Savitribai Phule Pune University

(Formerly University of Pune)

Three Year Degree Program in Biotechnology
(Faculty of Science & Technology)

T. Y. B.Sc. (Biotechnology)

(For Colleges Affiliated to Savitribai Phule Pune University)

Choice Based Credit System Syllabus

(Based on Guidelines of NEP-2020)

To be implemented from Academic Year 2025-2026

Framed By

Boards of Studies (BOS) in Biotechnology

Savitribai Phule Pune University

Preamble of the Syllabus:

T.Y.B. Sc. Biotechnology course is designed to meet the growing challenges in fields like Molecular Biology, Immunology, Genetic Engineering, Animal and Plant Biotechnology, Industrial Biotechnology, Food & Pharmaceutical Biotechnology, and Computational Biology. The program aims to develop scientific temperament, analytical thinking, laboratory skills, and research aptitude among students.

The course provides both theoretical and practical knowledge, helping students understand modern biotechnological techniques and their applications. It also prepares learners for higher education, research, entrepreneurship, and employment opportunities in biotechnology-related industries and organizations.

1) **Eligibility:** F.Y.B.Sc. all clear and completion of at least 50% credit at S.Y. B.Sc. Level with Biotechnology as major subject and/or as prescribed by the Savitribai Phule Pune University

2) **Field Projects (FP)**

Continuous assessment part (15 marks out of 50) of this course should be done by the mentor of the student. This should be based on the regularity, participation and performance of the students. Semester End Assessment (35 marks out of 50) of this course should be done by a panel of examiners in two parts;

- Based on the work report submitted by the student (50% marks), and
- Remaining 50% marks should be based on his presentation and viva-voce on the work carried to be assessed by the panel of examiners.

3) **Scheme of Examination**

The total marks for a 2-credits course is 50.

Theory Paper of 02 Credits:

Internal Exam (15 M) + University Theory Exam (35 M) = Total 50 Marks.

Duration: For Internal exam = 40 Min. and for University Exam = 02 hours.

Practical Paper of 2 Credits:

Internal Exam (15 M) + University Practical Exam (35 M) = Total 50 Marks.

One Credit of Practical = 30 clock hours (2 Contact hours per credit per week)

- Practical for each course comprises of 02 Credits = 60 clock hours.
- Minimum 12 laboratory/ Filed sessions of 04 clock hours must be conducted in one semester.
- In case of short practical, two practical's should be conducted in one session.
- Each practical of 04 clock hours in the laboratory should consist of table performance for concerned practical, careful observations, calculation, writing results and conclusion, and submission of practical in written form.

Pattern for Internal Theory Assessment: (15 Marks)

- Q-1: Choose correct option (5-MCQs with Multiple Options) - 5 marks
- Q-2: Answer the following questions (Short answer questions) (any 5 out of 7) - 5 marks
- Assignment/ presentation/ attendance/discipline -5 marks

Objectives of On-the-Job Training (OJT)

1. Develop Practical Skills: Helps trainees learn actual job tasks and gain hands-on experience in a real work environment.
2. Improve Job Knowledge: Enhances understanding of workplace procedures, tools, equipment, and industry practices.
3. Build Confidence: Allows trainees to apply theoretical knowledge, improving self-confidence and decision-making abilities.

4. Adapt to Workplace Culture: Familiarizes trainees with company policies, teamwork, communication, and professional behavior.
5. Enhance Problem-Solving Skills: Exposes trainees to real workplace challenges and teaches them how to handle situations effectively.
6. Prepare for Future Employment: Develops work ethics, discipline, and experience that improve career readiness and employability.

- Assessment of on job training (OJT)

Teacher should be assigned as coordinator/ supervisor for the OJT. Supervisor will coordinate for the assessment of OJT. Supervisors may conduct interviews or discussions or presentation and written report to assess performance of students for 35 marks on the basis of following points. (Internal 15 marks will be provided by teacher supervisor)
Supervisors observe how trainees perform assigned duties and tasks.

1. Regular attendance and reporting to work on time
2. Professional behavior is also assessed during OJT
3. Trainees may submit reports or logbooks describing tasks completed and knowledge gained
4. Feedback from supervisors from workplace

Program: B.Sc. BIOTECHNOLOGY

Third Year Biotechnology

SEMESTER –V				
Sr. No	**Course Category**	**Course code**	**Course Title**	**Credit**
1	**Major Core**	BT-301- T	Recombinant DNA technology	2T
2		BT-302- T	Animal Tissue culture	2T
3		BT-303- T	Plant Tissue Culture	2T
4		BT-304- T	Microbial Biotechnology	2T
5		BT-305- P	Practical in ATC and PTC	2P
6		BT-306- P	Practical Microbial Biotechnology	2P
7	**Major Elective**	ME-301-BT-T	Food and Pharmaceuticals Biotechnology	2T
8		ME-302-BT-P	Practical in Food and Pharmaceuticals	2P
9		ME-303-BT-T	Nano biotechnology	
10		ME-304-BT-P	Practical in Nano Biotechnology	
11	**VSC**	VSC-301-BT-P	Practical in Recombinant DNA technology	2P
12	**FP/CEP**	CEP-301-BT-P	**FP/CEP**	2P
13	**Minor**	MN-301-BT-T	Tissue Culture Technology	2T
Total Credit				**22**
SEMESTER –VI				
Sr. No	**Course Category**	**Course code**	**Course Title**	**Credit**
1	**Major Core**	BT-351- T	Enzyme and Enzyme Technology	2T
2		BT-352- T	Industrial Microbiology	2T
3		BT-353- T	Immunology	2T
4		BT-354- T	Computational Biotechnology	2T
5		BT-355- P	Practical in Industrial Microbiology	2P
6		BT-356- P	Practical In Computational Biotechnology & Immunology	2P
7	**Major Elective**	ME-351-BT-T	Bioanalytical Technique	2T
8		ME-352-BT-P	Practical in Bioanalytical Techniques	2P
9		ME-353-BT-T	Biomathematics and Biostatistics	
10		ME-354-BT-P	Practical in Biomathematics and Biostatistics	
11	**VSC**	VSC-351-BT-P	Practical Enzymes and Enzyme Technology	2P
12	**FE/CEP/OJT**	OJT-351-BT-P	OJT	4P
Total Credit				**22**

SEM- V: Major Core
Course Code: BT-301- T
Course Name: Recombinant DNA Technology
Credit: 2T
No. of lectures: 30

Course Objective:

1. To provide fundamental knowledge of recombinant DNA technology and its significance.
2. To understand molecular tools and techniques used for DNA manipulation.
3. To study various cloning and expression vectors used in genetic engineering.
4. To explain gene amplification, library construction, and sequencing methods.
5. To highlight applications of recombinant DNA technology in healthcare and biotechnology.

Course outcome:

1. Students will be able to explain the basic concepts, tools, and laboratory requirements of recombinant DNA technology.
2. Students will learn enzymes and vectors used for DNA manipulation and cloning.
3. Students will learn methods such as PCR, gene libraries, and sequencing techniques.
4. Students will learn different types of vectors and their specific applications in genetic engineering.
5. Students will learn applications of recombinant DNA technology including therapeutics and genome editing (CRISPR/Cas9).

Unit	Topic	No. of lectures
I	• **Introduction to Recombinant DNA Technology:** Historical perspective, Concept and significance, A basic layout of R-DNA laboratory • **Molecular tools used in Recombinant DNA Technology:** DNA modifying enzymes – Restriction enzymes, Ligases, Polymerases, Alkaline Phosphatases, Nucleases (Mode of Actions & applications)	6
II	• **Vectors used in Recombinant DNA Technology:** Plasmid Vectors, Bacteriophages: λ (Lambda)and M13, Overview of Expression vectors, Agrobacterial Vectors – Ti plasmid, Chimeric Vectors - Cosmids, Phasmids, Phagemids, Introduction of YAC& BAC. • **Construction of Genomic and cDNA Library:** Genomic and cDNA library, Applications of libraries	9
III	• **PCR:** Introduction, Steps involved in PCR, Real time PCR, Applications • **Sequencing of Genes and Genomes:** Maxam- Gilbert Method, Sanger's enzymatic method, Automated DNA sequencing, Next Generation sequencing	9
IV	• **Applications of Recombinant DNA Technology:** Recombinant Bio therapeutics (Insulin production), Gene therapy, Introduction to CRISPR/Cas9 as genome editing tool	6

Reference Books:

1. Gene Cloning and DNA Analysis –An Introduction. T.A. Brown. Eighth Edition (2020). Wiley Blackwell.
2. Genetic Engineering. By Smita Rastogi and Neelam Pathak. Oxford University Press (2009).
3. Principles of Gene Manipulation & Genomics, 7th Edition (2006), Primrose and Twyman, Blackwell Publishing, USA.
4. Molecular Biology of the Gene, 7th Edition (2013), James D. Watson, Tania Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Lodwick, Pearson Education, Inc.
5. Genomes 3. T.A. Brown. Third Edition (2008). Garland Science Taylor and Francis Group, New York and London.

