KAMARAJ
COLLEGE OF ENGINEERING & TECHNOLOGY

(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 – 2021
AUTONOMOUS SYLLABUS
CHOICE BASED CREDIT SYSTEM
V TO VI 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

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V TO VI SEMESTER CURRICULUM

SEMESTER V

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	BT2301	Bioinformatics	PC	3	3	0	0	3
2	BT2302	Genetic Engineering	PC	3	3	0	0	3
3	BT2303	Mass Transfer Operations	ES	3	3	0	0	3
4		Professional Elective I	PE	3	3	0	0	3
5		Professional Elective II	PE	3	3	0	0	3
6		Professional Elective III	PE	3	3	0	0	3
PRACTICALS								
7	BT2304	Enzyme Engineering Laboratory	PC	4	0	0	4	2
8	BT2305	Molecular Biology and Genetic Engineering Laboratory	PC	4	0	0	4	2
9	EM2301	Summer Internship	EM	0	0	0	0	1
			TOTAL	26	18	0	8	23

SEMESTER VI

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	BT2351	Bioprocess Engineering Principles	PC	3	3	0	0	3

2	BT2352	Immunology	PC	3	3	0	0	3
3		Professional Elective IV	PE	3	3	0	0	3
4		Professional Elective V	PE	3	3	0	0	3
5		Professional Elective VI	PE	3	3	0	0	3
6		Open Elective I*	OE	3	3	0	0	3
PRACTICALS								
7	BT2353	Bioprocess Laboratory	PC	3	0	0	3	1
8	BT2354	Immunology Laboratory	PC	3	0	0	3	1
			TOTAL	24	18	0	6	20

*Course from the Curriculum of other UG programmes.

PROFESSIONAL ELECTIVE COURSES – VERTICALS

VERTICAL I	VERTICAL II	VERTICAL III	VERTICAL IV
INDUSTRIAL BIOTECHNOLOGY	**FOOD AND AGROSCIENCES**	**MEDICAL BIOTECHNOLOGY**	**COMPUTATIONAL BIOTECHNOLOGY**
Applied Chemical Reaction Engineering	Plant Tissue Culture and Transformation Techniques	Neurobiology and Cognitive Sciences	Protein Structure Function and Engineering
Bioreactor Design and Scaleup Process	Post Harvest Management and Value Addition	Animal Biotechnology	Metabolic Engineering
Bioanalytical Techniques and Instrumentation	Agricultural Waste Management	Tissue Engineering	Genomics and Proteomics
Nanobiotechnology	Food Process Engineering	Clinical Trials and Health Care Policies in Biotechnology	Computer Aided Drug Design
Algal Technology	Principles of Food Preservation	Biopharmaceuticals and Biosimilars	Data Mining And Machine Learning Techniques For Bioinformatics
Environmental Biotechnology	Food Quality Testing and Evaluation	Cancer Biology	Molecular Modelling
Intellectual Property Rights in Biotechnology	Food Safety Laws and Regulation	Lifestyle Diseases	Programming for Bioinformatics Applications

VERTICAL I: INDUSTRIAL BIOTECHNOLOGY

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	VBT311	Applied Chemical Reaction Engineering	PE	3	3	0	0	3
2	VBT312	Bioreactor Design and Scaleup Process	PE	3	3	0	0	3
3	VBT313	Bioanalytical Techniques and Instrumentation	PE	3	3	0	0	3
4.	VBT314	Nanobiotechnology	PE	3	3	0	0	3
5.	VBT315	Algal Technology	PE	3	3	0	0	3
6.	VBT316	Environmental Biotechnology	PE	3	3	0	0	3
7	VBT317	Intellectual Property Rights in Biotechnology	PE	3	3	0	0	3

VERTICAL II: FOOD AND AGROSCIENCES

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	VBT321	Plant Tissue Culture and Transformation Techniques	PE	3	3	0	0	3
2	VBT322	Post Harvest Management and Value Addition	PE	3	3	0	0	3
3	VBT323	Agricultural Waste Management	PE	3	3	0	0	3
4.	VBT324	Food Process Engineering	PE	3	3	0	0	3
5.	VBT325	Principles of Food Preservation	PE	3	3	0	0	3
6.	VBT326	Food Quality Testing and Evaluation	PE	3	3	0	0	3
7	VBT327	Food Safety Laws and Regulation	PE	3	3	0	0	3

VERTICAL III: MEDICAL BIOTECHNOLOGY

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	VBT331	Neurobiology and Cognitive Sciences	PE	3	3	0	0	3
2	VBT332	Animal Biotechnology	PE	3	3	0	0	3
3	VBT333	Tissue Engineering	PE	3	3	0	0	3
4.	VBT334	Clinical Trials and Health Care Policies in Biotechnology	PE	3	3	0	0	3
5.	VBT335	Biopharmaceuticals and Biosimilars	PE	3	3	0	0	3
6.	VBT336	Cancer Biology	PE	3	3	0	0	3
7	VBT337	Lifestyle Diseases	PE	3	3	0	0	3

VERTICAL IV: COMPUTATIONAL BIOTECHNOLOGY

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	VBT341	Protein Structure Function and Engineering	PE	3	3	0	0	3
2	VBT342	Metabolic Engineering	PE	3	3	0	0	3
3	VBT343	Genomics and Proteomics	PE	3	3	0	0	3
4.	VBT344	Computer Aided Drug Design	PE	3	3	0	0	3
5.	VBT345	Data Mining and Machine Learning Techniques For Bioinformatics	PE	3	3	0	0	3
6.	VBT346	Molecular Modelling	PE	3	3	0	0	3
7	VBT347	Programming for Bioinformatics Applications	PE	3	3	0	0	3

OPEN ELECTIVE – I (VI SEMESTER)

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	OBT781	Basics of Bioinformatics	OEC	3	3	0	0	3

SEMESTER V

Course Code	Course Name	L	T	P	C
BT2301	BIOINFORMATICS	3	0	0	3

Category: Professional Core

a. Preamble

This course enables the students to

- Understand the Bioinformatics core concepts.
- Provide knowledge on Biological databases, sequence analysis, evolutionary analysis and applications of Bioinformatics.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Describe bioinformatics data and information resources.	K2
CO2	Apply computational based solutions for biological perspectives	K3
CO3	Analyze the evolutionary relationship between the organisms	K4
CO4	Utilize the macromolecules structure prediction methods	K3
CO5	Implement the applications of bioinformatics approach for drug discovery, genomics and proteomics	K3

c. Course Syllabus **Total : 45 Periods**

BIOLOGICAL DATABASES **9**

Introduction to Bioinformatics and Computational Biology, Biological sequences, Classification of biological databases - Sequence Databases, Structure Databases, Genome specific databases, Special Databases and applications- Microarray, Metabolic pathway, motif, and domain databases, Data file formats.

SEQUENCE ANALYSIS **9**

Sequence Alignment- Homology vs Similarity, Similarity vs Identity. Types of Sequence alignment - Pairwise and Multiple sequence alignment, Global alignment, Local alignment, Dotplot, Alignment algorithms- Needleman wunsch and Smith and waterman algorithm, Substitution matrices- PAM, BLOSUM; Multiple Sequence Alignment- Application of multiple alignments, Viewing and editing of MSA and Scoring function; Database Similarity Search - Basic Local Alignment Search Tool (BLAST), FASTA, PHI BLAST, PSI BLAST, BLAST algorithm.

MOLECULAR PHYLOGENY **9**

Phylogenetics Basics, Molecular clock theory, Ultrametric trees; Distance matrix methods- UPGMA, NJ; Character based methods-Maximum Parsimony. Methods of evaluating phylogenetic methods- boot strapping, jackknifing.

MACROMOLECULAR STRUCTURE ANALYSIS **9**

Gene prediction, Conserved domain analysis, Protein structure visualization, Prediction of protein secondary structure, Tertiary structure prediction- Homology modeling, Threading, Ab-initio prediction. Validation of the predicted structure using Ramachandran plot, steriochemical properties, Structure- structure alignment

APPLICATIONS **9**

Introduction to Systems Biology and Synthetic Biology, Microarray data analysis, DNA computing, Bioinformatics approaches for drug discovery, Applications of Bioinformatics in genomics and proteomics- Assembling the genome, STS content mapping for clone contigs, Functional annotation, Peptide mass fingerprinting.

d. Activities

Students shall have a activites on database search and analysis which including assignments.

e. Learning Resources

Text Books

1. Arthur M. Lesk, *Introduction to Bioinformatics,* Oxford university press, 2019.
2. Xiong, J., *Essential Bioinformatics,* Cambridge University Press, 2006.
3. Sippl, M.J., Durbin, R., Eddy, S., Krogh, A., and Mitchinson, G., *Biological Sequence Analysis, Probabilistic Models of Proteins and Nucleic Acids,* Cambridge University Press, 1999.

Reference Books

1. Baldi, P., Brunak, S., and Bach, F., *Bioinformatics: The Machine Learning Approach*, MIT press, 2001.
2. Coulson, A., *Algorithms on Strings, Trees and Sequence by Dan Gusfield*, Cambridge University Press, 1998.

Course Code	Course Name	L	T	P	C
BT2302	GENETIC ENGINEERING	3	0	0	3

Category: Professional Core

a. Preamble

This course enables the students to

- Learn the fundamentals of recombinant DNA technology and DNA manipulation techniques**.**
- Apply the fundamentals of rDNA technology on construction of vectors and DNA libraries**.**
- Understand the applications of genetic engineering in various fields.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Outline the role of Restriction-Modification system in recombinant DNA technology	K2
CO2	Apply the suitability of cloning vectors for various recombinant DNA based applications.	K3
CO3	Illustrate different methods of DNA sequencing and amplification of DNA.	K3
CO4	Compare different types of DNA libraries and their screening methods	K4
CO5	Experiment with current mutagenesis tools & engineered nucleases for various recombinant DNA applications.	K4

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO RECOMBINANT DNA TECHNOLOGY 9

Overview of recombinant DNA technology (rDNA) and its applications; rDNA technology tools; Restriction and Modification systems (RM system) - biological

importance, restriction enzymes, cohesive ends, blunt ends, isoschizomers, neoschizomers, star activity, compatible cohesive ends; DNA polymerase; DNA ligase - blunt end ligation, linkers and adaptors, inter and intra molecular ligation; Alkaline phosphatase; Polynucleotide kinase; Terminal transferase, Exonuclease.

CLONING VECTORS AND HOST SYSTEMS **9**

Introduction to vectors and their types - cloning vector and expression vector; Plasmid vector – types, characteristics, importance, copy number regulation; Bacteriophage vector - λ DNA vectors, *in-vitro* packaging, single strand DNA vectors, M13 phage vector; Viral vectors; Combinatorial vectors – cosmid, phagemid and other hybrid vectors; Artificial chromosomes - bacterial and yeast artificial chromosomes; Prokaryotic and eukaryotic expression host systems; Introduction of rDNA into host cells; Methods of selection of recombinants - size-based selection, Spi^{-} selection and other selection methods.

AMPLIFICATION OF DNA AND SEQUENCING **9**

Polymerase Chain Reaction (PCR) - principle and steps involved, types of PCR - inverse PCR, nested PCR, AFLP-PCR, allele specific PCR, assembly PCR, asymmetric PCR, hot start PCR, colony PCR, methylation specific PCR, single cell PCR and real-time PCR/qPCR and its advantages, SYBR green assay, TaqMan assay, molecular beacons; DNA sequencing - Maxam-Gilbert's and Sanger's methods of DNA sequencing, pyrosequencing, nanopore DNA sequencing; Next Generation Sequencing (NGS) - 454 sequencing, solexa method, ion semiconductor sequencing, Life/APG – SOLiD system.

DNA LIBRARIES AND SCREENING TECHNIQUES **9**

Construction of genomic and cDNA library - introduction, methods, limitations; Chromosomal walking; Screening of DNA libraries - nucleic acid hybridization and PCR (degenerate probes and primers); Southwestern and Northwestern strategies; Immunochemical; Protein-protein/ligand interaction; Functional complementation/gain of function approaches; Differential cDNA library - differential expression analysis and screening; Subtracted cDNA library; PCR based differential display analysis and difference cloning.

APPLICATIONS OF RECOMBINANT DNA TECHNOLOGY 9

Site directed mutagenesis: Primer extension method, Kunkel's method and PCR based site directed mutagenesis; creation and application of transgenic animals and plants; Engineered Nucleases for genome editing: Meganucleases, Zinc finger nucleases, Transcription Activator-Like Effector Nucleases (TALENs), CRISPR-Cas; Specific case studies on site specific mutants, transgenic plants & animals; Human genome project – Recent advancements.

d. Activities

Students will be made aware of important techniques and concepts of rDNA technology through activities like Minute paper, Think-Pair-Share, Quiz, Role play, student seminars and Paper jigsaw puzzle activity.

e. Learning Resources

Text Books

1. Old, R.W., and Primrose, S.B., *Principles of gene manipulation: an introduction to genetic engineering* (Vol. 2), Univ of California Press, 2001.
2. Primrose, S.B., and Twyman, R., *Principles of genome analysis and genomics,* John Wiley & Sons, 2009.
3. Brown, T.A., *Gene cloning and DNA analysis: an introduction*, Wiley-Blackwell, 2020.

Reference Books

1. Primrose, S., and Twyman, R., *Principles of Gene Manipulation and Genomics*, Blackwell Publishing, 2006.
2. Krebs, J.E., Goldstein, E.S., and Kilpatrick, S.T., *Lewin's Genes XII*, Jones & Bartlett Learning, 2017.
3. Winnacker, E.L., *From Genes to Clones: Introduction to Gene Technology*, VCH Verlagsgesellschaft, Weinheim, FDR, 2003.

Course Code	Course Name	L	T	P	C
BT2303	MASS TRANSFER OPERATIONS	3	0	0	3

Category: Engineering Sciences

a. Preamble

This course enables the students to

- To learn about the principles of adsorption, absorption, leaching, extraction, distillation, and drying operations.
- To understand the importance and applications of the different mass transfer processes in the industry.
- To develop skills in the area of mass transfer operations with an emphasis on the separation and purification of products

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Utilize the concepts of molecular diffusion and mass transfer to design complex mass transfer operations	K3
CO2	Use the principles of gas absorption to design equipment for separating a gas from a mixture.	K3
CO3	Apply the concepts of Vapour-Liquid equilibrium to design the industrial distillation process.	K3
CO4	Construct equipment for liquid-liquid and solid-liquid extraction process	K3
CO5	Identify and design suitable adsorption and drying process for industrial applications	K3

c. Course Syllabus **Total: 45 Periods**

DIFFUSION AND MASS TRANSFER **9**

Eddy Diffusion - Molecular diffusion in fluids and solids; Interphase mass transfer; Mass Transfer coefficients; Mass transfer theories and analogies; Co-current and counter-current operations.

GAS-LIQUID OPERATIONS **9**

Principles of gas absorption; Single and Multi-component absorption; Design principles of absorbers – Height of Transfer Units (HTU), Number of Transfer Units (NTU) concepts; Absorption with Chemical Reaction; Industrial absorbers – Tray tower absorbers, Venturi scrubbers, Wetted wall columns, and packed tower absorbers.

VAPOUR LIQUID OPERATIONS **9**

Vapour-Liquid Equilibria; Simple, Steam, Flash and Continuous distillation; Height Equivalent to Theoretical Plate (HETP), HTU and NTU concepts; McCabe-Thiele principles; Industrial distillation equipment,

EXTRACTION OPERATIONS **9**

Liquid-Liquid equilibria; Solvent characteristics; Staged and continuous extraction - Spray, packed and mechanically agitated contactors, Pulsed and centrifugal extractors, supercritical extraction; Solid-liquid equilibria - Leaching Principles, leaching equipment, Percolation tank leaching, Thickeners, Bollman extractor, Roto cell extractor, Kennedy extractor.

