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Department of Biotechnology
School of Sciences

Course Structure and Syllabus
B.Sc. BIOTECHNOLOGY (HONS.)
2025-29

Total credit for Batch 2025-2029: 160 Credits

Details of the scheme for B.Sc. Biotechnology (Hons.) with various courses & their credits with hours.

S. No.	Semester	Course Code	Course	Course Type	Lecture Hours	Tutorial Hours	Practical Hours	Total Hours	Lecture Credit	Tutorial Credit	Practical Credit	Total Credits
1	1	BBI019C	Cell Biology	Major Core	3	0	0	3	3	0	0	3
2	1	BBI020C	Cell Biology Lab	Major Core Lab	0	0	2	2	0	0	1	1
3	1	BBI210A	Biochemistry	Major Core	3	0	0	3	3	0	0	3
4	1	BBI211A	Biochemistry Lab	Major Core Lab	0	0	2	2	0	0	1	1
5	1		Minor 1	Minor	3	0	0	3	3	0	0	3
6	1		Minor Lab 1	Minor Lab	0	0	2	2	0	0	1	1
7	1	DEN001C	Communication Skills	AEC	1	0	2	3	1	0	1	2
8	1	DCH010A	Environment Education	VAC	2	0	0	2	2	0	0	2
9	1	DCO021A	Digital, Data, AI Literacy	SEC	0	0	4	4	0	0	2	2
				Total	**12**	**0**	**12**	**24**	**12**	**0**	**6**	**18**
10	2	BBI212A	Principles of Genetics	Major Core	2	1	0	3	2	1	0	3
11	2	BBI213A	Genetics Lab	Major Core	0	0	2	2	0	0	1	1
12	2	BBI026C	Metabolic Pathways	Major Core	3	0	0	3	3	0	0	3
13	2	BBI214A	Metabolic Pathways Lab	Major Core Lab	0	0	2	2	0	0	1	1
14	2		Minor 2	Minor	3	0	0	3	3	0	0	3
15	2		Minor Lab 2	Minor Lab	0	0	2	2	0	0	1	1
16	2		Open Elective 1	Multidisciplinary	3	0	0	3	3	0	0	3
17	2		Professional Skills	AEC	1	0	2	3	1	0	1	2
18	2		Inculcation of Human Values and Professional Ethics in Higher Education Institutions	VAC	2	0	0	2	2	0	0	2
19	2		Advance Excel	SEC	0	0	4	4	0	0	2	2
				Total	**14**	**1**	**12**	**27**	**14**	**1**	**6**	**21**
20	3	BMI190A	Molecular Biology	Major Core	3	0	0	3	3	0	0	3
21	3	BMI191A	Molecular Biology Lab	Major Core Lab	0	0	2	2	0	0	1	1
22	3	BMI192A	Diversity of Microorganism	Major Core	3	0	0	3	3	0	0	3

23	3	BMI193A	Diversity of Microorganism Lab	Major Core Lab	0	0	2	2	0	0	1	1
24	3		Minor 3	Minor	3	0	0	3	3	0	0	3
25	3		Minor Lab 3	Minor Lab	0	0	2	2	0	0	1	1
26	3		Leadership and Management Skill	AEC	2	0	0	2	2	0	0	2
27	3		Any of IKS Basic Courses	VAC	2	0	0	2	2	0	0	2
28	3		Prompt Engineering (Generative AI) Program Specific	SEC	0	0	4	4	0	0	2	2
30	3		EDP	SEC	0	0	2	2	0	0	1	1
29	3		Open Elective 2	Multidisciplinary	3	0	0	3	3	0	0	3
				Total	**16**	**0**	**12**	**28**	**16**	**0**	**6**	**22**
21	4	BBI033C	Introductory Immunology	Major Core	3	0	0	3	3	0	0	3
22	4	BBI218A	Introductory Immunology Lab	Major Core Lab	0	0	2	2	0	0	1	1
23	4	BBI219A	Introductory Genetic Engineering	Major Core	3	0	0	3	3	0	0	3
24	4	BBI220A	Introductory Genetic Engineering Lab	Major Core Lab	0	0	2	2	0	0	1	1
27	4		Minor 4	Minor	3	0	0	3	3	0	0	3
28	4		Minor Lab 4	Minor Lab	0	0	2	2	0	0	1	1
29	4		Universal Human Value	AEC	2	0	0	2	2	0	0	2
30	4		Any of IKS Elective Course	VAC	2	0	0	2	2	0	0	2
31	4		R with Python (Program Specific)	SEC	0	0	4	4	0	0	2	2
				Total	**13**	**0**	**10**	**23**	**13**	**0**	**5**	**18**
32	5	BBI221A	Bioprocess Engineering	Major Core	3	0	0	3	3	0	0	3
33	5	BBI222A	Bioprocess Engineering Lab	Major Core Lab	0	0	2	2	0	0	1	1
34	5		Major DSE 1	Major DSE	3	0	0	3	3	0	0	3
35	5		Major DSE Lab 1	Major DSE Lab	0	0	2	2	0	0	1	1
36	5		Major DSE 2	Major DSE	3	0	0	3	3	0	0	3
37	5		Major DSE Lab 2	Major DSE Lab	0	0	2	2	0	0	1	1
38	5		Major DSE 3	Major DSE	3	0	0	3	3	0	0	3

39	5		Major DSE Lab 3	Major DSE Lab	0	0	2	2	0	0	1	1
40	5		Minor 5	Minor	3	0	0	3	3	0	0	3
41	5		Minor Lab 5	Minor Lab	0	0	2	2	0	0	1	1
				Total	**15**	**0**	**10**	**25**	**15**	**0**	**5**	**20**
42	6	BBI100A	Fundamental of Industrial Biotechnology	Major Core	3	0	0	3	3	0	0	3
43	6	BBI101A	Industrial Biotechnology Lab	Major Core Lab	0	0	2	2	0	0	1	1
44	6		Major DSE 4	Major DSE	3	0	0	3	3	0	0	3
45	6		Major DSE Lab 4	Major DSE Lab	0	0	2	2	0	0	1	1
46	6		Minor 6	Minor	3	0	0	3	3	0	0	3
48	6		Minor Lab 6	Minor Lab	0	0	2	2	0	0	1	1
49	6	BBI224A	Project	Major Core	0	0	8	8	0	0	4	4
50	6		Open Elective 3	Multidisciplinary	3	0	0	3	3	0	0	3
51	6	BBI225A	Basics of Bioinformatics Lab	Major core	0	0	4	4	0	0	2	2
			OR									
52	6	BBI226A	Summer internship	Summer internship	2	0	0	2	2	0	0	2
				Total	**14**	**0**	**14**	**28**	**14**	**0**	**7**	**21**
53	7	BBI069A	Animal Tissue Culture	Major core	3	0	0	3	3	0	0	3
54	7	BBI039D	Animal Tissue culture Lab	Major core	0	0	2	2	0	0	1	1
55	7		Major DSE 5	Major DSE	3	0	0	3	3	0	0	3
56	7		Major DSE Lab 5	Major DSE Lab	0	0	2	2	0	0	1	1
57	7		Minor 7	Minor	3	0	0	3	3	0	0	3
58	7		Minor Lab 7	Minor Lab	0	0	2	2	0	0	1	1
59	7		Minor 8	Minor	3	0	0	3	3	0	0	3
60	7		Minor Lab 8	Minor Lab	0	0	2	2	0	0	1	1
61	7	BBI200A	Major 13 (Research Methodology)	Major Core	3	1	0	4	3	1	0	4
				Total	**15**	**1**	**8**	**24**	**15**	**1**	**4**	**20**
62	8		Major DSE 6	Major DSE	3	0	0	3	3	0	0	3
63	8		Major DSE Lab 6	Major DSE Lab	0	0	2	2	0	0	1	1
64	8		Major DSE 7	Major DSE	3	0	0	3	3	0	0	3

65	8		Major DSE Lab 7	Major DSE Lab	0	0	2	2	0	0	1	1
66	8	BBI206A	Dissertation (In house)	Major core	0	0	24	24	0	0	12	12
				Total	**6**	**0**	**28**	**34**	**6**	**0**	**14**	**20**
			OR									
67	8	BBI204C	**Industry Internship / Dissertation (Experimental Research Outside Campus)**	Major core	**0**	**0**	**40**	**40**	**0**	**0**	**20**	**20**

*In 8th semester, either the student can adopt the structured courses or the candidate can earn the Credits for offered Major & Minor Courses through SWAYAM / MOOCS and can devote the Semester for Dissertation work in Research Institute/Industry. In case of doing Courses in Campus, Student can complete 45 Hours of Teaching for 3 Credits Theory & 30 Hours of Practical for 1 Credit in 6 Weeks taking double number of Classes on daily basis and after completing this can devote rest 12 Weeks exclusively for Dissertation work. In case of doing in House Dissertation he/she can do Simultaneously in regular mode.