SEM- V: Major Core
Course Code: BT-302- T
Course Name: Animal Tissue Culture
Credit: 2T

Course Outcome

1. Student will understand the basic principles, history, and scope of animal tissue culture, including laboratory setup and aseptic techniques.
2. Students will learn composition and preparation of culture media, and understand the nutritional and environmental requirements of animal cells.
3. Demonstrate knowledge of primary and secondary cell cultures, cell lines, organ culture and techniques for their maintenance and preservation.
4. Analyse the applications of animal tissue culture in fields like vaccine production, cancer research, drug screening, and genetic engineering.

Course Objective:

1. Understand basic aseptic skills for mammalian cell culture and their applications.
2. Gain knowledge of media constituents and media formulation strategies for mammalian cell culture.
3. Develop proficiency in mammalian cell culture and the maintenance of cell lines.
4. Apply cell and molecular techniques to in vitro situations.

Unit	Topic	No. of Lectures
I	**Introduction to Animal Tissue Culture** • History and development of Animal Tissue Culture • Major development in cell culture technology **Basic concepts and types of cultures in Animal Tissue Culture** • Primary Culture, Secondary Culture, Cell lines, 3D culture • Concept of monolayer culture and suspension culture **ATC Laboratory and Equipment** • Laboratory design Equipment and Lab wares	8
II	**Aseptic Techniques** • Maintenance of aseptic conditions • Contamination, types of contaminants • Methods of detection of contaminants • Cross contamination **Nutrition and Physiology of cultured cells** • Nutritional requirement and physiology of cultured cells. • Principles of media formulation. • Serum containing medium and serum free medium: Advantages and Disadvantages. • Balanced Salt Solution	7

III	**Primary cell culture** • Methods of establishing primary cell culture • Source selection and establishment of fibroblast and lymphocyte cultures **Cell lines** • Concept of cell line, Finite and transformed cell lines • Mammalian and insect cell line growth conditions, • Subculture and Characterization of cell line • Cell passage number and significance	7
IV	**Organ Culture** • Types of organ culture • Organotypic and Histotypic culture **Cell Repositories and Cell banks** • Cryopreservation of cells, • Cell repositories and cell distribution **Applications** • Applications of ATC • Tissue engineering: role of ECM proteins	8

Suggested Readings/ Material:

1. R. Ian Freshney, Amanda Capes-Davis, Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications. (2021) 8th Edition, Willey-Blackwell Publications.
2. Veer Bala Rastogi, Nirvika Rastogi, Animal Cell Culture and Technology. (2023) 1 st Edition, MedTech Science Press.
3. Principles and Practice of Animal Tissue Culture by Sudha Gangal, 2 nd Edition.
4. Shenoy M 2007 Animal cell culture Animal Biotechnology ch 1, p (New Delhi: Firewall)
5. Rajasekhar Pinnamaneni, Praveen Kumar Vemuri, Animal Cell Culture Technology. (2019) 1 st Edition, Scholars' Press.
6. Mell Carter & Jordan Hunt, Animal Cell Culture. (2018) 1 st Edition, Ed-Tech Press.

SEM- V: Major Core
Course Code: BT-303- T
Course Name: Plant Tissue Culture
Credit: 2T

Course Objectives

1. To understand the fundamental concepts of plant tissue culture.
2. To explore the role of nutrients and plant growth regulators in PTC media.
3. To study various plant tissue culture techniques.
4. To know the applications of plant tissue.

Course Outcomes (COs)

On completion of the course, students will be able to:

1. Student will understand the fundamental principles of Plant Tissue Culture.
2. Student will learn the role of nutrients and plant growth regulators in PTC media.
3. Student will acquire knowledge about various plant tissue culture techniques.
4. Student will learn the various applications of plant tissue culture.

Unit	Topic	No. of Lectures
I	**Introduction to Plant Tissue Culture:** • Introduction and history of Plant Tissue culture: Concept of cell theory and cellular totipotency, historical perspective, landmarks in plant tissue culture • Infrastructure and organization of plant tissue culture laboratory: Laboratory design - general laboratory, inoculation room and culture room, different work areas, glassware, equipment and instruments required in plant tissue culture laboratory. • Aseptic Techniques: Preparation of glassware, packing and sterilization, media sterilization, surface sterilization, aseptic work station, fumigation of lab, precautions to maintain aseptic conditions in plant tissue culture laboratory	7
II	• **Plant Tissue Culture Media**: Nutritional (organic and inorganic) requirements of the plant and explants, PGRs and their *in* vitro roles, types of media and media preparation. • Explant: Explant for plant tissue culture, sterilization of explant and establishment of culture, Response of explant to *in vitro* condition: Concept of differentiation, dedifferentiation and redifferentiation (callus formation, organogenesis (direct and indirect) and embryogenesis (direct and indirect)).	7
III	**Plant Tissue Culture Techniques and Applications** embryogenesis**:** • Organ culture: Introduction, principle and factors affecting root tip culture, leaf culture, shoot tip and meristem culture • Callus culture technique: Introduction, principle, factors affecting, morphology and internal structure • Suspension culture technique: Introduction, principle, types, assessment of growth and viability • Mass Multiplication: Introduction, stages, and pathways—axillary bud proliferation, adventitious shoot proliferation, organogenesis (direct and indirect), somatic embryogenesis (direct and indirect), and the concept of somaclonal variation.	8
IV	• Anther and pollen culture: Introduction, principle, pathways of development, factors affecting it • Ovary, Ovule, Embryo and Endosperm Culture: Introduction, principle, factors affecting it • Protoplast Isolation, Fusion and Culture: Methods of protoplast isolation, protoplast fusion and culture Applications of plant tissue culture	8

Suggested Readings:

1. Razdan M.K, Introduction to Plant Tissue culture. (2019) 3rd edition, Oxford & IBH Publications, New Delhi
2. Bhojwani S.S. & Razdan M.K. (1996) (2016)- Plant Tissue Culture: Theory & Practice (Elsevier, New Delhi)
3. Jha TB & Ghosh B, Plant tissue culture: Basic and applied, (2017) 2nd edition, Universities Press, Hyderabad
4. Kalyan Kumar De, Plant Tissue culture (2010), New central Book Agency Calcutta

SEM-V: Major Core
Course Code: BT-304- T
Course Name: Microbial Biotechnology
Credit: 2T
No. of lectures: 30

Course Objective:

1) To understand the diversity, physiology, and genetics of microorganisms and their role in various biotechnological processes.
2) To study the application of microorganisms in industrial, environmental, and agricultural biotechnology, including production of enzymes, antibiotics, and biofertilizers.
3) To develop knowledge of microbial techniques and fermentation technology used for large-scale production of valuable biological products.

Course Outcomes (COs)

1. Explain the role of microorganisms in food, including their involvement in fermentation, spoilage, and foodborne diseases.
2. Apply principles of food safety, preservation methods, and microbiological techniques to control and evaluate microbial quality in foods.
3. Describe the role of microorganisms in milk and dairy products, including their impact on fermentation, spoilage, quality control, and safety management in the dairy industry.
4. Explain the characteristics of medically important microorganisms and apply principles of pathogenesis, diagnosis, prevention, and control of infectious diseases.
5. Explain the role of microorganisms in waste treatment processes, including their application in biodegradation, sewage treatment, bioremediation, and environmental pollution control.
6. Apply microbial biotechnology techniques to develop and optimize processes for large-scale production of commercially valuable products.

Unit	Topic	No of lectures
I	• **History and Scope of Microbial Biotechnology** • **Food and Dairy Microbiology** **Food Microbiology** • Role of microorganisms in food spoilage, Factors affecting on growth of microbes in food (intrinsic and extrinsic factors), Spoilage of meat and poultry, Fruits and vegetable, Canned food. • Principles of Food Preservation. • Chemical and Physical methods of preservation. • Microbial food processing (fermentation) • Food borne diseases- Food infection and intoxication **Dairy Microbiology** • Milk: Definition, Composition of milk, Normal and abnormal microflora of milk, Sources of contamination of milk, International standards of Milk. • Milk Spoilage- Flavour and colour defects, Stormy fermentation, Sweet curdling, Ropiness. • Grading of milk- Direct and Indirect Tests • Preservation of Milk- Pasteurization and efficiency of pasteurization. • Microbial processing of milk- Curd, Yogurt, Butter, Kefir, Cheese.	**8**
II	**Medical Microbiology** • Medical Microbiology: Normal flora, Pathogenic microorganisms • Diseases of various system: Tuberculosis, Typhoid, Polio, Syphilis • Antibiotic resistance mechanisms	**7**

	• Microbial products in therapeutics • Vaccine development and production: i. Inactivated & Live-attenuated vaccines. ii. Recombinant vaccines	
IV	**Microbes in Waste Treatment Processes** • Bacteriological standards of drinking water. (WHO, BSI) • Water borne diseases, Indicators of faecal pollution, Routine bacteriological analysis of water for potability: Presumptive, Confirmed, Completed test, Membrane Filter Technique and Eijkman tests. • Role of microbes in waste water treatment • Microbial consortium for effluent treatment.	**7**
V	**Applications of Microbial Biotechnology** • Geomicrobiology-Ore leaching (methods and examples), MEOR. • Bioweapons, Bio-fertilizers and Bio-pesticides and Microbial plant growth Promoters (gibberellins and IAA) • Microbial Sweeteners (Thaumatin, Monelin) • Microbial toxins and their applications • Microbial Polysaccharide production: two examples • GMOs-Norms and applications	**8**

