



(An Autonomous Institution - AFFILIATED TO ANNA UNIVERSITY, CHENNAI)

S.P.G.Chidambara Nadar - C.Nagammal Campus

S.P.G.C. Nagar, K.Vellakulam – 625 701 (Near VIRUDHUNAGAR).

**B.Tech. BIOTECHNOLOGY
REGULATION – 2020
AUTONOMOUS SYLLABUS
CHOICE BASED CREDIT SYSTEM
VII TO VIII SEMESTER CURRICULUM AND SYLLABI**

VISION:

To make the Department of Biotechnology, unique of its kind in the field of research and development activities pertaining to the field of biotechnology in this part of the world.

MISSION:

To impart highly innovative and technical knowledge in the field of biotechnology to the urban and rural student folks through “Total Quality Education”.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

- PEO 1:** Program Specific Academic Excellence: The student will be able to pursue higher education in India/Abroad in Biotechnology and its related fields by taking up competitive exams like GATE, CSIR, TANCET, GRE, TOEFL etc
- PEO 2:** Professional Attitude: The student will be able to come up with solutions for any scientific or technical problems related to Biotechnological industries/institutes by engaging in independent and life-long learning.
- PEO 3:** Core Competence: The student will be able to plan and conduct experiments in modern biotechnology and allied field laboratories using modern tools including interpreting the significance of resulting data, reporting results and writing technical reports
- PEO 4:** Collaboration: The students will be able to work in multidisciplinary team with confidence and will be able to venture out with entrepreneurial activities.

PROGRAM OUTCOMES:

After going through the four years of study, the biotechnology graduates will have the ability to

POs	Graduate Attribute	Programme Outcome
1	Engineering knowledge	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2	Problem analysis	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3	Design / Development of solutions	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4	Conduct investigations of complex problems	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
5	Modern tool usage	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations
6	The engineer and society	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice

7	Environment and sustainability	Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8	Ethics	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9	Individual and team work	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10	Communication	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11	Project management and finance	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12	Life-long learning	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAMME SPECIFIC OUTCOMES (PSOs):

PSO1 : Future ready graduates: The student will be able to identify, choose and perform to their best ability in the next career step: Higher education/Job/Entrepreneurial initiatives.

PSO2 : Industry ready graduates: The student will be able to apply the acquired knowledge to provide cost-effective and sustainable solutions in Biotechnology.

SEMESTER VII

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	BT1701	Downstream Processing	PC	3	3	0	0	3
2	BT1702	Immunology	PC	3	3	0	0	3
3	GE1671	Total Quality Management	ES	3	3	0	0	3
4		Professional Elective VI	PE	3	3	0	0	3
5		Professional Elective VII	PE	3	3	0	0	3
6		Open Elective II*	OE	3	3	0	0	3
PRACTICALS								
7	BT1711	Downstream Processing Laboratory	PC	4	0	0	4	2
8	BT1712	Immunology Laboratory	PC	4	0	0	4	2
9	BT1721	Mini Project	EE	4	0	0	4	2
TOTAL				30	18	0	12	24

SEMESTER VIII

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	OL2	Online Course - II	OL	NPTEL/SWAYAM				3
PRACTICALS								
2	BT1821	Project work	EE	16	0	0	16	8
TOTAL				16	0	0	16	11

* Course from the Curriculum of other UG programmes.

PROFESSIONAL ELECTIVES (PEs)

PROFESSIONAL ELECTIVE VI (SEMESTER VII)

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	BT1731	Algal Technology	PE	3	3	0	0	3
2	BT1732	Bioconjugate Technology and Applications	PE	3	3	0	0	3
3	BT1733	Biopharmaceutical Technology	PE	3	3	0	0	3
4	BT1734	Foundation Skills in Integrated Product Development	PE	3	3	0	0	3
5	BT1735	Instrumentation and Process Control	PE	3	3	0	0	3

PROFESSIONAL ELECTIVE VII (SEMESTER VII)

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	BT1736	Bio-industrial Entrepreneurship	PE	3	3	0	0	3
2	BT1737	Bioprocess Economics and Plant Design	PE	3	3	0	0	3
3	BT1738	Developmental biology	PE	3	3	0	0	3
4	BT1739	Neurobiology and Cognitive Sciences	PE	3	3	0	0	3
5	BT1740	Stem Cell Technology	PE	3	3	0	0	3

OPEN ELECTIVE – II (SEMESTER VII)**OFFERED BY DEPARTMENT OF BIOTECHNOLOGY**

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
Offered to EEE, EIE, ECE and MTR								
1	OBT171	Instrumentation and Analytical methods	OE	3	0	0	3	3
Offered to EEE, EIE, MTR and PT								
2	OBT172	Introduction to Food Manufacturing	OE	3	0	0	3	3
Offered to CSE, IT and AI								
3	OBT173	Testing of Biological Materials	OE	3	0	0	3	3

L	T	P	C
3	0	0	3

OBJECTIVES:

- To impart basic knowledge in the area of separation technologies for biomolecules.
- To understand workflow for the separation of DNA, RNA, proteins and secondary metabolites.
- To assimilate recent research findings, advancement and development in the subject

UNIT I INTRODUCTION TO DOWNSTREAM PROCESSING 9

Introduction to separation of biomolecules and its importance in biotechnology, Characteristics of fermentation broth and biomolecules. Cell disruption for product release - Physical, chemical and enzymatic methods. Pretreatment and stabilization of bioproducts

UNIT II PHYSICAL METHODS OF SEPERATION 9

Unit operations for solid-liquid separation - Filtration, Centrifugation-based methods for separation of the cell organelles and biomolecules (DNA, RNA, Proteins and secondary metabolites).

UNIT III RECOVERY AND ISOLATION OF PRODUCTS 9

Liquid-liquid extraction - aqueous two-phase extraction; Membrane separation - microfiltration, ultrafiltration, nanofiltration and reverse osmosis, dialysis; Precipitation of proteins by different methods.

UNIT IV PRODUCT PURIFICATION 9

Basics of chromatography and its use in separation of biomolecules; Types of chromatography - adsorption, size exclusion, ion-exchange, chiral column, hydrophobic interaction, HPLC, bioaffinity, pseudo-affinity, hydroxyapatite chromatographic techniques.

UNIT V FINAL PRODUCT POLISHING AND FINISHING OPERATIONS 9

Crystallization - Basic Concepts, Crystal size distributions, Batch crystallization, Recrystallization, Drying - Basic Concepts, Equipments.

