ACHARYA NAGARJUNA UNIVERSITY

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

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

M.Sc. NANO-BIOTECHNOLOGY

SYLLABUS

2022 - 2023 onwards

UNIVERSITY COLLEGE OF SCIENCES

PROGRAM CODE:

ANUCS14


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 establish 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. NANO-BIOTECHNOLOGY

VISION OF THE DEPARTMENT:

The vision of the course M.Sc. Nano Biotechnology is to provide students with a comprehensive understanding of the application of nanotechnology in biotechnology, and the potential of nano biotechnology to solve global challenges related to healthcare, environment, and energy. The program aims to prepare students to become leaders in the field of nano biotechnology by providing them with the necessary knowledge, skills, and research experience.

The vision of the program includes:

1) Training future leaders in nano biotechnology: The program aims to train and develop future leaders in the field of nano biotechnology by providing them with a rigorous education in the interdisciplinary fields of nanotechnology and biotechnology.
2) Developing solutions to global challenges: The program aims to develop innovative solutions to global challenges related to healthcare, environment, and energy using nano biotechnology.
3) Promoting interdisciplinary research: The program promotes interdisciplinary research by bringing together experts from different fields, including chemistry, biology, physics, and engineering.
4) The program fosters entrepreneurial skills by providing students with the opportunity to develop their own research projects and business plans.
5) Encouraging ethical and responsible research: The program encourages ethical and responsible research by promoting scientific integrity, transparency, and social responsibility.

Overall, the vision of M.Sc. Nano Biotechnology is to create a community of scientists and researchers who are committed to advancing the field of nanobiotechnology and developing innovative solutions to global challenges. Graduates of this program will be well-equipped to pursue careers in research and development, academia, and industry.

MISSION OF THE DEPARTMENT:

The mission of M.Sc. Nano Biotechnology is to provide students with a strong foundation in the interdisciplinary fields of nanotechnology and biotechnology, and to prepare them for careers in research, academia, and industry. The program aims to achieve this mission through the following objectives:

1) Understanding the importance of comprehensive education: The program provides students with a comprehensive education in the principles and applications of nanotechnology and biotechnology, with an emphasis on the intersection of the two fields.
2) The program emphasizes hands-on training in laboratory techniques, data analysis, and research methodology, to prepare students for careers in research and development.
3) Applying the interdisciplinary collaboration: The program encourages interdisciplinary collaboration by bringing together experts from different fields to promote innovation and problem-solving.
4) Promoting research and development: The program promotes research and development in the field of nano biotechnology, by providing students with the opportunity to conduct original research projects under the guidance of experienced faculty.
5) Adopting entrepreneurship: The program adopts leadership and entrepreneurship by providing students with the skills and knowledge needed to become successful leaders in academia, industry, and other sectors.
6) Making the students understand the importance of ethical and responsible behavior: The program emphasizes the importance of ethical and responsible behavior in research and development, by promoting scientific integrity, transparency, and social responsibility.

Overall, the mission of M.Sc. Nano Biotechnology is to provide students with a strong foundation in the interdisciplinary fields of nanotechnology and biotechnology, and to prepare them for successful careers in research, academia, and industry, while promoting ethical and responsible behavior in scientific research.

ACHARYA NAGARJUNA UNIVERSITY
UNIVERSITY COLLEGE OF SCIENCES
DEPARTMENT OF BIOTECHNOLOGY
M.Sc. NANO-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. Nano biotechnology students are:

1) To explain the students of the foundation in fundamental concepts in nano biotechnology, including molecular biology, genetics, biochemistry, and microbiology, among others, enabling them to apply these principles to solve complex problems in biotechnology.
2) Describing the importance of 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 nanobiotechnology.
3) Explaining the importance of application of bioinformatics and computational tools for the analysis and interpretation of biological data.
4) Developing the skills of the students for better careers in academia, industry, and government, and to develop the skills necessary to succeed in nano biotechnology fields.
5) Understand and critically evaluate scientific literature and stay current with developments in nano biotechnology field.

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

PROGRAMME OUTCOMES (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. Nano biotechnology students are:

1) Apply knowledge of fundamental concepts in nano biotechnology, including molecular biology, genetics, biochemistry, and microbiology, among others, to solve complex problems in nano biotechnology.
2) Understanding and conducting experiments, analyze data, and interpret results using advanced laboratory techniques and methods used in nano 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 nano 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 nano biotechnology research and development.
8) Applying nano 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 nano biotechnology research and development.
10) Organizing the professional training in nano biotechnology or related fields, or transition into a nano biotechnology -related career.

These POs are designed to provide M.Sc. Nano 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. NANO-BIOTECHNOLOGY
COURSE STRUCTURE

SEMESTER-I

S. No	Components of Study	Code	Title of the Paper	No. of Credits	Internal Assessment Marks	Semester end Examinations Marks	Total Marks	No. of hours /week
1.	**Mandatory Core**	**NB1.1(22)**	General Microbiology &	4	30	70	100	5
2.		**NBT1.2(22)**	Principles of Nano chemistry	4	30	70	100	5
3.	**Compulsory Foundation**	**NB1.3 (a) (22)**	Nanotechnology	4	30	70	100	5
4.	**Elective Foundation**	**NB1.4 (a) (22)**	Bioanalytical techniques	4	30	70	100	5
		NB1.4 (b) (22)	Biomolecules					
		NB1.4 (c) (22)	Cell Biology					
5.	**Practical -I**	**NBP1.1 (22)**	Microbiology & Immunology	4	30	70	100	6
6.	**Practical-II**	**NBP1.2 (22)**	Nanochemistry & Nanotechnology	4	30	70	100	6
TOTAL				**24**	**180**	**420**	**600**	
Elective Foundation - Choose one paper.								

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**	**NB2.1(22)**	Molecular Biology & Genetic Engineering	4	30	70	100	5
2.		**NBT2.2(22)**	Biochemical engineering & Enzyme	4	30	70	100	5
3.	**Compulsory Foundation**	**NB 2.3 (22)**	Nanoinformatics & Cheminformatics	4	30	70	100	5
4.	**Elective Foundation**	**NB2.4 (a) (22)**	Environmental Nanotechnology	4	30	70	100	5
		NB2.4 (b) (22)	Biochemistry					
		NB2.4 (c) (22)	Bioinformatics					
5.	**Practical -I**	**NBP2.1 (22)**	Molecular Biology & Genetic Engineering	4	30	70	100	6
6.	**Practical-II**	**NBP2.2 (22)**	Environmental Nanobiotechnology & Enzyme Engineering	4	30	70	100	6
TOTAL				**24**	**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**	**NB 3.1(22)**	Industrial Nanotechnology	4	30	70	100	5
2.		**NB 3.2(22)**	Bioreactor designing, Modelling & Simulation of Bioprocess	4	30	70	100	5
3	**Elective-I**	**NB 3.3 (a)(22)**	Plant & Animal Biotechnology	4	30	70	100	5
		NB 3.3 (b)(22)	Food Technology					
		NB 3.3 (c)(22)	Bioethics, Bio-safety. IPR and Patent Laws					
4	**Elective-II**	**NB 3.4 (a)(22)**	Bioprocess Validation and Current Good Manufacturing Process CGMP	4	30	70	100	5
		NB 3.4 (b)(22)	Protein Engineering					
		NB 3.4 (c)(22)	Tools of Biotechnology					
5.	**Practical -I**	**NBP3.1 (22)**	Industrial Nanotechnology	4	30	70	100	6
6.	**Practical-II**	**NBP3.2 (22)**	Plant & Animal Biotechnology	4	30	70	100	6
	SKILL ENHANCED COURSE			4	00	00		
	TOTAL			**28**	**180**	**420**	**600**	
Elective II- Choose one paper								
Elective II- Choose one paper								