Department Specific tracks

Track	Elective No.	Course Code	Course Name	Credits	Lab Code	Lab Name	Lab Credits
Environmental Biotechnology	1	BBI128A	Environmental Biology	3	BBI129A	Environmental Biology Lab	1
	2	BBI130A	Solid Waste Management	3	BBI131A	Solid Waste Management Lab	1
	3	BBI132A	Environmental Pollution	3	BBI133A	Environmental Pollution Lab	1
	4	BBI134A	Environmental Microbiology	3	BBI135A	Environmental Microbiology Lab	1
	5	BBI136A	Biodiversity	3	BBI137A	Biodiversity Lab	1
	6	BBI138A	Microbial and Industrial Application	3	BBI139A	Industrial Microbial Lab	1
	7	BBI140A	Bioremediation	3	BBI141A	Bioremediation Lab	1
Agriculture Biotechnology	1	BBI042C	Plant Biotechnology	3	BBI043C	Plant biotechnology Lab	1
	2	BBI116A	Agriculture Microbiology	3	BBI117A	Agriculture Microbiology Lab	1
	3	BBI118A	Molecular Plant Breeding	3	BBI119A	Molecular Plant Breeding Lab	1
	4	BBI120A	Principles of Plant Physiology	3	BBI121A	Plant Physiology Lab	1
	5	BBI122A	Biotechnology for Biotic and Abiotic Stress Tolerance	3	BBI123A	Plant Stress Lab	1
	6	BBI114A	Advances in Agriculture Biotechnology	3	BBI115A	Agriculture Biotechnology Lab	1
	7	BBI126A	Techniques in Biochemistry and Molecular Biology	3	BBI127A	Molecular Biology Lab	1
Industrial Biotechnology	1	BBI100A	Fundamentals of Industrial Biotechnology	3	BBI101A	Industrial Biotechnology Lab	1
	2	BBI102A	Microbial Physiology	3	BBI103A	Practicals of Microbial Physiology	1
	3	BBI104A	Microbial Genetics and r-DNA Technology	3	BBI105A	Microbial Genetics Lab	1
	4	BBI106A	Pharmaceutical Chemistry	3	BBI107A	Pharmaceutical Chemistry Lab	1
	5	BBI108A	Bioprocess Engineering	3	BBI109A	Bioprocess Engineering Lab	1
	6	BBI110A	Enzyme Technology and Biotransformation	3	BBI111A	Enzyme Technology Lab	1

	7	BBI112A	Industrial Manufacturing	3	BBI113A	Industrial Manufacturing Lab	1
Bioinformatics	1	BBI157A	Basics of Bioinformatics	3	BBI158A	Bioinformatics Lab	1
	2	BBI159A	Structural Bioinformatics	3	BBI160A	Practicals of Structural Bioinformatics	1
	3	BBI161A	Informatics in Omics and Its Application	3	BBI162A	Practicals of Omics Applications	1
	4	BBI163A	Molecular Modelling and Molecular Mechanics	3	BBI164A	Practical on Molecular Modelling and Mechanics	1
	5	BBI165A	Genomics Analysis	3	BBI166A	Practicals on Genome Analysis	1
	6	BBI167A	Advance in Bioinformatics	3	BBI168A	Advance in Bioinformatics Lab	1
	7	BBI169A	In Silico Drug Designing	3	BBI170A	Practicals in Silico Drug Designing	1
Nanotechnology	1	BBI171A	Nanoscience and Nanotechnology	3	BBI172A	Practical of Nanotechnology	1
	2	BBI173A	Synthesis of Nanomaterials	3	BBI174A	Lab of Synthesis of Nanomaterials	1
	3	BBI175A	Surface Science in Nanotechnology	3	BBI176A	Surface Studies in Nanotechnology	1
	4	BBI177A	Chemistry of Nanotechnology	3	BBI178A	Practical of Nanotechnology in Chemistry	1
	5	BBI179A	Application of Nanomaterials	3	BBI180A	Instrumentation in Nanotechnology Lab	1
	6	BBI181A	Nanotoxicology and Biosafety	3	BBI182A	Ethical and Safety Practices	1
	7	BBI183A	Overview of Nanotechnology	3	BBI184A	Practical of Different Approaches of Nanotechnology	1

PROGRAM OUTCOMES

PO 1. Disciplinary Knowledge and Skills: Good knowledge and understanding of major concepts, theoretical principles in Biotechnology and its allied fields. The knowledge about the experimental findings in Biotechnology and its different subfields like Cell biology, Biochemistry, Microbiology, Genetic Engineering, medical biotechnology, environmental biotechnology, plant biotechnology, molecular biology, industrial biotechnology and immunology including broader interdisciplinary subfields like Chemistry, Mathematics, Life sciences, Environmental sciences, Computer science, Information Technology, forensic science and etc.

PO 2. Skilled communicator: Ability to transmit complex technical information relating all areas in Biotechnology in a clear and concise manner in writing and oral ability to present complex and technical concepts in a simple language for better understanding.

PO 3. Critical thinker and problem solver: Ability to employ critical thinking and efficient problem-solving skills in all the basic areas of Biotechnology

PO 4. Sense of inquiry: Capability for asking relevant/appropriate questions relating to the issues and problems in the field of Biotechnology, and planning, executing and reporting the results of a theoretical or experimental investigation

PO 5. Skilled project manager: Capable of identifying/mobilizing appropriate resources required for a project, and managing a project through to completion, while observing responsible and ethical scientific conduct; and safety and laboratory hygiene regulations and practices.

PO 6. Ethical awareness / reasoning and Environmental Sustainability: The graduate should be capable of demonstrating ability to think and analyze rationally with modern and scientific outlook and identify ethical issues related to one's work, avoid unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, not adhering to intellectual property rights, and adopting objectives, unbiased and truthful actions in all aspects of work. Understand the issues of environmental contexts and sustainable development.

PO 7. Self-directed, Team player and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context of social technological changes. Capable of working effectively in diverse teams in both classroom, laboratory, Biotechnology projects and workshops and in industry and field-based situations.

PROGRAM SPECIFIC OUTCOME

PSO1: To impart training in Biotechnology at advanced level and enthuse the students to understand basic concept of Biotechnology (Understanding skills)

PSO2: To educate the students to make them confident and capable of accepting any challenge at Global Level (Problem-Solving Skills)

PSO3: To train the students for creating innovative careers in research and for higher studies. (Successful Career and Entrepreneurship)

SEMESTER-I

S. No.	Semester	Course Code	Course	Course Type	Lecture Hours	Tutorial Hours	Practical Hours	Total Hours	Lecture Credit	Tutorial Credit	Practical Credit	Total Credits
1	1	BBI019C	Cell Biology	Major Core	3	0	0	3	3	0	0	3
2	1	BBI020C	Cell Biology Lab	Major Core Lab	0	0	2	2	0	0	1	1
3	1	BBI210A	Biochemistry	Major Core	3	0	0	3	3	0	0	3
4	1	BBI211A	Biochemistry Lab	Major Core Lab	0	0	2	2	0	0	1	1
5	1		Minor 1	Minor	3	0	0	3	3	0	0	3
6	1		Minor Lab 1	Minor Lab	0	0	2	2	0	0	1	1
7	1	DEN001C	Communication Skills	AEC	1	0	2	3	1	0	1	2
8	1	DCH010A	Environment Education	VAC	2	0	0	2	2	0	0	2
9	1	DCO021A	Digital, Data, AI Literacy	SEC	0	0	4	4	0	0	2	2
				Total	**12**	**0**	**12**	**24**	**12**	**0**	**6**	**18**

B.Sc. Semester – I
Course – Cell Biology
Course Code –BBI019C
Lectures: 3 Hrs/week

Course Outcome

CO-1 Students will be able to understand the structure and function of cell and cell organelles. Describe the structure and function of membranes, especially the phospholipid bilayer.

CO-2 Student will be able to understand the types and mechanism of cell division and able to identify the different stages of cell division

CO-3 Students will be able to distinguish between passive and active transport; explain how substances are directly transported across a membrane.

CO-4 Describe the primary mechanisms by which cells import and export macromolecules and protein folding.

CO-5 Students will be able to understand the organization of flagella. Explain the assembly of microtubules and microfilaments. Also, able to explain structure and chemical composition of centrioles and basal bodies.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course Outcome	Program Outcome						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	3	0	1	0	0	1
CO2	1	2	0	1	0	0	1
CO3	3	3	1	0	1	2	0
CO4	2	1	0	1	1	0	0
CO5	3	1	0	0	2	0	0

3 = Highly Related; 2 = Medium; 1 = Low

BBI019C: Cell Biology Credit(s): 3

Unit-I

Cell: Shapes, Morphology, difference between plant cell and Animal cell, Prokaryotes and Eukaryotes, Structure, Function, Cell theory; Membrane structure, cell wall.

Unit-II

Cell divisions: Cell cycles, Amitosis, Mitosis phases, structure and functions of spindle apparatus; anaphasic chromosome movement; Meiosis: phases, synaptonemal complex formation of chiasmata. Significance of mitosis and meiosis

Unit-III

Transport across membrane: Active, Passive, facilitated; Protein synthesis and folding in the cytoplasm; Degradation of cellular components.

Unit-IV

Chromosome organization: eukaryotic and prokaryotic, Chromosomes morphology: Centromere, Telomere; Specialized types of chromosomes: Sex chromosomes, Lampbrush chromosome, polytene chromosomes, Nucleosomes, Solenoid and Super solenoid modal

Unit-V

Structure of cilia and flagella, microtubule and microfilament microtubule assembly, functions of filament and microtubules, Structure of Plastids and the light reaction and dark reaction, Centrioles and basal bodies: structure, chemical composition, duplication of centrioles, function of centrioles and basal bodies, Structure of Mitochondria, Ribosomes, Signal transduction.

Text / Reference Books

1. Genetics: Monroe W. Strickberger, 1968, Macmillan.
2. Cell biology: Garreld Karp, 2018, Wiley.
3. Cell biology: C.B. Pawar, 1983, Himalayas.
4. The World of the Cell: W.M. Becker, L.J. Kleinsmith, J. Hardin and G. P. Bertoni, 2008, Benjamin Cummings.