TOTAL: 45 PERIODS

OUTCOMES

- CO1:** Outline the importance of separation technologies for the biomolecules
- CO2:** Explain the underlying principles of filtration and centrifugation
- CO3:** Choose the appropriate techniques to isolate and concentrate the bioproducts
- CO4:** Select the specific chromatography based on the nature of the product and required purity level
- CO5:** Outline the principle behind crystallization and filtration process

TEXT BOOKS

1. Belter P.A, Cussler E.L, and Wei-Houhu, 1988, *Bioseparations- Downstream Processing for Biotechnology*, Wiley Interscience.
2. Roger G.H, Paul W.T, Scott R.R, and Demetri P.P, 2015, *Bioseparations Science and Engineering*, 2nd Edition, Oxford University Press.
3. Jenkins R.O, 1992, *Product Recovery in Bioprocess Technology - Biotechnology*, Open Learning Series, Butterworth-Heinemann.

REFERENCE BOOKS

1. Janson J.C, and Ryden L, 1989, *Protein Purification - Principles, High Resolution Methods and Applications*, VCH publications.

L	T	P	C
3	0	0	3

OBJECTIVES:

- To discuss the structure, functions and integration of immune system.
- To explain the antigen-antibody interactions and how the immune system is protecting the body from foreign pathogens/germs.
- To explain various techniques of monoclonal and engineered antibodies (important therapeutic molecules) production, for treating most of the human diseases

UNIT I INTRODUCTION TO IMMUNE SYSTEM 9

Organization and classification of immune system – immune cells and organs; innate and acquired immunity; immune response-types; classification of antigens - chemical and molecular nature, haptens, adjuvants; Antigen Presenting Cells (APCs); antigen processing and presentation; cytokines.

UNIT II HUMORAL AND CELLULAR IMMUNITY 9

Development, maturation, activation, regulation, differentiation and classification of T-cells and B-cells; theory of clonal selection; TCR & BCR; toll receptors and responses; antibodies- structure and functions; antibodies - genes and generation of diversity; antigen-antibody reactions; complement pathway; major histocompatibility complex (MHC).

UNIT III IMMUNITY AGAINST PATHOGENS AND TUMORS 9

Inflammation; protective immune responses to virus, bacteria, fungi and parasites; tumor immunology - tumor antigens, tumor immune response, tumor diagnosis, tumor immunotherapy.

UNIT IV TRANSPLANTATION, HYPERSENSITIVITY AND AUTOIMMUNITY 9

Immune tolerance; immuno deficiencies; transplantation – genetics of transplantation, laws of transplantation; allergy and hypersensitivity - types of hypersensitivity; autoimmunity- autoimmune disorders, diagnosis and therapy.

UNIT V APPLIED IMMUNOLOGY

9

Vaccines- classification and methods of development; monoclonal antibodies and applications; engineering of antibodies; immunodiagnostic methods – immunodiffusion, ELISA, FACS, immunohistochemistry; immune modulatory drugs.

TOTAL: 45 PERIODS

OUTCOMES

- CO1:** Outline the structures and functions of different immune cells and organs
- CO2:** Outline the process of development of T-cells, B-cells and other components of humoral immune response.
- CO3:** Differentiate between immune response produced by our body against various pathogens and tumor.
- CO4:** Categorize various hypersensitivity reactions and autoimmune disorders.
- CO5:** Distinguish between different methods of vaccine production and engineering of antibodies.

TEXT BOOKS

1. Punt, J., 2019. *Kuby Immunology*. WH Freeman, Macmillan Learning. (8th Edition)
2. David Male, Jonathan Brostoff, David Roth, Ivan Roitt, 2012. *Immunology*, 8th Edition.
3. Parham, P., 2014. *The immune system*. Garland Science.

REFERENCE BOOKS

1. Coico, R., 2021. *Immunology: a short course*. John Wiley & Sons.
2. Khan, F.H., 2009. *The elements of immunology*. Pearson Education India.
3. Abbas, A.K., Lichtman, A.H. and Pillai, S., 2014. *Cellular and molecular immunology E-book*. Elsevier Health Sciences.

L	T	P	C
3	0	0	3

OBJECTIVES:

- To learn the concepts of quality and quality management, TQM framework, barriers and benefits of TQM.
- To apply the Principles and techniques of Quality Management for real time
- To understand the need and importance of quality assurance and certification

UNIT I INTRODUCTION 9

Concept of Quality and Quality Management- Determinants of quality of product & service-Quality vs. Reliability - Definition of TQM - Basic concepts of TQM - TQM Framework - Barriers to TQM – Benefits of TQM – Gurus of TQM (Brief introduction) - Quality statements - Vision, Mission, Policy.

UNIT II PRINCIPLES AND PHILOSOPHIES OF QUALITY MANAGEMENT 9

Overview of the contributions of Deming , Juran Crosby, Masaaki Imai, Feigenbaum, Ishikawa, Taguchi, Shingeo and Walter Shewhart - Concepts of Quality circle, Japanese 5S principles and 8D methodology

UNIT III TOOLS AND TECHNIQUES FOR QUALITY MANAGEMENT 9

Quality functions development (QFD) – Benefits, Voice of customer, information Organisation, House of quality (HOQ), building a HOQ, QFD process. Failure mode effect analysis (FMEA) – requirements of reliability, failure rate, FMEA stages, design, process and documentation-Taguchi techniques

UNIT IV STATISTICAL QUALITY CONTROL 9

Juran's concept of quality cost-components of Quality Cost- Statistical Quality Control – Inspection, Sampling, Sample Size, Sampling Plan, AQL, OC curve, Producer Risk, Consumer Risk, AOQ, AOQL, Control Charts & Control Limits – X, R & S charts and their application- causes of variations – Assignable & Random; Runs-Test, Chart-Sensitivity Test and Run-Sum Test; Normal-Distribution curve and concept of Six Sigma

UNIT V QMS- QUALITY MANAGEMENT SYSTEM 9

Introduction - Benefits of ISO Registration - ISO 9000 Series of Standards-Sector - Specific Standards - AS 9100, TS16949 and TL 9000 - ISO 9001 Requirements –

Implementation - Documentation - Internal Audits-Registration - ENVIRONMENTAL MANAGEMENT SYSTEM: Introduction - ISO 14000 Series Standards - Concepts of ISO 14001 - Requirements of ISO 14001- Benefits of EMS.

TOTAL: 45 PERIODS

OUTCOMES

- CO1:** Ability to apply TQM concepts in a selected enterprise
- CO2:** Ability to apply TQM principles in a selected enterprise
- CO3:** Ability to understand Taguchi's techniques, Performance Measures, QFD, HOQ
- CO4:** Ability to understand Six Sigma and apply Traditional tools, New tools, Benchmarking
- CO5:** To confirm quality standards and implementing QMS in business organization

TEXT BOOKS

1. L. Suganthi and Anand Samuel, 2004, *Total Quality Management*. Prentice Hall, Publications.
2. Dale H. Besterfield, Carol B. Michna, Glen H. Besterfield, Mary B. Sacre, Hemant Urdhwareshe and Rashmi Urdhwareshe, 2013, *Total Quality Management*, Pearson Education Asia, Revised Third Edition, Indian Reprint, Sixth Impression.