SEMESTER-IV

1	**NB 4.1. (22)- Project Report**	8	-	200	200
2	**NB 4.2. (22)- Seminar**	4	-	100	100
GRAND TOTAL		**92**	**540**	**1560**	**2100**

FIRST SEMESTER

ACHARYA NAGARJUNA UNIVERSITY
UNIVERSITY COLLEGE OF SCIENCES
DEPARTMENT OF BIOTECHNOLOGY
M.Sc. NANO-BIOTECHNOLOGY
SEMESTER-I

NB 1.1 (22): GENERAL MICROBIOLOGY AND IMMUNOLOGY

CREDITS: 04

COURSE OUTCOMES: General Microbiology and Immunology is a course that covers the basic principles and concepts of microorganisms and the immune system. By the end of this course, students should be able to:

CO1	Understanding the characteristics and classification of microorganisms such as bacteria, viruses, fungi, and parasites.
CO2	Explaining the structure and function of microbial cells, including their metabolism, growth, and reproduction.
CO3	Understand the principles of microbial genetics and gene expression.
CO4	Discuss the relationship between microorganisms and human health, including the role of microorganisms in disease, infection, and immunity.
CO5	Understand the basic concepts of immunology, including the innate and adaptive immune responses, antigen recognition, and the mechanisms of immune regulation, f vaccine development, immunotherapy, and the use of antibiotics and antiviral drugs.

Overall, this course provides a foundation in the field of microbiology and immunology, including the basic concepts and principles that underlie our understanding of microorganisms and the immune system.

Unit I: Introduction to microbiology - Scope and history, Characterization and outline classification of micro organisms, Ultra structure and function of bacterial cell, Cultivation of bacteria, Nutrient media, Isolation and enrichment of cultures, Pure culture, Maintenance and preservation of bacteria. Brief description of Algae, Fungi, Viruses, Bacteriophages, and Mycoplasmas. Economic importance of microorganisms.

Unit II: Nutritional requirements of bacteria; Essentials of microbial nutrition. Phototrophs, chemotrophs,and heterotrophs; Pure and enrichment culture methods; Microbial growth kinetics amitosis and binary fission, Batch and continuous cultures; Chemostats and turbidostats.

Unit III: Methods of sterilization of media. bacteria; Control of microorganisms - physical and chemical methods. Aspects of metabolism - Aerobic and anaerobic. Microbiology of water, food, soil and milk. Microbial toxins.

Unit IV: Immunology - The lymphoid system - Types of immunity. Cells and organs of the immune system. Antigens, Antibodies. Antibody diversity. generation of Immunodiagnostics - antigen-antibody interactions, RIA, FACS, ELISA and Immunoblotting. Hybridoma Technology and applications.

Unit V: Major Histocompatibility Complex, Antigen processing and presentation pathways,. Transplantation immunology. The T cell receptor - structure and function. Types of Hypersensitivity. Complement system - and pathways . Autoimmunity, hypersensitivity. Vaccines - Routes of administration. Designing and production of vaccines.

RECOMMENDED BOOKS:

1) Prescott L.M. Harley J.P Klein D.A Microbiology, 6th ed, 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 KindtThomas J. ,Osborne, Barbara A., Goldsby, Richard A. Kuby Immunology 6/e, 2006, W.H. Freeman, Madison avenue, New York.
6) Immunobiology, 6th edition, Charles A. Janeway, Garland Science Publishers.
7) Cellular and Molecular Immunology, 5th edition, Abul K. Abbas and Andrew H. Lichtman. Elsevier publications.
8) Immunology, Immunopathology and Immunity, Stewart Sell, Edward E M, 6 ed,2001 ASM press, Washington.
9) Roitt's Essential Immunology Roitt I.M and Delves P.I, 10th edition, 2001, Blackwell publishers.

LEARNING OBJECTIVES: The learning objectives of General Microbiology and Immunology typically include:

LO 1	Understanding the basic principles of microbiology, including the classification, structure, and function of microorganisms.
LO 2	Understanding the diversity of microorganisms, including bacteria, viruses, fungi, and protozoa, and their roles in ecosystems and human health.
LO 3	Understanding the basic principles of immunology, including the structure and function of the immune system, the mechanisms of immune responses, and the principles of vaccination.
LO 4	Understanding the major classes of pathogens and their mechanisms of pathogenesis, including bacterial, viral, fungal, and parasitic infections.
LO 5	Understanding the major classes antibodies and MHC colecules and know in the properties of antigens and learning the principles of microbial genetics and genomics, including the mechanisms of genetic variation and the use of genetic techniques in microbiology and immunology research.

Overall, the learning objectives of General Microbiology and Immunology are to provide students with a solid foundation in the basic principles of microbiology and immunology, and to prepare them for further study and careers in these fields.

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	2	2	3	2
CO2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2
CO3	3	2	3	2	3	2	2	3	3	2	2	2	2	3	2
CO4	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2
CO5	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2

NB 1.2 (22): PRINCIPLES OF NANOCHEMISTRY

Credits: 04

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 ID, 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.

RECOMMENDED BOOKS:

1) Ozin, Geoffrey A., Arsenault, Andre C., Cademartiri, Ludovico A Chemical Approach to Nanomaterials 2nd ed., 2009, 820 p, Springer Publications.
2) Jonathan W. Steed, David R. Turner, Karl Wallace Core 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:

CO1	Explain the basic principles of nanoscale science and the properties of nanomaterials, including their synthesis and characterization
CO2	Discuss the applications of nanotechnology in various fields, including electronics, energy, medicine, and catalysis.
CO3	Understand the environmental, health, and safety concerns associated with the production and use of nanomaterials
CO4	Understanding and optimizing nanomaterials for specific applications using critical thinking and problem-solving skills.
CO5	Describing the laboratory experiments for the synthesis, characterization, and analysis of nanomaterials

Overall, a course Biotechnology with Nanochemistry as one of the subjects 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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO	PSO2	PSO3	PSO	PSO5
CO1	3	2	3	2	3	2	2	3	3	2	2	2	2	3	2
CO2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2
CO3	3	2	3	2	3	2	2	3	3	2	2	2	2	3	2
CO4	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2
CO5	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2

NB 1.3 (A) (22): NANOTECHNOLOGY

Credits: 04

Unit I: Introduction to Quantum and Statistical Physics: Electrons as waves, wave mechanics, Schrodinger 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 od surcace 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.

RECOMMENDED 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 byWR Fahrner- Springer.
5) Encyclopedia of Nano technology by M. Balakrishna Rao and K.Krishna Reddy Vol I to X

LEARNING OBJECTIVES: Nanotechnology is a field of science that focuses on the study and manipulation of materials at the nanoscale level. By the end of a course on nanotechnology, learners should be able to:

LO l	Understand the fundamental principles of nanotechnology, including the physical and chemical properties of nanomaterials, their synthesis, and characterization
LO 2	Identify and describe the various types of nanomaterials, including nanoparticles, nanotubes, and nanofibers, and their potential applications in various fields such as electronics, energy, medicine, and environmental science.
LO 3	Describe the unique properties of nanomaterials, including their size-dependent properties, optical and electronic properties, and their interactions with biological systems.
LO 4	Understand the ethical, social, and environmental implications of nanotechnology, including potential risks associated with the use and disposal of nanomaterials.
LO 5	Understand the ethical, social, and environmental implications of nanotechnology, including potential risks associated with the use and disposal of nanomaterials

Overall, a course on nanotechnology provides students with a foundation in the science and technology of materials at the nanoscale, and prepares them to apply this knowledge in various fields and to critically evaluate the potential benefits and risks of nanotechnology.