Suggested Readings/Material:

1. Food Microbiology, Frazier & Westhoff, 4th edition, Tata McGraw Hill Publications
2. Modern Food Microbiology, James Jay, 7th edition, Springer Publications
3. Advances in Biotechnology, S. N. Jogdand, Himalaya Publishing House
4. Milk & Milk Products, C. Eckles, 4th edition, Tata McGraw Hill Publications
5. Prescott, S.C. and Dunn, C.G., (1983) Industrial Microbiology, Reed G. AVI tech books
6. General Microbiology - Stanier R.Y., 5th edition, (1987) Macmillan Publication, UK.
7. Fundamental Principles Of Bacteriology**,** Salle, A.J., McGraw Hill Company, New York
8. Tortora, G.J., Funke, B.R., Case, C.L, 1992. Microbiology: An introduction 5th Edition, Benjamin Pub. Co. NY
9. Davis B.D., Delbacco, 1990 Microbiology 4th edition, J.B. Lippincott Co. NY
10. Dey, N.C and Dey, TK. 1988, Medical Bacteriology, Allied Agency, Calcutta, 17thEdition
11. Ananthnarayana, R. and C.E, Jayaram Panikar, 1996 Text book of microbiology, 5th edition, Orient Longman.
12. Park and Park, Preventive and Social medicine. 2013, Publisher: Banarsidas Bhanot, Jabalpur
13. Ingraham J.L. and Ingraham C.A. (2004) Introduction to Microbiology. 3nd Edition. Thomson Brooks / Cole.
14. Madigan M.T, Martinko J.M. (2006) Brock's Biology of Microorganisms. 11th Edition. Pearson Education Inc.
15. Sing, B. D. Biotechnology, (2010), Kalyani Publishers, New Delhi

SEM- V: Major Core
Course Code: BT-305- P
Course Name: Practical in plant tissue culture and animal tissue culture
Credit: 2P
No. of Practical: 15

Course Objective:

1. To provide hands-on training in plant and animal tissue culture techniques
2. To study preparation of media, stock solutions and sterilization methods
3. To understand aseptic techniques required for tissue culture work
4. To perform basic plant tissue culture methods such as callus, meristem and embryo culture
5. To understand initiation, maintenance and sub culturing of animal cell cultures

Course Outcomes (COs)

After completion of the course, students will be able to:

1. Perform basic laboratory techniques and maintain aseptic conditions
2. Prepare culture media and stock solutions accurately
3. Carry out plant tissue culture techniques such as callus and meristem culture
4. Initiate and maintain animal cell cultures using standard methods
5. Perform sub culturing, cell observation and basic analysis of cultures

Sr. No.	Title of Experiments	No of Practical
1	Introduction to the PTC Laboratory: Organization of Facilities and Equipment	1
2	Aseptic manipulations-washing, capping, packing and sterilization of glassware, laboratory, work area, media and its components, explant & safety precautions.	1
3	Preparation of stock solutions and preparation of PTC media	1
4	Aseptic seed germination and embryo culture	1
5	Initiation of callus culture and study of callus morphology and internal structure.	1
6	Initiation of shoot tip/axillary bud culture	1
7	Initiation of anther culture	1
8	Study of ATC laboratory design and equipment Structure and design of ATC laboratory Equipment: Laminar air flow/Biosafety cabinate, CO_2 incubator, inverted microscope, autoclave, centrifuge, filter sterilization assembly, pH meter, etc.	1
9	Aseptic techniques in ATC Aseptic manipulations-washing, capping, packing and sterilization of glassware Media preparation and its sterilization	2
10	Initiation of primary culture: Primary culture from chick embryo by trypsinization	2
11	Maintenance and subculturing of cell line: Observation and feeding of cell line Subculturing, viable cell count, split ratio	2
12	Visit to commercial Plant/Animal Tissue Culture facility	1

Suggested Readings/Material:

1) Freshney, R. I., *Culture of Animal Cells: A Manual of Basic Technique*. 5th Edition (2005), Wiley-Liss, New York.
2) Bhojwani, S. S. and Razdan, M. K., *Plant Tissue Culture: Theory and Practice*. 1st Edition (1996), Elsevier Science, Amsterdam.
3) Gamborg, O. L. and Phillips, G. C., *Plant Cell, Tissue and Organ Culture*. 1st Edition (1995), Springer-Verlag, Berlin.
4) Dixon, R. A. and Gonzales, R. A., *Plant Cell Culture: A Practical Approach*. 2nd Edition (1994), Oxford University Press, UK.
5) Masters, J. R. W., *Animal Cell Culture: A Practical Approach*. Oxford University Press, UK.

SEM -V: Major Core
Course Code: BT-306-P
Course Name: Practical in Microbial Biotechnology
Credit: 2C
No. of Practical: 15

Course Objective:

1. To gets hands on training to handle various microorganisms for the applications in various biotechnological processes.
2. To get practical knowledge about bacteriological analysis of drinking water
3. To develop knowledge of microbial techniques for production of bio fertilizers and production of valuable biological products
4. To get hands training to analyse find quality of milk

Course Outcomes (COs)

1. Students will able to isolate the spoilage causing organism and identify the basic cause (microorganism) of food spoilage.
2. Carry out experiments to find the quality of the milk and grading of the milk
3. Students will train to conduct experiments to check potability of the drinking water
4. Apply practical knowledge for the production of various microbial; products like bio fertilizers single cell proteins etc.
5. Students will understand role of microorganism in various processes and products

Sr. No.	Title of Experiments	No of Practical
1	Isolation and identification (Genus level) of spoilage causing microorganisms from spoiled foods	3
2	Analysis of Milk a) Grading of raw milk (Dye reduction test, DMC) b) Determination of efficiency of Pasteurization by phosphatase test	2
3	Assessment of potability of water: a. Presumptive b. Confirmed c. Completed test d. Eijkman's test	4
4	Isolation of nitrogen fixing bacteria and preparation of bio fertilizer	2
5	Microbial degradation of pollutants (oil/dyes)	2
6	Cultivation of yeast /chlorella/ spiriluna for Production of Single Cell Protein (SCP)	1
7	Visit to waste treatment facility/ dairy industry	1

SEM-V: Major Elective
Course Code: ME-301-BT-T
Course Name: Food and Pharmaceutical Biotechnology
No. of lectures: 30

Course Objective:

1. To introduce the basic concepts and principles of biotechnology applied in food and pharmaceutical industries.
2. To understand the role of microorganisms, enzymes, and fermentation technology in the production of food products and pharmaceuticals.
3. To study modern biotechnological techniques used in the development of functional foods, vaccines, antibiotics, and therapeutic proteins.
4. To explain the importance of quality control, safety, and regulatory aspects in food and pharmaceutical biotechnology.
5. To develop knowledge about the industrial applications of biotechnology in improving food quality and producing biopharmaceutical products.

Course Outcomes (COs)

1. Understand the basic principles of Food Biotechnology and explain the role of microorganisms and enzymes in food production and processing.
2. Apply biotechnological techniques for the production, preservation, and quality improvement of food products such as fermented foods and beverages.
3. Analyze the nutritional, safety, and quality aspects of food using biotechnological methods and understand their applications in the food industry.
4. Understand the basic concepts of Pharmaceutical Biotechnology and explain the role of biotechnology in the development of pharmaceutical products.
5. Apply biotechnological techniques for the production of therapeutic products such as vaccines, antibiotics, and recombinant proteins.
6. Evaluate the regulatory, ethical, and quality control aspects involved in the development and production of biopharmaceutical products in the pharmaceutical industry.