REFERENCE BOOKS

1. Rose J.E. 1997, *Total Quality Management*, S. Chand & Co.,
2. Kiran.D.R , 2016, *Total Quality Management: Key concepts and case studies*, Butterworth – Heinemann Ltd
3. Shridhara Bhat K, *Total Quality Management: Text and Cases*, Himalaya Publishing House India, 2016 (2nd Edition)

L	T	P	C
0	0	4	2

OBJECTIVES:

- To understand the nature of the end product, its concentration, stability and degree of purification required
- To design processes for the recovery and subsequent purification of targeted biological products.

LIST OF EXPERIMENTS

1. Solid liquid separation – Filtration
2. Solid liquid separation – Centrifugation
3. Cell disruption techniques – Ultrasonication
4. Cell disruption techniques – Homogenization
5. Precipitation – Ammonium sulphate
6. Membrane separation – Dialysis, Ultrafiltration
7. Gel filtration chromatography
8. Ion exchange chromatography
9. Affinity chromatography
10. Aqueous two phase extraction of biological molecules (Protein)
11. Product polishing – Spray drying
12. Product polishing –Freeze drying

TOTAL: 60 PERIODS**EQUIPMENTS NEEDED (FOR 30 STUDENTS)**

S.NO.	NAME OF THE EQUIPMENT	QTY.
1	Centrifuge	1 No.
2	Cross flow filtration set up	1 No.
3	Sonicator	1 No.
4	Freeze dryer	1 No.
5	Deep freezer	1 No.
6	Homogenizer	1 No.

OUTCOMES:

- CO1:** Design experiments for the efficient solid to liquid separation.
- CO2:** Choose the appropriate cell disruption techniques based on the cell type.
- CO3:** Identify the specific method of concentrating techniques for the bioproducts
- CO4:** Demonstrate different type chromatography techniques for the purification of bioproducts at required purity level
- CO5:** Demonstrate different product polishing techniques based on the physiological properties of bioproducts

REFERENCE BOOKS

1. Belter, P.A, Cussler, E. L, and Hu, W.S, 1988, *Bioseparation - Downstream Processing for Biotechnology*, Wiley Interscience,.
2. Jenkins, R.O. (Ed.), 1992, *Product Recovery In Bioprocess Technology*, Biotechnology By Open Learning Series, Butterworth-Heinemann.
3. Janson, J.C. And Ryden, L. (Ed.), 1989, *Protein Purification – Principles, High Resolution Methods And Applications*, VCH Pub

L	T	P	C
0	0	4	2

OBJECTIVES:

- Learn the isolation and staining of different blood cells
- Learn the different immunological assays

LIST OF EXPERIMENTS

1. Selection of animals and introduction to animal handling (mice/rat/rabbit/chicken /fish etc) – Theoretical Study
2. Routes of immunization*
3. Methods of bleeding, serum separation and storage*
4. Preparation of antigens/immunization schedule for raising antisera*
5. Identification of leukocytes from blood smear by differential staining (Geimsa stain)
6. Separation of Peripheral Blood Mononuclear Cells (PBMC) by Ficoll - Hypaque and enumeration by Neubar chamber
7. Agglutination reaction: Blood grouping and Widal test
8. Immunoprecipitation reaction: immunodiffusion / immune electrophoresis
9. Identification of T Cells by T Cell rosette using Sheep RBC
10. Determination of antibody titre by ELISA

TOTAL: 60 PERIODS**EQUIPMENTS NEEDED (FOR 30 STUDENTS)**

S.NO.	NAME OF THE EQUIPMENT	QTY.
1	ELISA reader	1 No.
2	Microscopes	8 No.
3	Microwave oven	1 No.
4	Hot plate	4 No.
5	Vortex mixer	4 No.
6	Table top refrigerated Centrifuge	1 No.
7	Fluorescent microscope	1 No.

OUTCOMES:

- CO1:** Gain knowledge about handling of animals and routes of immunization
- CO2:** Identify immune cells in blood smear and enumerate cells using Neubar chamber.
- CO3:** Demonstrate separation of PBMCs from Blood and perform experiments using them
- CO4:** Demonstrate experiments to show agglutination and precipitation reactions between Antigen and Antibody
- CO5:** Perform ELISA technique for any given antigen or antibody

REFERENCE BOOKS

1. Roitt I, Male, Brostoff., 2002. *Immunology*, Mosby Publishers..
2. Kuby J., 2013. *Immunology*, 7th Edn. WH Freeman & Co.
3. Ashim K. Chakravarthy., 2008. *Immunology*. TataMcGraw-Hill.
4. Edward A. Greenfield, Dana-Farber., 2014. *Antibodies: A Laboratory Manual*, 2nd Edn. Cancer Institute, Cold Spring, Harbour Laboratory.
5. John E. Coligan, Ada M. Kruisbeek, David H. Margulies, Ethan M. Shevach, Warren Strober., 2004. *Current protocols in Immunology*. Vol.1-3. John Wiley & Sons.

L	T	P	C
0	0	4	2

OBJECTIVES:**To enable the students to**

- Develop the ability to solve specific problem right from its identification and literature review and identify appropriate solutions for the same
- Prepare and deliver effective scientific solutions

The students will be working in single or group of 3 to 4 on a scientific problem approved by the Head of the Department under the guidance of the faculty member and prepare a comprehensive report after completing the work to the satisfaction of the supervisor. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated based on oral presentation on project topic jointly by external and internal examiners constituted by the Head of the Department

TOTAL: 60 PERIODS**OUTCOMES**

- CO1:** Identifying a potential problem based on literature survey/impending industrial/real time needs.
- CO2:** Categorizing various solution methodologies to solve problem taken for study.
- CO3:** Carry out design/experimental procedure relevant to the problem.
- CO4:** Analyze design/experimental results.
- CO5:** Draw conclusion based on analysis and recommend solution to potential engineering problems.

L	T	P	C
3	0	0	3

OBJECTIVES:

- To receive an idea about different types of algae, their diversification
- To know association with the biotic factors, biomass production
- To learn application in various biotechnological perspectives.

UNIT I INTRODUCTION 9

Introduction to Algae - Fundamental discoveries and Origin of algae; Algae and their position in Domains and Kingdoms system - Classification and taxonomy of Algae, Economic importance

UNIT II STRUCTURE AND CHARACTERIZATION OF ALGAE 9

General characteristics, Cell structure, Pigmentation, Reproduction and Life cycle; Sampling methodology, Isolation and characterization of algae; Conservation of algae; Algae in food web and other biotic associations- Biotechnological values of algal species.