ADSORPTION AND DRYING OPERATIONS **9**

Adsorption equilibria – Nature of adsorbents; Batch and fixed bed adsorption; Adsorbers – steady-state moving bed adsorber and unsteady state moving adsorbers; breakthrough curves; Drying- Mechanism, rate of drying, Time of Drying; Batch and continuous dryers.

d. Activities

Through industrial visits, students will understand the various types of mass-transfer operation equipment used in industries and prepare a report on the same.

e. Learning Resources

Text Books

1. Treybal, R.E., *Mass Transfer Operations*, 3rd Ed, McGraw-Hill, 1981. (8th Reprint 2015)
2. Geankoplis, C.J., *Transport Processes and Unit Operations*, 4th Edition, Prentice Hall Inc., New Jersey, 2003.
3. McCabe W.L, Smith J.C., and Harriot P., *Unit Operations of Chemical Engineering*, 7th edition, McGraw Hill, 2022.

Reference Books

1. Coulson J. M., Richardson J.F., Backhurst J. R., and Harker J. H., *Coulson and Richardson's Chemical Engineering*, Vol II, V edition, Butterworth-Heinemann, 2013.
2. Welty, J. R., Wilson, R. E., Wicks, C. E., and Rorer, G. L., *Fundamentals of Momentum, Heat and Mass Transfer*, V edition, John Wiley & sons Inc., 2010.
3. Henley, Ernest J., Seader, J. D., and Roper, D. K., *Separation Process Principles*, III Edition, Wiley, 2012.

Course Code	Course Name	L	T	P	C
BT2304	ENZYME ENGINEERING LABORATORY	0	0	4	2

Category: Professional Core

a. Preamble

The course enables the students to

- Understand the importance of enzymes usage in various biochemical reactions.
- Develop a strategy to prepare and test functionally hyper active enzyme for various applications.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Identify the ideal sources for recovery of α-amylase enzyme and its characterization	K3
CO2	Choose suitable method for purification of enzyme	K3
CO3	Determine the optimum conditions to increase the enzyme activity.	K3
CO4	Construct an enzyme-based reactor set-up for various biochemical reactions	K4
CO5	Develop enzyme-based tool for biosensing applications.	K4

Total : 60 Periods

c. Course Syllabus

LIST OF EXPERIMENTS

1. Isolation of α – Amylase from Potato and determination of enzyme activity
2. Determination of Km and Vmax of an enzyme
3. Purification of an enzyme using ammonium sulfate salt precipitation
4. Effect of temperature on enzyme activity
5. Effect of pH on enzyme activity
6. Determination of type of enzyme inhibition for the given inhibitor

7. Determination of the inhibitor concentration for the given enzyme
8. Preparation of immobilized enzyme based on gel entrapment method
9. Preparation of Packed bed enzyme reactor
10. Design and Fabrication of enzyme-based biosensor

d. Learning Resources

Text Books

1. Thomas Crowley and Jack Kyte, *Experiments in the Purification and Characterization of Enzymes - A Laboratory Manual*, Academic Press, 2014.
2. Howard H. Weetall and Shuichi Suzuki, *Immobilized Enzyme Technology*, Springer New York, NY, 2012.

Reference Books

1. Trevor Palmer and Philip L. Bonner, *Enzymes: Biochemistry, Biotechnology, Clinical Chemistry*, East West, 2008.
2. Klaus Buchholz, Volker Kasche and Uwe Theo Bornscheuer, *Biocatalysts and Enzyme Technology*, Wiley VCH, 2005.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S. No	Description of the Equipment	Quantity Required
1.	UV-Vis Spectrophotometer	1
2.	Water Bath	1
3.	Shaker Incubator	1
4.	Cooling Centrifuge	1
5.	pH Meter	1
6.	Packed-Bed Column Reactor	1
7.	Peristaltic Pump	1
8.	Laminar Air-Flow chamber	1

Course Code	Course Name	L	T	P	C
BT2305	MOLECULAR BIOLOGY AND GENETIC ENGINEERING LABORATORY	0	0	4	2

Category: Professional Core

a. Preamble

This course enables the students to

- Learn the basic DNA isolation techniques.
- Learn about the identification and characterization of gene and protein.
- Provide hands-on experience in performing basic recombinant DNA techniques.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Demonstrate isolation and manipulation of plasmid DNA.	K3
CO2	Apply the process of DNA amplification and transformation in recombinant DNA studies.	K3
CO3	Make use of strategies for optimization of foreign gene expression in host system.	K3
CO4	Illustrate the principles underpinning modern tools for analysis of DNA and protein.	K3
CO5	Practice appropriate good laboratory practices to carry out recombinant DNA studies.	K3

c. Course Syllabus **Total : 60 Periods**

LIST OF EXPERIMENTS

1. Agarose gel electrophoresis

2. Isolation of genomic DNA – Microbial, Animal & Plant sources

3. Isolation of plasmid DNA

4. Digestion of DNA with Restriction enzymes

5. DNA ligation

6. DNA elution

7. Polymerase Chain Reaction (PCR)

8. Competent cell preparation & Transformation

9. Screening of recombinants

10. Induction and Analysis of Protein expression- SDS-PAGE

11. Southern Hybridization - Non radio-isotopic method

12. Western Blotting - Non radio-isotopic method

d. Activities

Students will be given Mini projects to learn the application of various tools learnt in the laboratory.

e. Learning Resources

Reference Books

1. Green, M.R., Hughes, H., Sambrook, J., and MacCallum, P., *Molecular cloning: a laboratory manual. In Molecular cloning: a laboratory manual*, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York, 2012.
2. Carson, S., Miller, H., Srougi, M., and Witherow, D.S., *Molecular Biology Techniques: A classroom laboratory manual*, Academic Press, Elsevier, 2019.
3. Stephenson, F.H., *Calculations for Molecular Biology and Biotechnology*, Academic Press, Elsevier, 2016.
4. Wilson, K., and Walker, J., *Principles and Techniques of Biochemistry and Molecular Biology*, Cambridge University Press, 2018.
5. Gerstein, A.S., *Molecular Biology Problem Solver – A Laboratory Guide*, Wiley-Liss, Inc., 2017.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S. No	Description of the Equipment	Quantity Required

1	Refrigerated centrifuge	1No.
2	Spectrophotometer	2 Nos.
3	Chemical fume hoods (for handling toxic solvents)	2 Nos.
4	Temperature controlled Incubator shaker	1No.
5	Temperature controlled water bath	1No.
6	Ice flake machine	1 No.
7	Agarose gel apparatus with power packs	2 Nos.
8	Laminar Air flow (3 or 4 ft length)	2 Nos.
9	PCR machine (96/48 Wells)	1 No.
10	SDS-PAGE apparatus	2 Nos.
11	Western transfer apparatus (wet)	2 Nos.
12	Glasswares / Plasticwares/Chemicals/Media as required	As per requirement
13	Refrigerated centrifuge	1No.
14	Spectrophotometer	2 Nos.

SEMESTER VI

Course Code	Course Name	L	T	P	C
BT2351	BIOPROCESS ENGINEERING PRINCIPLES	3	0	0	3

Category: Professional Core

a. Preamble

This course enables the students to

- Develop an understanding of bioreactors' basic design and various bioprocessing cultivation strategies.
- Understand various media components, sterilization kinetics and strategies involved in growth and product formation.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Outline the essential parameters in a bioreactor, which need to be controlled and monitored for optimum bioprocess.	K2
CO2	Explain the formulation of medium, which supports maximization of product / target.	K3
CO3	Choose an appropriate sterilization design for sterilizing different media.	K3
CO4	Make use of appropriate cultivation strategies for maximum product formation.	K3
CO5	Develop an appropriate medium based on the stoichiometric requirement of the microbial system.	K3

c. Course Syllabus **Total: 45 Periods**

OVERVIEW OF FERMENTATION PROCESSES **9**

Overview of fermentation industry - general requirements of fermentation processes, phases of bacterial growth, the basic configuration of fermenter and ancillaries; Main parameters to be monitored and controlled in fermentation processes (pH, temperature, dissolved oxygen), sensors.

MEDIA DESIGN AND OPTIMIZATION **9**

Criteria for good medium, medium requirements for fermentation processes, carbon, nitrogen, minerals, vitamins and other complex nutrients, oxygen requirements, medium formulation for optimal growth and product formation, examples of simple and complex media, medium optimization methods - Plackett Burman design, Response Surface Methodology.

STERILIZATION KINETICS **9**

Concept of media sterilization; Thermal Death Kinetics; Design of batch and continuous sterilization processes; Filter sterilization of liquid media and air; filter sterilization based numerical problems.

KINETICS OF MICROBIAL GROWTH AND PRODUCT FORMATION **9**

Biomass estimation - Direct and Indirect methods, Kinetics of cell growth & substrate utilization; Unstructured kinetic models for microbial growth (Monod & modified Monod models - logistic equation); Kinetics of product formation - Luedeking-Piret equation and analysis; Substrate and product inhibition of cell growth and product formation; Batch and continuous cultivation.

METABOLIC STOICHIOMETRY AND ENERGETICS **9**

Stoichiometry of cell growth and product formation - elemental balances, degrees of reduction of substrate and biomass, available electron balances, yield coefficients of biomass and product formation, maintenance coefficients; Microbial growth and product formation energetics, oxygen consumption and heat evolution in aerobic cultures, thermodynamic efficiency of growth.

d. Activities

Students will be given assignments in the media design process by using case studies.

e. Learning Resources

Textbooks

1. Stanbury, P.F., Whitaker, A., and Hall, S.J., *Principles of Fermentation Technology*, 3rd Edition, Elsevier, 2016.
2. Michael L., Shuler and Fikret Kargi, *Bioprocess Engineering: Basic Concepts*, 2nd Edition, Prentice Hall, 2017.
3. Doran, P.M., *Bioprocess Engineering Principles*, Academic Press, 2012.

Reference Books

1. Clark, D.S., and Blanch, H.W., *Biochemical Engineering*, 2nd Edition, CRC press, 1997.
2. Bailey, J.E., and Ollis, D.F., *Biochemical Engineering Fundamentals*, Chemical Engineering Education, 2nd Edition, 1986.

Course Code	Course Name	L	T	P	C
BT2352	IMMUNOLOGY	3	0	0	3

Category: Professional Core

a. Preamble

This course enables the students to

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

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the structures and functions of different immune cells and organs.	K2
CO2	Illustrate the process of development and activation of T-cells, B-cells and other components of humoral immune response.	K3
CO3	Demonstrate various immune responses produced by our body against various pathogens and tumor.	K3
CO4	Analyze various hypersensitivity reactions and autoimmune disorders.	K4
CO5	Experiment with different methods of vaccine production and immunodiagnostic methods.	K4

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO IMMUNE SYSTEM **9**

Organization and classification of immune system – immune cells and organs- innate and acquired immunity- types of immune responses: primary and secondary- classification of antigens: chemical and molecular nature, haptens, adjuvants- Antigen Presenting Cells (APCs)- antigen processing and presentation- major histocompatibility complex (MHC)- cytokines- Toll receptors and responses- Inflammation.

HUMORAL AND CELLULAR IMMUNITY **9**

Development, maturation, activation, regulation, differentiation and classification of T-cells and B-cells; Theory of clonal selection; TCR & BCR; Antibodies - structure and functions, antibody genes and generation of diversity; Antigen-antibody reactions; Complement pathway.

IMMUNITY AGAINST PATHOGENS AND TUMORS **9**

Immune regulation - T reg; Protective immune responses to virus, bacteria, fungi and parasites; Tumor immunology - tumor antigens, tumor immune response, tumor diagnosis, tumor immunotherapy.

TRANSPLANTATION, HYPERSENSITIVITY AND AUTOIMMUNITY **9**

Immune tolerance; Immuno deficiencies; Transplantation - genetics of transplantation; Allergy and hypersensitivity - types of hypersensitivity; Autoimmunity - autoimmune disorders, diagnosis and therapy.

APPLIED IMMUNOLOGY **9**

Vaccines - classification and methods of development; Monoclonal antibodies – applications and engineering of antibodies; Immunodiagnostic methods - immunodiffusion, Enzyme Linked Immuno Sorbent Assay (ELISA), Fluorescence-activated cell sorting (FACS); Immunohistochemistry; Immune modulatory drugs.

d. Activities

Students will be made aware of important techniques and concepts of immunology through activities like Minute paper, Think-Pair-Share, Quiz, Role play, student seminars and other Classroom Assessment Techniques (CATs) activities.

e. Learning Resources

Text Books

1. Punt, J., *Kuby Immunology*, WH Freeman, Macmillan Learning. (8th Edition), 2019.
2. Delves, P.J., Martin, S.J., Burtn, D.R., and Roitt, I.M., *Roitts Essential Immunology*, Wiley-Blackwell, 13th Edition, 2016.
3. Parham, P., *The Immune System*, Garland Science, 2014.

Reference Books

1. Coico, R., *Immunology: a Short Course*, John Wiley & Sons, 2021.
2. Khan, F.H., *The Elements of Immunology*, Pearson Education India, 2009.
3. Abbas, A.K., Lichtman, A.H., and Pillai, S., *Cellular and Molecular Immunology*, Elsevier Health Sciences, 2014.

Course Code	Course Name	L	T	P	C
BT2353	BIOPROCESS LABORATORY	0	0	3	1

Category: Professional Core

a. Preamble

This course enables the students to

- Design and evaluate the performance of bioreactors by analyzing the mass transfer, heat transfer and mixing capabilities in bioreactors.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Identify the different ancillaries of the bioreactor.	K3
CO2	Design and optimize the media for the cultivation of microorganisms	K3
CO3	Utilize the different kinetics of the reactor.	K3
CO4	Estimate the Oxygen transfer and heat transfer in the bioreactor.	K4
CO5	Assess the substrate, growth and product kinetics in different modes of bioreactor	K4

c. Course Syllabus **Total: 45 Periods**

LIST OF EXPERIMENTS

1. Reactor Preparation – Dismantle, Cleaning and reassembly.
2. Media optimization – Plackett-Burman Design & Response Surface Methodology
3. Batch Sterilization – Thermal Death kinetics
4. Residence Time Distribution Profiling in a continuous reactor
5. Estimation of $K_L a$– Dynamic Gassing-out method,
6. Estimation of $K_L a$ – Sulphite Oxidation Method and Power Correlation

Method

7. Estimation of the Heat Transfer Coefficient of the reactor
8. Batch cultivation: Growth rate, Substrate utilization kinetics, Product analysis
9. Fed-batch cultivation: Growth rate, Substrate utilization kinetics, Product analysis
10. Continuous cultivation: Growth rate, Substrate utilization kinetics, Product analysis.
11. Photobioreactor – Cyanobacteria /Algal cultivation

d. Activities

Students will design the media for a microorganism and estimate its growth kinetics in a bioreactor at different modes of operation.

e. Learning Resources

Reference Books

1. Stanbury, P.F., Whitaker, A., and Hall, S.J., *Principles of Fermentation Technology*, 3rd Edition, Elsevier, 2016.
2. Michael L., Shuler and Fikret Kargi, *Bioprocess Engineering: Basic Concepts*, 2nd Edition, Prentice Hall, 2017.
3. Doran, P.M., *Bioprocess Engineering Principles*, Academic Press, 2012.
4. Bailey, J.E., and Ollis, D.F., *Biochemical Engineering Fundamentals*, Chemical Engineering Education, 2nd Edition, 1986.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S. No	Description of the Equipment	Quantity Required
1.	UV-Visible Spectrophotometer	1
2.	Laminar Air flow Hood	1
3.	Incubator	1
4.	Shaking Incubator	1
5.	Batch Reactor	1
6.	Continuous Reactor	1

