation: pH probes, dissolved oxygen probes, other biosensors. Large scale production of recombinant proteins. Scenario of Indian Biotechnology

REFERENCE BOOKS:

1) Aiba S., Humphrey A E., and Miliis N.F., Biochemical engineering 2nd ed, 1973, University of Tokyo press,Tokyo.
2) Bailey J.E., Ollis D.F., Biochemical engineering fundamentals, 2nd ed,1986,Mcgra-Hill international edition, Singapore.
3) Shauler M.L., Kargi F., Bioprocess engineering Basic concepts 2ed, 2003,Pearson education press, Singapore.
4) Ahuja S., Hand book of bioseparations 2nd ed,2000,Academic press , New york.
5) Ladish M., Bioseparation engineering principles, practice and economics,1st ed,2001, John Wiley & sons. Inc.,Newyork.

6) Asenjo J A., Separation process in Biotechnology, 1st ed, 1990, Marcel Dekker,Inc., New york
7) Bioprocess Engineering Principles, Doran, PM, 1995, Academic Press.

LEARNING OBJECTIVES: Biochemical engineering is a branch of engineering that uses biological systems and processes to develop products and technologies. The learning objectives of biochemical engineering include:

LO 1	Understanding of biochemical principles: Students of biochemical engineering should have a good understanding of the principles of biochemistry, including metabolism, enzyme kinetics, and cellular signaling.
LO 2	Knowledge of bioprocessing: Bioprocessing is the use of biological systems to produce value-added products. Students should be familiar with the design and operation of bioreactors, downstream processing, and product recovery
LO 3	Knowledge of bioprocessing: Bioprocessing is the use of biological systems to produce value-added products. Students should be familiar with the design and operation of bioreactors, downstream processing, and product recovery
LO 4	Understanding of process control: Process control is the use of feedback control systems to maintain optimal operating conditions in bioprocesses. Students should be familiar with the principles of process control, including sensors, controllers, and actuators.
LO 5	Knowledge of regulatory affairs: Regulatory affairs is the field that deals with the regulations and guidelines governing the development, production, and marketing of biotechnology products. Students should be familiar with the regulatory environment for biotechnology products and the process of obtaining regulatory approval

Overall, the learning objectives of biochemical engineering aim to provide students with a comprehensive understanding of the principles and techniques of using biological systems and processes to develop products and technologies. Graduates of biochemical engineering programs can pursue careers in biotechnology, pharmaceuticals, healthcare, food and beverage, and other related industries. They can also work in academic research institutions, government agencies, or non-profit organizations focused on biochemical engineering.

REGENERATE RESPONSE

COURSE OUTCOMES: The course outcomes of biochemical engineering are:

CO 1	Proficiency in biochemistry principles: Students will be able to apply principles of biochemistry to analyze and design biochemical processes.

CO 2	Explaining the biochemistry principles: Students will be able to apply principles of biochemistry to analyze and design biochemical processes**.**
CO 3	Developing and designing bioreactors for the production of various biochemical products, including pharmaceuticals, biofuels and food additives.
CO 4	Understanding of downstream processing: Students will be able to develop and optimize downstream processing techniques for the recovery and purification of biochemical products.
CO 5	Understanding of downstream processing: Students will be able to develop and optimize downstream processing techniques for the recovery and purification of biochemical products.

Overall, the course outcomes of biochemical engineering aim to provide students with the knowledge and skills to apply scientific and engineering principles to the processing of biochemicals for various applications. Graduates of biochemical engineering programs can pursue careers in biotechnology, pharmaceuticals, healthcare, food and beverage, and other related industries. They can also work in academic research institutions, government agencies, or non-profit organizations focused on biochemical engineering.

CO-PO MAPPING TABLE:

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	2	2	2	2	3	2	2	2	2	2	3
CO2	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO3	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO4	2	2	3	2	2	2	2	3	3	2	2	2	2	2	3
CO5	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3

MBT4.3 (B) (22): NANOINFORMATICS AND CHEMIINFORMATICS

Credits: 4

Unit I: Introduction to Nanoinforamtics, Significance of nanoscope in the nanotechnology, nano materials, nano gels, nano scaffolds, nano sensors Nanotechnology for Cellular and Genetic Engineering, Biomedical Informatics and Nanotechnology, Molecular Biomimetics.