Unit	Topic	No of lectures
I	**Food Biotechnology** **Basics of Food and Human Nutrition** • Macro-and micro nutrients and its role in human nutrition • Food additives • Enzymes as food processing aids • Nutraceuticals, Functional Food • Food allergens and allergenicity • Food adulterants and their effects on human health **Food Microbiology** • Sources of microorganisms in food • Probiotics and their role in food processing and human nutrition • Concept of prebiotic • Food contaminants and their effects on human health **Non-Alcoholic Beverages:** • Introduction to non-alcoholic beverages • Non-fermented beverages, current trends of non-fermented beverages (use in health benefits, stress reliever, immune system booster), flavoured milk, coconut water, sweet toddy, coconut milk, flavoured syrups), fruit beverages, tea, coffee • Fermented beverages: kombucha, probiotic drinks, buttermilk	9

II	**Food packaging Technology:** • Functions of packaging, types of packaging materials, selection of packaging material for different foods. • Biodegradable plastics, edible packaging and bio-composites, environmental concerns recycling and disposal of plastic waste, food packaging laws and regulations, barcodes and other marking **Quality assurance and Certification** • Introduction to quality, Role of QC (Quality control) and QA (Quality assurance), Concept of TQM (Total Quality Management) • General principles of food safety management system (FSMS) and HACCP system to prevent food borne illness. • Food safety and standards authority of India (FSSAI), Accreditation and certification introduction certification bodies in India BIS, AGMARK	**6**
B	**Pharmaceutical Biotechnology** **Biotechnology**	
III	**Introduction** • Introduction to pharmaceutical biotechnology • Microbes in pharmaceutical industries • Therapeutic and clinical applications **Drug Discovery and Development** • Drug Discovery, Recombinant, Biochemical and Molecular level screening systems, small molecule database and their construction/ design strategies • Rational Drug Discovery • Preclinical and Clinical trials; Estimation of toxicity: LD50 and ED50; • Biosimilars, biopharmaceuticals. • Production of useful proteins in transgenic animals, growth promoting factors, hormones.	**8**
IV	**Regulatory aspects in pharmaceuticals** • Introduction to pharmacopoeia; FDA regulation and IP, BP, USP; Reimbursement of drugs and biological • GMP in pharmaceuticals • ICH and WHO guidelines for quality control • Formulation of following pharmaceutical preparation as per IP: • Antibiotics (with any one example) • Steroids (with any one example) • Vitamins (with any one example).	**7**

Suggested Readings/Material:

A. Food Biotechnology

1. Food Microbiology, 5th edition, William C. Frazier and Dennis C. Westoff, McGraw Hill Education India.
2. Food Biotechnology – S. C. Bhatia Publisher: Woodhead Publishing India
3. Food Biotechnology: Principles and Practices – V. K. Joshi & R. S. Singh IK International
4. Advances in Agri-Food Biotechnology – Edited by Tilak Raj Sharma, Rupesh Deshmukh, Humira Sonah
5. Training Manual for Food Safety Regulators (Vol I, II, III & IV), Introduction to Food and Food Processing (2010), Food Safety and Standard authority of India.
6. Beverages: Technology, Chemistry, and Microbiology Varman and Sutherland Springer, 1994
7. Food Safety and Standards Act, 2006 Commercials Law Publications, New Delhi
8. Food Safety and Standards Act, 2006 FSSAI, New Delhi.

B. Pharmaceutical Biotechnology:

9. Biopharmaceuticals: Biochemistry and Biotechnology – Gary Walsh
10. Pharmaceutical Biotechnology – S. P. Vyas & V. K. Dixit
11. Biotechnology – U. Satyanarayana
12. Pharmaceutical Biotechnology: Principles and Applications – Ashutosh Kar
13. Biotechnology: Expanding Horizons – P. K. Gupta
14. Hugo, WB and Russell, AD, Pharmaceutical Microbiology, (2003). Blackwell Science Oxford, UK
15. Krogsgaard L, Lilijefors T. and Madsen, U. Textbook of Drug Design and Discovery, (2004). Taylor and Francis, London
16. Geoffrey Hanlon and Norman Hodges. Essential Microbiology for pharmacy and pharmaceutical science. (2013). Wiley Blackwell.
17. Microbiological methods – Part 1: Determination of the population of microorganisms on product. 3. PDA Technical Report No. 21, Bioburden Recovery Validation. 1990
18. Bhatia R and Ichhpujani RL. Quality Assurance in Microbiology. (1995). CBS Publishers, New Delhi.
19. Gregory Gregoriadis. Drug Carriers in biology & Medicine. (2001). Academic Press New York.
20. Satoskar R. S. and S. D. Bhandarkar (1991) Pharmacology and Pharmacotherapeutics, 12th Edition. Vol. 1 and 2. Popular Prakashan, Mumbai.

SEM - V: Major Elective
Course Code: ME-302-BT-P
Course Name: Practical in Food and Pharmaceutical Biotechnology
Credit: 2P
No. of Practical: 15

Course Objective:

1. To familiarize students with biotechnological techniques used in food processing and pharmaceutical production**.**
2. To understand quality control and sterility testing methods used in food and pharmaceutical industries.
3. To provide hands-on experience with laboratory instruments and techniques used in biotechnology laboratories.

Course Outcomes (COs)

1. Evaluate basic food quality and safety parameters using microbiological and biochemical tests.
2. Isolate and identify microorganisms involved in food fermentation and spoilage
3. Recognize the fundamentals of pharmaceutical biotechnology, such as genetic engineering, microbial fermentation, and biopharmaceutical manufacture.
4. Analyze microbial metabolites and evaluate their pharmaceutical applications.

Unit	Topic	No of Practical
1	Isolation, colony characterization and Gram characteristics of bacteria from fermented food (curd/ idli batter/ dhokla batter)	**2**
2	Testing of food adulteration (milk/ milk products/haldi or any food sample)	**1**
3	Determination of moisture in food sample. /Determination of ash in food sample	**1**
4	Determination of total poly phenol content in any non- alcoholic beverage	**2**
5	Preparation of fermented foods and determination of its shelf life	**2**
6	Detection and isolation of anti-bacterial from Indian medicinal plant i. Extraction of bioactive principles from plant and activity fractionation ii. Estimation of its antimicrobial activity using standard(CLSI) guidelines	**3**
7	Antibiotic Potency test- Plate diffusion method (Minimum Inhibitory Concentration)	**2**
8	Sterility test for pharmaceutical products	**\1**
9	Visit to Food/ Pharmaceutical industry	**1**

Suggested Readings/Material:

1. Cappuccino, J.G. & Sherman, N. *Microbiology: A Laboratory Manual.*
2. Sandikar, B.M. & Mamdapure, S.V. *Laboratory Manual in Microbiology.*
3. da Silva, N. et al. *Microbiological Examination Methods of Food and Water.*
4. Chauhan, A. & Jindal, T. *Microbiological Methods for Environment, Food and Pharmaceutical Analysis.*
5. Shen, C. & Zhang, Y. *Food Microbiology Laboratory for the Food Science Student.*

SEM - V: Major Elective
Course Code: ME-303-BT-T
Course Name: Nano biotechnology
Credit: 2T
No. of Lecture: 30

Course Objectives

1. To introduce the concept of nanotechnology and its biological applications to the biotechnology students
2. To study the technique to synthesis various metals and polymer nanoparticles as well as to find its characterstics
3. To find out applications of nanoparticles in various biologicals sectors like agriculture, medicine, environment and industries

Course Outcomes (COs)

After completion of this course, students will be able to:

1. Understand fundamental principles and evolution of nanotechnology and nanobiotechnology.
2. Classify nanomaterials based on structure, composition, and properties.
3. Explain synthesis methods including physical, chemical, and biological approaches.
4. Analyze characterization techniques for nanomaterials.
5. Evaluate applications of nanobiotechnology in medicine, environment, agriculture, and food systems.
6. Assess safety, toxicity, and ethical concerns in nanotechnology.

Unit	Topic	No of lectures
I	**Fundamentals of Nanoscience and Nanobiotechnology** • Definition, scope, and history of nanotechnology • Concept of nanobiotechnology and DNA nanotechnology • Size scale and nanoscale effects • Surface area to volume ratio and quantum effects	6
II	**Types and Properties of Nanomaterials** • Classification of nanomaterials: • Carbon-based (nanotubes, graphene) • Metal and metal oxide nanoparticles • Polymeric nanoparticles • Lipid nanoparticles • Biological nanomaterials • Types of nanostructures: • Nanoparticles, nanowires, nanotubes, quantum dots • Dendrimers and nanocomposites • Properties: • Optical, electrical, magnetic, and mechanical properties • Size-dependent properties	8
III	**Synthesis of Nanomaterials** i) Physical Methods ii) Chemical Methods	7

	iii) Biological Synthesis iv) Post-synthesis Processing v) Stabilization (capping agents) vi) Surface modification and functionalization	
IV	**Characterization Techniques** • Determination of size, shape, surface properties, and stability • Scanning Electron Microscopy (SEM) • Transmission Electron Microscopy (TEM) • UV–Visible spectroscopy • Fluorescence spectroscopy • X-ray diffraction (XRD)	6
V	**Applications of Nanobiotechnology** i) Medical and Healthcare Applications ii) Industrial and Biological Applications iii) Environmental Applications iv) Nanotechnology in agriculture v) Safety, Ethics, and Future Perspectives	3

Suggested Readings

1. Kulkarni S. K. – *Nanotechnology: Principles and Practices*
2. Niemeyer C. M. & Mirkin C. A. – *Nanobiotechnology: Concepts, Applications and Perspectives*
3. Klabunde K. J. – *Nanoscale Materials in Chemistry*
4. Rao C. N. R. – *Chemistry of Nanomaterials*
5. Schmidt G. – *Nanoparticles: From Theory to Applications*

SEM - V: Major Elective
Course Code: ME-304-BT-P
Course Name: Practical in Nano Biotechnology
Credit: 2P
No. of Practical: 15

Course Objectives

1. To provide practical knowledge to synthesis of various nanoparticles using chemical, microbial and green (plant) methods
2. To understand the physical characteristics of nanoparticles by performing advance tools like SEM, XRD FTIR
3. To evaluate the medicinal, environmental, agriculture applications of nanoparticles

Course Outcomes

1. Synthesize metal and metal oxide nanoparticles using chemical, microbial, and green (plant-based) methods.
2. Perform spectroscopic and analytical characterization of nanoparticles and interpret data.
3. Understand and interpret advanced characterization techniques (SEM, TEM, XRD, FTIR, DLS) through experimental/digital modes.
4. Evaluate biological and environmental applications of nanoparticles such as antimicrobial activity and dye degradation.
5. Analyze nanoparticle properties such as size, stability, and toxicity.