UNIT III MICROALGAL TECHNOLOGY 9

Algal technology of Microalgae: Cultivation of microalgae, Microalgae in aquaculture, Types of cultivation systems and biomass production, processing of algae. Biological importance of algae – Food, Feed, Cosmetics, Biofertilizers, Bioactive compounds, Biofuel.

UNIT IV MACROALGAL TECHNOLOGY 9

Algal technology of Macro-algae: Diversity and cultivation of macro algae (sea weed); Applications of macro algae - Food, Fodder, Phycocolloids, Agar, Polysaccharides, Probiotics, Nutraceuticals, Cosmetics and Cosmeceuticals, Pharmaceuticals, Pigments.

UNIT V ENVIRONMENTAL AND INDUSTRIAL APPLICATIONS 9

Biogeochemical cycles; Algal toxicology; Applications of Algae with specific case studies: CO₂ sequestration; Bioremediation; Wastewater treatment; Bioenergy; Biomineralization; Algal Bioplastics.

TOTAL: 45 PERIODS

OUTCOMES

- CO1:** Describe the basics of algae, their importance, classification and diversity.
- CO2:** Describe algal characteristic features, their isolation, conservation and its association other entities.
- CO3:** Explain microalgal cultivation methods, biomass and their biotechnological applications.
- CO4:** Explain macroalgal distribution and biomass collections and their various applications.
- CO5:** Apply algal systems in biotechnological industries and environmental solutions.

TEXT BOOKS

1. Konur, O. ed., 2020. *Handbook of Algal Science, Technology and Medicine*. Academic Press.
2. Muthu Arumugam, S. Nagaraj, Shanmugam Kathiresan, 2021. . Nova Science Publishers.
3. Chojnacka, K., Wieczorek, P.P., Schroeder, G. and Michalak, I. eds., 2018. *Algae biomass: Characteristics and applications: Towards algae-based products* (Vol. 8). Springer.

REFERENCE BOOKS

1. Linda E. Graham, James M. Graham, Lee W. Wilcox, Matha E. Cook., 2015. *Algae* 3rd Edition LJLM Press, LLC, USA.
2. G. W. Prescott, John Bamrick, Edward Cawley, Wm. Jaques. WC Brown, 1978. *How to Know the Freshwater Algae*, 3rd Edition, Pennsylvania State University.
3. P. Baweja, P., S. Kumar, D. Sahoo, and I.A. Levine. Eds. J. Fleurence and I. Levine 2016. *Biology of Seaweeds. In: Seaweed in Health and Disease Prevention*, Elsevier, Academic Press, Amsterdam.
4. Levine, I. and Fleurence, J. eds., 2018. *Microalgae in health and disease prevention*. Academic Press.

OUTCOMES

- CO1:** Identify the biological activity and structural properties of the molecules as well as the location and reactivities of various functional groups that can be used for conjugation purposes.
- CO2:** Outline the active groups of various chemical reactions and targets of the functional groups.
- CO3:** Relate Joining of two molecules to form a hybrid conjugate with the help of linkers
- CO4:** Outline on enzyme and nucleic acid modification and conjugation techniques
- CO5:** Apply the knowledge about Antibody modification and conjugation

TEXT BOOKS

1. Hermanson, G.T., 2013. *Bioconjugate techniques*. Academic press.
2. Niemeyer, C.M. ed., 2004. *Bioconjugation protocols: strategies and methods* (Vol. 283). Springer Science & Business Media.
3. Narain, R. ed., 2013. *Chemistry of bioconjugates: synthesis, characterization, and biomedical applications*. John Wiley & Sons.

REFERENCE BOOKS

1. Wong, S.S., 1991. *Chemistry of protein conjugation and cross-linking*. CRC press.
2. Mark, S.S., 2011. *Bioconjugation Protocols*. Totowa, NJ, USA: Humana Press.
3. Beck, A. and Reichert, J.M., 2014, January. *Antibody-drug conjugates: present and future*. Taylor & Francis

L	T	P	C
3	0	0	3

OBJECTIVES:

- To understand national and international regulatory guidelines regarding clinical trials and pharmaceutical production industry
- To understand general protocols, process and validation guidelines for pharmaceutical technology
- To learn about manufacturing of various formulations and basics of pharmacokinetic applications

UNIT I INTRODUCTION 9

Pharmaceutical industries – classification, Indian and MNCs with their current economic status. Regulatory bodies of pharmaceuticals, WHO regulations and layout for pharmaceutical industries including R&D centre; Steps and process involved in the establishment of pharmaceutical industry; Drug discovery and development pipeline; Classification of pharmaceutical formulations; Biopharmaceuticals and pharmaceutical biotechnology.

UNIT II PROCESS IN PHARMACEUTICAL TECHNOLOGY 9

Reaction Process and machineries involved in bulk drug production from plant, animal and microbial sources. Industrial hazards and safety precautions, Principle and applications of centrifugation, crystallization, humidity control, evaporation, distillation, drying, size reduction and separations in pharma industry; FDA Process validation guidelines for manufacturing of biopharmaceuticals – validation with CMO, vaccine and Viral clearance validation, Analytical Test Methods for Characterized Biologicals.

UNIT III PRINCIPLES OF DRUG MANUFACTURING 9

Pharmacopoeia; Drugs and Cosmetics rules and schedules, Compressed tablets; dry and wet granulation; slugging or direct compression; tablet presses; coating of tablets; capsule preparation; oral liquids – vegetable drugs – topical applications, blood products and substitutes, radioactive therapeutics, preservation of drugs. Pharmaceutical packing techniques; quality management; GMP, Quality Assurance – features of ISO 9000

UNIT IV APPLIED PHARMACOLOGY & PHARMACOKINETICS 9

Basic anatomy and physiology of human systems, routes of drug administration, pharmacological classification of Drugs, Bioavailability, bioequivalence and volume of distribution. Mechanism of drug action. Pharmacokinetics -factors affecting ADME, physico-chemical principles of drug metabolism; compartment modelling, Pharmacokinetic principles in controlled release drug designing..

UNIT V BIOPHARMACEUTICALS AND CASE STUDIES 9

Classification and production methods of vitamins, laxatives, analgesics, contraceptives, antibiotics, hormones and biologicals; Pharmacokinetic case studies on humanized and chimeric mAbs, nucleotide therapeutics, insulin, Viral Vaccine - H1N1 and Bacterial Vaccine - typhoid vaccine; Antidrug-antibodies (ADA) applications and assays.