Unit II: Introduction to Nanodatabses, types of nanodatabases, Nano data processing, Nano imprinting lithography, different types of nano imprinting lithographys in biotechnology, Nano images validation,

Unit III: Introduction to cheminformatics, History and Evolution of cheminformatics, Use of cheminformatics, Prospects of cheminformatics, Molecular Modeling and Structure Elucidation.

Unit IV: Nomenclature; Different types of Notations; SMILES Coding; Matrix Representations; Structure of Molfiles and Sdfiles; Libraries and toolkits; Different electronic effects; Reaction classification. DatabaseConcepts. Structured Query Language. Design of Chemical Databases, Data Abstraction; Data Models; Instances & Schemes; E-R Model - Entity and entity sets; Relations and relationship sets; E-R diagrams; Reducing E-R Diagrams to tables;

Unit V: Network Data Model: Basic concepts; Hierarchical Data Model: Basic Concepts; Metadatabases; Indexing and Hashing; Basic concepts; Text Databases; Introduction to Distributed Database Processing, Data Security. Intefacing programs with databases; Computer Assisted Synthesis Design, Introduction to drug design; Target Identification and Validation; Lead Finding and Optimization; Analysis of HTS data; Virtual Screening; Design of Combinatorial Libraries; Ligand-Based and Structure Based Drug design; Application of Cheminformatics in Drug Design

LEARNING OBJECTIVES: Nanoinformatics and cheminformatics are interdisciplinary fields that apply principles of informatics to the design and analysis of nanomaterials and chemical compounds, respectively. The learning objectives of nanoinformatics and cheminformatics include:

LO 1	Familiarity with molecular modeling: Students should be familiar with the principles and techniques of molecular modeling, including molecular mechanics, quantum mechanics, and molecular dynamics simulations.
LO 2	Knowledge of databases and data analysis: Students should be able to use databases and data analysis tools to collect, organize, and analyze large datasets of chemical and biological information.
LO 3	Understanding of machine learning: Machine learning is a method of artificial intelligence that uses algorithms to learn from data and make predictions. Students should be familiar with the principles and techniques of machine learning, including supervised and unsupervised learning, clustering, and classification.

LO 4	Proficiency in computer-aided drug design: Students should be able to use computer-aided drug design (CADD) tools to design and optimize chemical compounds for various applications, including drug discovery and development.
LO 5	Knowledge of regulatory affairs: Students should be familiar with the regulatory requirements for the development, production, and marketing of chemical and nanomaterial-based products

Overall, the learning objectives of nanoinformatics and cheminformatics aim to provide students with the knowledge and skills to apply informatics principles to the design and analysis of chemical compounds and nanomaterials for various applications, including drug discovery, nanomedicine, and nanoelectronics. Graduates of nanoinformatics and cheminformatics programs can pursue careers in pharmaceuticals, biotechnology, nanotechnology, and other related industries. They can also work in academic research institutions, government agencies, or non-profit organizations focused on nanoinformatics and cheminformatics.

COURSE OUTCOMES: The Course Outcomes of Nanoinformatics and Cheminformatics are as follows:

CO 1	Knowledge of Nanoinformatics and Cheminformatics: Students will gain a thorough understanding of the principles and applications of nanoinformatics and cheminformatics, including the use of computational tools and techniques for the analysis of nanomaterials and chemical compounds.
CO 2	Analysis of Data: Students will learn how to collect and analyze data related to nanomaterials and chemical compounds, using a range of computational tools and techniques.
CO 3	Interdisciplinary Collaboration: Students will gain experience working in interdisciplinary teams, collaborating with experts from different fields to solve real-world problems related to nanotechnology and chemistry.
CO 4	Communication Skills: Students will develop strong oral and written communication skills, and will be able to effectively communicate their research findings to a variety of audiences.
CO 5	Ethical and Responsible Behavior: Students will develop a strong commitment to ethical and responsible behavior in scientific research, including the responsible use of computational tools and the appropriate handling of confidential data

Overall, the Course Outcomes of Nanoinformatics and Cheminformatics reflect the program's commitment to providing students with a strong foundation in the interdisciplinary fields of nanotechnology and chemistry, and preparing them for successful careers in research, academia, and industry, while promoting ethical and responsible behavior in scientific research.