BBI020C: Cell Biology Lab — Credit(s): 1

Course Outcomes

CO1- Understand the different stages of cell cycle.
CO2- familiar with the procedure of Dialysis.
CO3- students will be able to understand the chromosomes organization.
CO4- to understand the biochemical composition of biological macromolecules.
CO5- also able to understand fixation and section cutting of the cells.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course Outcome	Program Outcome						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	2	2	0	1
CO2	3	2	2	2	1	1	1
CO3	3	3	2	1	1	1	1
CO4	3	2	2	1	1	0	0
CO5	3	2	2	1	0	0	1

3 = Highly Related; 2 = Medium; 1 = Low

1. To analyze prepared slides of mitosis.
2. To perform and identify different stages of mitosis in onion root tip.
3. To analyze prepared slides of meiosis.
4. To perform and identify different stages of mitosis in onion flower buds.
5. To prepare the slide of the Giant chromosome.
6. Introduction to microtomy and apparatus handling.
7. To localize lipid, starch and proteins histochemically.
8. To perform paper chromatography for dyes.
9. To perform chromosomal banding using dyes.
10. Demonstration of dialysis.
11. Microtomy: Fixation, block making, section cutting, double staining of animal tissues like liver, esophagus, stomach, pancreas, intestine, kidney, ovary, testes.

Virtual Lab link

S. No.	Course name	Sources	Link
1.	Cell Biology Virtual Lab I	Amrita Vishwa Vidyapeetham	http://cbi-au.vlabs.ac.in/
2.	Cell Biology Virtual Lab II	Amrita Vishwa Vidyapeetham	http://cbii-au.vlabs.ac.in/
3.	Cell Biology Tutorials I	Genetic Science Learning Center by Arthur Lakes Library Colorado School of Mines	https://learn.genetics.utah.edu/content/cells/
4.	Cell Biology Tutorials II	MIT	http://star.mit.edu/CellBio/animations/index.html

Course- Biochemistry
Course Code-BBI210A
Lectures: 3 Hrs/week

Course Outcome

CO-1 Explain the classification, structure, and biological significance of carbohydrates, including key reactions such as mutarotation and osazone formation.
CO-2 Describe the structure, classification, and physiological roles of lipids, including fats, phospholipids, steroids, and prostaglandins.
CO-3 Illustrate the classification of amino acids and structural organization of proteins from primary to quaternary levels.
CO-4 Differentiate the structure and biological functions of DNA and RNA, including their nucleotide components.
CO-5 Interpret enzyme classification, catalytic mechanisms, kinetics, inhibition, and clinical significance.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course Outcome	Program Outcome						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	0	2	1	2	2
CO2	0	2	2	1	0	1	1
CO3	3	2	2	1	2	2	2
CO4	3	2	2	1	1	0	1
CO5	2	3	2	1	0	0	1

3 = Highly Related; 2 = Medium; 1 = Low

BBI210A: Biochemistry Credit(s): 3

Unit- I

Carbohydrates: Introduction, biological importance. Definition, Classification, Monosaccharides, glycosidic bond, disaccharides, polysaccharides (starch, glycogen, peptidoglycan), Hetero polysaccharides, Mutarotation, osazone formation.

Unit- II

Lipids: Introduction Structure, distribution and biological importance of fats and fatty acids; Chemical properties and characterization of Fats, Waxes, Cerebrosides, gangliosides, phospholipids and their types and proteolipids; Steroids and Prostaglandins

Unit- III

Amino acids: Definition, Classification, Structure and types; Proteins: Classification, structure and properties, biologically active peptides, classification and properties of proteins, structure of proteins-primary, secondary, tertiary and quaternary structure of proteins.

Unit- IV

Nucleic acids: Structure of purines, pyrimidines, nucleosides and nucleotides; Structure, types and biological role of RNA and DNA.

Unit-V

Enzymology: Classification, Principles of catalysis, Mechanism of enzyme action, Enzyme kinetics, types of enzyme inhibition, Enzyme regulation, Isozymes, clinically important enzymes.

Text / Reference Books

1. Outlines of Biochemistry: Eric C. Conn, Paul K., G. Bruening, Roy H. Doi, 2006, Wiley
2. Principles of Biochemistry: Geffory L. Zubey, William W. Parson, Dennis E. Vance, 1995, Wm. C. Brown.
3. Biochemistry: Lubert Stryer, John Tymoczko, Gregory Gatto, 2019, WH Freeman

BBI211A: Biochemistry Lab Credit(s): 1

Course Outcomes

CO1- Students are able to understand the physiological pH and biological buffer preparations.
CO2- Students will understand the qualitative estimation of biomolecules.
CO3- Students will be able to understand mathematical calculations.
CO4- Students will understand the biochemical composition of biological macromolecules
CO5- Students will also able to understand titration estimations.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

CO/PO	Program Outcome						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	3	2	2	1	1
CO2	2	2	2	2	1	1	0
CO3	3	1	3	1	1	1	0
CO4	2	2	2	1	1	0	1
CO5	3	3	1	1	0	0	2

3 = Highly Related; 2 = Medium; 1 = Low

1. To prepare the solutions of given normality and its standardization.

2. To Calibrate the pH meter by using different buffer solutions.
3. To Prepare the buffer solutions.
4. To determine the pKa value and hence the Dissociation constant of a given acid by using pH meter.
5. To prepare buffer solutions in the pH range of 2.2 to 8.0.
6. To perform Qualitative estimation of carbohydrates.
7. To perform Qualitative estimation of proteins.
8. To perform Qualitative estimation of lipids.
9. To perform the Titrimetric estimation of molar and mass concentration of sulfuric acid.
10. To Determine the acid value of oil.
11. To verify Lambert and beer laws.
12. To calibrate spectrophotometer using $K_2Cr_2O_7$ solution.
13. To study activity of any enzyme under optimum conditions.
14. To study the effect of pH, temperature on the activity of salivary amylase enzyme.
15. To study relation between absorbance and % transmission.

Virtual Labs link

S. No.	Course name	Sources	Link
1	Biochemistry Virtual Lab I	Amrita Vishwa Vidyapeetham	http://biotech01.vlabs.ac.in/
2	Biochemistry Virtual Lab II	Amrita Vishwa Vidyapeetham	https://vlab.amrita.edu/?sub=3&brch=64

SEMESTER II

S. No.	Semester	Course code	Course	Course Type	Lecture Hours	Tutorial Hours	Practical Hours	Total Hours	Lecture Credit	Tutorial Credit	Practical Credit	Total Credits
1	2	BBI212A	Principles of Genetics	Major Core	2	1	0	3	2	1	0	3
2	2	BBI213A	Genetics Lab	Major Core	0	0	2	2	0	0	1	1
3	2	BBI026C	Metabolic Pathways	Major Core	3	0	0	3	3	0	0	3
4	2	BBI214A	Metabolic Pathways Lab	Major Core Lab	0	0	2	2	0	0	1	1
5	2		Minor 2	Minor	3	0	0	3	3	0	0	3
6	2		Minor Lab 2	Minor Lab	0	0	2	2	0	0	1	1
7	2		Open Elective 1	Multidisciplinary	3	0	0	3	3	0	0	3
8	2		Professional Skills	AEC	1	0	2	3	1	0	1	2
9	2		Inculcation of Human Values and Professional Ethics in Higher Education Institutions	VAC	2	0	0	2	2	0	0	2
10	2		Advance Excel	SEC	0	0	4	4	0	0	2	2
				Total	**14**	**1**	**12**	**27**	**14**	**1**	**6**	**21**

Course - Principles of Genetics
Course Code – BBI212A
Lectures: 3 Hrs/week

Course Outcome

Students will be able to

CO1- Describe and explain Mendelian principles, gene interactions, pleiotropy, and multiple alleles in classical genetics.

CO2- Illustrate the concepts of linkage and crossing over, and apply two- and three-point test cross data to construct genetic maps.

CO3- Compare and contrast mechanisms of sex determination and analyze inheritance patterns of sex-linked disorders like hemophilia and color blindness.

CO4- Evaluate the principles of extra-chromosomal inheritance, heteroploidy, chromosomal aberrations, and types of mutations and their biological significance.

CO5- Interpret population genetics data using Hardy-Weinberg equilibrium and assess the impact of evolutionary forces on genetic variation.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

CO	Program Outcome							Program Specific Outcome		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	2	2	2	1	1	1	3	2	1
CO2	3	2	3	3	2	1	1	3	3	2
CO3	3	2	3	2	1	1	1	3	2	2
CO4	3	2	3	3	2	2	1	3	3	2
CO5	3	2	3	3	2	2	2	3	3	3

3 = Highly Related; 2 = Medium; 1 = Low

BBI212A: Principles of Genetics Credit(s): 3

Unit-I

Mendelian principles: Mendel's Laws of Inheritance; Interaction of Genes: Inter-allelic, non-allelic interactions, Pleiotropic effect of genes; Multiple alleles.

Unit-II

Linkage and crossing over: cytological basis of crossing over; Linkage and recombination in Neurospora, Chromosome maps: chromosome mapping by two factor and three factor crosses; Genes: molecular structure of gene; Genetic code.

Unit-III

Sex determination: Mechanism of sex determination; Sex linked inheritance: Hemophilia and Color blindness.

Unit-IV

Extra-chromosomal inheritance- Rules of extra nuclear inheritance, cases showing cytoplasmic inheritance. Variation in chromosome number (Heteroploidy): euploidy and aneuploidy and other types of variations. Chromosomal Aberrations: change involving number of gene loci and arrangement of genes, Mutations: substitution and frame shift mutation.

Unit-V

Population genetics and Evolution- Population, Gene pool, gene frequency and genotype frequency, genetic equilibrium and Hardy-Weinberg Law of Equilibrium, Evolutionary forces or Factors of Evolution.

Text / Reference Books

1. Griffiths, A. J. F., Wessler, S. R., Carroll, S. B., & Doebley, J. (2020). Introduction to genetic analysis (12th ed.). New York: W. H. Freeman and Company.
2. Klug, W. S., Cummings, M. R., Spencer, C. A., Palladino, M. A., & Killian, D. J. (2021). Concepts of genetics (12th ed.). New York: Pearson Education.
3. Russell, P. J. (2016). Genetics: A molecular approach (3rd ed.). San Francisco: Pearson Benjamin Cummings.
4. Gardner, E. J., Simmons, M. J., & Snustad, D. P. (2006). Principles of genetics (8th ed.). New York: John Wiley & Sons.