Unit	Topic	No of Practical
1	**Synthesis of Nanoparticles using:** 1. Biological method 2. Chemical method 3. Physical method 4. Synthesis of metal oxide nanoparticles 5. Synthesis of any one nanostructure (Nanotube, nanowire, Nano composite, Nano sheets)	6
2	**Characterization of Nanomaterials** 1. UV-Visible spectrophotometric analysis of nanoparticles 2. Interpretation of **SEM/TEM images** (image-based study) 3. Analysis of **XRD data** (digital/demo mode) 4. Nanoparticle stability analysis	5
3	Applications of Nanoparticles 1. Antibacterial activity (MIC/MBC determination) 2. Dye degradation/absorption using nanoparticles 3. Case study on medical/diagnostic applications	4

SEM –V: VSC
Course Code: VSC-301-BT-P
Course Name: Practical in Recombinant DNA Technology
Credit: 2P
No. of lectures: 30P

Course Objective

1. To provide hands-on training in basic molecular biology and recombinant DNA techniques.
2. To develop skills in isolation, purification, and analysis of nucleic acids.
3. To familiarize students with enzymatic manipulation of DNA such as restriction digestion and ligation.
4. To impart practical knowledge of gene cloning techniques including transformation in *E. coli*.
5. To train students in amplification and analysis of DNA using PCR and gel electrophoresis.

Course Outcome

After successful completion of the course, students will be able to:

1. Isolate and analyze plasmid and genomic DNA from biological samples.
2. Perform restriction digestion and ligation for recombinant DNA construction.
3. Carry out transformation of competent bacterial cells and select recombinants.
4. Perform PCR amplification and analyze products using agarose gel electrophoresis.
5. Apply molecular biology techniques for gene cloning and basic genetic analysis.

Unit	Topic	No. of Practical
1	Plasmid DNA Isolation and Gel Electrophoresis	2
2	DNA Ligation and Gel Electrophoresis	1
3	Restriction Digestion of DNA Sample and Gel Electrophoresis	1
4	Transformation of *E. coli* Cells (Competent cell preparation, Transformation, Selection of recombinants)	3
5	PCR Reaction and Gel Electrophoresis	2
6	RNA Isolation and Purification from Biological Samples	2
7	Isolation of Genomic DNA from Bacterial Cells	1
8	Isolation of Genomic DNA from Plant Tissue	1
9	Isolation of Genomic DNA from Animal Tissue	1
10	Determination of purity and quantification of DNA and RNA preparation using Spectrophotometer	1

SEM- V: Minor
Course Code: MN-301-BT-T
Course Name: Tissue Culture Technology
Credit: 2T
No. of Lectures: 30

Course Outcome

On completion of course students will be able to,

1. Understand the fundamental concepts of Plant tissue culture (PTC) and Animal Tissue Culture (ATC).
2. Familiarize the techniques and applications of plant animal tissue culture techniques.
3. Gather knowledge and apply it to grab future opportunities in this field.

Course Objective:

1. Understanding basic concept of Plant and Animal Tissue Cultures including laboratory design, equipment and aseptic techniques.
2. Exploring basic concept of media composition, various types of media and its role.
3. Understanding of different techniques used in tissue culture.
4. Comprehending applications of tissue culture in industry and academia.

Unit	Topic	No. of Lectures
	Plant Tissue Culture (15 L)	
I	**Introduction to Plant Tissue Culture** • Introduction and brief history of PTC. • Definitions and Concepts: 1.1. Plant tissue culture, In vitro culture, cellular totipotency, differentiation, dedifferentiation, and re-differentiation. 1.2. *In vitro* culture, *in vivo* culture, plantlet, seedling, and micropropagation 1.3. Aseptic condition, sterilization, contamination, decontamination. 1.4. Callus culture, suspension culture, organogenesis, somatic embryogenesis **Basics Facilities of Plant Tissue culture** • Laboratory design of plant tissue culture laboratory • Principle and Working of equipment & instruments: Glass distillation unit, Hot air oven, Autoclave, Laminar Air Flow, pH meter, Hot plate magnetic stirrer, Microwave oven, Culture racks, Air	8
II	**Aseptic Techniques in PTC** • Precautions to maintain aseptic conditions in PTC Lab • Washing & preparation of glassware, Packing & sterilization of Glassware, plastic ware and instruments • Media sterilization and surface sterilization **Media Preparation** • Introduction, definition and concept of medium. • Role of essential nutrients in plant growth and development. • Types of culture media: MS, B5, White's and Nitsch medium. • Composition of MS nutrient culture media – macronutrients (Major stock), micronutrients (minor stock), organic supplements (vitamins and amino acids), carbon/energy source, plant growth regulators, other additives, pH, gelling agent. **Applications of plant tissue culture in Industry and academia**	7

Animal Tissue Culture (15 L)		
III	**Introduction to Animal Tissue Culture** • History and development of Animal Tissue Culture • Concept of Primary Culture, Secondary Culture, Cell lines, 3D culture • Concept of monolayer culture and suspension culture **Aseptic conditions in ATC** • Maintenance of aseptic conditions in ATC lab • Contamination, types of contaminants • Methods of detection of contaminants • Cross contamination **ATC Laboratory and Equipment** • Laboratory design • Equipment and Lab wares: CO_2 incubator, inverted microscope, laminar air flow hood, T flasks	8
IV	**Nutrition and Physiology of cultured cells** • Nutritional requirement and physiology of cultured cells. • Principles of media formulation. • Serum containing medium and serum free medium: Advantages and Disadvantages. **Primary cell culture and Cell Line** • Methods of establishing primary cell culture • Concept of cell line, Finite and transformed cell lines **Cryopreservation of cells** **Applications of ATC**	7

Suggested Readings/ Material:

5. Razdan M.K, Introduction to Plant Tissue culture. (2019) 3rd edition, Oxford & IBH Publications, New Delhi
6. Bhojwani S.S. & Razdan M.K. (1996) (2016)- Plant Tissue Culture: Theory & Practice (Elsevier, New Delhi)
7. Jha TB & Ghosh B, Plant tissue culture: Basic and applied, (2017) 2nd edition, Universities Press, Hyderabad
8. Kalyan Kumar De, Plant Tissue culture (2010), New central Book Agency Calcutta
9. R. Ian Freshney, Amanda Capes-Davis, Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications. (2021) 8th Edition, Willey-Blackwell Publications.
10. Veer Bala Rastogi, Nirvika Rastogi, Animal Cell Culture and Technology. (2023) 1st Edition, MedTech Science Press.
11. Principles and Practice of Animal Tissue Culture by Sudha Gangal, 2nd Edition.

SEMESTER-VI

SEM - VI: Major Core
Course Code: BT-351- T
Course Name: Enzyme and Enzyme Technology
Credit: 2C
No. of lectures: 30

Course Objective:

1) To understand the structure, classification and mechanism of enzymes
2) To develop knowledge of enzyme kinetics and regulation with reference to CSIR-NET
3) To introduce the industrial applications of enzymes and enzyme technology
4) To provide insight into modern techniques such as enzyme immobilization and biosensors

Course Outcomes (COs)

After completion of the course, students will be able to:

1) Understand the structure and classification of enzymes
2) Explain enzyme catalysis mechanisms and basic enzyme kinetics
3) Analyze enzyme inhibition and regulatory mechanisms
4) Apply knowledge of enzymes in industrial and clinical fields
5) Understand modern tools such as immobilized enzymes and biosensors

Unit	Topic	No of lectures
I	**Introduction and Classification of Enzymes** • IUBMB classification of enzymes and their general properties • Structure of enzymes with reference to active site and specificity • Concept of ribozymes and DNAzymes • Role of cofactors and coenzymes in enzyme function	5
II	**Enzyme Catalysis and Mechanism** • Types of enzyme catalysis including acid-base, covalent and metal ion catalysis • Models of enzyme action: Lock and Key and Induced Fit hypothesis • Mechanism of enzyme action with reference to chymotrypsin	5
III	**Enzyme Kinetics** • Basic concepts of enzyme kinetics and factors affecting enzyme activity • Michaelis-Menten kinetics and significance of Km and Vmax • Concept of turnover number (Kcat) • Lineweaver-Burk plot and its interpretation • Types of enzyme inhibition: competitive, non-competitive and uncompetitive	8
IV	**Enzyme Regulation** • Mechanisms of enzyme regulation including allosteric regulation and feedback inhibition • Regulation by covalent modification • Concept and significance of isoenzymes • Basic concept of enzyme degradation	5

V	**Enzyme Technology and Applications** • Techniques of enzyme immobilization and their significance • Industrial applications of enzymes such as amylase, protease and lipase • Clinical applications of enzymes • Concept of biosensors with reference to glucose oxidase • Enzyme Engineering & Directed Evolution with suitable example	**7**