CO-PO MAPPING TABLE:

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO2	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO3	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO4	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3
CO5	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3

MBT4.3 (C) (22): MEDICAL BIOTECHNOLOGY

Credits: 4

UNIT-I Medical biotechnology- History, Definition, applications and uses of recombinant DNA technology Products like "Insulin, growth factor, factor- VIII, tissue plasminogen activator, interferons, B-cell, Blood products-Erythropoietin"

UNIT – II Disease Diagnosis - Gene therapy- vector engineering and gene delivery methods, gene replacement, gene agumentation, gene silencing. Current strategies for development of vaccines against HBV, Malaria, Tuberculosis. Role of PCR and RFLP in disease prognosis

UNIT – III Definition – history of development of pharmaceutical products by biotechnology, scope of biotech products in pharmaceutical industry. Drug designing, drug receptor interactions, antagonism- reversible and irreversible.

UNIT-IV Vaccines- Genetic recombinant vaccine, recombinant vector based vaccines- live, subunit and their production of Hepatitis-B vaccines, HIV vaccine, pre-clinical, toxicological acute, sub acute and chronic studies,

Unit V: Definition of Clinical trials, Types of clinical trials Phase-I, Phase-II and Phase III. Animal models and Human trails. Human Rights Commissions.

REFERENCE BOOKS:

1) Biotechnology by B.D. Singh (Kalyani).
2) Molecular Biology and Biotechnology by Meyers, RA, A comprehensive Desk reference (VCH Publishers).
3) Biotechnology by U. Satyanarayna (Books & Allied (P) Ltd).
4) Biopharmaceuticals-Walsh, John Willey and Sons, New York 1998
5) Pharmaceutical Biotechnology – Daan J.A. Crommelin, Robest D. Sindelar, Daan J.A. Crommelin Amazon. WM
6) Physical Methods to characterize Pharmaceutical Protines-James N. Herron, Wimjishkoor and Daan J.A. Crommelin Amazon. Wm
7) From clone to clinic (Developments in Biotherapy) Daan J.A. Crommelin and H. SchellekomAmazon.Wm
8) Hand Book of Pharmaceutical Biotechnology - Jay P.Rho, Star 4 lonie The Haworth press, Alice Sr. Bringhamtoon, NY 13904, US Tramasbartifai, Harold L. Dorn's M. Sc.,

LEARNING OBJECTIVES: Medical biotechnology is an interdisciplinary field that applies principles of biology, chemistry, and engineering to the development of medical products and technologies. The learning objectives of medical biotechnology include:

LO 1	Understanding of human physiology: Students should have a thorough understanding of human physiology and anatomy, including cellular and molecular biology, biochemistry, and genetics.
LO 2	Knowledge of molecular biology techniques: Students should be proficient in molecular biology techniques, including DNA sequencing, gene expression analysis, and protein analysis.

LO 3	Understanding of drug discovery and development: Students should be familiar with the principles and techniques of drug discovery and development, including target identification and validation, high-throughput screening, and preclinical testing.
LO 4	Proficiency in biomanufacturing: Students should be able to design and optimize biomanufacturing processes for the production of various medical products, including biologics, vaccines, and gene therapies.
LO 5	Knowledge of biomaterials: Students should be able to design and synthesize biomaterials for various applications, including drug delivery, tissue engineering, and medical devices.