5. Veer Bala Rastogi. (2018). Fundamentals of genetics (Revised ed.). Meerut, India: Medtech/Narendra Publishing House.
6. Strickberger, M. W. (2008). Genetics (3rd ed.). Delhi, India: Prentice Hall of India.
7. Hartl, D. L., & Ruvolo, M. (2011). Genetics: Analysis of genes and genomes (8th ed.). Burlington: Jones & Bartlett Learning.

Course Code: BBI213A
Course name: Genetics Lab Credit(s): 1

Course Outcomes

Student will be able to

CO1- Solve inheritance problems based on Mendelian genetics, gene interactions, and multiple alleles using analytical approaches.

CO2- Construct genetic linkage maps using recombination data and distinguish linkage from independent assortment.

CO3- Interpret pedigrees and inheritance patterns involving sex-linked traits and various sex determination mechanisms.

CO4- Evaluate cytoplasmic inheritance, chromosomal abnormalities, and mutation types using case-based and data-driven exercises.

CO5- Calculate allele and genotype frequencies using Hardy-Weinberg law and analyze the effects of evolutionary forces on populations.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

CO Code	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	2	3	2	1	2	1	3	3	2
CO2	3	2	3	2	2	2	3	3	3	2
CO3	3	2	3	2	2	1	1	3	2	2
CO4	3	1	3	3	1	2		3	3	2
CO5	3	2	3	3	2	1	1	3	3	2

3 = Highly Related; 2 = Medium; 1 = Low

1. Problems involving Monohybrid Crosses
2. Problems involving single gene inheritance and calculate phenotypic/genotypic ratios.
3. Problems involving two genes with independent assortment; determine 9:3:3:1 ratio.
4. Analyze and solve problems involving inter-allelic, non-allelic gene interaction and pleiotropic effect of gene interaction.
5. Analyze and solve problems involving multiple alleles & codominance (e.g., ABO Blood Group Inheritance, coat color in animals).
6. Analyze Rh positive/negative inheritance involving dominant-recessive traits.
7. Estimate distance between two linked genes i.e. two-point test cross mapping by using recombination frequency data.
8. Determine gene order, map distances, and calculate interference using test cross data i.e. three-point test cross mapping
9. Identify linked vs. unlinked genes based on deviation from Mendelian ratios.
10. Use a DNA sequence to find start/stop codons and predict open reading frames.
11. Translate a nucleotide sequence into an amino acid chain using the standard codon table.
12. Solve pedigree charts for sex-linked (X-linked) inheritance patterns like hemophilia or color blindness.
13. Criss-Cross Inheritance in Drosophila
14. Solve inheritance problems where traits alternate between generations.

15. Comparison of Sex Determination Systems
16. Analyze examples of XX/XY, ZZ/ZW, and environmental sex determination systems.
17. Mitochondrial Inheritance Case Study
18. Interpret inheritance patterns from maternal line involving mitochondrial genes.
19. Identify chromosomal abnormalities like Down syndrome, Turner syndrome, or Klinefelter syndrome by karyotype analysis.
20. Detect and classify point mutations (silent, missense, nonsense) and frameshift mutations from nucleotide sequences.
21. Calculate allele and genotype frequencies in a population and test if the population is in equilibrium.

Course – Metabolic Pathways
Course Code – BBI026C
Lectures: 3 Hrs/week

Course Outcome

CO-1 Students will able to explain the major pathways of carbohydrate metabolism including glycolysis, TCA cycle, oxidative phosphorylation, gluconeogenesis, glycogen metabolism, and HMP shunt.

CO-2 Students will able to describe the key processes of amino acid metabolism including transamination, deamination, urea cycle, and amino acid biosynthesis and degradation.

CO-3 Students will able to analyze the pathways of fatty acid and cholesterol metabolism, including synthesis, degradation, and regulation

CO-4 Students will Illustrate the biosynthesis, salvage, and degradation pathways of purine and pyrimidine nucleotides.

CO-5 Students will understand the biochemical basis and metabolic implications of selected inherited and acquired metabolic disorders.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course Outcome	Program Outcome						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	2	2	2	2
CO2	3	3	3	2	2	1	1
CO3	3	3	3	2	2	1	1
CO4	2	3	2	1	3	2	1
CO5	3	2	2	2	1	1	2

3 = Highly Related; 2 = Medium; 1 = Low

BBI026C: Metabolic Pathways — Credit(s): 3

Unit-I

Carbohydrate metabolism: Glycolysis, Fermentation, Citric acid cycle, Oxidative Phosphorylation and ETS, Gluconeogenesis, Glycogenesis and Glycogenolysis, HMP shunt.

Unit-II

Amino acid metabolism: Transamination, deamination, oxidative deamination, Amino acid degradation & Biosynthesis, Urea cycle and its regulation.

Unit-III

Lipid metabolism: Fatty acid degradation (beta, alpha, and omega degradation), degradation of odd chain fatty acids, Fatty acid synthesis, Regulation of fatty acid metabolism. Cholesterol Biosynthesis.

Unit-IV

Nucleotide metabolism: Synthesis of purines & pyrimidines nucleotides, salvage pathway, nucleotide degradation.

Unit-V

Associated metabolic disorders: Lesch-Nyhan syndrome, SCID syndrome, Ketone Bodies formation and degradation.

Text / Reference Books

1. General Microbiology: E E Conn, P K Stumpf, G Bruening and R Y; 1987, John Wiley and Sons,
2. Principles of Biochemistry: Jeffory Zubey, 1997, McGraw-Hill College.
3. Biochemistry: Jeremy M Berg, John L Tymoczko, and Lubert Stryer, 2002, W.H. Freeman.
4. Principles of Biochemistry: Donald Voet, Judith G. Voet, Charlotte W. Pratt, 2018, Wiley.
5. Principles of Biochemistry: David L. Nelson, Michael M. Cox; Lehninger, 2017, WH Freeman.

BBI214A: Metabolic Pathways Lab Credit(s): 1

Course Outcomes

CO1: Students will demonstrate the ability to estimate carbohydrates and reducing sugars using standard colorimetric methods such as Anthrone assays.

CO2: Students will estimate nucleic acids (DNA and RNA) quantitatively using DPA and Orcinol methods.

CO3: Students will analyze protein estimation using Biuret and Bradford assays and interpret the results accurately.

CO4: Students will determine physicochemical properties of lipids such as acid value and saponification value of oils.

CO5: Students will separate and identify amino acids using paper chromatography.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course Outcome	Program Outcome						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	2	2	1	1
CO2	3	2	1	3	1	0	1
CO3	3	3	2	1	1	1	0
CO4	3	2	1	0	0	1	1
CO5	3	3	1	1	0	1	0

3 = Highly Related; 2 = Medium; 1 = Low

1. To perform Quantitative estimation of carbohydrates by Anthrone method
2. To perform acid value for given oil
3. To perform Quantitative estimation of RNA using Orcinol method
4. To perform Quantitative estimation of DNA using DPA method
5. To separate Amino acid using paper chromatography
6. To Determine saponification value of oil

7. To perform Quantitative estimation of Protein by Biuret method
8. To perform Quantitative estimation of Protein by Bradford method
9. To perform Quantitative estimation of reducing sugar

Virtual Labs Link

S. No.	Course Name	Sources	Link
1	Biochemistry Virtual Lab I	Amrita Vishwa Vidyapeetham	http://biotech01.vlabs.ac.in/
2	Biochemistry Virtual Lab II	Amrita Vishwa Vidyapeetham	https://vlab.amrita.edu/?sub=3&brch=64

SEMESTER III

S. No.	Semester	Course code	Course	Course Type	Lecture Hours	Tutorial Hours	Practical Hours	Total Hours	Lecture Credit	Tutorial Credit	Practical Credit	Total Credits
1	3	BMI190A	Molecular Biology	Major Core	3	0	0	3	3	0	0	3
2	3	BMI191A	Molecular Biology Lab	Major Core Lab	0	0	2	2	0	0	1	1
3	3	BMI192A	Diversity of Microorganism	Major Core	3	0	0	3	3	0	0	3
4	3	BMI193A	Diversity of Microorganism Lab	Major Core Lab	0	0	2	2	0	0	1	1
5	3		Minor 3	Minor	3	0	0	3	3	0	0	3
6	3		Minor Lab 3	Minor Lab	0	0	2	2	0	0	1	1
7	3		Leadership and Management Skill	AEC	2	0	0	2	2	0	0	2
8	3		Any of IKS Basic Courses	VAC	2	0	0	2	2	0	0	2
9	3		Prompt Engineering (Generative AI) Program Specific	SEC	0	0	4	4	0	0	2	2
10	3		EDP	SEC	0	0	2	2	0	0	1	1
11	3		Open Elective 2	Multidisciplinary	3	0	0	3	3	0	0	3
				Total	**16**	**0**	**12**	**28**	**16**	**0**	**6**	**22**

B.Sc. Semester-III
Course - Molecular Biology
Course code-BMI190A
Lectures: 3Hrs/week

Course Outcome

Students will able to

CO1: Describe the structure of DNA, RNA, and chromatin organization.

CO2: Explain the basic process of DNA replication and repair.

CO3: Understand the transcription process and RNA modifications.

CO4: Outline the steps of protein synthesis and its regulation.

CO5: Recognize key concepts in gene regulation and genetic engineering.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course Outcome	Program Outcome						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	2	2	3	2	2
CO2	3	2	2	2	3	2	2
CO3	3	2	2	1	2	2	2
CO4	3	2	2	1	2	2	2
CO5	3	3	3	2	3	3	3

3 = Highly Related; 2 = Medium; 1 = Low

BMI190A: Molecular Biology — Credit(s): 3

Unit I

Structure and types of DNA and RNA, properties of nucleic acids, basic organization of genetic material in prokaryotes and eukaryotes, concept of gene and genome.