Suggested Readings/Material:

1) Nelson, D. L. and Cox, M. M., *Lehninger Principles of Biochemistry*. 5th Edition (2008), W.H. Freeman and Company, New York.
2) Voet, D. and Voet, J. G., *Biochemistry*. 4th Edition (2011), John Wiley and Sons, USA.
3) Palmer, T., *Enzymes: Biochemistry, Biotechnology and Clinical Chemistry*. 2nd Edition (2001), Horwood Publishing, UK
4) Price, N. C. and Stevens, L., *Fundamentals of Enzymology*. 3rd Edition (1999), Oxford University Press, UK.
5) Buchholz, K., Kasche, V. and Bornscheuer, U. T., *Biocatalysts and Enzyme Technology*. 2nd Edition (2012), Wiley-Blackwell, Germany.
6) Principles of Biochemistry, 4th edition (1997), JefforyZubey, McGraw-Hill College, USA

SEM - VI: Major Core
Course Code: BT-352- T
Course Name: Industrial Microbiology
Credit: 2T
No. of lectures: 30

Course Objective:

1. To understand the role of microorganisms in industrial processes and the principles of microbial growth and metabolism used for production of industrial products.
2. To study fermentation technology and bioreactor systems used for large-scale production of microbial products such as antibiotics, enzymes, organic acids, and alcohol.
3. To develop knowledge of upstream and downstream processing techniques involved in the recovery and purification of industrially important microbial products.

Course Outcomes

1. Define fermentation, fermentation types (batch, fed-batch, continuous), and their industrial significance.
2. Explain the principles of microbial growth, metabolism, and strain improvement relevant to industrial applications.
3. Describe the design, components, and operation of bioreactors, including aeration, agitation, and process control systems.
4. Demonstrate knowledge of fermentation technology, including media formulation, sterilization, inoculum preparation, and bioreactor design production and recovery.
5. Reveal the large-scale manufacturing and recovery processes of fermentation products of various sectors

Unit	Topic	No of lectures
I	**Introduction to Industrial Microbiology:** • Concept of Fermentation Process- Definition, Historical perspective, • Typical Lay out of a fermentation process • Types of fermentations: Batch, Continuous, Fed Batch , Submerged, Surface, Solid State, Dual **Screening** • Isolation and Screening of industrially important microorganisms • Definition and Objectives, Primary and Secondary Screening **Strain Improvement Techniques:** • Objectives, Methods for strain improvement with examples (mutants with altered permeability, auxotrophic mutants, analogue resistant mutants), • rDNA technology for strain improvement.	**8**
II	**Bioreactor Design**: • Characteristics of an ideal Fermenter,	**9**

	• Design of a typical Batch Fermenter, Aerator and Agitator- types, Baffles, Seals and valves used, steam traps. • Different designs of bioreactors: Air Lift (internal and external loop), Packed Bed reactor, Fluidized bed reactor **Media components, optimization and sterilization:** • Carbon sources: Cane and Beet molasses, Malt, Corn, Starch, oils, hydrocarbons, alcohols. • Nitrogen sources: Corn steep liquor, Soybean meal, peanut meal, • Buffering agents, Chelators, Water, Precursors, Inhibitors, Inducers Antifoams. • Concept of Medium Optimization: Classical Approach, Placket and Burman design **Media Sterilization:** • Principles, Del factor, Indicator organism for design of sterilization cycle, • Batch and Continuous sterilization process. **Air sterilization:** • Principles and Mechanism of Fixed (absolute) and non-fixed pore (depth) filters.	
III	**Measurement and Control of different Bioprocess parameters:** • Temperature, pH, Foam, Dissolved oxygen, Microbial biomass • Concept of Scale up and scale down **Downstream Processing of fermentation product- Methods and equipment's** • Definition, Unit operations and downstream processing, General strategy of product recovery • **Precipitation:** (Agents used: Salts, Organic solvents, polyelectrolytes, acids and bases) • **Filtration:** (Plate Frame. Rotary Vacuum, Filter Aids, Flocculating agents) • **Centrifugation:** (types used in Industry: basket, tubular bowl, disc bowl) • **Cell Disruption:** (Physico–mechanical and chemical methods). • **Solvent extraction**: Liquid - liquid extraction • **Drying**: Drum and spray	**9**
IV	**Large Scale Manufacturing Process-** • Organic acid (Citric Acid), • Vitamin B12 • Alcohol • Enzyme- Amylase	**4**

Suggested Readings/Material:

1. Stanbury P., Whitaker *A.,* Stephen H. Principles of Fermentation Technology 3rd Edition Butterworth-Heinemann 2017
2. Wulf Cruger and Anneliese Crueger, Biotechnology: A Textbook of Industrial Microbiology, 2nd edition, Panima Publishing Corporation, 2004.
3. Casida Jr, L.E., Industrial Microbiology, 1st edition, New Age International (P) Ltd, 2007.
4. Presscott, Dunn, Industria lMicrobiology, 1st edition, Agrobios (India), CBS Publication,2004.
5. A.H. Patel, Industrial Microbiology, 1st edition, MacMillan Publication, 2008.
6. Mathuriya S Abhilasha Industrial Biotechnology ANE books, 2009
7. Prescott SC and Dunn CG Industrial Microbiology Jodhpur Agrobios.2011
8. Biochemical Engineering Fundamentals by James E. Bailey and David F. Ollis 2nd edition, McGraw Hill, (1986)
9. Doran P Bioprocess Engineering Principles Academic Press Ltd 2nd edition 2013
10. Michael J. Waites, Neil L. Morgan, John S. Rockey Blackwell Science. Industrial Microbiology.

11. Richard H. Baltz, Julian E. Davies, Arnold L. Demain Publisher: ASM Press. Manual of Industrial Microbiology and Biotechnology
12. H. J. Peppler & D. Perlman, Academic Press. Microbial Technology

e Resources:

1. https://biokamikazi.files.wordpress.com/2013/09/principles_of_fermentation_technology-stanburry_whittaker.pdf
2. http://site.iugaza.edu.ps/mwhindi/files/ebooksclub.org__Bioprocess_Engineering_Principles.pdf
3. http://rims.ruforum.org/B5C1BA5D7194/industrial-microbiology-prescott-dunn.pdf
4. http://str-tn.org/biochemical_engineering_fundamentals_bailey.pdf

SEM -VI: Major Core
Course Code: BT-353- T
Course Name: Immunology
Credit: 2T
No. of lectures: 30

Course Objectives

1. To understand the structure and function of the immune system.
2. To study immune responses against pathogens.
3. To understand immune disorders and modern immunotherapies.
4. To introduce students to advanced immunological techniques and vaccines**.**

Course Outcome

1. Students will understand structure and function of the immune system
2. Able to describe the mechanism of immune response against pathogens
3. Explain the immune disorder and the dysfunctioning of physiological system behind it
4. Demonstrate the knowledge of various serological technique to find abnormalities in immune system

Unit	Topic	No of lectures
I	**Introduction to the Immune System** **History and Scope of Immunology** • Development of immunology as a scientific discipline, Contributions of early scientists in immunology **Types of Immunity** • Innate immunity – mechanisms, Immediate response, non-specific defense • Acquired immunity – Types, Specific immune response, Immunological memory **Cells and Organs of the Immune System** • Immune cells – Neutrophils, Macrophages, Dendritic cells, Natural killer cells, Lymphocytes (B and T cells) • Lymphoid organs - Primary lymphoid organs (Bone marrow, Thymus), Secondary lymphoid organs (Spleen, lymph nodes, MALT) **Immunologically relevant receptor: host and pathogen receptor**	**10**
II	**Component of immune systems** **Antigens** • Definition and properties, • Immunogenicity and antigenicity, • Epitopes and antigen determinants, Haptens and carrier molecules **Immunoglobulins** • Structure of antibodies- Heavy and light chains, Variable and constant regions • Classes of immunoglobulins- IgG, IgM, IgA, IgE, IgD, Biological functions of antibodies • Antibody Diversity: V(D)J Recombination • Major Histocompatibility Complex (MHC): Structure and functions of MHC Class I, and MHC Class II, • Cytokines: properties and function • Complement system: component and function	**10**

V	**Hypersensitivity and Immunological Disorder** • Hypersensitivity Reactions: Types • Autoimmune Diseases: concept and examples • Immunodeficiency Disorder: concept and example **Serological Techniques:** Antigen–antibody reaction principles, precipitation reaction, Immunodiffusion, Agglutination reactions, ELISA	**10**

Suggested References

1. Ananthanarayan R and Paniker CKJ. Textbook of Microbiology. University Press Publication.
2. Roitt I. Essential Immunology. 10th Ed. Blackwell Science.
3. Kuby. Immunology. 4th edition. W. H. Freeman & company.
4. Sudha Gangal and Shubhangi Sontakke, Textbook of basic and clinical immunology, 1st edition (2013), University Press, India

SEM - VI: Major Core
Course Code: BT-354- T
Course Name: Computational Biotechnology
Credit: 2T
No. of lectures: 30

Course Objective:

1. To introduce fundamental concepts of bioinformatics.
2. To develop practical skills in bioinformatics tools and software.
3. To introduce B.Sc. Biotechnology students to the fundamental concepts of Artificial Intelligence and its applications in biotechnology

Course Outcomes (COs)

1. Explain fundamental concepts of bioinformatics, including biological databases, sequence formats, and basic algorithms used in sequence analysis.
2. Perform sequence alignment and similarity searches using standard bioinformatics tools (e.g., BLAST) and interpret the results accurately.
3. Retrieve and analyse biological data from major databases (such as GenBank, PDB, and UniProt) to understand gene and protein structure–function relationships.
4. Students will be able to explain basic AI and machine learning concepts and know their applications in various biotechnology

Unit	Topic	No of lectures
I	**Introduction to Bioinformatics** • History & scope • Branches • Bioinformatics to Biotechnology **Biological Databases** • Data generation and types (NGS Genome Sequencing, Protein sequencing, NMR Spectroscopy, and Microarray) • Databases (Primary, Composite, and Secondary) • Literature database: Pubmed, MEDLINE • Nucleic acid databases (DDBJ, GENBANK and EMBL). • Protein databases (Swissprot, UniProt).	10
II	**Data Retrieval** • Nucleic acid - DNA & RNA (DDBJ, GENBANK and EMBL) • Protein data (Swissprot, UniProt) • Download strategies file format and automation	7
III	**Tools in Bioinformatics** • Sequence alignment tools: Types - global and local, multiple sequence alignment and pairwise alignment • Visualization tools for sequence and structure data: alignment visualization structure visualization	7
IV	• **Introduction to Artificial Intelligence (AI)** Definition of AI, Machine Learning, and Deep Learning, Importance of AI in biotechnology, • **Fundamentals of Machine Learning and Biological Data** Definition of Machine Learning, Types: Supervised learning, Unsupervised learning, Reinforcement learning, Use in biological data types • **Use of common AI tools** ChatGPT, Google Gemini, Canva, Claude	6

	• **Challenges and Future Prospects** Challenges to biotechnologies in AI world, Ethical and societal aspects of AI, data privacy, and limitations, Future scope of AI in biotechnology	

Suggested Readings/Material:

1. Mount David W., Bioinformatics: Sequence and Genome Analysis. (2005) 2nd edition, Cold Spring Harbor Laboratory Press.
2. Jin Xiong. Essential Bioinformatics. First Edition Edition - 1 January 2007. ISBN-13: 978-0521706100 ISBN-10: 0521706106
3. Orpita Bosu, Simminder Kaur Thukral, Bioinformatics: Experiments, Tools, Databases, and Algorithms. (2007), Oxford Higher Education.
4. Teresa Attwood, Parry Smith, David J. Introduction to Bioinformatics. (2007), Pearson Education (Singapore) Pvt. Ltd.
5. Durbin R., Eddy S., Krogh A. and Mithchison G. 2007 Biological Sequence Analysis, Cambridge University Press.
6. Web resources and online computational tools available at NCBI, Swissprot, Uniprot etc.
7. Introduction to Molecular Docking – Nachiket-M- Atale, Tusar R Gaikwad, Omkar M Atale;
8. Molecular Docking and Molecular Dynamics Edited by Amalia Stefaniu

Key Free Tools

1. AutoDock Vina: A popular open-source program for drug discovery, often featured in tutorial-based guides.
2. PyRx: A virtual screening tool that simplifies the use of AutoDock.
3. SwissDock: A web-based server for molecular docking, ideal for beginners

SEM - VI: Major Core
Course Code: BT-355- P
Course Name: Practical in Industrial Microbiology
Credit: 2P
No. of Practical: 15

Course Objective:

1. To develop practical skills in the isolation, cultivation, and maintenance of industrially important microorganisms.
2. To understand and perform basic fermentation techniques used in the production of industrial products.
3. To learn methods for screening, production, and analysis of microbial metabolites such as enzymes, antibiotics, and organic acids.

Course Outcomes (COs)

1. Students will be able to isolate, culture, and maintain industrially important microorganisms using standard microbiological techniques.
2. Students will be able to perform basic fermentation processes and analyse microbial production of industrially important metabolites.
3. Students will be able to apply screening and analytical methods for evaluating microbial products used in industry.

Unit	Topic	No of Practical
1	Screening and isolation of antibiotic producing organism from soil (Crowded plate and Giant colony method) Improvement of production strain using UV radiation	**4**
2	Preservation of Industrial Microorganisms by using glycerol stock/ lyophilization /oil overlay / soil method**.**	**1**
3	Lab scale Production, Recovery (Filtration, Precipitation, solvent extraction) and estimation (Titrimetric, colorimetric, bioassay) of: i) Primary metabolite: Organic acid ii) Secondary metabolite: Antibiotic	**4**
4	Lab scale production, recovery and estimation of Ethanol	**2**
5	Study of various parts and working of Lab Bench fermenter	**1**
6	Preparation of wine and estimation of alcohol content, total titrable acidity and volatile acidity of wine	**2**
7	Visit to vaccine/ pharma/ wine industry	**1**

Suggested Readings/Material:

1. Practical Manual on Fermentation Technology, eds Kulandaivel & S. JanarthananI K, International Publishing House Pvt. Ltd, 2012 2.
2. Experiments in Microbiology, Plant Pathology and Biotechnology, K.R. Aneja, New age International, 2017
3. Practical Handbook of Microbiology – Lorrence H. Green & Emanuel Goldman
4. Handbook of Practical Microbiology – Senthilkumar Palanisamy et al.

- Web Resources
  https://www.researchgate.net/publication/344465390_Practical_Manual_Cum_Wo Rkbook_On_Industrial_Microbiology

SEM - VI: Major Core
Course Code: BT-356- P
Course Name: Practical in Computational Biotechnology & Immunology
Credit: 2P
No. of Practical: 15

Course Objective:

1. To introduce students to basic bioinformatics databases and tools used for retrieval and analysis of biological sequence data.
2. To develop practical skills in sequence alignment, gene prediction, and protein structure analysis using bioinformatics software and online resources.
3. To enable students to interpret biological data using computational tools for applications in genomics, proteomics, and molecular biology.
4. To provide hands on training on various immunological technique require to analyse abnormalities in immune system

Course Outcomes (COs)

1. Retrieve and analyze biological data from major bioinformatics databases such as NCBI, UniProt, and PDB.
2. Perform sequence alignment and similarity searches using bioinformatics tools such as BLAST and Clustal tool.
3. Analyze and interpret nucleotide and protein sequences using various bioinformatics tools for basic genomic and proteomic studies.
4. Students will perform various immunological technique to study human immune system

Unit	Topic	No of Practical
1	Introduction to biological databases and retrieving the information • Genbank • EMBL • UNIPORT	2
2	Literature search using PubMed and Medline	1
3	Introduction of sequence alignment: Introduction to pairwise sequence Alignment: Use of BLAST and FASTA tools for Pairwise sequence alignment.	2
4	Designing of prompt for ethical use of AI: Canva for presentation making & Chat GPT	3
5	**Immunological Techniques** 1. Blood cell counting 2. Blood group determination (ABO and Rh typing) 3. Ouchterlony double diffusion test 4. Radial immunodiffusion 5. Qualitative ELISA	7

Suggested Readings/Material:

1. Bioinformatics: Sequence and Genome Analysis – David W. Mount
2. Bioinformatics: Methods and Applications – S. C. Rastogi, N. Mendiratta, P. Rastogi
3. Introduction to Bioinformatics – Arthur M. Lesk
4. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins – A. D. Baxevanis & B. F. F. Ouellette
5. Essential Bioinformatics – Jin Xiong

SEM - VI: Major Elective
Course Code: ME-351-BT-T
Course Name: Bioanalytical Techniques
Credit: 2T
No. of lectures: 30

Course Objective:

1. To introduce fundamental laboratory practices, safety, and basic biochemical calculations.
2. To provide understanding of analytical techniques used in biological sciences.
3. To explain principles and applications of spectroscopy in biomolecular analysis.
4. To familiarize students with separation techniques such as centrifugation, chromatography, and electrophoresis.
5. To develop skills for analysis and interpretation of experimental data.

Course outcome:

1. Students will be able to apply laboratory safety guidelines and perform basic biochemical calculations accurately.
2. Students will be able to explain the principles and working of spectroscopic techniques.
3. Students will be able to describe centrifugation and chromatographic methods for separation of biomolecules.
4. Students will learn electrophoretic techniques for biomolecular analysis.
5. Students will be able to analyze experimental data and select appropriate bioanalytical techniques for specific applications.