Overall, the learning objectives of medical biotechnology aim to provide students with the knowledge and skills to apply scientific and engineering principles to the development of medical products and technologies. Graduates of medical biotechnology programs can pursue careers in biotechnology, pharmaceuticals, healthcare, medical devices, and other related industries. They can also work in academic research institutions, government agencies, or non-profit organizations focused on medical biotechnology**.**

COURSE OUTCOMES: The course outcomes of medical biotechnology are designed to ensure that students are able to apply the principles of biotechnology to the development of medical products and technologies. Some of the key course outcomes of medical biotechnology include:

CO 1	Ability to design and perform experiments: Students should be able to design and perform experiments related to medical biotechnology, including molecular biology techniques, cell culture, and animal studies.
CO 2	Understanding of medical product development: Students should be familiar with the process of medical product development, including the stages of research, development, and regulatory approval.
CO 3	Ability to analyze and interpret data: Students should be able to analyze and interpret data obtained from experiments and clinical trials, and use this data to make informed decisions about the development of medical products
CO 4	Knowledge of regulatory requirements: Students should be familiar with the regulatory requirements for the development, production, and marketing of medical products, including FDA regulations.
CO 5	Ability to communicate scientific information: Students should be able to communicate scientific information effectively to both scientific and non-scientific audiences, through written reports, oral presentations, and other forms of communication.

Overall, the course outcomes of medical biotechnology aim to provide students with the knowledge and skills necessary to apply biotechnology principles to the development of medical products and technologies. Graduates of medical biotechnology programs can pursue careers in biotechnology, pharmaceuticals, healthcare, medical devices, and other related industries. They can also work in academic research institutions, government agencies, or non-profit organizations focused on medical biotechnology.

CO-PO MAPPING TABLE:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
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CO2	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO3	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO4	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3
CO5	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3

MBT 4.4 (A) (22): FERMENTATION TECHNOLOGY

Credits: 4

Unit I: Isolation, Screening, Preservation and Improvement of Industrially Important Microorganisms. Fundamentals involved in the Production of Industrial Microbial Products such as Details of the Fermenter, Synthetic and Natural Medium, Precursors, Antifoams, Sterilization Methods and Inoculum Preparation.

Unit II: Ethanol Production by Fermentation using Molasses, Starchy Substances. Production of Alcoholic Beverages like Beer and Wine. Production of Vinegar, Production of Citric Acid by Submerged and Solid State Fermentations.

Unit III: Sources of Industrial Enzymes, Production of Microbial Enzymes like Amylase and protease. Backer's Yeast and SCP Production. Production of Antibiotics: Penicillin & Streptomycin.

Unit IV: Introduction to Down Stream processing in Biotechnology – Recovery in Modern Versus Classical biotechnology. Principles behind separations. Solid-Liquid separation methods: Filtration, sedimentation and centrifugation, foam separation; Methods whole broth processing, Cell disruption techniques- General theory of Filtration, microfiltrafion, batch filters-plate and frame filters, continuous filters- rotary vacuum filters, cross flow filters and Role of filter aids. Precipitation method for recovery of protein.

Unit V: Concentration of products: Liquid-Liquid extraction - Batch techniques, Continuous techniques; Two phase aqueous extraction, and solvent recovery; adsorption Chromatography techniques: HPLC, Gas chromatography, and affinity chromatography Membrane processes: Ultra filtration. Reverse osmosis. Alternative separation processes: whole broth treatment, Liquid membranes and Electrophoresis, super critical fluid extractions, recombinant DNA for recovery. Drying and crystallization, Product stability, formulation and analysis.

REFERENCE BOOKS:

1) Stanbury P F., Whittaker A., and Hall S.J Principles of fermentation technology 2nd ed, 1997, Aditya books pvt. Ltd, New Delhi.
2) Cassida (Jr) L.E, Industrial microbiology 5th ed, 1993, Wileys eastern limited, New Delhi.
3) Asenjo J A., Separation process in Biotechnology, 1sted, 1990, Marcel Dekker, Inc., Newyork.
4) Ahuja S., Hand book of bioseparations 2nd ed, 2000, Academic press, Newyork.
5) Ladish M., Bioseparation engineering principles, practice and economics, 1st ed, 2001, John Wiley & sons. Inc.,Newyork.
6) Industrial Microbiology, Prescott and Dunn, 4th Edition, Chapman & Hall.