TOTAL: 45 PERIODS

OUTCOMES

- CO1:** Acquire knowledge in clinical trials and pharmaceutical industry
- CO2:** Define the general processes and tests involved in pharmaceutical industry including safety measures
- CO3:** Demonstrate the manufacturing principles of various formulations
- CO4:** Describe the mechanism of drug action and its kinetics
- CO5:** Describe the production methods of biopharmaceuticals

TEXT BOOKS

1. Banker, S.G., Anderson, R.N., Tablets, L.L., Liberman, A.H. and Kanig, L.J., 1991. *Text book of the theory and practice of industrial pharmacy*.
2. Brahmankar, D.M. and Jaiswal, S.B., 2005. *Biopharmaceutics and pharmacokinetics: A treatise*. Vallabh prakashan.
3. Allen, L. and Ansel, H.C., 2013. *Ansel's pharmaceutical dosage forms and drug delivery systems*. Lippincott Williams & Wilkins.
4. Thomas, G., 2011. *Medicinal chemistry: an introduction*. John Wiley & Sons.

REFERENCE BOOKS

1. Remington, J.P., 2006. *Remington: The science and practice of pharmacy* (Vol. 1). Lippincott Williams & Wilkins.
2. Khar, R.K., 2013. *Lachman/liebermans: the theory and practice of industrial pharmacy*. CBS Publishers & Distribution.
3. Rathore, A.S. and Sofer, G. eds., 2012. *Process validation in manufacturing of biopharmaceuticals*. CRC press.
4. Katzung, B.G., 2012. *Basic and clinical pharmacology*. Mc Graw Hill

BT1734 FOUNDATION SKILLS IN INTEGRATED PRODUCT DEVELOPMENT

L	T	P	C
3	0	0	3

OBJECTIVES:

- To understand the global trends and development methodologies of various types of products and services
- To conceptualize, prototype and develop product management plan for a new product based on the type of the new product and development methodology integrating the hardware, software, controls, electronics and mechanical systems
- To develop documentation, test specifications and coordinate with various teams to validate and sustain

UNIT I FUNDAMENTALS OF PRODUCT DEVELOPMENT 9

Global Trends Analysis and Product decision - Social Trends, Technical Trends, Economical Trends, Environmental Trends, Political/Policy Trends; Introduction to Product Development Methodologies and Management; Overview of Products and Services; Types of Product Development; Overview of Product Development methodologies; Product Life Cycle – Product Development, Planning and Management.

UNIT II REQUIREMENTS AND SYSTEM DESIGN 9

Requirement Engineering – Types, Traceability Matrix and Analysis; Requirement Management; System Design & Modeling -Introduction to System Modeling, System Optimization, System Specification, Sub-System Design, Interface Design.

UNIT III DESIGN AND TESTING 9

Conceptualization; Industrial Design and User Interface Design; Introduction to Concept generation Techniques; Challenges in Integration of Engineering Disciplines; Concept Screening & Evaluation; Detailed Design - Component Design and Verification; Mechanical, Electronics and Software Subsystems; High Level Design/Low Level Design of S/W Program; Types of Prototypes; S/W Testing; Hardware Schematic - Component design, Layout and Hardware Testing; Prototyping - Introduction to Rapid Prototyping and Rapid Manufacturing; System Integration; Testing; Certification and Documentation.

3. Vinod Kumar Garg and Venkita Krishnan N K., 2003. *Enterprise Resource Planning - Concepts*. 2nd Edn. Prentice Hall.

OUTCOMES

- CO1:** Understand the working principles of process instruments and measurement for biochemical industry.
- CO2:** Apply Laplace transform and ordinary differential equations to the open loop control systems.
- CO3:** Develop the closed loop control systems and transfer function for various controllers.
- CO4:** Design the frequency response of closed-loop control systems and tuning of controller settings.
- CO5:** Describe about the various types of advanced control systems and computer control of chemical processes.

TEXT BOOKS

1. Stephanopoulos G. 2003. *Chemical Process Control*. Prentice Hall of India.
2. Coughnowr D. 2008. *Process Systems Analysis and Control*. 3rd edition. McGraw-Hill.
3. Marlin, T. E. 2000. *Process Control*. 2nd edition, McGraw-Hill.

REFERENCE BOOKS

1. Smith, C. A. & Corripio, A. B., 1997. *Principles and Practice of Automatic Process Control*. 2nd edition. John Wiley.
2. Singh, S. K. 2003. *Industrial Instrumentation & Control*. 2nd edition. Tata McGraw-Hill Education

L	T	P	C
3	0	0	3

OBJECTIVES:

- To understand the sources of innovation opportunities and development of the skills to identify and analyze these opportunities for entrepreneurship and innovation.
- To develop personal skills set for creativity, innovation and entrepreneurship and specific concepts and tools for combining and managing creativity in organization

UNIT I INTRODUCTION 9

Introduction to Entrepreneurship; Skills required for an entrepreneur; Entrepreneurs in a Market Economy; Identify and Meet a Market Need; Research the Market; Survey Data analysis; Type of Ownership; Legal form of business; Registration and Legal Issues and Business ownership.

UNIT II BUSINESS PLAN 9

Turning an Idea into a Business Plan; The importance of Business Plan Preparation; Basic elements of a Business Plan; Effective Business Plan creation using online sources; Evaluation of the Business Plan; Determine Price for product, service and technique; Branding and Positioning.

UNIT III LAYOUT DESIGN, PURCHASE & HIRING PROCESS 9

Selection of Location and Setting up for Business; Design of Business layout; Equipment Purchase; Supplies and Inventory; Hire and Manage a Staff - Hiring Process, Compensation Package, employees insurance and benefits.

UNIT IV FINANCE SOURCES & BUSINESS RISK 9

Finance sources – Introduction, Record Keeping and Accounting; Cash flow management - Prepare and analyze financial statements; Business Risk – Type of Theft, Protect and Insure Business.

UNIT V BUSINESS ETHICS & GROWTH STRATEGY 9

Ethics in Business; Social responsibilities; Respect to environment; Growth in Marketplace; Growth strategy selection and merger; New Product development and life cycle assessment

OUTCOMES

- CO1:** Comprehend the fundamentals of entrepreneurship
- CO2:** Turn an idea into bio-industry based business by developing an effective business and operation plan
- CO3:** Research and present the market potential for particular Bio-industry business
- CO4:** Integrate financial strategies for continuous growth of a business
- CO5:** Determine relevant licensing and regulatory issues for a specific bio-industry business

TEXT BOOKS

1. Alpana Trehan., 2018. *Entrepreneurship*. 6th Edn, Dreamtech Press, New Delhi
2. Craig Shimasaki., 2020. *Biotechnology Entrepreneurship*. 2nd Edn. Academic Press
3. Sangram Keshari Mohanty., 2006. *Fundamentals of Entrepreneurship*. PHI Learning Private Limited, Delhi

REFERENCE BOOKS

1. Holger Patzelt and Thomas Brenner., 2010. *Handbook of Bioentrepreneurship*. 4th Edn. Springer.
2. Robert D. Hisrich, Michael P. Peters, Dean A. Shepherd., 2018. *Entrepreneurship*. 10th Edn. Mc Graw Hill Education.
3. James Harrington. H., 2018. *Creativity, Innovation, and Entrepreneurship: The Only Way to Renew Your Organization*. Productivity Press.