Course Code	Course Name	L	T	P	C
BT2354	IMMUNOLOGY LABORATORY	0	0	3	1

Category: Professional Core

a. Preamble

This course enables the students to

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

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Gain knowledge about handling of animals and routes of immunization	K2
CO2	Identify immune cells in blood smear and enumerate cells using Neubar chamber.	K3
CO3	Illustrate separation of PBMCs from blood and perform experiments using them	K3
CO4	Demonstrate experiments to show agglutination and precipitation reactions between antigen and antibody	K3
CO5	Perform ELISA technique for any given antigen or antibody	K3

c. Course Syllabus **Total : 45 Periods**

LIST OF EXPERIMENTS

1. Selection of animals and introduction to animal handling (mice/rat/rabbit/chicken /fish etc) – Theoretical Study

2. Routes of immunization and methods of bleeding

3. 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. Immunoprecipitaion reaction: immunodiffusion / immune electrophoresis

9. Identification of T Cells by T-Cell rosette using Sheep RBC

10. Determination of antibody titre by ELISA

d. Activities

Students will be taken to labs that do animal handling to have a first hand exposure in animal handling

e. Learning Resources

Reference Books

1. John E. Coligan, Ada M. Kruisbeek, David H. Margulies, Ethan M. Shevach and Warren Strober, *Current Protocols in Immunology*, Vol.1-3, John Wiley & Sons, 2004.
2. Edward A., Greenfield and Dana-Farber, *Antibodies: A Laboratory Manual*, 2nd Edn., Cancer Institute, Cold Spring, Harbour Laboratory, 2014.
3. Ashim K., and Chakravarthy, *Immunology*, Tata McGraw-Hill, 2008.
4. Kuby J., *Immunology*, 8th Ed., WH Freeman & Co., 2018.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S. No	Description of the Equipment	Quantity Required
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

PROFESSIONAL ELECTIVES

VERTICAL I – INDUSTRIAL BIOTECHNOLOGY

Course Code	Course Name	L	T	P	C
VBT311	APPLIED CHEMICAL REACTION ENGINEERING	3	0	0	3

Category: Professional Elective

a. Preamble

This course enables the students to

- Impart the basic concepts in reaction kinetics
- Develop knowledge for the design of ideal and non ideal reactors
- Endow knowledge in industrial reactors and its functions

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the basic laws on chemical kinetics and its application on different types of reactions.	K2
CO2	Apply the performance equations for determining the conversion efficiency of ideal reactors.	K3
CO3	Utilize the characteristics of residence time distribution in a non-ideal reactor.	K3
CO4	Make use of the rate controlling step of a reacting system.	K3
CO5	Analyze the performance of reactors in industries.	K4

c. Course Syllabus **Total: 45 Periods**

CHEMICAL REACTION RATE AND CHEMICAL KINETICS 9

Chemical Kinetics - Classification of chemical reactions, Reaction Rate, Factors affecting the rate of reaction; Definition of order and molecularity, rate constant; Temperature dependent term of rate equation (Arrhenius law, Collision Theory,

Transition state theory) and Activation energy; Interpretation of batch reactor data - Integral and differential method of analysis (Only for constant volume batch reactor).

IDEAL REACTORS **9**

Design of performance equations -for batch, plug flow and mixed flow reactors; space time and space velocity; Size comparison of single reactors, multiple reactor systems, recycle reactor and autocatalytic reactions.

NON IDEAL REACTORS **9**

Basics of non ideal flow - Residence Time Distribution (RTD) function and measurement, RTD in plug flow and mixed flow reactor, conversion in non ideal flow, relation between E, F and C curve; non ideal flow models - tank in series and dispersion models.

HETEROGENEOUS REACTING SYSTEM **9**

Introduction to heterogeneous reacting systems - solid catalyzed reactions, rate equation for surface kinetics and pore diffusion resistance combined with surface kinetics; Performance equation for reactors containing porous catalyzed particles; Kinetics of non-catalytic fluid particle systems - Progressive conversion model and shrinking core model; Determination of rate controlling step.

INDUSTRIAL REACTORS **9**

Reactors to carry out G/L reactions on solid catalysts -Trickle bed, slurry reactors; three phase-fluidized beds; fluid-fluid reactions kinetics.

d. Activities

Experiments to be conducted related to reactors

e. Learning Resources

Text Books

1. Octave Levenspiel, *Chemical Reaction Engineering,* 3rd Edition, John Wiley & Sons, 2008.
2. Fogler, H.S., *Elements of Chemical Reaction Engineering,* 3rd Edition, Prentice Hall of India, 2014.

3. Missen, R.W., Mims, C. A., and Saville, B.A., *Introduction to Chemical Reaction Engineering and Kinetics*, 3rd Edition, John Wiley, 2000.

Reference Books

1. Coulson and Richardson, *Chemical Engineering, Chemical & Biochemical Reactors & Process control*, 3rd Edition, Butterworth – Heinemann, United Kingdom, 2009.
2. Walker, D., *Chemical Reactions*, 2nd Edition, Evans Brothers, 2007.

Course Code	Course Name	L	T	P	C
VBT312	BIOREACTOR DESIGN AND SCALEUP PROCESS	3	0	0	3

Category: Professional Elective

a. Preamble

This course enables the students to

- Understand different modelling and simulation concepts of bioprocess.
- Develop an understanding on the concepts involved in the design of different bioreactors and its operation mechanism.
- Enhance knowledge in diffusional mass transfer in immobilized enzyme reactor and recombinant cell cultivation with their simulation process.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Model and simulate concepts of bioprocesses to reduce costs and enhance the quality of products and systems.	K3
CO2	Design appropriate bioreactors for various bioprocesses for enhanced growth and product formation	K3
CO3	Apply the concepts of aeration and agitation in different process conditions to determine the mass transfer and power required for the bioprocess.	K3
CO4	Make use of the concepts of external and internal mass transfer correlations towards the design of immobilized reactors.	K3
CO5	Utilize different strategies towards the maximum production of recombinant proteins from microbial bioprocess.	K3

c. Course Syllabus **Total: 45 Periods**

MODELLING & SIMULATION OF BIOPROCESSES – STRUCTURED KINETICS **9**

Dynamic Simulation of bioprocess; Study of structured models for the analysis of various bioprocess – compartmental models, cellular energetics and metabolism models, single cell models, plasmid replication and plasmid stability model; Cybernetic Model; Black box model

OPERATIONAL MODES OF BIOPROCESS AND BIOREACTORS **9**

Different modes of cultivation - Batch, fed-batch and continuous cultivation; Cell recycle cultivation - application in wastewater treatment; Design equations of Batch reactor, Fed-Batch reactor, and Continuous reactor – Continuous Stirred Tank Reactor (CSTR) & Plug Flow Reactor (PFR); Chemostat & Turbidostat; Two-stage cultivation

AERATION, AGITATION AND SCALE – UP STRATEGIES **9**

Concepts of aeration – Oxygen Uptake Rate (OUR) and Oxygen Transfer Rate (OTR); regime analysis in aerated bioprocess; Oxygen mass transfer correlations in bioreactors; Methods to determine mass transfer coefficients; Concepts of agitation; Power requirement in Newtonian Ungassed systems, Non-Newtonian Ungassed systems and Gassed system; Scale up criteria for bioreactors based on oxygen transfer, power consumption and impeller tip speed.

BIOREACTOR FOR IMMOBILIZED AND ENZYME SYSTEMS **9**

Analysis of film and pore diffusion - effects on immobilized enzyme reaction kinetics; formulation of dimensionless groups and calculation of effectiveness factors; Design of immobilized enzyme reactors – packed bed, fluidized bed and membrane reactors.

BIOREACTOR FOR RECOMBINANT SYSTEMS **9**

Different host-vector system for recombinant cell cultivation strategies and advantages. Bacteria - *E.coli*, Yeast (*Pichia pastoris / Saccharomyces cerevisiae*), insect cell cultivation, plant cell cultivation, animal cell cultivation; High cell density cultivation, process strategies, reactor considerations in the above system.

d. Activities

Modelling of bioprocess in MATLAB®

e. Learning Resources

Textbooks

1. Pauline, M. Doran., *Bioprocess Engineering Principles,* Elsevier, 2012.
2. Michael L. Shuler and Fikret Kargi., *Bioprocess Engineering: Basic Concepts,* 2nd Edition, Prentice Hall, 2017.
3. Sarfaraz K. Niazi and Justin L. Brown., *Fundamentals of Modern Bioprocessing*, Taylor & Francis, 2017.

Reference Books

1. Shijie, Liu., *Bioprocess Engineering Kinetics, Sustainability, and Reactor Design,* Elsevier, 2020.
2. Stanbury, P.F., Whitaker, A., and Hall, S.J., *Principles of Fermentation Technology*, 3rd Edition, Elsevier, 2016.
3. James M. Lee., *Biochemical Engineering*, Prentice-Hall Inc, 1992.

Course Code	Course Name	L	T	P	C
VBT313	BIOANALYTICAL TECHNIQUES AND INSTRUMENTATION	3	0	0	3

Category: Professional Elective

a. Preamble

This course enables the students to

- Gain fundamental knowledge about the Light spectrum, Absorption, Fluorescence
- Gain knowledge about NMR, Mass spectroscopy and acquire knowledge on various analytical techniques and instruments.
- Acquire knowledge on microscopy.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Comprehend the fundamental need of bioanalytical techniques.	K2
CO2	Classify the fundamental knowledge of microscopy, working principle behind various types of microscopes.	K2
CO3	Interpret the knowledge of spectroscopy in various spectrometric analysis.	K3
CO4	Apply the basic principle behind various spectroscopic technique to characterize samples.	K3
CO5	Demonstrate the concept of biosensor design for the analysis of samples.	K3

c. Course Syllabus **Total: 45 Periods**

INTRODUCTION **9**

Introduction to the field of bioanalysis and bioanalytical methods; Types of Instrumental methods; Bioanalytical technique development and validation; Biological sample collection & preparation techniques.

MICROSCOPY **9**

Study of surfaces – Scanning probe microscopes: Atomic force microscopy (AFM) and Scanning Tunneling Microscopy (STM), Inverted microscopy, Polarization microscopy: Polarized light, optical design, theory, image interpretation, Confocal laser scanning microscopy (CLSM), Specular Microscopy. Multiphoton laser scanning microscopy.

FUNDAMENTALS OF SPECTROMETRY **9**

Spectrometry; Properties of electromagnetic radiation; Absorption of radiation, Beer-Lamberts' Law; Gas chromatography/Mass spectrometry (GC-MS); Liquid Chromatography/Mass spectrometry (LC-MS); UV-Visible molecular adsorption spectrometry, Molecular luminescence spectrometry.

SPECTROSCOPIC TECHNIQUES **9**

Raman spectroscopy; Infrared & Fourier Transform Infrared (FTIR) Spectroscopy; Theory of Nuclear Magnetic Resonance (NMR) - chemical shift - NMR-spectrometers – applications of 1H and 13C NMR- Molecular mass spectra – ion sources; Molecular mass spectrometer. Applications of Molecular mass spectrometry - Electron paramagnetic resonance- g values – instrumentation.

BIOSENSORS **9**

Basic principle and general configuration of biosensor; Basic principle and instrumentation of different biosensors: electrochemical, optical, acoustic, piezoelectric, and calorimetric biosensors; Biological recognition systems: enzyme, antibody, nucleic acid, cell, and tissue; Application of biosensors for food and fermentation processes, environment monitoring, and clinical diagnostics.

d. Activities

Students shall be exposed to the different analytical instruments in our laboratory.

e. Learning Resources

Text Books

1. Skoog, D.A., James Holler, F., and Stanly R. Crouch, *Instrumental Methods Of Analysis*, Cengage Learning, 2007.
2 Skoog D.A., Holler and Crouch, *Principles of Instrumental Analysis*, 7th edition, Cengage Learning, 2016.

Reference Books

1. Braun Robert D., *Introduction to Instrumental Analysis*, Pharma Med Press, 2016.
2. Sharma, B.K., *Instrumental Methods of Chemical Analysis*, Krishna Prakashan Media (P) Ltd., 2014.

Course Code	Course Name	L	T	P	C
VBT314	NANOBIOTECHNOLOGY	3	0	0	3

Category: Professional Elective

a. Preamble

This course enables the students to

- Learn about the fundamentals of nanomaterials.
- Learn about bionanomaterial characterization using advanced techniques.
- Learn about the applications of nanomaterials in various biotechnological fields.
- Learn about the societal impacts of nanomaterials.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Compare the fundamental properties of nanomaterials.	K2
CO2	Make use of various methods for synthesis of nanomaterials.	K3
CO3	Utilize different techniques for nanoparticle characterization.	K3
CO4	Categorize the various nano-sized materials in Biotechnology	K3
CO5	Apply the concept of Nanotechnology for Biotechnological applications.	K3

c. Course Syllabus **Total: 45 Periods**

INTRODUCTION TO NANOTECHNOLOGY **9**

History of the Super Small; definition of Nanotechnology; classifications of nanostructured materials - nano particles, quantum dots, nanowires, ultra-thin films, multilayered materials; Length Scales involved and effect on properties - Mechanical,

Electrical, Optical, Magnetic and Thermal properties; Qualitative properties of nanomaterials.

METHODS OF NANOMATERIAL PREPARATION 9

Introduction; Synthesis of nanomaterials by physical, chemical and biological methods - Bottom-up and Top-down approaches; Co-Precipitation, Ultra-sonication, Mechanical Milling, Colloidal routes, Self-assembly, Vapour phase deposition, Metal organic chemical vapour deposition (MOCVD), Sputtering, Evaporation, Molecular Beam Epitaxy, Atomic Layer Epitaxy.

NANOMATERIAL CHARACTERIZATION 9

Nanoanalytics; Fourier Transform Infrared (FTIR) spectroscopy, Dynamic force spectroscopy; Force Spectroscopy & force microscopy, Surface biology: Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Environmental Scanning Electron Microscopy (ESEM), Atomic force microscopy-molecular pulling. Surface enhanced Raman scattering.

NANOMATERIAL IN BIOTECHNOLOGY 9

Biomimetic nanotechnology; protein-based nanostructures; Nanomotors - bacterial (*E.coli*) and mammalian (Myosin family); DNA nanotechnology - nanostructures in cell study, microarray platforms, Nano printing of DNA, RNA; proteins biochips; lab-on-a-chip devices (LOC).

NANOBIOTECHNOLOGY APPLICATIONS & IMPACTS 9

Nano electromechanical devices in drug delivery; other applications in drug delivery; DNA nanostructures for mechanics and computing; Nano biosensors; applications of quantum dots in biotechnology; Nanoparticles as non-viral transfection agents; Societal impacts of nano-biotechnology – toxic effects on health, bioterrorism

d. Activities

Students will be divided into groups and a quiz competition will be conducted after the completion of each unit.

e. Learning Resources

Text Books

1. Niemeyer, C.M., and Mirkin., C.A., *Nanobiotechnology - Concepts, Applications and Perspectives*, Wiley-VCH, Weinhelm, Germany, 2004.
2. Chad A. Mirkin and Christ M. Niemeyer., *Nanobiotechnology - II More Concepts and applications*, Wiley VCH, Weinhelm, Germany, 2007.
3 David S. Goodsell., *Bionanotechnology: Lessons from Nature*, A John Wiley & Sons, INC, Publication, New Jersey, USA, 2004.

Reference Books

1. John Dinardo, N., *Nanoscale Characterization of Surfaces & Interface*, Weinheim Cambridge, Wiley-VCH, 2nd edition, 2008.

Course Code	Course Name	L	T	P	C
VBT315	ALGAL TECHNOLOGY	3	0	0	3

Category: Professional Elective

a. Preamble

This course enables the students to

- Know about different types of algae and their diversification.
- Know about association of algae with the biotic factors and abiotic factors.
- Learn the application of algae in various biotechnological perspectives.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the basics of algae, their importance, classification and diversity.	K2
CO2	Describe the algal characteristic features, their isolation, conservation and its association with other entities.	K2
CO3	Summarize the micro algal cultivation methods, biomass and their biotechnological applications.	K2
CO4	Identify the macro algal distribution, biomass collections and their various applications.	K3
CO5	Apply the algal systems in biotechnological industries and in environmental solutions.	K3

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION **9**

Introduction to Algae; General characteristics; Fundamental discoveries and origin of algae; Algae and their position in Domain and Kingdom system; Brief descriptions and taxonomic identification of micro and macroalgae of fresh water and marine

habitats; Distribution of economically important algae in India; Conservation of algae.