LEARNING OBJECTIVES: Fermentation technology involves the use of microorganisms to produce a variety of useful products, such as antibiotics, vaccines, biofuels, and food ingredients. The learning objectives of fermentation technology include:

LO 1	Understanding of microbiology: Students should have a thorough understanding of microbiology, including microbial growth, metabolism, and genetics
LO 2	Knowledge of fermentation processes: Students should be familiar with the principles and techniques of fermentation processes, including batch, fed-batch, and continuous fermentation.
LO 3	Proficiency in process design and optimization: Students should be able to design and optimize fermentation processes for the production of various products, including biologics, vaccines, and biofuels**..**
LO 4	Knowledge of bioreactor design: Students should be able to design and operate bioreactors for various applications, including microbial and mammalian cell culture.
LO 5	Proficiency in data analysis: Students should be able to analyze and interpret data obtained from experiments and industrial processes, and use this data to make informed decisions about process optimization.

Overall, the learning objectives of fermentation technology aim to provide students with the knowledge and skills to apply scientific and engineering principles to the development and optimization of fermentation processes for the production of various products. Graduates of fermentation technology programs can pursue careers in biotechnology, pharmaceuticals, food and beverage, and other related industries. They can also work in academic research institutions, government agencies, or non-profit organizations focused on fermentation technology.

COURSE OUTCOMES: The course outcomes of fermentation technology aim to ensure that students are equipped with the knowledge and skills to design, optimize, and operate fermentation processes for the production of various products. Some of the key course outcomes of fermentation technology include:

CO 1	Ability to design and optimize fermentation processes: Students should be able to design and optimize fermentation processes for the production of various products, including biologics, vaccines, and biofuels.
CO 2	Understanding the microbial physiology: Students should have a thorough understanding of microbial physiology, including microbial growth, metabolism, and genetics
CO 3	Understanding of downstream processing: Students should be familiar with downstream processing techniques, including cell harvesting, filtration, purification, and formulation.
CO 4	Ability to analyze and interpret data: Students should be able to analyze and interpret data obtained from experiments and industrial processes, and use this data to make informed decisions about process optimization.

CO 5	Proficiency in laboratory techniques: Students should be proficient in laboratory techniques related to fermentation technology, including microbial culture, media preparation, and analytical methods.

Overall, the course outcomes of fermentation technology aim to provide students with the knowledge and skills necessary to design, optimize, and operate fermentation processes for the production of various products. Graduates of fermentation technology programs can pursue careers in biotechnology, pharmaceuticals, food and beverage, and other related industries. They can also work in academic research institutions, government agencies, or non-profit organizations focused on fermentation technology.

CO-PO MAPPING TABLE:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	3	2	2	2	2	2	2	2	2	2	3
CO2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	3
CO3	2	2	2	2	3	2	2	2	2	2	2	2	2	2	3
CO4	2	2	3	2	3	2	2	2	3	2	2	2	2	2	3
CO5	2	2	3	2	3	2	2	2	3	2	2	2	2	2	3

MBT4.4 (B) (22): PHARMACEUTICAL BIOTECHNOLOGY

Credits: 4

UNIT-I: Definition - History of development of Pharmaceutical Products by biotechnological methods like genetic recombinant vaccines, microbial and non-microbial products - scope of biotech products and biochemical in pharmaceutical industry. Need to design a drug, drug receptor interactions, antagonisms, biological activity, efficacy and stimulus, recepors and ion channels, ion gating cooperatively effect of solvent on drug - receptor interactions, drug docking.

UNIT-II: Methods of testing products for abti-microbial potentials, pharmacological activities and biopesticidal properties -conventional and rapid enzyme inhibitor techniques; in vivo methods - use of animals models for confirmation of in vitro properties - transgenic systems - preclinical, toxicological studies, Acute, subacute, chronic studies. Clinical trials - definition - design - specific objectives - types of clinical trials -phase I, II & II - randomised controlled clinical trails - multicentric double nlind clinical trials - pharmaceutical/drug regulations for commercialising new biotech products for human use - PDA and Indian regulations.