L	T	P	C
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OBJECTIVES:

- To familiarize the students with modern process plant as per the regulations of government
- To perform the cost estimation in bioprocess.
- To analyse the profitability of the product and its optimization strategies and to demonstrate the good manufacturing practices

UNIT I PROCESS DESIGN 9

Design of project; material and energy balance; technical feasibility survey; process development; flow diagrams; equipment design and specifications; comparison of different processes; scale-up design; safety factors.

UNIT II GENERAL DESIGN CONSIDERATION 9

Marketability of the product; availability of technology; raw materials; equipment; human resources; land and utilities; site characteristics; waste disposal; government regulations and other legal restrictions; community factors and other factors affecting investment and production costs.

UNIT III COST ESTIMATION 9

Capital investments- fixed capital investments including land, building, equipment and utilities, installation costs (including equipment's, instrumentation, piping, electrical installation and other utilities), working capital investments; manufacturing costs - direct production costs (including raw materials, human resources, maintenance and repair, operating supplies, power and other utilities, royalties.), fixed charges (including depreciation, taxes, insurance, rental costs.); administration; safety and other auxiliary services; payroll overheads; warehouse and storage facilities.

UNIT IV PROFITABILITY ANALYSIS 9

Profitability standards; project profitability; evaluation; rate of return on investment; discounted cash flow; net present worth; capitalized costs; continuous interest compounding; determining acceptable returns; alternative investments; small investment increments; various profitability measures; replacements.

UNIT V OPTIMUM DESIGN AND DESIGN STRATEGY

9

Procedure for determining optimum conditions with one, two or more variables; Break-Even chart for optimum analysis; optimum production rates in plant operation; optimum conditions in cyclic operations; strategy of linear and dynamic programming for optimization analysis

TOTAL: 45 PERIODS

OUTCOMES

- CO1:** Understand the process development and economics of the process.
- CO2:** Understand the government regulations and the factors effecting the marketability of the product
- CO3:** Estimate various cost effecting parameters
- CO4:** Analysis of profitability and accounting.
- CO5:** Calculate the value of variable influencing the process for their optimum conditions.

TEXT BOOKS

1. Peters, M.S., Timmerhaus, K.D. and West, R.E., 2003. *Plant design and economics for chemical engineers* (Vol. 4). New York: McGraw-Hill.
2. Rudd and Watson, 1987. *Strategy of Process Engineering*. Wiley.
3. Schweyer, H.E., 1969. *Process Engineering Economics*. McGraw-Hill.

REFERENCE BOOKS

1. Lydersen, B.K., D'Elia, N. and Nelson, K.L. eds., 1994. *Bioprocess engineering: systems, equipment and facilities*. New York: Wiley.

L	T	P	C
3	0	0	3

OBJECTIVES:

- To understand the basics of development
- To know the differences in the developmental pathways of different organisms.
- To make the students aware how the basic developmental pathways are regulated in vertebrates and invertebrates

UNIT I HISTORY & BASIC CONCEPTS OF DEVELOPMENT 9

Overview of how the modern era of developmental biology emerged through multidisciplinary approaches; Stages of development- zygote, blastula, gastrula, neurula; Cell fate & commitment, potency; concept of embryonic stem cells, differential gene expression, terminal differentiation, lineages of three germ layers, fate map; Mechanisms of differentiation- cytoplasmic determinants, embryonic induction, mosaic and regulative development. Pattern formation- axis specification, positional identification (regional specification). Morphogenetic movements.

UNIT II EARLY DEVELOPMENT IN INVERTEBRATE / VERTEBRATE MODELS 9

Model organisms in Developmental biology- *Drosophila*, *C.elegans*, *Xenopus*, Mouse/human; Cleavage, gastrulation, Axis specification (Dorsoventral, anterior, posterior); body plan patterning, left right asymmetry in vertebrates

UNIT III LATE DEVELOPMENT IN INVERTEBRATE / VERTEBRATE MODELS 9

Organogenesis- development of central nervous system in vertebrates, formation of neural tube-primary and secondary neurulation, differentiation of neural tube, tissue architecture of central nervous system; vulval formation in *C.elegans* - stages in vulval development.

UNIT IV GERM CELL SPECIFICATION & MIGRATION 9

Germplasm and determination of primordial germ cells; germ cell migration - *Drosophila*, vertebrates; Gamete maturation -amphibians, mammal

UNIT V APPLICATIONS 9

Medical implications of developmental biology; genetic errors- genetic errors in human development; teratogenesis; stem cell therapy; developmental therapies.

TOTAL: 45 PERIODS

OUTCOMES

- CO1:** Able to explain the basics of development
- CO2:** Compare the process of fertilization and early developmental processes in different organisms
- CO3:** Paraphrase the late developmental process and organogenesis invertebrate and vertebrate models
- CO4:** Explain the concepts of germ cell migration and gamete maturation in vertebrates
- CO5:** Discuss the medical implications of developmental biology

TEXT BOOKS

1. Gilbert, S.F. and Barresi, M., 2019. *Developmental biology* 12th edition, Oxford University Press.
2. Slack, J.M., 2012. *Essential developmental biology*. John Wiley & Sons.
3. Werner A. M., 2012. *Developmental Biology*, Springer Science and Business media

REFERENCE BOOKS

1. Wolpert, L., Tickle, C. and Arias, A.M., 2015. *Principles of development*. Oxford University Press, USA.
2. Carlson, B.M., 2018. *Human Embryology and Developmental Biology*, Elsevier Health Sciences.
3. Schatten, G.P., 2007. *Current topics in developmental biology*. Elsevier

OUTCOMES

- CO1:** Describe the anatomy of nervous systems and neurons
- CO2:** Demonstrate the molecular mechanism of neuronal function
- CO3:** Relate the drug action on neuronal receptors and related diseases
- CO4:** Explain the molecular mechanism to drug discovery and biotechnological related research
- CO5:** Describe various facts about brain function and experimental approaches, theories, and models to integrate neuroscience information with biotech discipline

TEXT BOOKS

1. Kandel, E.R., Schwartz, J.H., Jessell, T.M., Siegelbaum, S.A. and Hudspeth, A.J., 2013. *Principles of Neural Science*, Fifth Edition.
2. Waugh, A. and Grant, A., 2014. *Ross & Wilson Anatomy and physiology in health and illness E-book*. Elsevier Health Sciences.
3. Purves, D., Augustine, G.J., Fitzpatrick, D., Hall, W.C., LaMantia, A.S., McNamara, J.O. and White, L.E., 2008. *Neuroscience*. 4th. Sunderland.