STRUCTURE, GROWTH AND CHARACTERIZATION OF ALGAE 9

Algal Cell structure; Chemical composition – Protein, amino acids, lipids, waxes, glycerol, vitamins, pigments; Reproduction and Life cycle; Sampling methodology; Isolation and characterization; Culture media, growth curve and measurement of algal growth; Harvesting algae.

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.

MACROALGAL TECHNOLOGY 9

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

ENVIRONMENTAL AND INDUSTRIAL APPLICATIONS 9

Algae in food web and other biotic associations; Biotechnological values of algae; Algal toxicology; Applications of Algae with specific case studies - CO_2 sequestration, Bioremediation, Wastewater treatment, Bioenergy, Biomineralization, Algal Bioplastics; Culture collection centers – India and Abroad; Centers pursuing algal research in India.

d. Activities

Students will be provided with a hands-on session on algal sample collection, culturing and growth estimation techniques.

e. Learning Resources

Text Books

1. Konur Ozcan, *Handbook of Algal Science, Technology and Medicine*, Academic Press, 2020.
2. Muthuarumugam Nagaraj, Shanmugam Kathiresan, S., *Applied Algal Biotechnology*, Nova Science Publishers, 2021.
3. Chojnacka Katarzyna, et al., *Algae Biomass: Characteristics and Applications: Towards algae-based products*, Vol. 8, Springer, 2018.

Reference Books

1. Becker, E. Wolfgang, *Microalgae: Biotechnology and Microbiology*, Vol. 10, Cambridge University Press, 1994.
2. Jayabalan Sangeetha, Devarajan Thangadurai, Sanyasi Elumalai and Shivasarana Chandrbanda Thimmappa, *Phycobiotechnology Biodiversity and Biotechnology of Algae and Algal Products for Food, Feed and Fuel*, CRC Press, 2021.
3. Trivedi, P.C., *Algal Biotechnology*, Pointer publishers, Jaipur, India, 2001.

Course Code	Course Name	L	T	P	C
VBT316	ENVIRONMENTAL BIOTECHNOLOGY	3	0	0	3

Professional Elective

a. Preamble

The course enables the students to

- Develop sustainable solutions to various environmental problems
- Reduce the pollution based on the bioremediation approaches

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Understand the importance of microbial ecology and impacts of human activities on the environment	K2
CO2	Identify the suitable biodegradation strategies to various environmental pollutions	K3
CO3	Relate the concept of bioremediation in the field of biomining, removal of pesticide and heavy metal contamination.	K3
CO4	Demonstrate the scope for value addition using the principle of microbial technology	K3
CO5	Illustrate the types and process of environmental monitoring	K3

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION **9**

Definition; Basics of ecosystem structure and function; Concepts and importance of microbial ecology in Environmental Biotechnology; Sampling, culture and cultivation of natural microorganisms; Genetically engineered organisms - Merits and demerits; Bio tools for environmental monitoring.

BIODEGRADATION **9**

Principles of Biodegradation, Biodetoxification, Bio-decolorization; Biotechnology of wastewater treatment; Microbial system in waste water stabilization; Biofilms; Bioreactors for industrial effluent treatments; Immobilization technology in waste water treatment; Oil Spill degradation; Reed bed technology; Rhizosphere engineering; Case study - Biodegradation of Agro-chemicals and Microplastics.

BIOREMEDIATION **9**

Bioremediation - concepts, methods and applications of natural attenuation and engineered bioremediation (e.g bioaugmentation and biostimulation); Biotransformation of xenobiotic compound; Bioscrubbers; Biomining of metals; Biopulping; Phytoremediation: Waste water treatment using aquatic plants; Root zone treatment.

BIOTECHNOLOGY AND VALUE ADDITION **9**

Production of value-added products from waste - Single Cell Protein (SCP), Biopolymers, Bioplasticizers, biofuels; Biofertilizers – principle, types, production process; Biopesticides – principle, types, production process; Effective Microorganisms for composting; Biochar; Microbial role in carbon storage and capture (Carbon sequestration).

ENVIRONMENTAL MONITORING **9**

Definition and environmental monitoring process – solid sampling, water sampling, air sampling; Analysis - physical, chemical and biological analysis methods; Bioindicators and Biomarkers; Biosensors – types, principle and instrumentation; Environment Impact Assessment: EIA complete process, Importance of EIA.

d. Activities

Students will visit the waste water treatment plant at college premises to understand the concept of microbial role in biodegradation.

e. Learning Resources

Text Books

1. Chatterji. A.K., *Introduction to Environmental Biotechnology*, Prentice Hall of India Pvt. Ltd., New Delhi, 2003.
2. Miller Jr. G.T., *Environmental Science,* 10th Edn., Thompson Brooks/Cole. United States, 2004.

Reference Books

1. Bhattacharya, B.C., and Ritu Banerjee, *Environmental Biotechnology*, Oxford Press, 2007
2. Agarwal S.K., *Environmental Biotechnology*, APH Publishing Corporation, New Delhi, 1998.

Course Code	Course Name	L	T	P	C
VBT317	INTELLECTUAL PROPERTY RIGHTS IN BIOTECHNOLOGY	3	0	0	3

Category: Professional Elective

a. Preamble

This course enables the students to

- Develop an Ability to manage Intellectual Property portfolio to enhance the value of the firm

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Describe basic concepts of Intellectual Property	K2
CO2	Understand practical concepts of different forms of IPR	K2
CO3	Analyze different International treaties and conventions on IPR	K4
CO4	Make use of different digital products and laws	K3
CO5	Apply the different issues related to infringment of IPR	K3

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION **9**

Introduction to IPRs; Basic concepts and need for Intellectual Property - IPR in India and Abroad – Genesis and Development – the way from WTO to WIPO –TRIPS; Nature of Intellectual Property; Industrial Property; Technological Research - Inventions and Innovations – Important examples of IPR.

REGISTRATION OF IPRs **9**

Meaning and practical aspects of registration of Copyrights; Trademarks; Patents; Geographical Indications; Trade Secrets and Industrial Design registration in India and Abroad

AGREEMENTS AND LEGISLATIONS **9**

International Treaties and Conventions on IPRs; TRIPS Agreement; PCT Agreement; Patent Act of India; Patent Amendment Act; Design Act; Trademark Act; Geographical Indication Act.

DIGITAL PRODUCTS AND LAW **9**

Digital Innovations and Developments as Knowledge Assets – IP Laws; Cyber Law and Digital Content Protection; Unfair Competition – Meaning and Relationship between Unfair Competition and IP Laws – Case Studies.

APPLICATIONS **9**

Infringement of IPRs; Enforcement Measures; Emerging issues – Case Studies.

d. Activities

Students shall have a activites on patent search and drafting.

e. Learning Resources

Text Books

1. Scople Vinod, V., *Managing Intellectual Property*, Prentice Hall of India Pvt Ltd, 2012
2. Satakar, S. V., *Intellectual Property Rights and Copy Rights*, ESS Publications, New Delhi, 2002.

Reference Books

1. Deborah E. Bouchoux, *Intellectual Property: The Law of Trademarks, Copyrights, Patents and Trade Secrets*, Cengage Learning, Third Edition, 2012.
2. Prabuddha Ganguli, *Intellectual Property Rights: Unleashing the Knowledge Economy*, McGraw Hill Education, 2011.

VERTICAL II - FOOD AND AGROSCIENCES

Course Code	Course Name	L	T	P	C
VBT321	PLANT TISSUE CULTURE AND TRANSFORMATION TECHNIQUES	3	0	0	3

Category: Professional Elective

a. Preamble

This course enables the students to

- Understand the basic concepts *in vitro* regeneration techniques
- Emphasize the techniques used in development of transgenic plants

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Outline the fundamentals of plant tissues culture and *in vitro* regeneration of plants from different explants.	K2
CO2	Compare the molecular mechanism behind the gene transfer using different transformation methods	K3
CO3	Interpret the contemporary issues related to gene editing in plants	K3
CO4	Demonstrate the contemporary issues about genetically modified plants and the ethical issues related with them	K3
CO5	Analyze the biosafety and regulatory issues related to genetically modified organisms	K4

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION TO PLANT TISSUE CULTURE **9**

Introduction to plant tissue culture, Tissue Culture Laboratory Design and organization, Types of media and their preparation, plant hormones; Types of Cultures - single cell, callus, cell-suspension, protoplast, leaf, root, shoot tip and

meristems, embryo, anther, microspore and ovary culture; Micropropagation (and hardening); *De novo* organogenesis and Somatic embryogenesis, artificial seeds; Role of Nanotechnology in Plant tissue culture.

PLANT TRANSFORMATION METHODS **9**

Direct and indirect gene transfer methods; Biology of *Agrobacterium tumefaciens*, agrobacterium mediated plant transformation and selection of transgenic crops; Cointegrate and binary vectors, selection and screening markers, marker free transgenics, chloroplast transformation using gene gun and in planta transformation.

GENE EDITING IN PLANTS **9**

Targeted genetic modification CRISPR-Cas9, double stranded break, guideRNA (gRNA) homology directed repair, non-homologous end joining, Site-Directed-Nucleases (Knock-in, Knock-out), design of gRNA, cloning of gRNA in binary vector, validation of gRNA and transformation into the plants.

TRANSGENIC PLANTS – CASE STUDIES **9**

Herbicide tolerance (Round Up Ready), BT crops, Golden Rice, Transgenic systems to derive carbohydrates, plantibodies, edible vaccines, enzymes, biopharmaceuticals; Gene edited plants - semi-dwarf (sd1) mutant rice and *Zea mays* with reduced phytic acid content.

BIOSAFETY AND REGULATORY GUIDELINES **9**

Biosafety of genetically modified plants, containment in laboratory and transgenic green house, safety assessment of genetically modified plants; Competent authorities-Recombinant DNA Advisory Committee, Institutional Bio-safety Committee, Review Committee on Genetic Manipulation, Genetic Engineering Appraisal Committee, State Biotechnology Co-Ordination Committee and District level committee; Quarantine involved in import and export of genetically modified crops.

d. Activities

Seminar related to different recent advancements in development of transgenic plants

e. Learning Resources

Text Books

1. Slater Adrian, Nigel Scott and Mark Fowler, *Plant Biotechnology: The Genetic Manipulation of Plants,* OUP Oxford, 2008.
2. Donald P.W., and Bing Yang, *Gene Editing in Plants,* Academic Press, 2017.
3. Hull, R., Graham H., and George T. Tzotzos, *Genetically Modified Plants: Assessing Safety and Managing Risk,* Academic Press, 2020.

Reference Books

1. Smith Roberta H., *Plant Tissue Culture: Techniques and Experiments,* Aacademic Press, 2012.
2. Hammond John, Peter McGarvey, and Vidadi Yusibov, *Plant Biotechnology: New Products and Applications,* Vol. 240, Springer Science & Business Media, 2012.
3. Upadhyay, S. K., *Genome Engineering for Crop Improvement*, John Wiley & Sons, 2021.

Course Code	Course Name	L	T	P	C
VBT322	POST HARVEST MANAGEMENT AND VALUE ADDITION	3	0	0	3

Category: Professional Elective

a. Preamble

The course enables the students to

- Learn the basic concepts of post-harvest technology, which includes efficient systems for harvesting, conveying, shipping, handling, storage, processing, preservation, packing and quality analysis during storage.
- Learn about the post-harvest prevention loss strategies by suitable value addition

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Describe the basics of post-harvest management practices and its methods of assessment.	K2
CO2	Demonstrate the suitable harvest methods and treatment process to reduce the post-harvest loss.	K3
CO3	Utilize packaging materials for right application in Food industry.	K3
CO4	Illustrate the significance of value addition in food products.	K3
CO5	Apply various control strategies to prevent the post-harvest diseases	K3

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION **9**

Scope and importance of post-harvest management; Nature and causes of post-harvest losses; Methods of assessment of maturity; Physiological and biochemical changes during maturity and ripening of fruits and vegetables; Enzymatic and textural changes; Ethylene evaluation.

HARVEST METHODS AND TREATMENT **9**

Harvesting methods - tools and harvesting practices for specific market requirement (Chilli, Tomato, Banana, Papaya, Mango); Grading; Pre-treatment – chlorination, treatment with chemicals; Minimal processing strategies and hurdle technology; wax coating; edible coating; pre-packing and irradiation.

PACKAGING AND STORAGE **9**

Packaging materials and types of packaging; Smart packaging; Modified atmosphere packaging; Storage methods – ventilated, refrigerated, Controlled atmosphere storage, hypobaric storage, cold storage, zero energy cool chamber; Chilling storage injury in fruits and vegetables.

VALORIZATION OF WASTE TO VALUE ADDITION **9**

Scope and market potential for value addition – Dried and dehydrated products, nutritionally enriched products, fermented products, Powders and pre mixes; Case study – value addition of flowers and Spices

POST-HARVEST DISEASES AND QUALITY STANDARDS **9**

Concept of postharvest diseases in fruits and vegetables; Prevention from infestation; Natural insecticide, fungicides for controlling postharvest diseases; Case study - Postharvest diseases and microbial pathogens of citrus fruits; Food safety standards and FSMS guidelines for fruits and vegetables; import and export standards.

d. Activities

Students will be exposed to field visit to understand the process of post-harvest disease diagnosis.

e. Learning Resources

Text Books

1. Rathore, N.S., Mathur, G.K., and Chasta, S.S., *Post-Harvest Management and Processing of Fruits and Vegetables,* The Energy And Resources Institute, New Delhi, 2012.
2. Sivasankar, B., *Food Processing and Preservation*, PHI Learning Private Limited, 2015.

Reference Books

1. Eleni Tsantili and Jinhe Bai, *Postharvest Management of Fruits and Vegetables*, MDPI Books, 2022
2. John, P. Jacob, *A Handbook on Post-Harvest Management of Fruits and Vegetables*, Daya Books, New Delhi, 2008

Course Code	Course Name	L	T	P	C
VBT323	AGRICULTURAL WASTE MANAGEMENT	3	0	0	3

Category: Professional Elective

a. Preamble

The course enables the students to

- Understand the engineering concepts in agricultural waste collection process and its management,
- Emphasize the various processing methods involved in converting waste material into value added products.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain various points of agricultural waste generation.	K2
CO2	Determine the efficacy of different methods of Agro-waste characterization.	K3
CO3	Apply the knowledge of composting in agricultural waste management practices.	K3
CO4	Relate the concept of briquetting as a solution for waste management.	K3
CO5	Illustrate the process of biofuel generation from agricultural waste.	K3

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION **9**

Introduction to generation and characteristics of waste; Principles and system of waste management; Agricultural biomass residue waste management; Food

Processing waste management; Dairy waste management; Integrated waste management -Animal husbandry waste, Municipal sludge waste management.

WASTE COLLECTION AND CHARACTERIZATION 9

Waste disposal - Key issues and features; Waste collection methods; Segregation; Storage and transport; Record Keeping; Control, Inventory and Monitoring; Analysis of wastes - Proximate Analysis, Organic compounds, Microbial pathogens, Heavy metals; Case study –Tea waste, flower waste, Fruit pulp manufacturing industry.

COMPOSTING 9

Definition; Principle of composting, Selection suitable solid waste for composting; Methods of composting; Mineralization process in composting; Biochemistry of composting; Factors involved in composting; Value addition – vermicomposting, Bokashi composting – Principle and design.

BIOMASS BRIQUETTING 9

Potential agro-residues and their characteristics for briquetting; Fundamental aspects and technologies involved in briquetting; Economic analysis of briquetting; Setting up of briquetting plant- Design and infrastructure requirements.