UNIT – III Biotech products as medicines and pharmaceutical products: Biochemicals - enzymes like proteases - chemical like ethanol, vinegar, citric acid and glutamic acid; vitamins like B12; drugs for infection and metabolic, immunomodulatory -insulin - interferons, B-cell growth factors, Tissue plasminagen activator. r-DNA based production of regulatory protins, blood products, hormones, vaccines, Application of RELP in forensic, disease prognosis, genetic counselling, pedigree, variation.

UNIT - IV Vaccines - cell culture based vaccines - genetic recombinant vaccines - recombinant vector based vaccines -live and subunit - their production model - fermentation technology - expression systems - guideline for the production of genetic recombinant vaccines - Eg. Hepatitis B vaccine, HIV vaccine and other vaccines in pipeline.

Unit V: Application of biotechnology to Animal health and disease diagnosis, Development of kits and their application in disease diagnosis. Gene theraphy, vector engineering, strategies of gene deliver, gene replacement, augmentation, gene correction, gene regulation and silencing safety and bioethical issues in biotechnology.

REFERENCE BOOKS:

1) Biopharmaceuticals-Walsh, John Willey and Sons, NewYork 1998.
2) Pharmaceutical Biotechnology-DaanJ.A. Crommelin, RobestD. Sindelar, DaanJA Crommelin Amazon.
3) Physical Methods to characterize Pharmaceutical Protines- James. N.Herron, Wim Jiskoor and DaanJ.A.Crommelin Amazon. Wm From clone to clinic (Developments in Biotherapy)-DaanJ.A.Crommelin and H.Schellekom Amazon.Wm.
4) Hand Book of Pharmaceutical Biotechnology- Jay P.Rho, Star4lonie The Haworth press.
5) Alice Sr. Bringhamtpn, NY13904]US Drug discovery, Tamasbartifai, Harold L.Dorn's The Scientific world Ltd., Newburry, U.K.

LEARNING OBJECTIVES: Pharmaceutical biotechnology is a field of biotechnology that involves the use of biological systems to develop drugs and therapies for various diseases. The learning objectives of pharmaceutical biotechnology include:

LO 1	Understanding of the drug discovery process: Students should have a thorough understanding of the drug discovery process, including target identification, lead discovery, lead optimization, and preclinical testing.
LO 2	Knowledge of protein engineering: Students should be familiar with protein engineering techniques, including protein expression, purification, and modification, for the development of biologics and other protein-based drugs.
LO 3	Understanding gene therapy: Students should be able to design and develop gene therapies for various diseases, including cancer, genetic disorders, and infectious diseases.
LO 4	Understanding of drug delivery systems: Students should be familiar with drug delivery systems, including nanoparticles, liposomes, and other carrier systems, for the targeted delivery of drugs to specific tissues or cells.
LO 5	Knowledge of clinical trials: Students should have a thorough understanding of clinical trial design and conduct, including phases of clinical trials, ethical considerations, and data analysis.

Overall, the learning objectives of pharmaceutical biotechnology aim to provide students with the knowledge and skills to apply scientific and engineering principles to the development of drugs and therapies for various diseases. Graduates of pharmaceutical biotechnology programs can pursue careers in the biotechnology and pharmaceutical industries, academic research institutions, government agencies, or non-profit organizations focused on drug development and discovery.

COURSE OUTCOMES: The course outcomes of Pharmaceutical Biotechnology are as follows:

CO 1	Understanding of Pharmaceutical Biotechnology: Students will gain an in-depth understanding of the principles and applications of pharmaceutical biotechnology, including the use of biotechnological tools and techniques for the development and production of pharmaceuticals.
CO 2	Knowledge of Drug Design and Development: Students will learn about the process of drug design and development, including the identification of drug targets, the design and synthesis of lead compounds, and the preclinical and clinical testing of candidate drugs.
CO 3	Understanding of Drug Delivery Systems: Students will gain knowledge of various drug delivery systems, including nanoparticle-based drug delivery systems, liposomal drug delivery systems, and gene delivery systems.
CO 4	Biomanufacturing: Students will learn about the principles of biomanufacturing, including the development of scalable and cost-effective processes for the production of biopharmaceuticals.
CO 5	Communication Skills: Students will develop strong oral and written communication skills, and will be able to effectively communicate their research findings and biopharmaceutical development plans to a variety of audiences.