COURSE OUTCOMES: By the end of a course on nanotechnology, students should be able to:

CO1	Explain the principles of nanotechnology, including the unique physical and chemical properties of nanomaterials and their applications.
CO2	Understand the synthesis and characterization techniques of nanomaterials.
CO3	Analyze the properties of different types of nanomaterials and their potential applications in various fields.
CO4	Describe the ethical, social, and environmental implications of nanotechnology.
CO5	Understand the current state of research and development in nanotechnology and the challenges and opportunities in this field.

Overall, the course aims to provide students with a solid foundation in the science and technology of materials at the nanoscale, preparing them to apply this knowledge in various fields and to critically evaluate the potential benefits and risks of nanotechnology**.**

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	2	2	2	2	2	3	2
CO2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2
CO3	3	2	3	2	3	2	2	3	3	2	2	2	2	3	2
CO4	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2
CO5	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2

NB 1.4 (A) (22): BIOANALYTICAL TECHNIQUES

Credits: 04

Unit I: Centrifugation: Principles of centrifugation. Concept of RCF. Different types of instruments and rotors used. Preparative, differential and density gradient centrifugation. Analytical Ultracentrifuge. Chromotography: 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 -Lambert's law. Principles and applications of colorimetry. Flourimetry, Atomic absorption spectrophotometry. Basic Principles and applications of UV, IR, ESR, NMR and Mass spectroscopy.

Unit III: Microscopy: Basic principles of phase contrast, polarization, fleuorescence and electron microscopy. Electrophoresis: Principles of electrophoretic separation, Zonal and continuous electrophoresis. Different types of electrophoresis - Paper, Cellulose acetate. 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-label1ed biomolecules. Radiation hazards and methods for prevention and containment

Unit V: Biostatistics: Probability and distribution, polsson and binomial distributions. Measurement of central tendency (Mean. mode and range) and dispersion (Standard error and standard deviation). Populations and Sampling, Tests of significance, students t-test for small samples, chi2 test of analysis, Large scale analysis of sample -SNV and ANOVA; Computer applications in biotechnology.

RECOMMENDED BOOKS:

1) Pattabhi V. and Gautham N. Biophysics, 1st ed, 2005, Narosa publishing house, New Delhi. Manz A, Pamme. N. Lossifidis. D, Bioanalytical Chemistry 1st ed, 2004, Pmperial college press, London.
2) Upadhyay, Upadhyay and Nath, Biophysical chemistry, 5th edition, 2002, Himalya publishing house, New Delhi
3) Pagano M. and Gauvreau K., Principles of Biostatistics, Duxbury Thomson learning.
4) Wilson, K. and Walker, 1M, 5th edition, Principles and Techniques of Practical Biochemistry, Cambridge University Press, New York, USA

LEARNING OBJECTIVES: Bioanalytical Techniques is a course that teaches students how to analyze biomolecules using various laboratory techniques. By the end of this course, learners should be able to:

LO l	Understand the different types of bioanalytical techniques and their applications.
LO 2	Perform basic laboratory techniques used in the analysis of biomolecules.
LO 3	Analyze and interpret data obtained from bioanalytical techniques.
LO 4	Evaluate the advantages and limitations of different bioanalytical techniques.
LO 5	Choose the appropriate bioanalytical technique for a given research question.

Overall, this course provides students with the necessary skills and knowledge to perform and interpret different laboratory techniques used in the analysis of biomolecules. It prepares students to apply these skills in various fields such as biotechnology, biochemistry, and medical research.

COURSE OUTCOMES: A course on Bioanalytical Techniques aims to teach students how to analyze biomolecules using laboratory techniques. By the end of this course, students should be able to:

CO1	Understand the theory and principles of bioanalytical techniques such as chromatography, electrophoresis, mass spectrometry, and immunoassays.
CO2	Perform basic laboratory techniques used in the analysis of biomolecules, such as protein purification, enzyme assays, and DNA sequencing.
CO3	Analyze and interpret data obtained from bioanalytical techniques to draw conclusions about the composition and properties of biomolecules.
CO4	Understanding the advantages and limitations of different bioanalytical techniques and choose the appropriate technique for a given research question.
CO5	Understanding the experiments to analyze biomolecules using bioanalytical techniques and interpret the results.

Overall, this course provides students with a solid foundation in the theory and practical skills required to analyze biomolecules using laboratory techniques. The course prepares students to apply this knowledge to research questions in a variety of fields, including biochemistry, biotechnology, and medical 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	3	2	3	2	2	3	3	2	2	2	2	3	2
CO2	3	2	3	2	3	2	2	3	3	2	2	2	2	3	2
CO3	3	2	3	2	3	2	2	3	3	2	2	2	2	3	2
CO4	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2
CO5	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2

NB 1.4 (B) (22): CHEMISTRY OF BIOMOLECULES

Credits: 04

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 Go.

Unit II: Chemical equilibrium: Equilibrium and non-equilibrium reactions. The relationship between Go, Equilibrium constant and standard state. Measurement of changes in standard free energy, Oxidation - reduction potentials in biological processes, Relationship between equalibrium 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.

RECOMMENDED BOOKS:

1) Lehninger Principles of Biochemistry,4th edition, Nelson, David L. , Cox, Michael M. 2005, W.H. Freeman, Madison avenue,New york.
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. Freean, Madison avenue, New york.
4) Harper's Biochemistry, Murray R.K, Granner D.K , Mayes P.A and Rodwell V.W 26th edition,
5) 2003 Mc graw-Hill professional publishers, New Delhi.
6) 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	Interpret 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 nanobiotechnology research and development

These learning objectives are designed to provide M.Sc. nanobiotechnology 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 nanobiotechnology, as well as careers in biotech-related fields.

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

CO I	Understanding the chemical structures of biomolecules such as carbohydrates, lipids, nucleic acids, and proteins.
CO2	Evaluating scientific literature related to the chemistry of biomolecules, and communicating scientific findings effectively in written and oral formats
CO3	Developing critical thinking skills necessary for designing and conducting experiments related to the chemistry of biomolecules
CO4	Applying the principles of the chemistry of biomolecules to solve problems in nanobiotechnology research and development
CO5	Developing 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 nanobiotechnology 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	PO1	PO2	PO3	PO4	POS	PO6	PO7	POS	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	2	2	2	2	2	2	3	2	3	2	3
CO2	2	2	2	2	2	2	2	2	2	2	3	2	3	2	3
CO3	3	2	3	2	3	2	2	3	3	2	3	2	3	2	3
CO4	3	2	3	2	3	2	2	3	3	2	3	2	3	2	3
CO5	3	2	3	2	3	2	2	3	3	2	3	2	3	2	3

NB 1.4 (C) (22): CELL BIOLOGY

Credits: 04

Unit I: Diversity of cell size and shape, Ultrastructure, Cell theory, Cell isolation, Cell disruption, Centrifugation for separaton of cell contents, Biochemical methods for the identification of Cell organnelles (Marker enzytmes) Ultra structure, Composition and functions of organells in eukaryotes. Nucleus, Endoplasmicreticulam, 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.