BIOGAS AND BIO ETHANOL PRODUCTION 9

Screening of suitable ligno cellulosic substrate for biogas production; Determination of bio-energy potential of agro-waste by estimating total solids – volatile solids – calorific value- total carbohydrates, moisture, lignin and cellulosic contents; Preparation of feed stocks for anaerobic bio- digestion – types of digesters – factors affecting; Ethanol production from lingo cellulosic wastes - Processing of Biomass, Pre-treatment, fermentation, distillation.

d. Activities

Students will be involved in a field study to understand the process of agricultural waste collection, characterization, and composting.

e. Learning Resources

Text Books

1. Raymond C. Loehr, *Agricultural Waste Management- Problems, Processes and Approaches,* First edition, Academic Press, 2012.
2. Thelma Bosso, *Agricultural Waste Management*, Callisto Reference, New York, 2016.

Reference Books

1. Yong Sik Ok, Sophie M. Uchimiya, Scott X. Chang and Nanthi Bolan., *Biochar: Production, Characterization and Applications,* CRC Press, Boca Raton, Florida, 2015.
2. Uta Krogmann, Ina Korne and Luis F. Diaz., *Solid Waste Technology and Management,* Blackwell Pub Ltd., Wiley Online library, 2010.

Course Code	Course Name	L	T	P	C
VBT324	FOOD PROCESS ENGINEERING	3	0	0	3

Category: Professional Elective

a. Preamble

This course enables the students to

- Learn the engineering concepts in food processing and various machines used in food industry.
- Emphasize the various processing methods involved in converting raw material into quality food products and monitor the spoilage microorganisms in foods.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Classify the engineering properties of foods.	K2
CO2	Elucidate the efficacy of a heating process to interpret its key parameters.	K3
CO3	Apply the knowledge on drying technology in various food industries.	K3
CO4	Illustrate the size reduction operations of foods and its equipment	K3
CO5	Demonstrate the importance of non-thermal methods for food preservation	K3

c. Course Syllabus **Total : 45 Periods**

PROPERTIES OF FOODS **9**

Scope and Importance of Food process engineering - Preliminary operations; Engineering properties of foods - Thermal, physical, chemical, electrical, rheological;

Texture of food materials - definition and terminologies; Viscometry – principle, construction and types of viscometers.

THERMAL PROCESSING OF FOODS **9**

Thermal processing of foods - cooking, blanching, sterilization, pasteurization, canning; Interaction of heat energy on food components - Reaction kinetics, Decimal reduction time, Thermal Death Time Curve, 12D concept with applications; Retort processing –principles and applications; Microwave and Radio frequency heating in food processing.

DRYING AND DEHYDRATION **9**

Drying – principle & methods, Types of dryers – tray dryer, vacuum dryer, heat pump dryer, microwave dryer, fluidized bed dryer; foam mat dryer and tunnel dryer. Dehydration – principle, methods and applications, Osmotic dehydration, Rehydration.

EXTRUSION & CONCENTRATION **9**

Extrusion cooking – principles and types of extruders, single and double screw extruder - construction and working, Effect of different parameters, Quality of the extruded products; Concentration - membrane and freeze concentration, theory and principles; Crystallizers and Separators – construction, working, types and applications.

ADVANCED METHODS OF FOOD PROCESSING **9**

Radiation preservation of foods – properties of ionizing radiation –quality of irradiated foods; Ohmic heating, Pulsed electric field processing, Pulsed light treatment, High pressure processing, Ultra-sonic treatment method, Individual Quick Freezing (IQF), Cold plasma technology.

d. Activities

Students shall be exposed to hand-on training on various instruments for food processing methods.

e. Learning Resources

Text Books

1. Fellows, P., *Food Processing Technology – Principles and Practice*, second edition, CRC Press, Woodland Publishing Limited, Cambridge, England, 2000.
2. Owen, R. Fennema, *Principles of Food Science, Part II, Physical Principles of Food Preservation*, Marcel Dekker Inc. New York and Basel, 2017.

Reference Books

1. Singh, R. Paul and Heldman, R. Dennis, *Introduction to Food Engineering*, 2rd Edition. Academic Press, London, 2005.
2. James, F. Steffe, *Rheological Methods in Food Process Engineering*, Freeman Press, East Lansing, USA, 1992.

Course Code	Course Name	L	T	P	C
VBT325	PRINCIPLES OF FOOD PRESERVATION	3	0	0	3

Category: Professional Elective

a. Preamble

This course enables the students to

- Learn the area of food processing and necessary for effective understanding of a detailed study of food preservation.
- Enable about shelf life, quality and minimal processing of foods and food additives with respect to manufacturer and consumer.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Describe the major and minor constituents of food and the chemical reactions in processed foods.	K2
CO2	Apply the knowledge on food additives and study the toxicity of food additives.	K3
CO3	Relate the interactions between microorganisms and food environment, and factors influencing their growth and survival.	K3
CO4	Make use of the low temperature food preservation methods and its equipment.	K3
CO5	Identify the relationship between food processing and chemical reactions that limit shelf life of foods.	K3

Total : 45 Periods

c. Course Syllabus

INTRODUCTION **9**

Constituents of food - role and functional properties in food; Contribution to

organoleptic and textural characteristics; Characteristics of tissues and non-tissues foods, Degree of perishability of unmodified foods; Causes of quality deterioration and spoilage of perishable foods.

FOOD ADDITIVES **9**

Classification: intentional and non-intentional additives; Functional role in food preservation; food colorants – natural and artificial; food flavours; Enzymes as food processing aids.

MICROORGANISMS ASSOCIATED WITH FOOD **9**

Bacteria, yeasts and molds – sources, types and species of importance in food processing and preservation; Fermented foods from various sources - dairy, cereal, meat, beverages. Single cell protein – production and applications.

PRESERVATION BY LOW TEMPERATURE **9**

Chilling and freezing – principles and applications; Freezing - Phase diagram, ice crystal formation, comparison of freezing and thawing. Freezing methods - air freezing, plate freezing, liquid immersion freezing and cryogenic freezing. Freeze concentration of liquid foods.

PRESERVATION METHODS **9**

Preservation of foods by use of sugar, salt, chemicals, smoking, pickling, curing, fermentation, baking, extrusion and canning; Hurdle technology; Packaging – Controlled Atmosphere Packaging, Modified Atmosphere Packaging.

d. Activities

Students shall be exposed to practical knowledge of various preservation methods through hands-on training.

e. Learning Resources

Text Books

1. Sivasankar, B., *Food Processing and Preservation*, PHI Learning Private Limited, 2015.
2. Fellows, P.J., *Food Processing Technology: Principles and Practice*, Wood head Pub. Ltd, 2nd Edition, 2002.

Reference Books

1. Shafeiur Rahman, M., *Handbook of Food Preservation*, Marcel Dekker, Inc, 2020.
2. Khetarpaul, N., *Food Processing and Preservation*, Dya Publishing House, New Delhi, 2005.

Course Code	Course Name	L	T	P	C
VBT326	FOOD QUALITY TESTING AND EVALUATION	3	0	0	3

Category: Professional Elective

a. Preamble

This course enables the students to

- Learn the basic concepts of food quality analysis methods
- Understand the theoretical knowledge in quality assurance and food safety to the practical environment of food manufacturing industries.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Describe the basics of food quality control and quality assurance.	K2
CO2	Apply the knowledge of statistics in sampling techniques.	K3
CO3	Demonstrate the food samples and interpret the proximate analysis.	K3
CO4	Identify the adulterants in food additives with control limits.	K3
CO5	Explore the packaging materials for appropriate application in food industry.	K3

Total : 45 Periods

c. Course Syllabus

INTRODUCTION **9**

Objectives, functions and principles of quality control; Difference between food quality control and quality assurance; Assessment of raw materials and finished products. Sensory quality evaluation - Introduction, method, sensory panel, instrumental analysis in quality control.

SAMPLING TECHNIQUES **9**

Population and sampling - importance of sampling, types of sampling, sampling plan, preparation of samples, problems in sampling; Range of sampling plans and choice of appropriate plan -100% inspection; Statistical sampling, Control charts and their uses– Mean & range chart, P chart and C chart

FOOD ANALYSIS METHODS **9**

Proximate analysis of foods – Moisture, Carbohydrate, Fat, Protein; Analysis of Vitamins & Minerals - Official method of analysis, International Organization for Standardization (ISO) methods, Food Safety and Standards Authority of India (FSSAI) methods; Microbial parameters, Organic test for Genetically Modified Organisms (GMO); Tests used to authenticate food products - meats, dairy products and culinary oils.

FOOD ADULTERATION **9**

Definition, Classification - intentional and incidental, Health hazard caused by various adulterants, Common adulterants in food and their testing - milk and milk products, atta, edible oils, cereals and pulses, spices (whole and ground), coffee, tea, confectionery, baking powder, non-alcoholic beverages, vinegar, besan and curry powder.

FOOD STORAGE AND ANALYSIS **9**

Quality control of packaged foods - intrinsic, extrinsic and shelf life limiting factors, Packaging Methods, Problems in packaging; Test methods – Migration test, Bisphenol-A detection test, toxins test, Phthalate analysis. Importance of Labeling - Food safety issues related to Ready to Eat food.

d. Activities

Students shall be exposed to practical knowledge on various testing methods of food through field visit.

e. Learning Resources

Text Books

1. Kalia, M., *Food Analysis and Quality Control*, Kalyani publishers, New Delhi, 2002.
2. Nielsen, S.S., *Introduction to the Chemical Analysis of Foods*, Jones and Bartlett publishers, Boston, London, 2003.

Reference Books

1. Ronald, S. Kirk, Ronald Sawyer., *Pearson's Composition and Analysis of Foods*, 9th Edition, 1991.
2. Pomeranz, Y., and Meloan C.E., *Food analysis: Theory and practice*, Chapman & Hall, New York, USA, 3rd Edition, 1994.

Course Code	Course Name	L	T	P	C
VBT327	FOOD SAFETY LAWS AND REGULATION	3	0	0	3

Category: Professional Elective

a. Preamble

This course enables the students to

- Learn the basic concepts of food laws, importance and functions of food safety management systems.
- Understand the concepts of food laws and Hazard Analysis and Critical Control Point (HACCP) in food processing.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Characterize different type of food hazards, physical, chemical and biological in the industry.	K2
CO2	Apply the food safety management tool such as HACCP.	K3
CO3	Interpret the international food laws and standards.	K3
CO4	Illustrate the national food laws and standards.	K3
CO5	Analyze the food labeling regulations and health claims for food products.	K4

c. Course Syllabus **Total : 45 Periods**

INTRODUCTION **9**

Introduction to food safety and security, Hygienic design of food plants and equipment, Sources of contaminants and types, Maintenance cleaning and sanitation - Personal Hygienic, Food quality management system – Good Laboratory Practice (GLP), Good Handling Practice (GHP), Good Manufacturing Practice (GMP), Food Safety managements system: ISO/22000.

HAZARD ANALYSIS AND CRITICAL CONTROL POINT **9**

HACCP – principles, Hazard analysis, determine CCP, control limits, monitoring procedures, corrective action, record keeping, verification; HACCP plan chart, Average Outgoing Quality Level; Food safety policy, glass and jewelry policy, visitor policy, environmental policy.

INTERNATIONAL FOOD LAWS AND REGUALTIONS **9**

Structure, organization and practical operation of World Trade Organization (WTO), World Health Organization (WHO), United States Food and Drug Administration (USFDA), Food and Agriculture Organization (FAO), Codex Alimantarious Commission (CAC), International Consultative Group on Food Irradiation (ICGFI), Export Inspection Agency.

NATIONAL FOOD LAWS AND REGUALTIONS **9**

Structure, organization and practical operation of Bureau of Indian Standards (BIS), AgMark, Prevention of Food Adulteration (PFA), Agricultural and Processed Food Products Export Development Authority (APEDA), Marine Products Export Development Authority (MPEDA), Food Safety and Standards Authority of India (FSSAI) – structure and organization.

LABELLING REGULATIONS **9**

Need for labelling, limitations of labelling- safety issues, labelling for irradiated foods, genetically modified foods, nutritional labelling, health claims and marketing claims, transportation, traceability, recall.

d. Activities

Students shall be exposed to different food safety management systems in the food industries through field visit.

e. Learning Resources

Text Books

1. Manoranjan Kalia, *Food Quality Management*, Agrotech Publishing Academy, 2nd Edition, 2014.

2. Inteaz Alli, *Food Quality Assurance,* CRC Press, 2004.

Reference Books

1. Taxmann, *Guide to the Food Safety and Standards Act 2006,* Allied Services Pvt. Ltd, 2006.
2. Rajesh Mehta and George, J., *Food Safety Regulation Concerns and Trade*, Macmillan India Ltd, New Delhi, 2005.

VERTICAL III – MEDICAL BIOTECHNOLOGY

Course Code	Course Name	L	T	P	C
VBT331	NEUROBIOLOGY AND COGNITIVE SCIENCES	3	0	0	3

Category: Professional Elective

a. Preamble

This course enables the students to

- Understand the fundamental anatomy and physiology of human neuronal system
- Apply the molecular mechanisms of drugs and cognition behaviors related to neurology.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Define the anatomy of various nervous systems and neurons	K1
CO2	Demonstrate the molecular mechanism of neuronal function	K2
CO3	Relate the drug action on neuronal receptors and related diseases	K2
CO4	Apply the molecular mechanism to drug discovery and biotechnological related research	K3
CO5	Analyze various facts about brain function and experimental approaches, theories, and models to integrate neuroscience information with biotech discipline	K4

c. Course Syllabus **Total: 45 Periods**

NEUROANATOMY **9**

Classification of central and peripheral nervous systems; Structure and function of neurons- Types of neurons, Cranial nerves, Spinal nerves, Glial cells; Myelination; Brief anatomy - Brain and Spinal cord, Blood Brain barrier; Meninges and Cerebrospinal fluid.

NEUROPHYSIOLOGY **9**

Resting and action potentials - Mechanism of action potential conduction, Voltage dependent channels; Nodes of Ranvier; Chemical and electrical synaptic transmission; Information representation and coding by neurons; Classification of neurotransmitters; Neuropeptides; Adrenergic and cholinergic transmission; Hormones and their effect on neuronal function.

NEUROPHARMACOLOGY **9**

Drug mechanism of action and classification - Parasympathetic and Sympathetic drugs, Neuroleptics, Thymoleptics, Analeptics; Drugs used in Alzheimer's and Parkinson's disease; Drug addiction

APPLIED NEUROBIOLOGY **9**

Basics of neurologic mechanism - touch, pain, smell, taste, vision and audition; Neuro muscular junction; Research models for study and investigation in neurosciences and neuro pharmacologic drug development

BEHAVIOUR AND COGNITIVE SCIENCE **9**

Basic mechanisms associated with motivation; Behavioral studies; Interpersonal interaction models; Transactional Analysis; Neurology of memory; Disorders associated with the nervous system; Importance of Artificial Neural Network in neurobiology and cognitive based research.

d. Activities

Students shall be exposed to medical terms and models through class room activities like model making etc.,

e. Learning Resources

Text Books

1. Kandel, E.R., Schwartz, J.H., Jessell, T.M., Siegelbaum, S.A., and Hudspeth, A.J., *Principles of Neural Science*, Fifth Editon, 2013.
2. Waugh, A., Grant, A. Ross and Wilson, *Anatomy and Physiology in Health and Illness E-Book,* Elsevier Health Sciences, 2014.

Reference Books

1. Siegel, A., and Sapru, H.N., *Essential Neuroscienc,* Lippincott Williams & Wilkins, 2006.
2. Squire, L., Berg, D., Bloom, F.E., Du Lac, S., Ghosh, A., and Spitzer, N.C. eds., *Fundamental Neuroscience,* Academic Press, 2012.