Unit II

DNA replication in prokaryotes, enzymes involved (polymerase, ligase, helicase), semi-conservative model, DNA damage and repair mechanisms.

Unit III

Transcription process in prokaryotes, role of RNA polymerase, basic concept of promoters and terminators, Types of RNA, RNA splicing and capping.

Unit IV

Structure and role of ribosomes and tRNA, genetic code, steps of translation – initiation, elongation, and termination, post-translational changes.

Unit V

Operon model of gene regulation: Lac operon, Trp operon, Arabinose operon. Gene expression, restriction enzymes, vectors, gene cloning.

Suggested Readings

1. Verma, P. S., & Agarwal, V. K. (2020). *Cell biology, genetics, molecular biology, evolution and ecology* (Rev. ed.). S. Chand Publishing.
2. De Robertis, E. D. P., & De Robertis, E. M. F. (2017). *Cell and molecular biology* (8th ed.). Lippincott Williams & Wilkins.
3. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. (2014). *Molecular biology of the gene* (7th ed.). Pearson Education.
4. Karp, G. (2013). *Cell and molecular biology: Concepts and experiments* (7th ed.). Wiley.
5. Malacinski, G. M. (2008). *Essentials of molecular biology* (4th ed.). Jones & Bartlett Learning.
6. Satyanarayana, U. (2019). *Biotechnology* (Rev. ed.). Books & Allied (P) Ltd.

BMI191A: Molecular Biology Lab — Credit(s): 1

Course Outcomes

Student will able to

CO1: Perform basic experiments to isolate DNA and RNA from biological samples.

CO2: Visualize DNA using agarose gel electrophoresis.

CO3: Understand and perform basic steps of PCR.

CO4: Use restriction enzymes to cut DNA and observe the results.

CO5: Use simple online tools for DNA sequence analysis.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course Outcome	Program Outcome						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	2	2	3	2	2
CO2	3	2	2	1	3	2	2
CO3	2	2	2	1	2	1	2
CO4	3	2	2	1	2	2	3
CO5	3	2	3	2	3	2	2

3 = Highly Related; 2 = Medium; 1 = Low

1. Preparation of buffers used in molecular biology
2. Isolation of Genomic DNA from Bacteria
3. Estimation of DNA concentration using Diphenylamine method
4. Preparation of reagents and casting of agarose gel for electrophoresis
5. Agarose Gel Electrophoresis of DNA
6. Visualization of DNA Bands and Interpretation of Gel Results
7. Plasmid DNA Isolation from E. coli
8. RNA Isolation from Plant Tissue
9. PCR Amplification (Polymerase Chain Reaction)

10. Restriction Digestion of DNA Using Restriction Enzymes

Virtual Labs Link

S. No.	Course Name	Source	Link
1.	Molecular Biology Virtual Lab I	Amrita Vishwa Vidyapeetham	http://mbvi-au.vlabs.ac.in/
2.	Molecular Biology Virtual Lab II	Amrita Vishwa Vidyapeetham	https://mbvii-au.vlabs.ac.in/
3.	Biomedical and Signal Processing Laboratory	COEP, Pune	https://bmspcoep.vlabs.ac.in /List%20of%20experiments.html? domain=Biotechnology

B.Sc. Semester-III
Course- Diversity of Microorganism
Course Code: BMI192A
Lectures: 3 Hrs/week

Course Outcome

Student will able to
CO1- Understand the history of microbiology and classification of microorganism.
CO2- Understand the scope and classification system
CO3- Analyze the structural organization of microorganism.
CO4- Understand the cellular structure, biosynthesis and function of bacterial system.
CO5- Evaluate the structures of algae, fungi and protozoan.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course Outcome	Program Outcome						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	3	3	1	1	2	2
CO2	3	3	3	2	1	1	2
CO3	3	3	3	3	2	1	2
CO4	2	2	3	3	3	2	1
CO5	2	3	3	3	2	2	1

3 = Highly Related; 2 = Medium; 1 = Low

BMI192A: Diversity of Microorganism Credit(s): 3

Unit-I

History of Microbiology – Overview, Biogenesis and abiogenesis, golden age of microbiology and development in the field of medical microbiology, immunology, environmental microbiology, contributions of Robert Hooke, Antonie von Leeuwenhoek, Redi, Spallanzani, Needham, Pasteur, Tyndal, Joseph Lister, Robert Koch (Germ Theory), Edward Jenner and Alexander Flemming, Martinus Beijerinck

Unit -II
Principles of classification, systematics and taxonomy, conventional, molecular and recent approaches to polyphasic bacterial taxonomy. Binomial Nomenclature, Whittaker's five kingdom and Carl Woese's three kingdom classification systems and their utility.

Unit -III
General characteristics, occurrence, structure, reproduction and importance of bacteria, Algae, Fungi, Protozoa, wall-less forms - MLO (mycoplasma and spheroplasts); Beneficial and harmful microbes and their role in daily life.

Unit -IV
Bacterial morphology and subcellular structures; Slime layer, Capsule, Cell wall, cell membrane, Ribosome, inclusion bodies - inorganic, organic; Exospores & Cysts: types & structure. Plasmids and episomes. Differences between eubacteria and archaebacteria.

Unit –V
Methods of studying microorganism; Staining techniques: simple staining, Gram staining, negative staining and acid-fast staining. Sterilization techniques (physical & chemical sterilization). Culture media & conditions for microbial growth. Pure culture isolation: Streaking, serial dilution and plating methods; cultivation, maintenance and preservation of pure cultures.

Suggested readings:

1. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR, General Microbiology, 5th edition, 2005, McMillan.
2. Atlas, Principles of Microbiology, 2nd ed.,1997, McGraw-Hill
3. Alexopoulos CJ, Mims CW, and Blackwell M, Introductory Mycology. 4thedition, 1996, John and Sons, Inc.
4. Cappucino J and Sherman N., Microbiology: A Laboratory Manual. 9thedition, 2010, Pearson Education limited.
5. Kumar HD., Introductory Phycology, 2ndedition, 1990, Affiliated East Western Press.
6. Madigan MT, Martinko JM and Parker J., Brock Biology of Microorganisms.12th edition, 2009, Pearson/Benjamin Cummings.
7. Pelczar MJ, Chan ECS and Krieg NR., Microbiology. 5thedition, 1993, McGraw Hill Book Company.
8. Tortora GJ, Funke BR, and Case CL., Microbiology: An Introduction, 9th edition, 2008, Pearson Education.

BMI193A: Diversity of Microorganism Lab Credit(s): 1

Course Outcomes
Student will able to
CO1- Analyze the simple techniques of the bacteria and fungi.
CO2- Analyze the morphological structure of microbes.
CO3- Evaluate the identification of cyanobacteria, algae and fungi.
CO4- Analyze the identification of viruses.
CO5- Analyze the motility of bacteria and examination of free-living protozoan.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3

Outcomes (COs)										
CO1	3	3	2	2	3	2	2	3	3	2
CO2	3	3	2	1	3	1	2	3	3	2
CO3	3	3	2	2	3	1	2	3	3	2
CO4	3	2	2	1	2	1	2	3	2	2
CO5	2	3	2	1	2	1	2	2	3	2

3 = Highly Related; 2 = Medium; 1 = Low

1) Demonstration of sterilization by moist heat using autoclave.
2) Preparation of culture media – liquid and solid media.
3) Preparation of bacterial smear.
4) Simple staining of bacteria and fungi.
5) Identification of common morphological forms of bacteria.
6) Identification of Cyanobacteria (blue-green algae).
7) Identification of some common fungi (*Aspergillus, Penicillum, Mucor* and *Rhizopus*).
8) Identification of common algae.
9) Demonstration and explanation of different types of viruses.
10) Demonstration of Simple staining.
11) Microscopic examination of free-living protozoa of a pond.
12) Hanging drop technique demonstrating motility of Bacteria.

Virtual Labs link

S. No.	Course Name	Source	Link
1.	Microbiology Virtual Lab I	Amrita Vishwa Vidyapeetham	https://mvi-au.vlabs.ac.in/
2.	Microbiology Virtual Lab II	Amrita Vishwa Vidyapeetham	https://vlab.amrita.edu/?sub=3&brch=76

Recommended Books:

1. Cappuccino, J. G., & Welsh, C. (2020). Microbiology: A Laboratory Manual (12th ed.). Pearson.
2. Aneja, K. R. (2009). Experiments in microbiology, plant pathology and biotechnology (Reprint ed.). New Age International. ISBN 81-224-1494-X

SEMESTER IV

S. No.	Semester	Course code	Course	Course Type	Lecture Hours	Tutorial Hours	Practical Hours	Total Hours	Lecture Credit	Tutorial Credit	Practical Credit	Total Credits
1	4	BBI033C	Introductory Immunology	Major Core	3	0	0	3	3	0	0	3
2	4	BBI218A	Introductory Immunology Lab	Major Core Lab	0	0	2	2	0	0	1	1
3	4	BBI219A	Introductory Genetic Engineering	Major Core	3	0	0	3	3	0	0	3
4	4	BBI220A	Introductory Genetic Engineering Lab	Major Core Lab	0	0	2	2	0	0	1	1
5	4		Minor 4	Minor	3	0	0	3	3	0	0	3
6	4		Minor Lab 4	Minor Lab	0	0	2	2	0	0	1	1
7	4		Universal Human Value	AEC	2	0	0	2	2	0	0	2
8	4		Any of IKS Elective Course	VAC	2	0	0	2	2	0	0	2
9	4		R with Python (Program Specific)	SEC	0	0	4	4	0	0	2	2
				Total	**13**	**0**	**10**	**23**	**13**	**0**	**5**	**18**

B.Sc. Semester-IV
Course name- Introductory Immunology
Course Code- BBI033C
Lectures: 3Hrs/week

Course Outcome

Student will able to

CO1- Explain the historical development, scope, and types of immunity including innate and acquired responses.