RECOMMENDED 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,
3) *ASM Press and Sinauer Associates, Inc.*
4) De robertis E.D.P and E.M.F Derobertis Cell and molecular biology 8th ed, 1996, Warley publishers, New Delhi.
5) Cell and Molecular Biology: Concepts and Experiments, 4th edition, Gerald Karp, Wiley Publishers, New York
6) 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 nanobiotechnology students may include:

LO 1	Understanding the basic structure and functions of cells, including organelles and the cytoskeleton
LO 2	Understanding the principles of membrane transport, including diffusion, osmosis, and active transport.
LO 3	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
LO 5	Developing critical thinking skills necessary for designing and conducting experiments related to cell biology.

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 nanobiotechnology 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 nanobiotechnology students may include:

CO1	Describe the basic structure and functions of cells, including organelles and the cytoskeleton.
CO2	Analyze the principles of cell signaling, including receptor-ligand interactions, signal transduction pathways, and gene expression regulation.
CO3	Evaluate the ethical and regulatory issues related to cell biology research.
CO4	Apply the principles of cell biology to solve problems in biotechnology research and development.
CO5	Analyze and interpret 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 nanobiotechnology 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 nanobiotechnology 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	PO1	PO2	PO3	PO4	POS	PO6	PO7	POS	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	2	2	2	2	2	2	2	2	3	2	3
CO2	3	2	3	2	3	2	2	3	3	2	3	2	3	2	3
CO3	2	2	2	2	2	2	2	2	2	2	3	2	3	2	3
CO4	3	2	3	2	3	2	2	3	3	2	3	2	3	2	3
CO5	3	2	3	2	3	2	2	3	3	2	3	2	3	2	3

PRACTICAL-I:

NBP 1.1 (22): MICROBIOLOGY AND IMMUNOLOGY

Credits: 04

MICROBIOLOGY

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

IMMUNOLOGY

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

PRACTICAL-II:

NBP 1.2 (22): NANOCHEMISTRY AND NANOTECHNOLOGY

Credits: 04

1) Preparation of nanocrystals
2) Liposome targeted directed drug delivery using nanotechnology
3) Synthesis of nanoPolymers
4) Optical and electronic measurement of charge transport in biomolecules
5) Detection methods of drug delivery Biomarker generation using nanoparticles Polymer nanoparticles in cancer therapy

SECOND SEMESTER

M.Sc. NANO-BIOTECHNOLOGY

SEMESTER-II

NB 2.1 (22): MOLECULAR BIOLOGY & GENETIC ENGINEERING

Credits: 04

Unit I: Replication of DNA, Mutations, Repair mechanisms, Transcription, Post transcriptional modifications, Translation, Protein trafficking. Regulation of gene expression.

Unit II: Introduction to Gene Manipulation. Host controlled restriction modification. Classification of restriction enzymes and isoschizomers. DNA methylation enzymes and modification of sites. Enzymes used in molecular cloning, Polymerases, ligases, phosphatases, kinases and nucleases. Cloning vehicles -Plasmid, Bacteriophage, Cosmid, Yeast shuttle and Viral vectors.

Unit III: Construction of genomic and cDNA libraries. Strategies for the construction of genomic and cDNA libraries and advantages of cDNA libraries. Methods of gene cloning - Complementation technique. Polymerase chain reaction technique. Transposon tagging and Map based cloning. Organisation of cloned insert; size, mapping of restriction sites, subcloning and location of segment of interest. Methods of gene sequencing. The Maxam-Gilbert's, Sanger's and automated sequencing.

Unit IV: Isolation of cloned genes based on genetic, immunochemical and blotting methods. Factors influencing the expression of cloned genes. Chemical synthesis of DNA (Oligos). Methods of gene transfer - Microinjection, Microprojectile bombardment (Gene gun method), Electroporation and Agrobacterium mediated transformation. Production of transgenic plants. Use of reporter genes.

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

LEARNING OBJECTIVES: The learning objectives for a subject on Molecular Biology and genetic engineering for PG nanobiotechnology students may include:

LO l	Understanding the fundamental concepts of molecular biology, including the structure and function of nucleic acids, DNA replication, transcription, translation, and gene regulation.
LO 2	Understanding the applications of molecular biology in nanobiotechnology, including gene therapy, genetic engineering, and bioproduction of proteins.
LO 3	Understanding the ethical and societal implications of molecular biology, including issues related to genetic testing, genetic counselling, and genetic privacy.

LO 4	Understanding the fundamental principles of genetic engineering, including gene cloning, DNA sequencing, and gene editing.
LO 5	Developing knowledge of genetic tools and techniques, including restriction enzymes, plasmids, Polymerase chain reaction (peR).

Upon completion of this course, students should be able to apply the principles and techniques of

molecular biology to real-world problems in nanobiotechnology. They should have a thorough understanding of the potential applications of molecular biology and genetic engineering in gene therapy, genetic engineering, and bioproduction of proteins. Graduates of this program may pursue careers in the nanobiotechnology 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 Outcome COURSE OUTCOMES: By the end of a course on Molecular Biology and Genetic Engineering in nanobiotechnology, students should be able to:

CO l	Understanding the molecular basis of life processes and the role of molecular biology in biotechnology. And knowing the structure, function, and regulation of DNA, RNA, and proteins.
CO2	Developing skills in genetic engineering, including the design and construction of recombinant DNA molecules.
CO3	Describe the molecular tools and techniques used in genetic engineering, such as restriction enzymes, DNA ligase, peR, and gene cloning.
CO4	Explain the principles of genetic engineering and its applications, including the production of recombinant proteins, genetic modification of crops.
CO5	Analyze the ethical, social, and legal issues surrounding genetic engineering and its applications.

Overall, the course should equip students with a comprehensive understanding of the concepts, techniques, and applications of Molecular Biology and 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	POS	PO6	PO7	POS	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	2	2	2	2	2	2	3	2	3	2	3
CO2	3	2	3	2	3	2	2	3	3	2	3	2	3	2	3
CO3	3	2	3	2	3	2	2	3	3	2	3	2	3	2	3
CO4	3	2	3	2	3	2	2	3	3	2	3	2	3	2	3
CO5	3	2	3	2	3	2	2	3	3	2	3	2	3	2	3

NB 2.2 (22): BIOCHEMICAL ENGINEERING & ENZYME BIOTECHNOLOGY

Credits: 04

Unit I: Introduction to Biochemical Engineering. Units and dimensions. Flow sheets. Material and energy balances. Basic biochemical engineering calculations. Stochiometry: Yield concepts. 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 agitated vessels with aeration and without aeration. Oxygen requirements of microbial cultures. Oxygen transfer by aeration and agitation. Methods of Determination of oxygen transfer coefficient. Factors affecting oxygen transfer coefficient. Correlation for volumetric oxygen mass transfer coefficient.

Unit III: 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 and other cell culture products.

Unit IV: Diversity and functions of enzymes. Enzymes from plant, animal and microbial sources. Production of industrially important enzymes. Application of enzymes in Chemical and Pharmaceutical industries. Application of immobilized enzymes. Techniques of enzyme extraction from plant, animal and microbial sources. Principles and techniques used for immobilization of enzymes and whole cells.