Course Code	Course Name	L	T	P	C
VBT332	ANIMAL BIOTECHNOLOGY	3	0	0	3

Category: Professional Elective

a. Preamble

This course enables the students to

- Learn the culturing methods of animal cells.
- Explain about advanced technologies in diagnostics and therapeutics of animal diseases
- Understand assisted reproduction and transgenic technology in animals and their applications

b. Course Outcome

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

• CO. No.	Course Outcome	Knowledge Level
CO1	Outline the different types of animal cell culture and techniques.	K2
CO2	Apply different molecular diagnostic techniques to animal infections	K3
CO3	Illustrate effectively the principles of monoclonal antibodies and recombinant cytokines and apply them in the field of therapeutics	K3
CO4	Make use of the concepts of micromanipulation technology and transgenic animal Technology	K3
CO5	Relate the concept of transgenic animal production in various applications	K3

c. Course Syllabus **Total : 45 Periods**

ANIMAL CELL CULTURE **9**

Introduction to basic tissue culture techniques - chemically defined and serum free media, animal cell cultures - their maintenance and preservation; various types of

cultures - suspension cultures, continuous flow cultures, immobilized cultures; cell cultures as a source of valuable products; Organ cultures.

ANIMAL DISEASES AND THEIR DIAGNOSIS **9**

Bacterial and viral diseases in animals; Monoclonal antibodies and their use in diagnosis; Molecular diagnostic techniques - Enzyme Linked immunosorbent Assay (ELISA), Polymerase Chain Reaction (PCR), in-situ hybridization, northern and southern blotting, Restriction Fragment Length Polymorphism (RFLP).

THERAPY OF ANIMAL DISEASES **9**

Recombinant cytokines and their use in the treatment of animal infections; Monoclonal antibodies in therapy; Vaccines and their applications in animal infections; gene therapy for animal diseases.

MICROMANIPULATION OF EMBRYOS **9**

Micromanipulation technology and breeding of farm animals; Molecular techniques in genetic conservation of farm animals; Equipment used in micromanipulation; Enrichment of X and Y bearing sperms from semen samples of animals; Artificial insemination and germ cell manipulations - *in vitro* fertilization and embryo transfer.

TRANSGENIC ANIMALS AND ANIMAL MODELS **9**

Concepts of transgenic animal technology - strategies for the production of transgenic animals and their importance; Somatic cell fusion; Stem cell cultures in the production of transgenic animals; Specific case studies - animals as bioreactors, animal models used in biomedical research; Ethical, legal and social implications in animal biotechnology research.

d. Activities

Co-operative learning using Jigsaw method, crossword puzzles, experiential learning-visit to tissue culture lab

e. Learning Resources

Text Books

1. Freshney, R.I., *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications*, John Wiley & Sons, 2015.

2. Ranga, M.M., *Animal Biotechnology*, Agrobios India Limited, 2002.

3 Ramadass, P., and Meera Rani, S., *Text Book of Animal Biotechnology*, Akshara Printers, 1997.

Reference Books

1. Verma, A., and Singh, A., *Animal Biotechnology: Models in Discovery and Translation*, Academic Press, 2014.
2. Ralf Pörtner Series, *Animal Cell Biotechnology: Methods and Protocols*, Publisher Humana Press, 2007.
3 Terence Cartwright Series, *Animal Cells as Bioreactors*, Cambridge University Press, 2008.
4 Masters, J.R.W., *Animal Cell Culture: Practical Approach*, Oxford University Press, 2000.

Course Code	Course Name	L	T	P	C
VBT333	TISSUE ENGINEERING	3	0	0	3

Category: Professional Elective

a. Preamble

This course enables the students to

- Learn principles of tissue engineering and tissue repair.
- Understand design considerations for tissue engineering focusing on the stem cells, biomaterials and its applications.
- Describe regulatory, ethical, and commercial considerations for tissue engineering.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the fundamentals of cell & tissue characteristics in designing a tissue engineered product.	K2
CO2	Describe the types of stem cells based on their role in tissue engineering.	K2
CO3	Manipulate wound healing process and angiogenesis with engineering of tissue *in vitro*.	K3
CO4	Make use of appropriate biomaterials for tissue engineering applications.	K3
CO5	Analyze the applications of stem cell technology in tissue engineering.	K4

c. Course Syllabus

Total : 45 Periods

FUNDAMENTALS OF TISSUE ENGINEERING **9**

Basics of tissue engineering; Current scope of development; Use in therapeutics - cells as therapeutic agents; Cell numbers and growth rates; Measurement of cell characteristics - morphology, number, viability, motility and functions; Measurement of tissue characteristics - appearance, cellular component, Extracellular Matrix (ECM) component, mechanical measurements and physical properties.

BIOLOGY OF STEM CELLS **9**

Stem cells - introduction, hematopoietic differentiation pathway, potency and plasticity of stem cells; Stem cell markers; FACS analysis; Types & sources of stem cell with characteristics - embryonic, adult, haematopoetic, mesenchymal stem cells, cord blood, placenta, bone marrow, primordial germ cells, cancer stem cells and induced pluripotent stem cells.

TISSUE ARCHITECTURE **9**

Tissue types and tissue components; Tissue repair - engineering wound healing and sequence of events; Basic wound healing applications of growth factors, vascular endothelial growth factor (VEGF)/angiogenesis - basic properties; Cell-matrix & cell-cell Interactions; Telomeres and self-renewal; Control of cell migration in tissue engineering; Cell's micro-mechanisms for regeneration and repair.

BIOMATERIALS **9**

Introduction to Scaffolds in tissue engineering; Biomaterials - surface, bulk, mechanical and biological properties; Types of biomaterials - biological and synthetic materials; Biopolymers; Applications of biomaterials; Modifications of biomaterials; Role of nanotechnology; 3D printing in tissue engineering; Controlled bioactive factor release mechanisms.

CLINICAL APPLICATIONS **9**

Stem cell application with case study - neurodegenerative diseases, spinal cord injury, heart disease, diabetes, burns and skin ulcers, muscular dystrophy, orthopedic applications; tissue engineering for skin transplantation, cartilage, bone, neural tissue engineering; Tissue engineered product characterization, safety, and efficacy; Cryobiology; Vitrification technology; Preservation - freezing and drying; Patent protection and regulation of tissue-engineered products; Ethical issues; Organ culture & tissue bioreactors; Xenoantigens and stem Cells.

d. Activities

Students will be made aware of important theories behind tissue engineering through activities like Memory matrix approach, Defining Features Matrix, Jigsaw activity.

e. Learning Resources

Text Books

1. Moroni, L., Schrooten, J., Truckenmüller, R., Rouwkema, J., Sohier, J., and van Blitterswijk, C.A., *Tissue Engineering: An Introduction. In Tissue engineering,* Academic Press, 2014.
2. Ratner, B.D., Hoffman, A.S., Schoen, F.J., and Lemons, J.E., *Biomaterials Science: An Introduction to Materials in Medicine,* Elsevier, 2004.
3. Pavlovic, M., and Balint B., *Stem Cells And Tissue Engineering,* Springer Science & Business Media, 2012.

Reference Books

1. Palsson, B.O., and Bhatia, S.N., *Tissue Engineering,* Upper Saddle River, New Jersey, 2004.
2. Clark, R.A., *The Molecular and Cellular Biology of Wound Repair,* Springer Science & Business Media, 2013.
3. Meyer, U., Meyer, T., Handschel, J. and Wiesmann, H.P., *Fundamentals of Tissue Engineering and Regenerative Medicine,* Springer Science & Business Media, 2009.

Course Code	Course Name	L	T	P	C
VBT334	CLINICAL TRIALS AND HEALTH CARE POLICIES IN BIOTECHNOLOGY	3	0	0	3

Category: Professional Elective

a. Preamble

This course enables the students to

- Learn the fundamentals of clinical trial study design, protocol preparation and conduction techniques involved in clinical research.
- Aware about the principles of ethical, legal, regulatory bodies and policies for clinical trials related to biotechnology.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Understand the methods in clinical trial design and process	K2
CO2	Design and assist to trial manager in all forms of clinical research.	K3
CO3	Apply Statistical methods and report clinical data	K3
CO4	Classify regulatory authorities and its functions related to clinical trials	K2
CO5	Summarize the ethics and policies of biotechnological clinical research	K2

c. Course Syllabus **Total: 45 Periods**

CLINICAL TRIAL AND DRUG DISCOVERY **9**

General terms in clinical trials - Healthy volunteers – Inclusion / exclusion criteria, Informed consent, Patient volunteer, Placebo, Data randomization, Single or double-blind studies, Mortality and morbidity; Types and phases of clinical trials;

Nonclinical research; Ethical conduct during clinical trials; Clinical trial protocol and its components

FUNDAMENTALS OF TRIAL DESIGN **9**

Uncontrolled trials; Randomised clinical trials, Cluster randomized trials and multi-centre trials; Protocol development – patient selection, Source and control of bias, Endpoints; Randomization protocols – blinding, sample size and power; Crossover design factorial design; Equivalence trials; Bioequivalence trials; Non-inferiority trials.

STATISTICAL ANALYSIS AND REPORTING **9**

Types of data and normal distribution- significance tests and confidence intervals, comparison of means, Comparison of proportions, Analysis of survival data, Subgroup analysis, Regression analysis and missing data; Software in clinical trials; Overview of reporting; Trial profile - presenting baseline data, use of tables, figures; Critical appraisal of report and meta-analysis

REGULATORY FRAMEWORK **9**

Constitution members and activities of Regulatory bodies - Department of Biotechnology nodal agency for policy, Genetic Engineering and Approval Committee, The Institutional Biosafety Committees, Review Committee on Genetic Manipulations, USDA Biotechnology Regulatory Services and other state level committees in India.

HEALTHCARE POLICIES IN BIOTECHNOLOGY **9**

World Health Organisation Trial Registration Policy; NIH Policy on the Dissemination of Clinical Trial Information - National coverage determination (NCD), Ethical Policies on the Human Genome, Genetic Research & Services; rDNA Vaccines Guidelines; Ethical Issues and Consent Process Pertaining to Stem Cell Research; Policy and ethical issues in applying medical biotechnology

d. Activities

Students shall be exposed to ethics, inclusion and exclusion criteria for clinical trial through various assignments.

e. Learning Resources

Text Books

1. Friedman, L.M., Furberg, C.D., DeMets, D.L., Reboussin, D.M. and Granger, C.B., *Fundamentals of Clinical Trials,* Springer, 2015.
2. Machin, D., Day, S. and Green, S., *Textbook of Clinical Trials,* John Wiley & Sons. eds., 2007.

Reference Books

1. Wang, D., and Bakhai, A., *Clinical Trials: A Practical Guide to Design, Analysis and Reporting,* Remedica, 2006.
2. Brody, T., *Clinical Trials: Study Design, Endpoints and Biomarkers, Drug Safety, and FDA and ICH Guidelines,* Academic Press, 2016.

Course Code	Course Name	L	T	P	C
VBT335	BIOPHARMACEUTICALS AND BIOSIMILARS	3	0	0	3

Category: Professional Elective

a. Preamble

This course enables the students to

- Get familiarize with the Core responsibilities for the development and monitoring of the drug and the preparation of medicines according to the norms.
- Gain knowledge in physicochemical properties, pharmacology and the formulation of commonly used biopharmaceuticals.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Summarize the different pharmaceutical parameters for the biotechnology related products on the market.	K2
CO2	Acquire knowledge on novel biotechnological and pharmaceutical products, current medicines and their applications in therapeutic and diagnostic fields	K2
CO3	Comprehend the advanced topics in different drug delivery systems	K2
CO4	Demonstrate the knowledge about the current and newly emerging aspects of pharmaceutical biotechnology	K3
CO5	Outline the legal steps involved in progressing a new drug to market and the current regulatory acts & safety norms of the modern pharmaceutical industries.	K3

c. Course Syllabus **Total: 45 Periods**

INTRODUCTION **9**

Definitions – Active Pharmaceutical Ingredient (API), Drug, Pharmaceuticals, Biologicals, Biosimilars; Different drug sources; Discovery and Development phases; Drugs and Cosmetics Act and regulatory aspects; Role of patents in the drug industry; Biopharmaceutical classification system; Drug Target; Drug metabolism; Pharmacokinetics; Pharmacodynamics; Bioavailability; Bioequivalence; Toxicity studies; Pharmacogenomics.

DOSAGE FORMS **9**

Classification of dosage forms: Solid dosage forms - Tablets, Capsules, Sniffs; Semi solid dosage forms - Lotion, Ointments, Cream, Paste, Suppositories, Parenteral; Liquid dosage forms – Syrups, Elixirs, Emulsion, Suspensions, Liniments; Pressurized dosage forms; Formulations; Excipients; Packaging techniques

ADVANCED DRUG DELIVERY SYSTEMS **9**

Controlled release dosage forms – Rationale; Pharmaco kinetic Principles in controlled drug designing and factor influencing; Design and Fabrication; Microencapsulation – Liposomes, Niosomes; Transdermal drug delivery – Ocular, Vaginal and Uterine controlled release.

BIOSIMILARS **9**

Classification of Biosimilars; Advantages; INN nomenclature system; Advances in biosimilar product development; Production of biosimilars; Difficulties with biosimilar drugs; Non clinical and clinical studies; Regulation and approval process; Future prospects.

CASE STUDIES ON BIOPHARMACEUTICALS **9**

Erythropoietin; Insulin; Somatotropin; Interleukin; Interferon; Granulocyte Macrophage Colony Stimulating Factor (GMCSF); Blood clotting Factors; Tissue plasminogen activator; Monoclonal antibodies and engineered antibodies; Case studies - Viral vaccine and Bacterial vaccine

d. Activities

The students will be given the role play activity, chart making and seminar presentation for the better understanding of the topics

e. Learning Resources

Text Books

1. Crommelin Dwan J.A., Robert D. Sindelar and Bernd Meibohm, *Pharmaceutical Biotechnology: Fundamentals and application*, Springer, 4th Edition, 2013.
2. Gary Walsh, *Pharmaceutical Biotechnology-Concepts and Application*, John Wiley and Sons Publishers, 1st Edition, 2007.
3. James Swarbrick, *Encyclopedia of Pharmaceutical Technology*, CRC Press, 4th Edition, 2013.

Reference Books

1. Shayne Cox Gad, *Pharmaceutical Manufacturing Handbook: Production and Processes*,Wiley, 2nd Edition, 2011.
2. Shein-Chung Chow, *Biosimilars: Design and Analysis of Follow-on Biologics*, CRC Press, 3rd Edition, 2013.

Course Code	Course Name	L	T	P	C
VBT336	CANCER BIOLOGY	3	0	0	3

Category: Professional Elective

a. Preamble

This course enables the students to

- Understand the regulation of cell cycle in cancer
- Understand the molecular mechanisms of carcinogenesis and cancer metastasis
- Familiarize with basic principles and applications of cancer therapies.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the role of cell cycle and its regulation in cancer	K2
CO2	Illustrate the mechanism of carcinogenesis by physical and chemical agents	K3
CO3	Make use of the molecular mechanisms and signaling pathways in cancer cell line studies	K3
CO4	Differentiate between strategies for cancer detection and diagnosis	K4
CO5	Compare the fundamental principles and applications of various cancer therapies	K4

c. Course Syllabus **Total : 45 Periods**

FUNDAMENTALS OF CANCER BIOLOGY **9**

Introduction to cancer biology; Growth characteristics of cancers cells - Morphological and structural properties of cancer cells; Types of growth - hyperplasia, dysplasia, anaplasia and neoplasia; Differences between benign and malignant tumors; Cell cycle - regulation of cell cycle, modulation of cell cycle in

cancer; Signal switches; Tumour suppressor genes; Apoptosis - intrinsic and extrinsic pathways; Genetic basis of cancer.

MECHANISM OF CARCINOGENESIS **9**

Carcinogenesis – Introduction and types; Chemical carcinogenesis – Direct acting and indirect acting carcinogens; Metabolism of carcinogens - CYP450 reductase mechanism; Physical carcinogenesis – Mechanism of Radiation carcinogenesis, ionizing and non-ionizing radiation; Retroviruses - Rous sarcoma virus life cycle and its role in cancer.