CO2- Describe hematopoiesis and distinguish the roles of various cells and organs involved in the immune system.

CO3- Analyze the properties of antigens and immunogens, including factors affecting immunogenicity, and identify epitopes and haptens.

CO4- Illustrate the structure and functions of different classes of immunoglobulins and explain the production and application of monoclonal antibodies.

CO5- Demonstrate understanding of antigen-antibody interactions and compare immunological assays like ELISA, RIA, Western blot, and flow cytometry.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

CO Code	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	2	1	1	0	2	1	3	2	0
CO2	3	1	2	2	1	2	2	3	2	0
CO3	3	1	3	2	0	2	1	3	3	0
CO4	3	2	2	2	2	2	2	3	3	2
CO5	3	2	3	2	1	3	2	3	3	2

3 = Highly Related; 2 = Medium; 1 = Low

BBI033C: Introductory Immunology Credit(s): 3

Unit-I
Overviews of the immune system: Historical perspectives. Types of immunity: Innate and acquired.

Unit-II
Hematopoiesis and differentiation; Cells and organs of the immune system.

Unit-III
Antigen: Immunogenicity v/s antigenicity, factors affecting immunogenicity, nature of immunogen, biological system, epitopes, haptens and antigenicity. Basics of antigen processing and presentation.

Unit-IV
Immunoglobulins: Structure of antibody, antibody mediated effector functions, antibody classes and biological activities; Monoclonal antibodies: Production and applications.

Unit-V
Antigen-Antibody interactions: types: precipitation and agglutination reaction, radioimmunoassay, ELISA, chemiluminescence, ELISPOT assay, western blot, immune precipitation, immunofluorescence, flow cytometry and fluorescence.

Text / Reference Books

1. Delves, P. J., Martin, S. J., Burton, D. R., & Roitt, I. M. (2016). Roitt's essential immunology (13th ed.). Wiley-Blackwell.
2. Owen, J. A., Punt, J., Stranford, S. A., & Jones, P. P. (2013). Kuby immunology (7th ed.). W. H. Freeman and Company.
3. Austyn, J. M., & Wood, K. J. (1993). Principles of cellular and molecular immunology. Oxford University Press.
4. Abbas, A. K., Lichtman, A. H., & Pillai, S. (2021). Basic immunology: Functions and disorders of the immune system (6th ed.). Elsevier.
5. Goldsby, R. A., Kindt, T. J., Osborne, B. A., & Kuby, J. (2007). Immunology (6th ed.). W. H. Freeman.
6. Male, D., Brostoff, J., Roth, D. B., & Roitt, I. (2012). Immunology (8th ed.). Mosby/Elsevier.
7. Parham, P. (2009). The immune system (3rd ed.). Garland Science.
8. Coico, R., & Sunshine, G. (2015). Immunology: A short course (7th ed.). Wiley-Blackwell.

BBI218A: Introductory Immunology Lab Credit(s): 1

Course Outcome

Student will able to

CO1 Demonstrate laboratory safety protocols, sterile techniques, and good lab practices specific to immunological experiments.

CO2 Identify and describe the structure and function of primary and secondary lymphoid organs using charts, models, and microscopy.

CO3 Perform and interpret basic haematological techniques such as TLC, DLC, and RBC count, and identify leukocyte types under a microscope.

CO4 Conduct and analyze basic antigen-antibody interactions through agglutination, precipitation, and ELISA techniques.

CO5 Understand and evaluate advanced immunological techniques such as immunoelectrophoresis, Western blotting, flow cytometry, and hybridoma technology.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	1	1	0	1	2	2	1	1	1	0
CO2	2	1	1	2	0	1	0	2	1	0
CO3	2	1	2	2	2	2	1	2	2	1
CO4	2	2	2	2	2	2	1	2	2	2
CO5	2	2	2	2	2	2	2	2	2	2

3 = Highly Related; 2 = Medium; 1 = Low

1. Introduction to Immunology Laboratory Safety and Good Lab Practices
2. Study of Primary and Secondary Lymphoid Organs through Charts and Models
3. Preparation of Blood Smear and Identification of WBCs under Microscope
4. Total Leukocyte Count (TLC)
5. Differential Leukocyte Count (DLC)
6. Total Red Blood Cells (RBCs) Count
7. Antigen-Antibody Reaction: Agglutination using Blood Typing Kit
8. Precipitation Reaction: Ouchterlony Double Immunodiffusion
9. Precipitation Reaction: Radial Immunodiffusion
10. Immunoelectrophoresis (demonstration or simulation)
11. ELISA (Enzyme Linked Immunosorbent Assay) – Qualitative Detection (e.g., DOT-ELISA)
12. Western Blotting (Demonstration or protocol study)
13. Flow Cytometry (Virtual demonstration/simulation)
14. Monoclonal Antibody Production – Study of Hybridoma Technology (chart/model/video)

Course name- Introductory Genetic Engineering
Course Code-BBI219A
Lectures: 3 Hrs/week

Course Outcome

CO-1 Students will be able to define the term regulation as it applies to genes. Discuss different components of prokaryotic and eukaryotic gene regulation.
CO-2 Students will be able to explain technical know-how on versatile tools and techniques in recombinant DNA technology. Describe the events involved in generating recombinant DNA molecules, to include cDNA generation.
CO-3 Students will able to explain the different expression vectors and the choice of host cell
CO-4 Students will be able to understand the different genetic engineering techniques in basic and applied experimental biology.
CO-5 Students will be able to understand the application of genetic engineering techniques in basic and applied experimental biology.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course Outcome	Program Outcome						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	1	2	2	1	2	2
CO2	2	1	1	2	3	1	1
CO3	3	2	2	1	1	2	2
CO4	2	1	2	1	1	1	1
CO5	3	1	2	1	1	1	1

3 = Highly Related; 2 = Medium; 1 = Low

BBI219A: Introductory Genetic Engineering Credit(s): 3

Unit-I

Expression of genes in prokaryotic and eukaryotic systems: Gene structure in prokaryotic and eukaryotic cells. Gene expression – concept of central dogma of life.

Unit-II

Tools and Techniques of gene cloning Restriction endonuclease, Ribonucleases, taq DNA, SI nuclease, Alkaline phosphatase, klenow enzyme, methyl transferase, Polymerase chain reaction, DNA Probe, Genomic and cDNA Library, Southern, Western and Northern blotting
Preparation of desired gene by genomic DNA, from reverse transcriptase and by gene machine.

Unit-III

Vectors: bacteriophage, cosmids, plasmids as vector, pBR322, pUC, yeast artificial chromosome, shuttle and binary vectors, Lac Z gene, Reporter Gene

Unit-IV

Different method of Ligation and transformation of rDNA into the host cell, Direct transformation, Microinjection, liposome method, Electroporation, Selection of Recombinants- using different methods, colony hybridization immunological method.

Unit-V

Application of rDNA technology Transgenic Plants, Bt cotton, edible vaccine, Biodegradable plastic, Transgenic Animal- creation of Dolly, Super mouse, Animal Pharming, Genetic engineering and Health care products- Insulin, Somatotropin, Interferon, Factor VIII.

Text / Reference Books

1. Genetic Engineering, Cloning DNA: D.M. Glover, 1980Chapman and Hall, New York.
2. Biotechnology-4 (rDNA Technology, Environmental biotechnology, Animal cell culture): S. Mahesh and A.B. Vedamurthy, 2018, New Age.
3. Gene cloning and DNA analysis: T. A. Brown, 2020, Wiley Blackwell.
4. Principles of gene manipulation and genetics: S.B. Primrose and R.M. Twyman, 2006, Blackwell.

BBI220A: Introductory Genetic Engineering Lab Credit(s): 1

Course outcomes

Student will able to

CO1- Understand the different methods of molecular cloning and estimation of DNA and RNA.
CO2- Understand the different methods of separation of biomolecules.
CO3- Students will be able to familiarize quantitative and qualitative estimation of biomolecules.
CO4- To understand the mathematical calculations.
CO5- Also able to understand characteristics of biomolecules.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course Outcome	Program Outcome						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	2	2	1	2
CO2	3	2	1	3	1	0	1
CO3	3	3	2	1	1	1	2
CO4	3	2	1	0	0	1	1
CO5	3	3	1	1	0	1	1

3 = Highly Related; 2 = Medium; 1 = Low

1. To Isolate the genomic DNA from bacteria.
2. To perform Isolation of plasmid from bacteria.
3. To perform Agarose gel electrophoresis for DNA separation.
4. To perform Restriction Digestion DNA/plasmid.
5. To perform DNA isolation from plant by CTAB method.
6. To perform Ligation.
7. To estimate DNA by DPA method.
8. To determine the molecular weight of DNA.