Unit V: Design and construction of novel proteins and enzymes, Conformation of proteins in general and enzymes in particular, Effect of amino acids on structure of proteins, Energy status of a protein molecule, Kinetics of protein folding, Physical methods such as x-ray crystallography for determination of protein structure. Types of site directed mutagenesis for specific protein function and their applications in enzyme engineering. Principles and applications of Nanotechnology

LEARNING OBJECTIVES: A course in Biochemical Engineering & Enzyme Biotechnology teaches students about the engineering principles and applications of enzymes in the biotechnology industry. By the end of this course, students should be able to:

LO l	Understand the fundamental principles of biochemical engineering and enzyme biotechnology, including enzyme kinetics and enzyme-catalyzed reactions.
LO 2	Analyze the production and purification of enzymes, including the use of recombinant DNA technology.
LO 3	Evaluate the applications of enzymes in various industrial processes, such as food and beverage production, pharmaceuticals, and bioremediation

LO 4	Understanding and optimizing enzyme-catalyzed processes, including bioreactor design and operation.
LO 5	Understand the challenges and limitations of enzyme biotechnology, including enzyme stability and immobilization.

Overall, this course provides students with a foundation in the theory and practical skills required to engineer and utilize enzymes in various industrial processes. The course prepares students to apply this knowledge to real-world problems in the biotechnology industry.

COURSE OUTCOMES: A course in Biochemical Engineering & Enzyme Biotechnology teaches students about the engineering principles and applications of enzymes in the nanobiotechnology industry. By the end of this course, students should be able to:

CO l	Understand the fundamental principles of biochemical engineering and enzyme biotechnology, including enzyme kinetics and enzyme-catalyzed reactions.
CO2	Analyze the production and purification of enzymes, including the use of recombinant DNA technology.
CO3	Evaluate the applications of enzymes in various industrial processes, such as food and beverage production, pharmaceuticals, and bioremediation.
CO4	Understanding and optimizing enzyme-catalyzed processes, including bioreactor design and operation.
CO5	Understand the challenges and limitations of enzyme biotechnology, including enzyme stability and immobilization.

Overall, this course provides students with a foundation in the theory and practical skills required to engineer and utilize enzymes in various industrial processes. The course prepares students to apply this knowledge to real-world problems in the nanobiotechnology industry.

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	2	2	3	2	3	2	3
CO2	3	2	3	2	3	2	2	3	3	2	3	2	3	2	3
CO3	3	2	3	2	3	2	2	3	3	2	3	2	3	2	3
CO4	2	2	2	2	2	2	2	2	2	2	3	2	3	2	3
CO5	2	2	2	2	2	2	2	2	2	2	3	2	3	2	3

NB 2.3 (22): NANOINFORMATICS AND CHEMIINFORMATICS

Credits: 04

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	Understanding the 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	Explaining the applications of 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

LO 4	Descrbing the 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	Explaing the 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:

CO1	Understanding 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.
CO2	Explaining the Data: Students will learn how to collect and analyze data related to nanomaterials and chemical compounds, using a range of computational tools and techniques.
CO3	Explaining the interdisciplinary teams, collaborating with experts from different fields to solve real-world problems related to nanotechnology and
CO4	Students will develop strong oral and written communication skills, and will be able to effectively communicate their research findings to a variety of audiences.
CO5	Understanding the 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	POS	PO6	PO7	POS	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSOS
CO1	2	2	2	2	2	2	2	2	2	2	3	2	3	2	3
CO2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	3
CO3	2	2	2	2	2	2	2	2	2	2	2	2	3	2	3
CO4	3	2	3	2	3	2	2	3	3	2	3	2	3	2	3
CO5	2	2	2	2	2	2	2	2	2	2	3	2	3	2	3

NB 2.4 (A) (22): ENVIRONMENTAL NANOTECHNOLOGY

Credits: 04

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: Reduced waste and improved energy efficiency, Pollution by Nano-particles.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: Energy conversion. Hierarchical self-assembled nano-structures for adsorption of heavy metals. Biocides, Four stage alternatives, Refuse disposal - Treatment methods, case studies and effluent from distillery, tannery, pharmaceuticals, fertilizers, pulp and paper industry.

Unit IV: Developing Environmental Regulations Pertinent to Nanotechnology. Toxic. Substances. Control. Act. (TSCA), Federal. Insecticide,. Fungicide and. Rodenticide. Act. (FIFRA), Clean. Air. Act.(CAA), Clean. W ater. Act. (CWA), Resource. Conservation and Recovery. Act. (RCRA), Pollution. Prevention. Act.(PPA), Federal. Food,. Drug,. and. Cosmetic. Act. (FEDCA, National Institute for.Occupational.Safety.and.Health.(NIOSH), Emerging. State. and. Local. Regulation. of. Nanomaterials

Unit V: Analyses of Nanoparticles in the Environment Compositional. Analysis Surface. Area, Product. Characterization and Air Monitoring, Sampling and Analysis of Waters and Soils for Nanoparticles. Treatment of Nanoparticles in Wastewater, Application of nanoparticles in Pollution control Waste remediation: Nanoporous polymers and their applications in water purification, Photo-catalytic fluid purification

LEARNING OBJECTIVES: A course on Environmental Nanotechnology teaches students about the use of nanotechnology in addressing environmental issues. By the end of this course, students should be able to:

LO l	Understand the principles of nanotechnology and its applications in environmental science and engineering.
LO 2	Describing the impact of nanoparticles on environmental systems, including toxicity and fate and transport.
LO 3	Explaining the potential applications of nanotechnology in environmental remediation, including the removal of Pollutants from soil and water.
LO 4	Understand the regulations and ethical considerations surrounding the use of nanotechnology in environmental applications.
LO 5	Describing the experiments to investigate the behavior of nanoparticles in environmental systems.

Overall, this course provides students with a foundation in the theory and practical skills required to apply nanotechnology to environmental issues. The course prepares students to apply this knowledge to real-world problems in environmental science and engineering.

COURSE OUTCOMES: Environmental Nanotechnology is a course that focuses on the use of nanotechnology in addressing environmental issues. By the end of this course, students should be able to:

CO l	Understanding the impact of nanoparticles on environmental systems, including toxicity and fate and transport.
CO2	Understand the basics of nanotechnology and its applications in environmental science and engineering.
CO3	Describing the potential applications of nanotechnology in environmental remediation, such as the removal of Pollutants from soil and water.
CO4	Understand the regulations and ethical considerations surrounding the use of nanotechnology in environmental applications.
CO5S	Understanding the experiments to investigate the behavior of nanoparticles in environmental systems.

Overall, this course provides students with the necessary knowledge and skills to apply nanotechnology to solve environmental problems. The course prepares students to analyze the potential risks and benefits of using nanoparticles in the environment and to design and conduct experiments to investigate the behavior of nanoparticles in environmental systems.

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	2	2	2	2	2	2	2
CO2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

NB 2.4 (B) (22): BIOCHEMISTRY

Credits: 04

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

Unit II: Biochemistry of photosynthesis, C3, C4 and CAM 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 NH4 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.