MOLECULAR MECHANISMS OF CANCER **9**

Signal targets and cancer - activation of kinases; Oncogenes - detection and identification of oncogenes, retroviruses and oncogenes, mechanism of activation of oncogenes; Growth factors and oncogenes - growth factors related to transformation; Telomerases; Clinical significances of invasion - three step theory of invasion; Heterogeneity of metastatic phenotype; Metastatic cascade, Basement membrane disruption; Proteinases and tumour cell invasion.

DETECTION OF CANCER **9**

Cancer screening and early detection; Detection using biochemical assays, tumor markers, molecular tools for early diagnosis of cancer; Prediction of aggressiveness of cancer; Tumor staging; Applications of new technologies in prevention, assessing risk and diagnostics; Use of cancer antigens in cancer detection; Monoclonal antibodies in cancer diagnosis; Cancer imaging technologies.

MECHANISMS OF CANCER THERAPY **9**

Different forms of therapy (Specific Case studies) - chemotherapy, radiation therapy, immunotherapy, chimeric antigen receptor (CAR) T-cell therapy; Advances in cancer detection - use of signal targets towards therapy of cancer, gene therapy, cancer antigen-based vaccines, cell-based therapy against cancer, targeted therapy, hormone therapy.

d. Activities

Students will be made aware of important theories behind most predominant types of cancers, their diagnosis and treatment strategies through activities like Memory matrix approach, Defining Features Matrix, Jigsaw activity.

e. Learning Resources

Text Books

1. Weinberg, R.A., *The Biology of Cancer*, Garland Science, 2013.
2. Pelengaris, S., and Khan, M., *The Molecular Biology of Cancer: A bridge from Bench to Bedside,* John Wiley & Sons, 2013.
3. MacDonald, F., Ford, C., and Casson, A., *Molecular Biology of Cancer*, Taylor & Francis, 2004.

Reference Books

1. King, R.J.B., and Robins, M.W., *Cancer Biology*, Pearson Education, 2006.
2. Ruddon, R.W., *Cancer Biology*, Oxford University Press, 2007.

Web References

1. http://archive.org/details/biologyofcancer00burc
2. http://oncousasd.files.wordpress.com/2014/09/cancer-principles-and-practice-ofoncology-6r.pdf

Course Code	Course Name	L	T	P	C
VBT337	LIFESTYLE DISEASES	3	0	0	3

Category: Professional Elective

a. Preamble

This course enables the students to

- Learn the various risk factors associated with lifestyle diseases and recognize that lifestyle choices are the root cause of many chronic diseases.
- Describe the aetiology, pathophysiology and diagnosis of different lifestyle diseases.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Describe the risk factors associated with life style disorders and adopt a positive attitude toward lifestyle intervention	K2
CO2	Summarize the diagnosis and treatment relevant to cancer and its management by modifying lifestyle	K3
CO3	Outline the aetiology, pathophysiology, diagnosis, and management of common cardiovascular disorders	K3
CO4	Comprehend the magnitude and the effects of diabetes and obesity	K3
CO5	Outline the diagnosis and treatment relevant to respiratory diseases prevention, surveillance, and management	K3

Total : 45 Periods

c. Course Syllabus

INTRODUCTION **9**

Lifestyle diseases – definition, deteminants; Risk factors – Eating, smoking, drinking, tobacco usge, stress, anxiety, epression, technology induced pathology, improper sleep physical activity, illicit drug use ; Prevention – diet and exercise.

CANCER **9**

Benign and malignant tumor; Types of cancer (lung cancer, mouth cancer, skin cancer, cervical cancer, carcinoma oesophagus)- causes, diagnosis (screening, blood tests, X-rays, CT scans & endoscopy), prevention (dietary, medication, vaccination), treatment and management (surgery, chemotherapy, radiation, palliative care).

CARDIOVASCULAR DISEASES **9**

Atherosclerosis - characteristics, causes - fat and lipids, Alchohol abuse; ischemia, myocardial infarction (definition); Diagnosis - electrocardiography, exercise stress test, echocardiography, coronary angiography; Prevention - lifestyle, diet; Management - drugs, angioplasty, stenting, bypass surgery; Exercise and cardiac rehabilitation.

DIABETES AND OBESITY **9**

Diabetes mellitus - classification (type 1, type 2, gestational diabetes), symptoms (polyuria, polydypsia, polyphagia); Causes; Diagnosis Glucose tolerance test (GTT), glycated haemoglobin); Management - diet, exercise, drugs; Obesity - classification according to BMI, symptoms, causes, diagnosis, treatment, and management.

RESPIRATORY DISEASES **9**

Chronic lung diseases - Asthma, Chronic obstructive pulmonary disease (COPD), obstructive sleep apnea; Causes - Breathing pattern (Nasal vs mouth), Smoking, Occuptional risk factors; Diagnosis - Pulmonary function test, Chest X-ray, Ultrasound, CT scan; Management - Long term oxygen therapy, Inhalation therapy and Pulmonary rehabilitation.

d. Activities

Assignment related to science behind onset of chronic lifestyle diseases and Lifestyle medicine

e. Learning Resources

Text Books

1. Sagner Michael, Garry Egger, Andrew Binns and Stephan Rossner, *Lifestyle Medicine: Lifestyle, The Environment and Preventive Medicine in Health and Disease*, Academic Press, 2017.
2. Vasudevan, Damodaran, M., Sreekumari, S., and Kannan Vaidyanathan, *Textbook of Biochemistry for Medical Students*, Jaypee Brothers Medical Publishers, 2019.
3. Kumar, M., and Kumar, R., *Guide to Prevention of Lifestyle Diseases,* Deep and Deep Publications, 2004.

Reference Books

1. Rippe, James., M., *Lifestyle Medicine,* CRC Press, 2019.
2. Miyazaki, Akira., *New Frontiers in Lifestyle-Related Diseases,* Edited by Michio Imawari. Springer Japan, 2008.
3. Burns, G.P., Macfarlane, J.G. and Bourke, S.J., *Respiratory Medicine: Lecture Notes.* John Wiley & Sons, 2022.

VERTICAL IV – COMPUTATIONAL BIOTECHNOLOGY

Course Code	Course Name	L	T	P	C
VBT341	PROTEIN STRUCTURE FUNCTION AND ENGINEERING	3	0	0	3

Category: Professional Elective

a. Preamble

This course enables the students to

- Learn information about the building blocks and other factors contributing to the structures.
- Gain fundamental knowledge on the existence of various structures of proteins and how these structures relate to their functions.
- Introduce the methods for characterization of proteins

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Apply the concept of the building blocks of proteins and other factors contributing to protein structures	K3
CO2	Illustrate the first two levels of protein structure hierarchy and the tools used to study them	K3
CO3	Identify the higher levels of protein structure organization and the techniques used to study them	K3
CO4	Relate how protein structures relate to protein functions	K3
CO5	Make use of protein engineering strategies for industrial applications	K3

c. Course Syllabus **Total : 45 Periods**

BONDS, ENERGIES, BUILDING BLOCKS OF PROTEINS **9**

Interactions in protein structure - covalent, ionic, hydrogen, coordinate, hydrophobic and vander waal; Amino acids and their molecular properties - three letter and single letter coding, size, solubility, charge, pKa; Chemical reactivity in relation to post-translational modification - amino, carboxyl, hydroxyl, thiol, imidazole groups; Peptide sequencing (automated Edman method & mass- spectroscopy, high-throughput protein sequencing setup)

PROTEIN ARCHITECTURE **9**

Primary structure - peptide mapping; Secondary structure - Alpha, beta and loop structures and methods to determine secondary structure (FTIR and Circular dichroism); Super-secondary structure- alpha-turn- alpha, beta-turn- beta (hairpin), beta-sheets, alpha-beta-alpha, topology diagrams, up and down & TIM barrel structures nucleotide binding folds, prediction of substrate binding sites; Tertiary structure - domains, folding, denaturation and renaturation; Quaternary structure - Modular nature, formation of complexes, computational tools in structure prediction.

STRUCTURE-FUNCTION RELATIONSHIP **9**

DNA-binding proteins - prokaryotic transcription factors, Helix-turn-Helix motif in DNA binding, Trp repressor, eukaryotic transcription factors, Zn fingers, leucine zippers; Membrane proteins - general characteristics, trans- membrane segments, prediction, bacteriorhodopsin and photosynthetic reaction center; Immunoglobulins - IgG Light chain and heavy chain architecture, abzymes; Enzymes - serine proteases, understanding catalytic design by engineering trypsin, chymotrypsin and elastase, substrate-assisted catalysis.

PROTEIN INTERACTIONS **9**

Introduction to the concept of proteome, components of proteomics, proteomic analysis, importance of proteomics in biological functions, protein-protein interactions and methods to study them - protein arrays, cross linking methods, affinity

methods, yeast hybrid systems and protein arrays; Computer exercise on the above aspects.

PROTEIN ENGINEERING STRATEGIES **9**

Rational design - site directed mutagenesis; Non-rational design - molecular evolution; Generation of combinatorial libraries; Surface display; *De novo* protein design (specific examples to be taken); Case Studies of engineered proteins - therapeutic proteins (insulin), therapeutic antibodies (designer antibodies), industrial enzyme - protease (engineering as per specific industry needs).

d. Activities

3D model making to understand structure and function, Jig saw group learning

e. Learning Resources

Text Books

1. Branden, C.I., and Tooze, J., *Introduction to protein structure*, Garland Science, 2012.
2. Edsall, J.T., *Proteins*, Thomas E. Creighton, WH Freeman, New York, 1993.
3 Almeida, P., *Proteins: Concepts in Biochemistry*, Garland Science, 2016.
4 Kessel, A., and Ben-Tal, N., *Introduction to Proteins: Structure, Function, and Motion*, CRC Press, 2010.

Reference Books

1. Williamson, M., *How Proteins Work*, Garland Science, 2012.
2. Lutz, S., and Bornscheuer, U.T., *Protein Engineering Handbook*, (Vol. 1), Weinheim: Wiley-VCH, 2009.
3. Voet, D., and Voet, J.G., *Biochemistry*, John Wiley & Sons, Inc-2008.
4. Liebler, D.C., *Introduction to Proteomics: Tools for The New Biology*, Springer Science & Business Media, 2001.

Course Code	Course Name	L	T	P	C
VBT342	METABOLIC ENGINEERING	3	0	0	3

Category: Professional Elective

a. Preamble

This course enables the students to

- Understand regulation of metabolic networks in single cells and at the organ level
- Learn the fundamentals of metabolic flux analysis and metabolic control analysis

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Correlate cellular metabolic pathways and their regulation	K2
CO2	Paraphrase the stoichiometry of metabolism.	K2
CO3	Examine various approaches to analyze metabolic flux	K3
CO4	Apply metabolic control analysis to metabolic pathways	K3
CO5	Analyze flux distribution in metabolic networks	K4

c. Course Syllabus **Total : 45 Periods**

CELLULAR METABOLISM AND REGULATION **9**

Introduction to Metabolic Engineering- Review of Cellular metabolism- Fueling reactions, biosynthetic reactions, transport processes; regulation of metabolic pathways - Examples of pathway manipulations-Enhancement of Product Yield and Productivity, Extension of substrate Range, Extension of Product spectrum and Novel products- Improvement of Cellular properties.

MATERIAL BALANCES AND DATA CONSISTENCY **9**

Comprehensive models of cellular reactions- stoichiometry of cellular reactions, reaction rates, dynamic mass balances, yield coefficients and linear rate equations-

analysis of over determined systems- identification of gross measurement errors- Introduction to MATLAB®

METABOLIC FLUX ANALYSIS **9**

Theory of Metabolic Flux Analysis (MFA) - over-determined systems, under-determined systems- linear programming, sensitivity analysis- methods for the experimental determination of metabolic fluxes by isotope labeling- applications of metabolic flux analysis.

METABOLIC CONTROL ANALYSIS **9**

Fundamentals of Metabolic Control Analysis (MCA)- control coefficients and the summation theorems- Determination of flux control coefficients; MCA of linear pathways, branched pathways; theory of large deviations

ANALYSIS OF METABOLIC NETWORKS **9**

Control of flux distribution at a single branch point, grouping of reactions- case studies, extension of control analysis to inter-metabolite; optimization of flux amplifications; consistency tests and experimental validation.

d. Activities

Students shall be exposed to the different softwares related to metabolic flux analysis.

e. Learning Resources

Text Books

1. Lee, S.Y., Nielsen, J., and Stephanopoulos, G., *Metabolic Engineering: Concepts and Applications*, Wiley VCH, 2021.
2. Wittmann, C., and Lee, S.Y., *Systems Metabolic Engineering*, Springer Science & Business Media, 2012.
3. Nielsen, J., and Villadsen, J., *Bioreaction Engineering Principles*, New York: Plenum Press, 1994.
4. Stephanopoulos, G., Aristidou, A.A., and Nielsen, J., *Metabolic Engineering: Principles and Methodologies*, Academic Press, 1998.

Reference Books

1. Eberhard, O. V., *Computational Analysis of Biochemical Systems: A Practical Guide for Biochemists and Molecular Biologists*, Cambridge University Press, 2000.
2. Cortassa, S.D.C., Aon, M.A., Aon, J.C., Iglesias, A.A., and Lloyd, D., *Introduction to Metabolic and Cellular Engineering,* An. World Scientific, 2011.
3. Zoltan, S., Jorg, S., and Vipul, P.(eds), *Systems Modeling in Cellular Biology: From Concepts to Nuts and Bolts*, MIT Press Cambridge, 2006.

Course Code	Course Name	L	T	P	C
VBT343	GENOMICS AND PROTEOMICS	3	0	0	3

Category: Professional Elective

a. Preamble

This course enables the students to

- Gain knowledge on the structure and function of genomes.
- Understand and learn about different protein characterization and profiling techniques

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the basic concepts of genome, proteome and transcriptome.	K2
CO2	Interpret the genome mapping and sequencing data analysis.	K3
CO3	Choose appropriate tools to analyze the functions of genes and protein.	K3
CO4	Make use of various techniques and applications in protein analysis.	K3
CO5	Apply the different protein characterization techniques.	K3

c. Course Syllabus **Total: 45 Periods**

INTRODUCTION **9**

Introduction – Organization and structure of genomes, Genome size, Sequence complexity, Introns and Exons; Introduction to transcriptome and proteome; Overview of genomes of bacteria, archaea, and eukaryote; Genomes of organelles.

GENOME MAPPING AND SEQUENCING **9**

Genetic and physical mapping; Linkage analysis – Restriction Fragment Length Polymorphism (RFLP), Single Nucleotide Polymorphism (SNP), Simple Sequence Length Polymorphisms (SSLP); Restriction mapping - Sequence-tagged site (STS) mapping, Fluorescence in situ hybridization (FISH); Top-down and bottom-up sequencing strategies; Whole genome sequencing; Gap closure; Pooling strategies

FUNCTIONAL GENOMICS **9**

Genome annotation; Open Reading Frame (ORF) and functional prediction; Gene finding; Subtractive DNA library screening; Differential display and Representational difference analysis; Serial analysis of gene expression (SAGE); Total gene expression analysis (TOGA); Introduction to DNA microarray; Applications of MATLAB® in genomics.

TECHNIQUES IN PROTEOMICS **9**

In-vitro and *In-vivo* labelling of proteins; One and two-dimensional gel electrophoresis; Detection of proteins on SDS gels; Protein cleavage; Edman protein microsequencing; Mass spectrometry principles; Matrix-assisted laser desorption/ionization-time of flight (MALDI-TOF); Peptide mass fingerprinting.

PROTEIN PROFILING **9**

Case studies - Large-scale protein profiling using proteomics; Post-translational modifications; Phosphoprotein and glycoprotein analysis; Analysis of protein-protein interactions; Protein microarrays

d. Activities

The students will be given tutorial sessions on different tools related to protein profiling and MATLAB®.

e. Learning Resources

Text Books

1. Suhai, S., *Genomics and Proteomics: Functional and Computational Aspects*, Springer Science & Business Media, 2007.
2. Pennington, S.R., and Dunn, M.J., *Proteomics: From Protein Sequence to Function*, BIOS Scientific Publishers, Oxford, 2001.