9. To estimate the amount of RNA by Orcinol method.
10. To isolate DNA from Onion cell.

SEMESTER V

S. No.	Semester	Course code	Course	Course Type	Lecture Hours	Tutorial Hours	Practical Hours	Total Hours	Lecture Credit	Tutorial Credit	Practical Credit	Total Credits
1	5	BBI221A	Bioprocess Engineering	Major Core	3	0	0	3	3	0	0	3
2	5	BBI222A	Bioprocess Engineering Lab	Major Core Lab	0	0	2	2	0	0	1	1
3	5		Major DSE 1	Major DSE	3	0	0	3	3	0	0	3
4	5		Major DSE Lab 1	Major DSE Lab	0	0	2	2	0	0	1	1
5	5		Major DSE 2	Major DSE	3	0	0	3	3	0	0	3
6	5		Major DSE Lab 2	Major DSE Lab	0	0	2	2	0	0	1	1
7	5		Major DSE 3	Major DSE	3	0	0	3	3	0	0	3
8	5		Major DSE Lab 3	Major DSE Lab	0	0	2	2	0	0	1	1
9	5		Minor 5	Minor	3	0	0	3	3	0	0	3
10	5		Minor Lab 5	Minor Lab	0	0	2	2	0	0	1	1
				Total	**15**	**0**	**10**	**25**	**15**	**0**	**5**	**20**

B.Sc. Semester-V
Subject- Bioprocess Engineering
BBI221A
Lectures: 3Hrs/week

Course Outcome

Students will able to

CO1	Explain the scope, objectives, and basic principles of fermentation technology including types of microbial cultures and classification of metabolites.
CO2	Analyze the criteria for selection and improvement of industrial microbial strains and describe the production of stock cultures.
CO3	Demonstrate the process of inoculum development, medium formulation, and sterilization involved in fermentation technology.
CO4	Interpret the design and function of bioreactor components such as impeller, baffles, and sparger, along with process control systems including computer applications.
CO5	Evaluate downstream processing techniques including cell harvesting, cell disruption, product recovery, and purification processes.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	1	2	2	0	2	1	3	2	2
CO2	3	1	3	2	2	2	1	3	3	3
CO3	3	1	2	2	3	2	2	3	3	3
CO4	3	2	3	2	3	2	2	3	3	3
CO5	3	1	3	2	3	3	2	3	3	3

3 = Highly Related; 2 = Medium; 1 = Low

BBI221A: Bioprocess Engineering — Credit(s): 3

Unit-I

Introduction, objectives, and scope of fermentation technology. Types of microbial culture systems: batch, fed-batch, and continuous.

Unit-II

Selection and characteristics of industrial microorganisms. Strain improvement techniques: mutation, selection, recombinant DNA technology. Preparation and maintenance of stock cultures.

Unit-III

Definition and major stages of fermentation process. Inoculum development and scale-up. Formulation and optimization of fermentation media. Methods of medium sterilization.

Unit-IV

Design and components of bioreactors: impellers, baffles, spargers. Measurement and control of

process parameters (pH, temperature, aeration, agitation). Overview of computer-aided process control systems.

Unit-V

Principles and steps of downstream processing: cell harvesting (filtration, centrifugation), cell disruption techniques, product isolation and purification, distillation, drying, and formulation (finishing steps).

Text / Reference Books

1. Shuler, M. L., & Kargi, F. (2017). Bioprocess engineering: Basic concepts (3rd ed.). Pearson. ISBN: 9780137062706
2. Doran, P. M. (2013). Bioprocess engineering principles (2nd ed.). Academic Press. ISBN: 9780122208515
3. Crueger, W., & Crueger, A. (2000). Biotechnology: A textbook of industrial microbiology (2nd ed.). Sinauer Associates. ISBN: 9780878932140
4. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2016). Principles of fermentation technology (3rd ed.). Butterworth-Heinemann. ISBN: 9780080999531
5. Satyanarayana, U. (2005). Biotechnology. Books and Allied (P) Ltd. ISBN: 81-224-1494-X
6. Wulf, P., & Luedeking, R. (2006). Industrial microbiology. McGraw-Hill Education. ISBN: 9780070667033
7. Mansi, E. M. T. E. F. A., & Bryce, C. F. A. (2002). Fermentation microbiology and biotechnology (2nd ed.). Taylor & Francis. ISBN: 9780849315998

BBI222A: Bioprocess Engineering Lab Credit(s): 1

Course Outcomes

Students will able to

CO1- Demonstrate aseptic techniques, media preparation, and sterilization procedures essential for microbial culture and fermentation.

CO2- Perform inoculum preparation, scale-up, and handling of microbial cultures used in industrial bioprocesses.

CO3- Operate and monitor small-scale batch and fed-batch fermentation systems and analyze growth kinetics.

CO4- Execute downstream processing steps such as centrifugation, cell disruption, and product recovery for bioproduct isolation.

CO5- Evaluate bioreactor design components and perform basic measurements and controls used in fermentation systems.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course Outcome (CO)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	2	2	3	2	1
CO2	3	2	3	2	3	2	2	3	3	2
CO3	3	2	3	2	3	2	2	3	3	2
CO4	3	2	3	2	3	2	1	2	3	2
CO5	3	2	3	2	3	2	2	2	3	2

3 = Highly Related; 2 = Medium; 1 = Low

List of practicals

1. Introduction to fermentation laboratory and safety practices
2. Demonstration of batch, fed-batch, and continuous culture using schematic models
3. Isolation and screening of industrially important amylase producing microorganisms
4. Isolation and screening of industrially important citrate utilizing microorganisms
5. Observation of primary vs secondary metabolite production using paper chromatography
6. Strain improvement by UV mutagenesis (demonstration/simulation)
7. Preparation of production and stock cultures
8. Formulation of fermentation media and sterilization
9. Inoculum preparation and scale-up steps
10. Study and sketch of laboratory-scale fermenter (bioreactor)
11. Demonstration/Simulation of impeller, sparger, and baffle working in bioreactors
12. Monitoring microbial growth using optical density (OD) method
13. Effect of pH, temperature, and agitation on fermentation process
14. Cell harvesting by centrifugation and filtration
15. Product recovery by solvent extraction or distillation (demonstration)

SEMESTER VI

S.No.	Semester	Course code	Course	Course Type	Lecture Hours	Tutorial Hours	Practical Hours	Total Hours	Lecture Credit	Tutorial Credit	Practical Credit	Total Credits
1	6	BBI100A	Fundamental of Industrial Biotechnology	Major Core	3	0	0	3	3	0	0	3
2	6	BBI101A	Industrial Biotechnology Lab	Major Core Lab	0	0	2	2	0	0	1	1
3	6		Major DSE 4	Major DSE	3	0	0	3	3	0	0	3
4	6		Major DSE Lab 4	Major DSE Lab	0	0	2	2	0	0	1	1
5	6		Minor 6	Minor	3	0	0	3	3	0	0	3
6	6		Minor Lab 6	Minor Lab	0	0	2	2	0	0	1	1
7	6	BBI224A	Project	Major Core	0	0	8	8	0	0	4	4
8	6		Open Elective 3	Multidisciplinary	3	0	0	3	3	0	0	3
9	6	BBI225A	Basics of Bioinformatics Lab	Major core	0	0	4	4	0	0	2	2
			OR									
10	6	BBI226A	Summer internship	Summer internship	2	0	0	2	2	0	0	2
				Total	**14**	**0**	**14**	**28**	**14**	**0**	**7**	**21**

B.Sc. Semester-VI
Course name – Fundamental of Industrial Biotechnology
Course code- BBI100A
Lectures: 3 Hrs/week

Course outcome:
Students will be able to:
CO1: Explain the scope, commercial potential, and historical development of industrial biotechnology in India.
CO2: Describe microbial fermentation processes and compare traditional vs modern bioprocesses.
CO3: Outline production methods for primary and secondary metabolites with process flow diagrams.
CO4: Detail industrial-scale production of enzymes and bioproducts (e.g. SCP, biopolymers).
CO5: Illustrate modern biotechnology products production, including recombinant proteins, vaccines, and monoclonal antibodies.

Mapping of PO/CO

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	1	1	1	3	1	1
CO2	3	1	3	3	2	2	1
CO3	1	3	1	3	3	2	2
CO4	3	3	1	3	1	2	1
CO5	3	1	3	2	2	1	2

1-Low, 2-Medium, 3-High

UNIT – I
Biotechnology: Scope and importance, Commercial potential of Biotechnology in India. Historical overview of industrial fermentation process -traditional and modern Biotechnology. Industrial Fermentation- microorganisms, mode of operation, fermentation processes-pictorial representation

UNIT – II
A brief outline of processes for the production of some commercially important organic acids (citric acid, lactic acid & acetic acid); amino acids (glutamic acid & tryptophan) and alcohols (ethanol & butanol)

UNIT – III
Production processes for various classes of secondary metabolites: antibiotics: (penicillin streptomycin & erythromycin), vitamins (Vit B12 and Vit B2) and steroid biotransformation.

UNIT – IV
Production of industrial enzymes (proteases & amylases), Production of biopesticide, Biofertilizers, bio preservative (Nisin), biopolymers (xanthan gum & PHB), cheese, SCP.

UNIT – V
Production of recombinant proteins having therapeutic and diagnostic applications (insulin, human growth hormone), Production of recombinant vaccines (Hepatitis B vaccine, cholera vaccine), production of monoclonal antibodies.

TEXT BOOKS:

1. Lee, S.Y., Nielsen, J. and Stephanopoulos, G., "Industrial Biotechnology: Products and Processes", John Wiley & Sons, 2016.
2. Waites, M.J., Morgan, N.L., Rockey, J.S., Higton, G., "Industrial Microbiology: An Introduction" Blackwell, 2001.
3. Cruger, W., Cruger, A., "A Textbook of Industrial Microbiology", Panima Publishing Corporation, 2nd Edition, 2005.

BBI101A: Industry Biotechnology Lab **Credit(s): 1**

Course Outcomes

Students will be able to:

CO1: Demonstrate aseptic techniques and microbial isolation methods for industrial fermentation microbes (e.g. *Aspergillus*, *Saccharomyces*, *Clostridium*).

CO2: Operate batch and fed-batch bioreactor setups to produce primary metabolites such as ethanol, citric acid, or lactic acid, and monitor key parameters (pH, dissolved oxygen, biomass).

CO3: Perform enzyme production and quantitative assay (e.g. protease, amylase), calculate specific activity, and interpret results.

CO4: Conduct downstream processing for recovery and purification of fermentation products (e.g. precipitation, filtration, chromatographic separation).