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

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.
LO 2	Understanding the regulation of metabolic pathways and the role of enzymes in catalyzing biochemical reactions.
LO 3	Understanding the structure and function of biomolecules, such as enzymes, receptors, and transporters, and their interactions with ligands.
LO 4	Developing critical thinking and problem-solving skills through case studies and real-world examples of biochemical processes.
LO 5	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 nanobiotechnology 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 l	Understanding of the structure, function, and regulation of biomolecules, including proteins, nucleic acids, carbohydrates, and lipids. Comprehensive knowledge of the metabolic pathways involved in energy production, biosynthesis, and degradation of biomolecules, and the regulatory mechanisms that control these pathways.
CO2	Understanding of the role of biochemistry in disease states and the development of therapeutic agents. Describing the biochemical techniques, including protein purification, enzymology, molecular biology, and biophysical techniques such as NMR and X-ray crystallography.
CO3	Development of critical thinking and problem-solving skills through case studies, research projects, and data analysis and describing the current research topics and emerging trends in biochemistry, including systems biology, synthetic biology, and drug discovery.
CO4	Explaining the ability of critical thinking and problem-solving skills through case studies, research projects, and data analysis.
CO5	Understanding the interdisciplinary nature of biochemistry, including its links to other fields such as molecular biology, genetics, biotechnology, and medicine.

Overall, the course outcomes of Biochemistry for Master's students aim to prepare them for careers in Nanobiotechnology and pharmaceutical industries, academia, research institutions, and government agencies. Postgraduates of Nanobiotechnology 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	2	2	2	2	2	2	2	2	2	2	2
CO2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO3	3	2	3	2	3	2	2	3	3	2	2	2	2	2	2
CO4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

NB 2.4 (C) (22): BIOINFORMATICS

Credits: 04

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

RECOMMENDED BOOKS:

1) Jambeck P, Gibas .C Developing Bioinformatics Computer Skills first edition2001 O'Reilly, Sebastaol.
2) David W Mount, Bioinformatics, 2004, second edition, CSHL Press, New York.
3) Primrose S.B, Twyman R.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, Sebastapo.,
5) Jin Xiong, 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

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 l	Understanding the literature reviews: Assignments that require students to read and critically analyze research articles related to bioinformatics, such as those on gene expression analysis, comparative genomics, and protein structure prediction.
CO2	Explaining the sequence analysis: Assignments that involve analyzing DNA or protein sequences using bioinformatics tools such as BLAST, ClustalW, and multiple sequence alignment software.
CO3	Describing 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.
CO4	Understanding the molecular modeling: 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
CO5	Explaining the data analysis: 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 Nanobiotechnology 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.

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	2	2	2	2	2	2	2
CO2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

PRACTICAL – I:

NBP 2.1 (22): MOLECULAR BIOLOGY AND GENETIC 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 Isolation of genomic DNA from *E.coli* Isolation of DNA from sheep liver
4) Isolation of DNA from plant leaves (Rice or Tobacco or any other plant) Transformation of bacteria using a plasmid and screening of colonies for transformants
5) Isolation of RNA from yeast or Rice or any other plant
6) Purity analysis of the Nucleic acids
7) Development of RAPD or AFLP markers in different species of cotton or Brinjal using PCR technique
8) Screening of gene libraries using colony hybridization technique
9) Thermal denaturation of DNA, correlation of Tm on base composition of DNA Determination of phosphorous in nucleic acids

GENETIC ENGINEERING

10) Transformation in Bacteria using plasmid
11) To test the integration of DNA in a transgenic system using a Southern Blotting technique
12) To test the expression of a gene in a transgenic system using a Northen Blotting technique
13) Restriction digestion of DNA and its electrophoretic separation Ligation of DNA molecules and their testing using electrophoresis Activity of DNAase and RNAse on DNA and RNA
14) Amplification of DNA using Polymerase Chain Reaction (PCR)
15) Cloning and expression of Green Fluorescent Protein in Bacteria or Plants
16) DNA sequencing - Sanger's method (manual sequencers are available at reasonable prices)
17) Construction of restriction maps (Assignments)

PRACTICAL–II:

NBP 2.2 (22): ENVIRONMENTAL NANOTECHNOLOGY AND ENZYME TECHNOLOGY

Credits: 04

ENVIRONMENTAL NANOTECHNOLOGY

1) Application of nanoparticles in the treatment of Industrial waste water
2) Estimation of COD, BOD of Industrial waste waters
3) Estimation of Carbonate and bicarbonate content of sewage water
4) Isolation of microbes from industrial effluents

ENZYME TECHNOLOGY

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

THIRD SEMESTER

M.Sc. NANO-BIOTECHNOLOGY

SEMESTER-III

NB 3.1 (22): INDUSTRIAL NANOTECHNOLOGY

Credits: 04

Unit I: Isolation, Screening, Preservation and Improvement of Industrially Important Microorganisms. Fundamentals of fermentation process - details of the Fermenters, Synthetic and Natural Medium, Precursors, Antifoams, Sterilization Methods and Inoculum Preparation, sampling ports, detection of contamination

Unit II: **Fabrication and synthesis of nanostructures:** Lithographic patterning methods optical lithography and its limitations, electron beam and its limitations, the use of SPM (STM, AFM and

SNOM) to fabricate nanostructures. Dip-pen AFM lithography. Soft lithography using elastomeric stamps. Solution chemical routes to nanoparticles

Unit III: Next-Generation Applications for Polymeric Nanofibres

Biomedical Applications: Medical Prostheses, Tissue Engineering Scaffolds, Drug Delivery, Wound Dressing, Haemostatic Devic es, Cosmetics. Filtration Applications: Filter Media, Protective Clothing, Nanotechnology, Applications in Textiles: Nano-Whisker Architecture, Polymer Synthesis and Additives.

Unit IV: Promising nanobiotechnologies for applications in medicine

Nucleic acid delivery and localizing delivery with magnetic nanoparticles, Magnetic nanoparticles in cancer diagnosis and hyperthermic treatment, Nanogels: chemistry to drug delivery, Targeted gold nanoparticles for imaging and therapy, Nanotechnologies in Adult Stem Cell Research, Nanotechnology and regenerative medicicne. Nanomedicine, Molecular design using biological selection, Harnessing molecular motors, Artificial life, Hybrid materials, Biosensors The future of Bio-nanotechnology: Ethical considerations, Case studies.

Unit V: Guidelines for Working with Engineered Nanomaterials

Potential for Occupational Exposure, Factors Affecting Exposure to Nanomaterials, Elements of a Risk Management Program, Engineering controls, Dust collection efficiency of filters, Work practices, Personal protective clothing, Respirators, Cleanup and disposal of nanomaterials

LEARNING OBJECTIVES: A course on Industrial Nanotechnology aims to teach students about the use of nanotechnology in industrial applications. By the end of this course, students should be able to:

LO 1	Understand the principles of nanotechnology and their applications in industrial processes.

LO 2	Analyze the properties and behavior of nanomaterials in industrial systems, including their synthesis and characterization.
LO 3	Evaluate the potential applications of nanotechnology in various industries, such as electronics, energy, and healthcare.
LO 4	Understand the regulations and safety considerations surrounding the use of nanotechnology in industrial applications.
LO 5	Understanding the industrial processes that incorporate nanomaterials to improve their efficiency and performance.

Overall, this course provides students with a foundation in the theory and practical skills required to apply nanotechnology to industrial processes. The course prepares students to apply this knowledge to real-world problems in various industries, to evaluate the potential benefits and risks of using nanomaterials in industrial applications, and to design and optimize industrial processes that incorporate nanotechnology.