Overall, the course outcomes of Pharmaceutical Biotechnology reflect the program's commitment to providing students with a strong foundation in the interdisciplinary field of biotechnology, with a focus on the development and production of pharmaceuticals, and preparing them for successful careers in research, academia, and industry, while promoting ethical and responsible behavior in scientific research and biopharmaceutical development.

CO-PO MAPPING TABLE:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
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CO2	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO3	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO4	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3
CO5	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3

MBT4.4 (C) (22): TOOLS IN BIOTECHNOLOGY

Credits: 4

Unit I: Methods of Analysis of Replication of Single locus Replication initiation point mapping: Approach and implications, purification of restriction fragments containing replication intermediates, Topological analysis of plasmid DNA replication intermediates, Analysis of telomeric DNA replication using neutral alkaline 2D gel electrophoresis, chromatin immunoprecipitation of replication factors moving with replication fork, density transfer as a method to analyze the progression of DNA replication fork,

Unit II: Genome wise analysis methods Chip-chip to analyze the binding of replication proteins to chromatin using oligonucleotides DNA microarrays, analyzing origin activation patterns by changing experiments. Detection of replication origins using comparative genomics and recombination ARS assay, Isolation of restriction fragments containing origin of replication from complex genomes.

Unit III: Biochemistry and Biophysics Methods Isolation of recombinant DNA elongation proteins Invitro assays for studying helicase activities, the use of two amino fluorescence to study DNA polymerase function, Single molecule observation of prokaryotic DNA replication, The FAST-HALO assay for the assessment of DNA damage for the single cell level, Electron microscopic methods for studying In vivo DNA replication intermediates.

Unit IV: Cell biology and Genetics methods Visualization of DNA replication sites in mammalian nuclei, measuring of DNA content by Floucytometry in Fission Yeast. Assays used to study replication check point in Fission Yeast. Use of DNA combining to study SNA replication in genus and in human cell free systems

Unit V: Determining the replication dynamics of specific gene loci by single molecule analysis of replicated DNA. Identification of replicated fragments. High resolution mapping of points of site specific replication, DNA replication in nucleus. Application of alkaline sucrose degradation and analysis of DNA replication after DNA damage.

REFERENCES BOOKS:

1) DNA replication methods and protocols in Methods in Molecular Biology Edited by John N walker co edited by Soniya and Jacob Gelgard 2009. Humana press, New York.
2) General biochemistry and biophysics methods books.

LEARNING OBJECTIVES: The learning outcomes of the subject "Tools in Biotechnology" aim to equip students with the knowledge and skills required to understand and apply the different tools and techniques used in biotechnology research and industry. Some of the key learning outcomes of the subject include:

LO 1	Understanding of molecular biology techniques: Students should have a good understanding of molecular biology techniques, including PCR, cloning, DNA sequencing, and gene expression analysis

LO 2	Knowledge of bioinformatics tools: Students should be familiar with bioinformatics tools, including sequence analysis software, genome databases, and structural analysis tools.
LO 3	Proficiency in protein analysis techniques: Students should be proficient in protein analysis techniques, including protein expression, purification, and characterization.
LO 4	Understanding of imaging techniques: Students should have a good understanding of imaging techniques used in biotechnology, including microscopy, flow cytometry, and imaging mass spectrometry.
LO 5	Knowledge of genomics and proteomics: Students should be familiar with the principles of genomics and proteomics and their application in biotechnology research.

Overall, the learning outcomes of the subject "Tools in Biotechnology" aim to provide students with a strong foundation in the tools and techniques used in biotechnology research and industry. Graduates of biotechnology programs with a strong understanding of these tools can pursue careers in research and development, biomanufacturing, academic research institutions, or government agencies.