3. Macleod, D., Primrose, S. B., and Twyman, R.M., *Principles of Gene Manipulation and Genomics*, Blackwell Publishing, 2006.

Reference Books

1. Cantor, C.R., and Smith, C.L., *Genomics: the Science and Technology Behind the Human Genome Project*, (Vol. 12), John Wiley & Sons, 2004.
2. Liebler, D.C., *Introduction to Proteomics: Tools for The New Biology*, Springer Science & Business Media, 2001.
3. Hunt, S., Hunt, S.P., Livesey, F., and Livesey, R., *Functional Genomics: A Practical Approach*, (Vol. 235) (Paperback), Oxford University Press, 2000.

Course Code	Course Name	L	T	P	C
VBT344	COMPUTER AIDED DRUG DESIGN	3	0	0	3

Category: Professional Elective

a. Preamble

This course enables the students to

- Understand the rational drug design process and various techniques used in drug development.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Comprehend the fundamentals of various stages in drug discovery	K2
CO2	Outline the physicochemical properties of drug and techniques involved in QSAR	K2
CO3	Illustrate the concept of pharmacophore and modelling techniques.	K3
CO4	Demonstrate the important tools available for cheminformatics.	K3
CO5	Apply various structure-based drug design methods.	K3

Total : 45 Periods

c. Course Syllabus

INTRODUCTION TO DRUG DISCOVERY AND DEVELOPMENT 9

Stages of drug discovery and development, lead discovery and analog based drug design: rational approaches to lead discovery based on traditional medicine, random screening, non-random screening, serendipitous drug discovery, lead discovery based on drug metabolism, lead discovery based on clinical observation.

QUANTITATIVE STRUCTURE ACTIVITY RELATIONSHIP 9

Structure-activity relationship (SAR) versus Quantitative structure-activity relationship (QSAR), History and development of QSAR, types of physicochemical parameters, experimental and theoretical approaches for the determination of physicochemical parameters such as partition coefficient, Hammet's substituent constant and Tafts steric constant. Hansch analysis, free wilson analysis, 3D-QSAR approaches like Comparative molecular field analysis (COMFA) and Comparative molecular similarity indices analysis (COMSIA).

PHARMACOPHORE MAPPING AND VIRTUAL SCREENING **9**

Concept of pharmacophore, pharmacophore mapping, identification of Pharmacophore features and Pharmacophore modeling; conformational search used in pharmacophore mapping; *in silico* drug design and virtual screening techniques: Similarity based methods and pharmacophore-based screening, structure based i*n-silico* virtual screening protocols.

INFORMATICS & METHODS IN DRUG DESIGN **9**

Introduction to chemoinformatics. ADME databases, chemical, biochemical and pharmaceutical databases, Application of Machine Learning algortihms in drug design.

MOLECULAR DOCKING AND VIRTUAL SCREENING TECHNIQUES **9**

Virtual Screening techniques: Drug likeness screening; Molecular docking - rigid docking, flexible docking, manual docking, docking based screening; *De novo* drug design.

d. Activities

Hands on Session on different tools related to molecular docking and pharmcophore mapping.

e. Learning Resources

Text Books

1. Sharma, Navneet, Himanshu Ojha, Pawan Raghav, and Ramesh K. Goyal, eds. *Chemoinformatics and bioinformatics in the pharmaceutical sciences*. Academic Press, 2021.

2. Cramer, C.J., *Essentials of computational chemistry: theories and models*. John Wiley & Sons, 2013.
3. Varnek, A., and Tropsha, A. eds., *Chemoinformatics approaches to virtual screening*. Royal Society of Chemistry, 2008.

Reference Books

1. Roy, K., Kar, S., and Das, R.N., *Understanding the basics of QSAR for applications in pharmaceutical sciences and risk assessment*. Academic press, 2015.
2. Hillisch, A., and Hilgenfeld, R., *Modern Methods of Drug Discovery*, (Vol. 93), Springer Science & Business Media, 2002.

Course Code	Course Name	L	T	P	C
VBT345	DATA MINING AND MACHINE LEARNING TECHNIQUES FOR BIOINFORMATICS	3	0	0	3

Category: Professional Elective

a. Preamble

This course will help the students to

- Understand and address the common problems in bioinformatics, alignment techniques, ethical issues, public data sources, and evolutionary modelling.
- Demonstrate fundamental bioinformatics tasks like sequence and structure analysis and evolution, biological networks, and machine learning methods in bioinformatics

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Summarize the basics of data mining in bioinformatics	K2
CO2	Explain the clustering techniques in biological data warehousing	K2
CO3	Demonstrate the applications of machine learning techniques in bioinformatics	K3
CO4	Apply sampling techniques regarding to biological data	K3
CO5	Compute and apply various clustering and array techniques	K3

c. Course Syllabus **Total: 45 Periods**

INTRODUCTION TO DATA MINING **9**

Data mining - Data mining Functionalities, Classification of Data mining Systems, Data Mining Task Primitives, Integration of Data mining systems, Major issues of

Data mining, Basic concepts of Knowledge discovery and Data Mining; Application of data mining in bioinformatics; Data Preprocessing- Data Cleaning, Data Integration and Transformation, Data Reduction, Data discretization and concept hierarchy generation.

DATA WAREHOUSING **9**

Bioinformatics data ware houses; clustering basics - partitional clustering, hierarchal clustering, density-based clustering, mixture model spectral clustering, map reduce in clustering, grid based clustering, clustering of high dimensional data, constraints-based clustering, Analysis of MD trajectories; network mining.

MACHINE LEARNING TECHNIQUES **9**

Supervised and unsupervised techniques; Empirical Risk Minimization, Structural Risk Minimization; Measuring the accuracy of learned hypotheses. Comparing learning algorithms: cross-validation, learning curves, and statistical hypothesis testing.

SAMPLING TECHNIQUES IN BIOLOGICAL DATAMINING **9**

Dimensional Reduction Techniques, Methods of Feature Selection, Resampling Techniques, Elements of Text Mining and Web Mining; Soft Computing and Fuzzy logic system, application in bioinformatics; Multi-Layer Perceptron (MLPs) and Graphical Neural Networks (GNN) in sample feature mining.

BIOINFORMATICS APPLICTION OF MACHINE LEARNING **9**

Classification: Decision tree, Bayesian, Rule based classification, Artificial Neural Network, Support Vector Machine, K- Nearest Neighbor; Case based reasoning and Applications in Bioinformatics, Protein array data Analysis.

d. Activities

Mini project will be given based on machine learning techniques in bioinformatics applications

e. Learning Resources

Text Books

1. Witten, H. I., Frank, E., and Hall, M. A., *Data Mining: Practical Machine Learning Tools and Techniques,* Science Direct, 2011.
2. Hastie, T., Tibshirani, R., Friedman, J. H., *The Elements of Statistical Learning: Data Mining Interface and Prediction,* Science Direct, 2009.

Reference Books

1. Clarke, S. B., Fokoue, E. and Zhang, H. H., *Principles and Theory for Data Mining and Machine Learning*, 2009.
2. Zhang, A., Lipton, Z.C., Smola, M. Li, A., *Dive Into Deep Learning*, Corwin, 2019.

Course Code	Course Name	L	T	P	C
VBT346	MOLECULAR MODELLING	3	0	0	3

Category: Professional Elective

a. Preamble

This course enables the students to

- Provide detailed knowledge of various computational methods and helps to carry out simple model calculations.
- Gain knowledge on modern approaches used in molecular modelling.

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Model and study the behavior of molecules from small chemical systems to large biological molecules	K2
CO2	Describe the quantum mechanical concepts of measurements for physical systems	K2
CO3	Calculate the forces acting on each particle and a suitable integrator to model the dynamics of the particles and predict trajectories.	K3
CO4	Perform molecular dynamics simulations and free energy calculations	K3
CO5	Apply appropriate tools for Modelling and refinement of protein structure	K3

c. Course Syllabus **Total: 45 Periods**

INTRODUCTION TO MOLECULAR MODELING **9**

Molecular modelling: applications of modelling, visualization of DNA and Proteins in VMD molecular tool; Basics of Principal compound analysis; Molecular Modelling in rational Drug Discovery.

QUANTUM MECHANICS IN MOLECULAR MODELING **9**

Introduction, coordinate systems, potential energy surfaces, introduction to quantum mechanics, postulates, Schrodinger wave equation, hydrogen molecule, Born-Oppenheimer approximation, force fields for molecular dynamics simulations, introduction to computer hardware and software.

MOLECULAR MECHANICS AND ENERGY MINIMIZATION **9**

Empirical force field models, Bond stretching, angle bending, torsional term, nonbonding interactions, thermodynamics properties using a forcefield; derived and non-derived energy minimization method, simplex, sequential univariate method, steepest descent method, conjugate gradient method, Newton-Rapson method.

MOLECULAR DYNAMICS (MD) AND MONTE CARLO (MC) SIMULATION **9**

Introduction, using single Model, time steps, Multiple steps, Setting up MD, energy conservation in MD Simulation, Examples; Monte Carlo, Random number generation, Difference in MD & MC.

HOMOLOGY MODELING **9**

Comparative modeling of proteins, comparison of 3D structure, Homology, steps in homology modeling, refinement of predicted model, tools and databases, side chain modeling, loop modeling.

d. Activities

Hands on activities on different tools related to molecular dynamics and simulation tools.

e. Learning Resources

Text Books

1. Mannhold, R., Kubinyi, H., and Timmerman, H., *Molecular Modeling: Basic Principles and Applications*, John Wiley & Sons, 2008.
2. Leach, A.R., *Molecular Modelling: Principles and Applications*, Pearson Education, 2001.
3. Lednicer, D., *Strategies for Organic Drug Synthesis and Design*, John Wiley & Sons, 2009.

Reference Books

1. Fenniri, H. ed., *Combinatorial Chemistry: A Practical Approach*, OUP Oxford, 2000.
2. Cohen, N.C. ed., *Guidebook on Molecular Modeling in Drug Design*, Gulf Professional Publishing, 1996.

Course Code	Course Name	L	T	P	C
VBT347	PROGRAMMING FOR BIOINFORMATICS APPLICATIONS	3	0	0	3

Category: Professional Electives

a. Preamble

This course enables the student to

- Summarize the basic concept of programming applied for biological data resources handling, and for biological analysis.
- Apply PERL, Python and R programs in Bigdata analysis on biological related files with current research applications

b. Course Outcome

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

• CO. No.	Course Outcome	Knowledge Level
CO1	Explain the various operating systems and their applications	K2
CO2	Infer the DNA, RNA and Protein sequence data in PERL environment	K2
CO3	Apply python commands in sequence analysis and data retrieval	K3
CO4	Apply R programming for bioinformatic data analysis and visualization	K3
CO5	Apply appropriate programs and tools with respect to purpose of the biological data analysis.	K3

c. Course Syllabus **Total: 45 Periods**

INTRODUCTION **9**

Basics of Computer parts and Operating systems, Linux Operating system, Introduction to programming Languages and Paradigms, Data Representation, Data Abstraction, Structured Programming, Block Structuring.

BIOPERL PROGRAMING IN BIOINFORMATICS **9**

BIOPERL - Data types; scalars and collections, operators, Program control flow constructs; Library Functions - String specific functions, User defined functions, File handling. Methods and commands for DNA and Protein Sequence Generation, Sequence split to Codons, retrieval of Sequence from Remote Server, Parsing Genbank, PDB, BLAST, and other file formats

APPLICATIONS OF PYTHON IN BIOINFORMATICS **9**

Basic Syntax; Variable and Data Types - Operator, Expression and Statements; Storing strings in variables - DNA concatenation, finding length of a string, reading and writing a FASTA file, splitting a string to make a list, Percentage of amino acid residues. Searching for a pattern in a string, plotting codon frequency, fetching Swiss Prot entry from a file, SwissProt to FASTA, Running Blast and ClustalW.

R PROGRAMMING IN BIOLOGICAL DATA ANALYSIS **9**

Introduction to R environment and Bioconductor packages, basic R commands, handling of micro array data in R, analysis of NGS data in R, Application of Bio-conductor analysis packages-Microarray, Data visualization: Heatmaps, Pie-charts, Venn diagrams

CASE STUDIES **9**

Sequence handling in LINUX, BioPerl in Human Genome Project, biological data retrieval and modifications using Python, usage of R in comparative analysis and data visualization

d. Activities

Students shall be exposed to example programming with available bioinformatics data

e. Learning Resources

Text Books

1. James, Tisdall., *Beginning Perl for Bioinformatics*, O'Reilly Media, 2001.
2. Robert, Gentleman., *R Programming for Bioinformatics*, CRC press, 2008.

3 Sebastian, Bassi., *Python for Bioinformatics* Chapman, Hall/CRC Computational Biology Series, 2017.

Reference Books

1. Ken Youens-Clark., *Mastering Python for Bioinformatics*, O'Reilly Media, 2021.
2. Curtis Jamison.D., *Perl Programming for Bioinformatics & Biologists*, Wiley, 2003.

OPEN ELECTIVE

Course Code	Course Name	L	T	P	C
OBT781	BASICS OF BIOINFORMATICS	3	0	0	3

Category: Open Elective

a. Preamble

This course will help the students to

- Adopt basic knowledge on various techniques and areas of applications in bioinformatics.
- Apply knowledge to address the common problems in bioinformatics, alignment techniques, public data sources, and evolutionary modelling.
- Illustrate the various tools and applications in bioinformatics

b. Course Outcome

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

CO. No.	Course Outcome	Knowledge Level
CO1	Understan the fundamentals of different biological data resources	K2
CO2	Interpret the data from online biological databases	K2
CO3	Apply biological data processing by using appropriate bioinformatics tools	K3
CO4	Compute sequence alignments and various kinds of BLAST	K3
CO5	Demonstrate the applications of bioinformatics in biological research	K3

c. Course Syllabus **Total: 45 Periods**

INTRODUCTION **9**

Introduction – Central dogma of life, Bioinformatics and its applications ; Biological databases- Motivation of biological database; Biological data retrieval - Retrieval methods for DNA sequence, protein sequence and protein structure information.

BIOLOGICAL DATABASES **9**

Conventions for database indexing and specification of search Terms; Format and Annotation - Common sequence file formats, Annotated sequence databases; Databases – primary sequence databases, protein sequence and structure database, Genome specific
databases.

DATA PROCESSING **9**

Data – Access, Retrieval and Submission; Standard search engines; Data retrieval tools – Entrez, DBGET and SRS; Submission of (new and revised) data; Sequence Similarity Searches - Local versus global, Similarity and homology, Scoring matrices.

METHODS OF SEQUENCE ALIGNMENT **9**

Dynamic programming algorithms - Needleman-Wunsch and Smith-Waterman; Heuristic Methods of sequence alignment - FASTA and BLAST; Multiple Sequence Alignment, software tools for pairwise and multiple sequence alignment.

APPLICATIONS OF BIOINFORMATICS **9**

Genome analysis - Genome Annotation and Gene Prediction, ORF finding; Phylogenetic Analysis; Comparative genomics; Computer aided drug discovery – Drug Likeness, ADMET and Molecular docking.

d. Activities

Hands on Activity in sequence alignment with phylogenetic analysis

e. Learning Resources

Text Books

1. Lesk, A., *Introduction to Bioinformatics*, Oxford university press, 2019.
2. Mount, D.W., *Bioinformatics: Sequence and Genome Analysis*, Cold spring harbor laboratory press (Vol. 1), 2001.
3 Gibas, C., Jambeck, P., and Fenton, J., *Developing Bioinformatics Computer Skills*, O'Reilly Media, 2001.

Reference Books

1. Attwood, T.K., and Parry-Smith, D.J., *Introduction to Bioinformatics*, Pearson Education,1999.
2. Pevsner, J., *Bioinformatics and Functional Genomics*, John Wiley & Sons, 2015.
3 Durbin, R., Eddy, S.R., Krogh, A., and Mitchison, G., *Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids,* Cambridge University press, 1998.