REFERENCE BOOKS

1. Siegel, A. and Sapru, H.N., 2006. *Essential neuroscience*. Lippincott Williams & Wilkins.
2. Schwartz, J.H., Jessell, T.M. and Kandel, E.R. eds., 1991. *Principles of neural science*. Elsevier.
3. Squire, L., Berg, D., Bloom, F.E., Du Lac, S., Ghosh, A. and Spitzer, N.C. eds., 2012. *Fundamental neuroscience*. Academic Press.

OUTCOMES

- CO1:** Outline the properties of stem cells and its types.
- CO2:** Differentiate between the stem cells of plants and animals.
- CO3:** Compare different methods of stem cell differentiation.
- CO4:** Analyze experimental methods to study the regeneration of stem cells.
- CO5:** Compare the clinical applications of stem cells highlighting the ethical issues involved.

TEXT BOOKS

1. Potten, C.S., 2006. *Stem cells*. Elsevier.
2. Lanza, R., Gearhart, J., Hogan, B., Melton, D., Pedersen, R., Thomas, E.D. and Thomson, J.A. eds., 2005. *Essentials of stem cell biology*. Elsevier.
3. Marshak, D.R., Gardner, R.L. and Gottlieb, D., 2001. *Stem Cell Biology*. Cold Spring Harbor Monograph Series

REFERENCE BOOKS

1. Quesenberry, P.J., Stein, G.S., Forget, B.G. and Weissman, S.M. eds., 1998. *Stem cell biology and gene therapy*. John Wiley & Sons.
2. Turksen, K. ed., 2002. *Embryonic stem cells: methods and protocols* (Vol. 185). Springer Science & Business Media.
3. Bongso, A. and Lee, E.H., 2005. *Stem cells: from bench to bedside*. World Scientific.
4. Gholamrezanezhad, A., 2011. *Stem cells in clinic and research*. InTech.

OBT171

INSTRUMENTATION AND ANALYTICAL METHODS

L	T	P	C
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OBJECTIVES:

- To gain fundamental knowledge about the Light spectrum, Absorption, Fluorescence, NMR, Mass spectroscopy
- To acquire knowledge on the electro analysis and surface microscopy

UNIT I SPECTROMETRY 9

Properties of electromagnetic radiation - wave properties; Components of optical instruments– Sources of radiation, wavelength selectors, sample containers, radiation transducers, Signal process and read outs; Signal to noise ratio, sources of noise, enhancement of signal to noise; Types of optical instruments and its applications.

UNIT II MOLECULAR SPECTROSCOPY 9

Molecular absorption spectrometry, Measurement of Transmittance and Absorbance; Beer's law; Instrumentation, Applications, Theory of fluorescence and Phosphorescence, Infrared absorption spectrometry; IR instrumentation, Applications; Theory of Raman spectroscopy, Instrumentation and applications.

UNIT III NMR AND MASS SPECTROMETRY 9

Theory of NMR, chemical shift, NMR-spectrometers; applications of ^1H and ^{13}C NMR; Molecular mass spectra – ion sources; Mass spectrometer; Applications of molecular mass, Electron paramagnetic resonance, g values, instrumentation.

UNIT IV ELECTRO ANALYSIS AND SURFACE MICROSCOPY 9

Electrochemical cells, Electrode potential cell potentials, potentiometry, reference electrode, ion selective and molecular selective electrodes; Instrument for potentiometric studies, Voltametry, Cyclic and pulse voltammetry, Applications of voltammetry; Study of surfaces, Scanning probe microscopes, AFM and STM.

UNIT V MEASUREMENT OF NON-ELECTRICALPARAMETERS 9

Temperature, respiration rate and pulse rate measurements. Blood Pressure: indirect methods - Auscultatory method, direct methods: electronic manometer, Systolic, diastolic pressure, Blood flow and cardiac output measurement: Indicator dilution, and dye dilution method, ultrasound blood flow measurement. Blood gas analyzers and

Non-Invasive monitoring, Sodium Potassium Analyser, spectrophotometer, blood cell counter, auto analyzer (simplified schematic description).

TOTAL: 45 PERIODS

OUTCOMES

- CO1:** Outline the properties of electromagnetic radiation and the spectrometry
- CO2:** Explain different molecular spectroscopy and its applications
- CO3:** Choose an appropriate spectrometry towards molecular characterization through NMR and mass spectrometry
- CO4:** Analyze and design electrochemical cell analysis and surface microscopy
- CO5:** Apply the instrumentation concepts on different biochemical measurements

TEXT BOOKS

1. Skoog, D.A. F. James Holler, and Stanky, R.Crouch 2007 *Instrumental Methods of Analysis*. Cengage Learning.
2. Willard, Hobart, et al., 1986. *Instrumental Methods of Analysis*.1986, CBS.
3. Braun, Robert D. 1987 *Introduction to Instrumental Analysis*, Pharma Book Syndicate.

REFERENCE BOOKS

1. Sharma, B.K. 1972. *Instrumental Methods of Chemical Analysis: Analytical Chemistry*. Goel Publishing House.
2. Haven, Mary C., et al., *Laboratory Instrumentation*, 1995, IVth Edition, John Wiley

L	T	P	C
3	0	0	3

OBJECTIVES:

- To understand the basics of various food processing techniques.
- To enhance the knowledge on minimal processing and hurdle technology.
- To understand the role of food additives in food industry.

UNIT I REFRIGERATION AND FREEZING 9

Requirements of refrigerated storage, controlled low temperature, air circulation and humidity, changes in food during refrigerated storage, progressive freezing, changes in the food during refrigeration and freezing, freezing methods - direct and indirect, still air sharp freezer, blast freezer, fluidized freezer, plate freezer, spiral freezer and cryogenic freezing.

UNIT II DRYING AND DEHYDRATION 9

Normal drying curve, effect of food properties on dehydration, changes in food during drying, drying methods, air convection dryer, tray dryer, tunnel dryer, continuous belt dryer, fluidized bed dryer, drum dryer, vacuum dryer, freeze dryer, foam mat dryer.