Unit	Topic	No. of lectures
I	Basic Laboratory Practices and Calculations 1. Scientific notation, units: biochemical calculation 2. Calibration of pipettes and balance	2
II	Spectroscopy 1. Electromagnetic spectrum 2. Transmittance and absorbance 3. Beer–Lambert's law and limitations 4. UV–Visible spectrophotometry: principle, instrumentation, applications	8
III	Separation Techniques: Principle, Types & Applications • Centrifugation • Chromatography • Electrophoresis	20

Reference Books:

1. Wilson K and Goulding K.H., A biologist's guide to Principles and Techniques of Practical Biochemistry.
2. Willard and Merrit, Instrumental Methods and Analysis
3. Ewing GW, Instrumental Methods of Chemical analysis.
4. Vogel's, Text Book of Quantitative Chemical Analysis, 6th Edition, 2004.
5. Raymond P. W. Scott, Techniques and Practice of Chromatography –Vol. 70.
6. Sethi P.D, DilipCharegaonkar, Chromatography –2nd Edition.
7. Hanes, Gel Electrophoresis of Proteins- A Practical Approach,
8. Biophysical chemistry by Upadhyay, Upadhyay and Nath, Himalaya publication house.

SEM - VI: Major Elective
Course Code: ME-352-BT-P
Course Name: Bioanalytical Techniques
Credit: 2P
No. of Practical: 15

Unit	Topic	No. of Practical
1	Micropipetting: Accurate pipetting, volumes of pipettes P10, P100, P1000.	1
2	pH Measurement & Buffers: Use of pH meter, Preparation of buffer solutions , Calibration with standard buffers	2
3	Differential centrifugation	1
4	Quantitative determination of free amino acid	1
5	Amino acids separation by ion exchange chromatography	2
6	Dye separation using Gel filtration Chromatography	1
7	Separation of proteins by SDS-polyacrylamide & Native gels	4
8	Estimation of reducing sugar by DNSA (dinitrosalicylic acid) method	1
9	Estimation of creatinine in urine or Preparation of lactalbumin from milk	1
10	Estimation of cholesterol by ZAK's method	1

SEM- VI: Major Elective
Course Code: ME-353-BT-T
Course Name: Biomathematics and Biostatistics
Credit: 2T
No. of Lectures: 30

Course Objectives

1. To develop an understanding of mathematical concepts for biological applications.
2. To enable students to apply mathematical tools in analyzing biological systems.
3. To introduce statistical methods for organizing, representing, and summarizing biological data.
4. To build competency in probability and inferential statistics for scientific data interpretation.

Course Outcomes

1. Students will be able to apply mathematical models to solve biological problems.
2. Students will be able to use mathematical tools for analyzing biological processes.
3. Students will be able to represent and interpret biological data using descriptive statistical tools.
4. Students will be able to perform hypothesis testing and apply statistical methods like t-test, chi-square, and ANOVA.

Unit	Topic	No. of Lectures
	Biomathematics	
I	**Introduction to Biomathematics** **Linear & Differentials equations** • Types (ordinary and partial), order and degree of differential equation. • Homogeneous and non-homogeneous differential equation. • Applications: growth and decay, low of cooling.	7
II	**Differential Calculus** • Derivative and its physical significance, derivative of a function, implicit function, basic rules for differentiation, maxima and minima – their applications in biology (wave equation, heat equation, laplace equation). **Integral Calculus** • Integration of functions, basic rules for integration, definite and indefinite integrals, applications in finding area under curves. Applications of integration in biology.	8
	Biostatistics	
III	**Introduction to statistics with scope in biosciences (examples)** • Statistics as statistical data: Measures of centrality, various types of data (Raw data, grouped data) Representation of data using frequency distribution diagram (Simple /Multiple /Subdivided bar diagram, Pie diagram), Graphs (Histogram, polygon, curve) **Probability and probability distribution** • Probability theory experiments • Discrete random variable, binomial distribution and the poisson distribution, Normal distribution and application in biosciences	8
IV	**Hypothesis testing and correlation** • Purpose of hypothesis testing, data, assumptions, hypothesis, significance level, types of errors • Test statistics: Testing mean, testing variance, distribution of test statistics (t and z). • Student's t – test, chi square test, ANOVA (One and Two way)	7

Suggested Readings:

1. Fundamentals of Mathematical Statistics by S.C. Gupta and V. K. Kapoor. Sultan Chand &Co.
2. Discrete Mathematics By B.S. Verma, Vishwa Prakashan.
3. Mathematics for Biological Science by JagdishArya & Ladner.1979. Prentice Hall.
4. Malick, S.C. and Arora Mathematical Analysis
5. Jenny Olive – Maths :- a self study Guide – Cambridge Low prices edition
6. E.D. Rainville and P.E. Bedient (1989), Elementary Differential equations – McMillan, New York
7. System of Linear Equations
8. Fundamentals of Biostatistics. By Irfan A Khan.
9. P.S.S. Sunderrao and J. Richards-An introduction to Biostatistics, Prentice Hall Pvt. Ltd. India.
10. Differential Calculus by Shanti Narain
11. Integral Calculus by Shanti Narain
12. Differential Equation by A. R. Forsyth

SEM- VI: Major Elective
Course Code: ME-353-BT-P
Course Name: Biomathematics and Biostatistics
Credit: 2P
No. of Practical: 15

Course Objective:

1. To introduce basic mathematical and statistical tools used in biology
2. To develop skills in data collection, representation and analysis
3. To perform basic statistical calculations using biological data
4. To interpret and present data using graphs and charts

Course Outcomes (COs)

1. After completion of the course, students will be able to:
2. Perform basic statistical calculations such as mean, median and standard deviation
3. Represent biological data using tables, charts and graphs
4. Apply simple statistical tests for data analysis
5. Interpret experimental data and draw conclusions

Unit	Title of the Experiment	No. of Practical
1	Demonstration of mathematical expression : linear, direct proportionality, sigmodal, exponential using biological example	4
2	Preparation of tables and tabulation of biological data	1
3	Graphical representation of data: bar diagram, histogram, pie chart	2
4	Calculation of mean, median and mode	2
5	Calculation of standard deviation and variance	2
6	Probability basics and simple problems	1
7	Chi-square test (goodness of fit)	1
8	t-test (basic concept and calculation)	1
9	Analysis of biological data using a calculator/Excel (basic)	1

Suggested Readings:

1) Zar, J. H., *Biostatistical Analysis*. 5th Edition (2010), Pearson Education, USA
2) Daniel, W. W., *Biostatistics: A Foundation for Analysis in the Health Sciences*. Wiley, USA.
3) Gupta, S. C. and Kapoor, V. K., *Fundamentals of Mathematical Statistics*. Sultan Chand & Sons, New Delhi.
4) Sundararajan, S., *Biostatistics Made Easy*. Tata McGraw Hill, India.

SEM - VI: VSC
Course Code: VSC-351-BT-P
Course Name: Practical in Enzyme and Enzyme technology
Credit: 2P
No. of Practical: 15

Course Objective:

1. Isolation and Purification: To provide hands-on training in isolating, purifying, and characterizing enzymes from biological sources, including cell disruption techniques like homogenization and sonication.
2. Enzyme Kinetics & Analysis: To teach the determination of kinetic parameters Km & Vmax and the impact of physical factors (pH, temperature) on enzyme activity.
3. Immobilization Techniques: To introduce various methods of enzyme immobilization and evaluate the performance of immobilized enzyme reactors.
4. Industrial Application: To demonstrate the industrial and clinical application of enzymes and the ability to optimize these processes for practical use.

Course Outcomes (COs):

1. Skill Acquisition: Students will be able to perform enzyme assays and analyze experimental data for quantification.
2. Kinetic Evaluation: Students will be able to calculate and interpret kinetic parameters (Km & Vmax) and analyse the effects of inhibitors.
3. Application Design: Students will be able to design and implement techniques for enzyme immobilization and adapt these for specific industrial processes.
4. Scientific Reporting: Students will be able to document, analyze, and interpret laboratory findings in the form of technical reports or scientific papers.
5. Troubleshooting: Students will be able to identify problems in enzymatic processes and suggest modifications to optimize performance.

Sr.No.	**Topic**	No. of Practical
1	Isolation of Amylase from Plant Sources	1
2	Microbial Production of Enzymes**:** Production of protease/lipase/amylase	2
2	Determination of Enzyme activity. • Preparation of Std. of graph of Maltose. • Calculation of enzyme activity. • Preparation of standard curve of protein (Albumin) by Folin's-Lowry method Calculation of specific activity.	5
3	Effect of following parameters on Enzyme activity • Temperature • pH • Time	3
4	Effect of Substrate concentration on enzyme activity and determination of Km and Vmax	1
5	Enzyme Immobilization using gel entrapment method	1
6	Detection of Serum enzymes: SGOT/SGPT /Alkaline phosphatase	2

Suggested Readings/Material:

1. An Introduction to Practical Biochemistry.3rd Edition, (2001), David Plummer, Tata McGraw Hill Edu. Pvt. Ltd. New Delhi, India

2. Biochemical Methods.1st , (1995), S. Sadashivam, A. Manickam, New Age International Publishers, India 3. Bisswanger, Hans. Practical enzymology. John Wiley & Sons, 2013.
3. Wilchek, Meir, and 4. Edward A. Bayer. "Methods in enzymology." (1990).
4. Sawhney, S. K., and Randhir Singh. Introductory practical biochemistry. Alpha Science Int'l Ltd., 2000.
5. A textbook of practical biochemistry- Joshi A. Reshmi. Practical clinical biochemistry- Harold Varley