COURSE OUTCOMES: Industrial Nanotechnology is a course that focuses on the use of nanotechnology in industrial applications. By the end of this course, students should be able to:

CO I	Understand the principles of nanotechnology and their applications in various industries.
CO2	Describing the properties and behavior of nanomaterials in industrial systems, including their synthesis and characterization.
CO3	Explaining the potential applications of nanotechnology in various industries, such as electronics, energy, and healthcare.
CO4	Understand the regulations and safety considerations surrounding the use of nanotechnology in industrial applications.
CO5	Understanding and optimizing industrial processes that incorporate nanomaterials to improve their efficiency and performance.

Overall, this course provides students with the necessary knowledge and skills to apply nanotechnology to industrial processes. The course prepares students to evaluate the potential benefits and risks of using nanomaterials in industrial applications, to design and optimize industrial processes that incorporate nanotechnology, and to comply with regulations and safety considerations.

CO-PO MAPPING TABLE:

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

NB 3.2 (22): BIOREACTOR DESIGN, MODELLING & SIMULATION OF BIOPROCESSES

Credits: 04

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

Unit II: Design of bioreactors using Monod growth kinetics and Michaelis-Menten Kinetics: Batch, CSTF, CSTF with recycle, CSTFs in series, Fed-batch reactors, Plug flow reactors (PFTF), Packed bed reactors, Fluidized reactors.

Unit III: 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 IV: Nano Polymers: Polymer based nanocomposites, Preparation and characterization of diblock coPolymer based nanocomposites. Polymer carbon nanotubes based composites, their mechanical properties, and industrial possibilities. Assembly of Polymer-nanoparticle composite material; Fabrication of Polymer - mediated organized nanoparticles assemblies; Applications of nanoPolymers in catalysis.

Unit V: Modelling Principles: Fundamentals of Modelling. Bioreactor Modelling. Modelling of Enzyme Kinetics. Simple Microbial Kinetics. Study of Structured and Unstructured Kinetic Models for analysis of various bioprocesses - Compartmental models and models of cellular energetic and metabolism. Modelling and Simulation of a Biofilter. Nanodesign, Nano-CAD and Modelling of Nanodevices.

LEARNING OBJECTIVES: A course on Bioreactor Design, Modelling & Simulation of Bioprocesses teaches students about the principles and applications of bioreactor design and modeling in bioprocessing. By the end of this course, students should be able to:

LO 1	Understand the principles of bioreactor design and operation, including mixing, aeration, and nutrient supply.
LO 2	Analyze the different types of bioreactors used in bioprocessing and their advantages and disadvantages.
LO 3	Develop mathematical models for bioprocesses, including mass balance and kinetic models.
LO 4	Evaluate the performance of bioprocesses using simulation software, such as MATLAB, Aspen Plus, or COMSOL
LO 5	Describing and optimizing bioreactor processes to maximize product yield and minimize waste.

Overall, this course provides students with the necessary knowledge and skills to design and model bioreactors for bioprocessing applications. The course prepares students to develop mathematical models of bioprocesses, to analyze bioreactor performance using simulation software, and to design and optimize bioreactor processes for maximum efficiency.

COURSE OUTCOMES: Bioreactor Design, Modelling & Simulation of Bioprocesses is a course that focuses on the principles and applications of bioreactor design and modeling in bioprocessing. By the end of this course, students should be able to:

CO I	Understand the principles of bioreactor design and operation, including mixing, aeration, and nutrient supply.
CO2	Describing the different types of bioreactors used in bioprocessing and their advantages and disadvantages.
CO3	Explaining the mathematical models for bioprocesses, including mass balance and kinetic models.
CO4	Describing the performance of bioprocesses using simulation software, such as MATLAB, Aspen Plus, or COMSOL.
CO5	Explaining the performance of bioprocesses using simulation software, such as MATLAB, Aspen Plus, or COMSOL.

Overall, this course provides students with the necessary knowledge and skills to design and model bioreactors for bioprocessing applications. The course prepares students to develop mathematical models of bioprocesses, to analyze bioreactor performance using simulation software, and to design and optimize bioreactor processes for maximum efficiency.

CO-PO MAPPING TABLE:

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

NB 3.3 (A) (22): PLANT & ANIMAL BIOTECHNOLOGY

Credits: 04

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

Unit II:. Methods of *in vitro* clonal propagation. Transfer and establishment of whole plants in the soil. Organogenesis, Meristem culture and production of virus free plants. Embryogenesis and Synthetic seeds Anther and Pollen culture, Production of haploids and homozygous diploid plants, Production of Triploids-endosperm culture. Embryo culture, Cryopreservation and Germplasm conservation. *In vitro* selection of mutants ,Somaclonal variations and crop improvement**.**

Unit III: Cryopreservation, Germplasm storage and establishment of gene banks. Production of pharmaceutically and industrially important compounds from cultured cells. Biotransformations of important compounds such as Digitoxin; Protoplast isolation. Culture and fusion. Selection of hybrids. Symmetric and asymmetric hybrids, Cybrids. Tissue culture and its biotechnological applications in agriculture, horticulture and industry.applications of nano particles in plant biotechnology

Unit IV: Introduction to animal cell culture - Biology of cells in culture, Source of material for cell culture. Brief outline of the chemical, physical and metabolic functions of different constituents of culture medium. Establishment of primary and secondary cell lines. Serum free media. Maintenance of cultures, Concept of growth, measuring parameters of growth Cytotoxicity and viability assays. Cell synchronization & transformation. .

Unit V: Scale up animal cell culture. *In vitro* fertilization and embryo transfer. Applications of animal cell culture. Organ and histotypic culture. Stem cell culture technology and its applications, Biotechnology of silk production. Gene manipulation in aquaculture and Ploidy. Manipulations to enhance growth. animal cells as bioreactors. Applications of nanoparticles in animal tissue culture.

LEARNING OBJECTIVES: Plant and animal biotechnology is a field of study that deals with the application of scientific and engineering principles to the processing of plants and understanding animals for human benefit. The learning objectives of plant and animal 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	Explaining the knowledge 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 animal biology: Students of animal biotechnology should have a good grasp of the biology, anatomy, physiology, genetics, and evolution of animals
LO 5	Understanding 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.

COURSE OUTCOMES: The course outcomes of plant and animal biotechnology are:

CO1	Students will have a comprehensive **understanding** of plant biology, including plant structure, physiology, genetics, and evolution.
CO2	Describing the principles and techniques of genetic engineering, including gene cloning, transformation, and genome editing, and their applications in plant biotechnology.
CO3	Understand and discuss and differentiate the basic structure and function of cell components in prokaryotes and eukaryotes cells.
CO4	Explaining the advanced streams like Stem Cell Biology, Animal Cell Culture, Genomics and Proteomics, Drug Design, Genetic Engineering and Bioinformatics.
CO5	Describing the advanced streams like Stem Cell Biology, Animal Cell Culture, Genomics and Proteomics, Drug Design, Genetic Engineering and Bioinformatics.

Overall, the course outcomes of plant and animal biotechnology of M.Sc. Nanobiotechnology aim to provide students with the knowledge and skills to apply scientific and engineering principles to the processing of animals and plants for human benefit. Graduates studying plant and animal biotechnology programs can pursue careers in animal and plant 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	2	2	2	2	2	2	2	2	2	2	2
CO2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

NB 3.3 (B) (22): FOOD TECHNOLOGY

Credits: 04

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: Food technology is an important field of study for PG biotechnology students for the following reasons:

LO 1	To develop a comprehensive understanding of the principles and applications of food biotechnology, including genetic engineering, fermentation, and enzyme technology**.**
LO 2	Describing the microbiological and biochemical aspects of food production, processing, and preservation.
LO 3	Explaining and evaluating the nutritional and functional properties of food products.
LO 4	Educating the ethical and regulatory issues associated with the use of genetically modified organisms (GMOs) and other biotechnological techniques in food production.
LO 5	Describing the skills to design and carry out experiments in food biotechnology, and to analyze and interpret experimental data using statistical methods and appropriate software tools.