UNIT III THERMAL PROCESSING OF FOODS 9

Classification of thermal processes, principles of thermal processing, commercial canning operations, Pasteurization, blanching, irradiation and microwave heating - principles, dosage, applications and mechanism.

UNIT IV MINIMAL PROCESSING AND HURDLE TECHNOLOGY 9

Principles and applications, hurdle effect in fermented foods, shelf stable products, intermediate moisture foods, application of hurdle technology. Minimal processing of foods with thermal methods and non-thermal methods, criteria in minimally processed foods, Minimal processing in practice and future developments.

UNIT V FOOD ADDITIVES, CONTAMINANTS AND REGULATION 9

Need of food additives in food processing and preservation, characteristics and classification of food additives; Contamination in Food - heavy metals, pesticide residues, antibiotics, veterinary drug residues, dioxins, environmental pollutants, radionuclide, solvent residues; natural toxins; Basics of food laws and regulations – CAC, HACCP, ISO, FSSAI etc.,

OUTCOMES

- CO1:** Understand the basic principle and application of refrigeration in freezing in food industries
- CO2:** Outline the applications of drying and dehydration
- CO3:** Explain the principle and application of thermal processing of food materials
- CO4:** Understand the need for hurdle technology and minimal processing for certain food
- CO5:** Understand about the food processing regulations, advantages and disadvantages of food additives

TEXT BOOKS

1. Potter N.N, and Hotchkiss J.H, 1998, *Food Science*, 5th Edition, Asben Publications.
2. Ramaswamy H, and Marcotte M, 2009, *Food Processing: Principles and Applications*, 2nd Edition, CRC Press.
3. Deman J.M, 2007, *Principles of Food Chemistry*, 3rd Edition, Springer.
4. Manay N.S, and Shadaksharaswamy M, 2001, *Food - Facts and Principles*, 2nd Edition, New Age International Pvt. Ltd. Publishers

REFERENCE BOOKS

1. Romeo T.T, Singh R.K, and Kong F, 2018, *Fundamentals of Food Process Engineering*, 4th Edition, Springer.
2. Rao D.G, 2010, *Fundamentals of Food Engineering*, PHI Learning Pvt. Ltd.
3. Desrosier N.W, and Desrosier J.N, 1998, *The Technology of Food Preservation*, 4th Edition, CBS Publishers.
4. Bawa A.S, Raju P.S, and Chauhan O.P, 2013, *Food Science*. New India Publishing Agency.

L	T	P	C
3	0	0	3

OBJECTIVES:

- To understand the current biomaterials scene, know how these materials are synthesized and fabricated
- To impart knowledge on testing and assessment of biomaterials
- To enhance exposure pertaining to the field of biomaterials and have broad understanding biomaterials research
- To design devices for specific scientific, industrial and medical applications using current biomaterials.

UNIT I FUNDAMENTALS OF BIOMATERIALS SCIENCE 9

Introduction to Materials, General structure and properties. Concept of biocompatibility, Fundamentals of Biocompatibility Tests. Classes of biomaterials used in medicine, basic properties, medical requirements and clinical significance. Disinfection and sterilization of biomaterials.

UNIT II CLASSIFICATION OF COMMON MATERIALS AND APPLICATIONS 9

Nanocomposites, Bioresorbable and Bioerodable Materials, Natural polymers, Carbon nanotubes, Metal and alloys in Medical application: Stainless steel, cobalt based alloys, titanium based alloys (including shape memory alloys). Ceramics and glasses-bio ceramics, Type of Ceramics and their classification.

UNIT III PHYSICO-CHEMICAL PROPERTIES OF BIOMATERIALS 9

Mechanical (elasticity, yield stress, ductility, toughness, strength, fatigue, hardness, wear resistance), tribological (friction, wear, lubricity), Morphology and Texture, Physical (electrical, optical, magnetic, thermal), Chemical and Biological properties.

UNIT IV DESIGN AND MANUFACTURING OF BIOCOMPATIBLE MATERIALS 9

Design of materials for biomedical application: Cardiovascular, Dental Implants, Orthopedic Application, Skin, Ophthalmologic Applications, Wound Healing, Sutures, Biomedical and Biosensors, Concept of biomimetic synthesis, Preparation of fiber and wire, Fabrication of Porous Materials, Direct molding Technique, Different advanced fabrication technique

UNIT V METHODS FOR ASSESSMENT OF BIOMATERIALS 9

In Vitro Assessment of Cell and Tissue Compatibility, In Vivo Assessment of Tissue Compatibility, Evaluation of Blood-Materials Interactions, Microscopy for Biomaterials Science, Problems and possible solutions in implant fixation; Failure analysis of medical devices and implants. Toxicokinetics in Biomaterial and Device Safety Evaluation

TOTAL: 45 PERIODS

OUTCOMES

- CO1:** Understand the current biomaterials scene, know how these materials are synthesized and fabricated
- CO2:** Outline the different classification of biomaterials
- CO3:** Understand the physio-chemical characterization of different biomaterials
- CO4:** Apply the knowledge in designing the biocompatible materials
- CO5:** Explain the principles in testing and assessment methods of biomaterials

TEXT BOOKS

1. Buddy D.R, Allan S. H, Frederick J.S, Jack EL. 2004, *Biomaterials Science: An Introduction to Materials in Medicine*, Academic Press, USA
2. Park J.B. and Bronzino J.D.. 2002, *Biomaterials: Principles and Applications*. CRC Press.
3. Gad-McDonald, Samantha, Gad, Shayne C, 2015, *Biomaterials, medical devices, and combination products: biocompatibility testing and safety assessment*, CRC Press.

REFERENCE BOOKS

1. Dee K.C., Puleo D.A and Bizios R. 2002, *An Introduction to Tissue-Biomaterial Interactions*. Wiley.
2. Ambrosio L. 2009, *Biomedical composites*, Woodhead Publishing Limited.

L	T	P	C
0	0	16	8

OBJECTIVES:**To enable the students to**

- Develop the ability to solve specific problem right from its identification and literature review and identify appropriate solutions for the same
- Prepare and deliver effective scientific solutions

The students will be working in single or group of 3 to 4 on a scientific problem approved by the Head of the Department under the guidance of the faculty member and prepare a comprehensive report after completing the work to the satisfaction of the supervisor. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated based on oral presentation on project topic jointly by external and internal examiners constituted by the Head of the Department

TOTAL: 240 PERIODS**OUTCOMES**

- CO1:** Identifying a potential problem based on literature survey/impending industrial/real time needs.
- CO2:** Categorizing various solution methodologies to solve problem taken for study.
- CO3:** Carry out design/experimental procedure relevant to the problem.
- CO4:** Analyze design/experimental results.
- CO5:** Draw conclusion based on analysis and recommend solution to potential engineering problems.