COURSE OUTCOMES: The course outcome of "Tools in Biotechnology" is to provide students with a comprehensive understanding of the various tools and techniques used in biotechnology research and industry. Some of the key course outcomes of this subject include:

CO 1	Developing molecular biology techniques: Students will be able to apply molecular biology techniques such as PCR, cloning, DNA sequencing, and gene expression analysis to solve research problems.
CO 2	Educating the studentsto analyze and characterize proteins using protein expression, purification, and characterization techniques.
CO 3	Understanding of imaging techniques: Students will have an understanding of imaging techniques such as microscopy, flow cytometry, and imaging mass spectrometry, and their application in biotechnology research.
CO 4	Proficiency in cell culture techniques: Students will be proficient in cell culture techniques such as media preparation, cell line maintenance, and transfection.
CO 5	Ability to practice laboratory safety: Students will be able to practice laboratory safety protocols when handling biological materials, hazardous chemicals, and equipment.

Overall, the course outcome of "Tools in Biotechnology" aims to equip students with the knowledge and skills required to work with the different tools and techniques used in biotechnology research and industry. Graduates of biotechnology programs with a strong understanding of these tools can pursue careers in research and development, biomanufacturing, academic research institutions, or government agencies.

CO-PO MAPPING TABLE:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
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CO3	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3
CO4	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3
CO5	3	2	3	2	3	2	2	3	3	2	2	2	2	2	3

PRACTICAL – I:

MBTP- 4.1. (22): PLANT AND ANIMAL TISSUE CULTURE

Credits -04

PLANT BIOTECHNOLOGY

1) Preparation of Murashige and Skoog's medium and its stock solutions
2) Sterilization of Medium, leaf or plant material
3) Sterilization of enzymes or hormones using membrane filters.
4) Formation of callus from leaf or cotyledons or seedling explants
5) Micropropagation of tree species or elite plants
6) Induction of somatic embryogenesis
7) Induction of shoots or roots (organogenesis)
8) Induction of cell suspension cultures
9) Production of secondary metabolites in cell suspension culture
10) Anther culture and Production of haploid plants
11) Induction of hairy root cultures using *Agrobacterium rhizogenesis*
12) Genetic transformation of tobacco leaf disks using *Agrobacterium tumefaciens*
13) Analysis of transformants using GUS activity (glucuronidase activity)
14) Protoplast isolation and fusion using polyethylene glycol

ANIMAL BIOTECHNOLOGY

1) Preparation of animal cell culture medium.
2) Media filtration
3) Determination of cell number and viability
4) Establishment of primary cultures from chick embryo liver
5) Establishment of primary cultures from chick embryo heart
6) Establishment of primary cultures from spleen cells
7) Culturing of lymphocytes
8) Karyotyping of animal cells (Lymphocytes)
9) Culturing of Hela cells
10) Subculturing of primary cultures
11) Cryopreservation of cells using liquid nitrogen

PRACTICAL –II:

MBTP- 4.2. (22): FERMENTATION TECHNOLOGY

Credits -04

1) Principles of bread making
2) Isolation of industrially important microorganisms from soil.
3) Isolation of amylase producing organisms from soil.
4) Production of α – amylase from *Bacillus Spp.* by shake flask culture.
5) Production of alcohol or wine using different substrates.
6) Estimation of alcohol by titrimetry.
7) Estimation of alcohol by calorimetric method.
8) Production of citric acid.
9) Estimation of citric acid by titrimetry.
10) Analysis of molasses by laneeynon double reduction method.
11) Quantification of biomass.
12) Determination of fermentation efficiency of batch production of ethanol.
13) Citric acid production by solid state fermentation.
14) Citric acid production by submerged fermentation.
15) Effect of sugar concentration on biomass yield for bakers yeast production and it's characterization.
16) Determination of kla.
17) Ethanol recovery from fermentation broth by distillation.
18) Citric acid recovery from filtration precipitation.
19) Recovery and purification of biomass from broth.

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