In conclusion, food technology is an essential field of study for PG biotechnology students as it plays a crucial role in the development of nutritious and safe food products, reduction of food waste, and the advancement of the food industry

COURSE OUTCOMES: Upon completion of the course, students will be able to:

CO1	Explaining the microbiological and biochemical aspects of food production, processing, and preservation, and evaluate the nutritional and functional properties of food products.
CO2	Developing the social, cultural, and economic factors influencing food choices and preferences, and understand the role of food biotechnology in addressing food security and sustainability issues.
CO3	Describing the skills to design and carry out experiments in food biotechnology, including the production of functional food ingredients and nutraceuticals.
CO4	Understand the industrial applications of food biotechnology, including food processing and preservation, development of novel food products, and production of biofuels and other value-added products.
CO5	Explaining the environmental impact of food production and consumption, and understand the potential of food waste reduction and the development of sustainable food systems.

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	2	2	2	2	2	2	2
CO2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

NB 3.3 (C) (22): BIOETHICS, BIO-SAFETY. IPR AND PATENT LAWS

Credits: 04

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 Patnt 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 Biotechnolgy - 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	Understanding 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	Describing 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	Explaining 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	Describing 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	Describing 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:

CO1	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.
CO2	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.
CO3	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
CO4	Explaining the 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.
CO5	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 nanobiotechnology 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	2	2	2	2	2	2	2	2	2	2	2
CO2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

NB 3.4 (A) (22): BIOPROCESS VALIDATION & CURRENT GOOD MANUFACTURING PRACTICES (cGMP)

Credits: 04

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.
LO 2	Understanding the principles and importance of risk assessment in bioprocess validation, including the identification and mitigation of potential risks in biomanufacturing processes.
LO 3	Understanding the principles and techniques used for process monitoring and control, including statistical process control and data analysis.
LO 4	Understanding skills in the design and execution of validation studies, including the preparation of protocols and reports.
LO 5	Describing the 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 nanobiotechnology 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 nanobiotechnology may include the following:

CO I	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.
CO2	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.
CO3	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.
CO4	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.
CO5	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.

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	2	2	2	2	2	2	2	2	2	2	2
CO3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO4	3	2	3	2	3	2	2	3	3	3	2	2	2	2	2
CO5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

NB 3.4 (B) (22): PROTEIN ENGINEERING

Credits: 04

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 stratergies 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

RECOMMENDED 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 Biotechnology 9th ed, 1991, Plenum Press, Newyork. Watson, James , Gilman, Michael , Witkowski, Jan , Zoller, Mark Recombinant DNA 2/e, 1992,
3) 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.
LO 2	Understanding the principles of protein folding, stability, and dynamics, and how they relate to protein engineering.

LO 3	Knowledge of the applications of protein engineering in biotechnology, including the production of recombinant proteins, biocatalysis, and drug discovery.
LO 4	Understanding critical thinking and problem-solving skills through case studies and real-world examples of protein engineering in biotechnology.
LO 5	Describing the 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 nanobiotechnology. 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 nanobiotechnology and pharmaceutical industries, research institutions, or government agencies. They may also work in academia, teaching and researching protein engineering in nanobiotechnology.

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

CO1	Understanding the structure, function, and properties of proteins, including their biological roles and interactions. Explain the techniques used in protein engineering, including mutagenesis, directed evolution, and rational design.
CO2	Understanding the principles of protein folding, stability, and dynamics, and how they relate to protein engineering.
CO3	Knowledge of the applications of protein engineering in biotechnology, including the production of recombinant proteins, biocatalysis, and drug discovery.
CO4	Understanding the critical thinking and problem-solving skills through case studies and real-world examples of protein engineering in biotechnology.
CO5	Describing the 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 nanobiotechnology. 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 nanobiotechnology and pharmaceutical industries, research institutions, or government agencies. They may also work in academia, teaching and researching protein engineering in nanobiotechnology.

CO-PO MAPPING TABLE:

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CO1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

NB 3.4 (C) (22): TOOLS IN BIOTECHNOLOGY

Credits: 04

Unit I: Methods of Analysis of Replication of Single locus Replication initiation polnt 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 polnt 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 polnts of site specific replication, DNA replication in nucleus. Application of alkaline sucrose degradation and analysis of DNA replication after DNA damage.

REFERENCE 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 peR, 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	Explaining the importance of 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:

CO1	Understanding the importance of molecular biology techniques: Students will be able to apply molecular biology techniques such as peR, cloning, DNA sequencing, and gene expression analysis to solve research problems.
CO2	Explain the students to analyze and characterize proteins using protein expression, purification, and characterization techniques.
CO3	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.
CO4	Describing the importance of culture techniques: Students will be proficient in cell culture techniques such as media preparation, cell line maintenance, and transfection.
CO5	Describing the 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. Postgraduates of nanobiotechnology 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	POS	PO9	PO10	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO4	3	2	3	2	3	2	2	3	3	3	2	2	2	2	2
CO5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

PRACTICAL-I

NBP 3.1 (22): INDUSTRIAL NANOTECHNOLOGY

Credits: 04

1) Principles of bread making
2) Isolation of industrially important microorganisms from soil. Isolation of amylase producing organisms from soil.
3) Production of a - amylase from *Bacillus Spp.* by shake flask culture. Production of alcohol or wine using different substrates.
4) Estimation of alcohol by titrimetry.
5) Estimation of alcohol by calorimetric method. Production of citric acid.
6) Estimation of citric acid by titrimetry.
7) Analysis of molasses by laneeynon double reduction method. Quantification of biomass.
8) Determination of fermentation efficiency of batch production of ethanol. Citric acid production by solid state fermentation.
9) Citric acid production by submerged fermentation. Ethanol recovery from fermentation broth by distillation. Citric acid recovery from filtration precipitation. Recovery and purification of biomass from broth

PRACTICAL - II:

NBP 3.2 (22): PLANT AND ANIMAL TISSUE CULTURE

Credits: 04

PLANT TISSUE CULTURE:

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. Formation of callus from leaf or cotyledons or seedling explants Micropropagation of tree species or elite plants
4) Induction of somatic embryogenesis Induction of shoots or roots (organogenesis) Induction of cell suspension cultures
5) Production of secondary metabolites in cell suspension culture
6) Anther culture and Production of haploid plants
7) Induction of hairy root cultures using *Agrobacterium rhizogenesis*
8) Genetic transformation of tobacco leaf disks using *Agrobacterium tumefaciens* Analysis of transformants using GUS activity (glucuronidase activity) Protoplast isolation and fusion using polethylene glycol

ANIMAL TISSUE CULTURE:

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

FOURTH SEMESTER

M.Sc. NANO-BIOTECHNOLOGY

SEMESTER-IV

NB 4.1. (22): PROJECT WORK

(THESIS/DISSERTATION IS TO BE SUBMITTED AT THE END OF THE SEMESTER)

Project Report: **Credits: 8**

Maximum Marks: 200

NB 4.2. (22): SEMINAR

Seminar: **Credits: 4**

Maximum Marks: 100

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