CO5: Analyze bioproducts qualitatively and quantitatively (e.g. antibiotic titer, vitamin content, polymer yield like xanthan or PHB) using standard analytical assays.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course Outcome	Program Outcome						
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
CO1	3	1	3	1	2	1	1
CO2	2	2	2	2	1	1	1
CO3	1	3	2	1	1	1	1
CO4	2	2	2	1	1	3	2
CO5	3	2	2	1	3	1	1

3 = Highly Related; 2 = Medium; 1 = Low

1. Isolation and screening of fermentation microbes in pure culture
2. Batch/fed-batch fermentation (ethanol, citric acid, lactic acid)
3. Enzyme (protease/amylase) production and quantitative assay
4. Downstream separation for product recovery (filtration, precipitation)
5. Analytical determination: antibiotic titer, biopolymer yield
6. Expression and affinity purification of recombinant protein in bacterial system
7. Lab safety, sterile technique validation, documentation practices

Course code: BBI225A
Course name- Basics of Bioinformatics Lab
Credit(s): 1

Course Outcomes

CO1 Understand the different data bases.
CO2 Retrieve and analyze 3D structures of proteins and nucleic acids from structural databases such as PDB.
CO3 Visualize and interpret structural features of biomolecules using tools like PyMOL, Chimera, or RasMol.
CO4 Compare and classify protein structures using SCOP, CATH, and related classification systems.
CO5 Perform homology modeling and validate predicted structures using tools like SWISS-MODEL and PROCHECK.

CO/PO Mapping

Course Outcome	Program Outcome						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	3	1	1	2
CO2	2	3	2	3	1	2	2
CO3	2	2	3	3	1	2	2
CO4	2	2	3	3	1	2	3
CO5	3	2	3	3	2	2	3

3 = Highly Related; 2 = Medium; 1 = Low

1. To study the different data bases.
2. To retrieve the protein sequences from NCBI database and to interpret the results.
3. To study protein X-ray diffraction data by using Protein Structure Database.
4. To find the conserved Domains in Protein Sequences.
5. To analyse the retrieve protein sequence for Ramachandran Plot by using PSVS.
6. To study structural features of RNA by using different RNA database and softwares.
7. To determine the motifs, present in your target proteins.
8. To perform homology alignment by using pdb-BLAST.

SEMESTER VII

S. No.	Semester	Course code	Course	Course Type	Lecture Hours	Tutorial Hours	Practical Hours	Total Hours	Lecture Credit	Tutorial Credit	Practical Credit	Total Credits
1	7	BBI069A	Animal Tissue Culture	Major core	3	0	0	3	3	0	0	3
2	7	BBI039D	Animal Tissue culture Lab	Major core	0	0	2	2	0	0	1	1
3	7		Major DSE 5	Major DSE	3	0	0	3	3	0	0	3
4	7		Major DSE Lab 5	Major DSE Lab	0	0	2	2	0	0	1	1
5	7		Minor 7	Minor	3	0	0	3	3	0	0	3
6	7		Minor Lab 7	Minor Lab	0	0	2	2	0	0	1	1
7	7		Minor 8	Minor	3	0	0	3	3	0	0	3
8	7		Minor Lab 8	Minor Lab	0	0	2	2	0	0	1	1
9	7	BBI200A	Major 13 (Research Methodology)	Major Core	3	1	0	4	3	1	0	4
				Total	**15**	**1**	**8**	**24**	**15**	**1**	**4**	**20**

B.Sc. Semester-VII
Course –Animal Tissue culture
Course Code – BBI069A
Lectures: 3Hrs/week

Course outcome

Students will able to

CO1: Understand the history, development, applications, equipment, media, and sterile techniques in animal tissue culture.
CO2: Identify types of tissues, culture media (MEM, DMEM, RPMI, Ham's), and steps in establishing primary and established cell lines, including subculture strategies and preservation.
CO3: Perform cell counting, viability and cytotoxicity assays, and interpret cell growth parameters.
CO4: Apply knowledge of gene therapy approaches (ex vivo/in vivo), specialized culture applications (e.g. vaccine production, tissue engineering).
CO5: Describe transgenic animal generation methods (retroviral, microinjection, ES-cell), and understand applications in biopharming, disease modeling, and knockouts.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	2	2	1	1	1
CO2	3	3	2	2	0	0	1
CO3	3	2	3	2	1	0	2
CO4	3	2	3	2	1	0	2
CO5	3	2	1	3	2	1	0

1-LOW, 2-MEDIUM, 3-HIGH

Unit-1

History and development of animal tissue culture; Application of animal tissue culture, Equipment and materials (culture vessels, CO_2 incubator, inverted microscope, cell counters). Principles of sterile techniques and basic protocol of sterilization; Sources of tissues, types of tissues-epithelial, muscle, connective, nerve and blood; Introduction to balanced salt solutions.

Unit-2

Cell culture media-components of the medium, physical, chemical and metabolic functions of media; Role of serum and supplements, serum-free media, features and specifications of MEM, DMEM, RPMI and Ham's medium. Role of antibiotics in media; Primary culture- Mechanical and enzymatic mode of desegregation, establishment of primary culture; Subculture-passage number, split ratio, seeding efficiency, criteria for subculture; Cell lines- definite and

continuous cell lines, characterization, authentication, maintenance and preservation of cell lines.

Unit-3

Measurement of cell number- hemocytometer, coulter counter; Measurement of cell viability and cytotoxicity; Dye exclusion and inclusion tests, colonigenic assay, macro molecular estimation, MTT based assay. Measuring parameters of growth-growth curves, PDT, Plating efficiency and factors influencing growth.

Unit-4

Gene therapy-ex vivo and in vivo gene therapy methods, applications; Application of animal cell culture - Vaccine production, specialized cell types. Concepts of tissue engineering - skin, liver, kidney, bladder and heart

Unit-5

Transgenic animals-retroviral, micro inject ion, and engineered embryonic stem cell method of transgenesis; Application of transgenic animal's biopharming, disease models, functional knockouts.

Suggested Readings

1. Culture of Animal Cells, (3rd Edn) R Ian Fredhney. Wiley-Liss
2. Animal Cell Culture – Practical Approach, Ed. John RW. Masters, Oxford
3. Cell Growth and Division: A Practical Approach Ed. R. Basega, IRL Press
4. Cell Culture Lab Fax. Eds. M Butler & M Dawson, Bios
Scientific Publications, Ltd. Oxford
5. Animal Cell Culture Techniques Ed Martin Clynes, Springer
6. Methods in Cell Biology, Vol. 57, Animal Cell Culture Methods Ed. Jenni P Mather
7. David Bames. Academic Press
8. Animal Cell Technology, Principles and practices, 1987, Butter, M Oxford press
9. Animal Cell Biotechnology, 1990- Spier, RE and Griffith, JB Academic Press, London.

BBI039D: Animal Tissue Culture Lab Credit(s): 1

Course outcomes:

Students will able to

CO1- Master the fundamentals of animal tissue culture—including history, applications, lab equipment, sterilization protocols, tissue sources/types, and balanced salt solutions.

CO2- Prepare and handle various culture media (MEM, DMEM, RPMI, Ham's), including supplementation (serum, antibiotics), and establish primary/continuous cell cultures via mechanical or enzymatic disaggregation.

CO3- Execute quantitative assays: cell counting (hemocytometer/counter), viability/cytotoxicity (Trypan blue, dye inclusion/exclusion), MTT/cell proliferation assays, growth curves, PDT, and plating efficiency.

CO4-Apply theoretical knowledge of gene therapy (ex vivo/in vivo), tissue engineering (skin, liver, kidney, bladder, heart), and specialized culture use cases (vaccines, engineered cell types).

CO5- Understand methodologies for generating transgenic animals (retroviral vectors, microinjection, ES-cell engineering) and explore applications in biopharming, disease modeling, and functional knockouts.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course Outcome	Program Outcome						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	1	2	1	1
CO2	3	3	2	2	3	1	1
CO3	2	3	3	2	1	3	2
CO4	3	2	2	3	1	1	1
CO5	3	2	1	1	2	3	2

1-LOW, 2-MEDIUM, 3-HIGH

List of practicals

1. Familiarization with lab layout and equipment: CO_2 incubator, inverted microscope, biosafety cabinet, autoclave, pipettes, centrifuge, pH meter.
2. Aseptic techniques and basic sterilization protocols: washing glassware, autoclaving, filter sterilization, lab practices.
3. Preparation of balanced salt solutions (e.g. HBSS, PBS) and culture media with buffering and supplements.
4. Tissue sourcing and disaggregation: mechanical vs enzymatic (trypsin/collagenase) methods.
5. Initiation of primary culture: setting up explants or single-cell suspensions from epithelial, muscle, connective, nerve, or blood sources.
6. Observation of culture establishment and morphology.
7. Establishment and maintenance of definite vs continuous cell lines (e.g. Vero or fibroblast).
8. Subculturing: trypsinization of monolayer, split ratio, seeding density, passage number.
9. Cryopreservation and revival of cell lines.
10. Hemocytometer use for cell counting; calculation of cell density and viability via Trypan blue exclusion.
11. MTT-based cytotoxicity assay or other viability assays, dye exclusion/inclusion methods.
12. Plotting growth curves, computing doubling time (PDT) and plating efficiency.
13. Model ex vivo gene therapy manipulations in culture (transfection/transduction protocols, conceptual).
14. Design exercises: simulate vaccine production or tissue engineering (e.g., skin scaffold culture).
15. Experimental demonstration of transgenic concepts (e.g. microinjection model or ES-cell chimera design).

B.Sc. Semester – VII
Course - Research Methodology
Course code - BBI200A
Lectures: 3 Hrs/week

Course Outcome

CO-1 Students will be able to develop Research Aptitude, Logical Thinking and Reasoning.
CO-2 Students will be able to understand basic principles of Research Methodology and identify a Research Problem.
CO-3 Students will understand a general definition and process of Research Design.
CO-4 Students will identify the overall process of Designing a Research Study. from its inception to its Report.
CO-5 Students will become independent researchers in the respective domain of research.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course Outcome	Program Outcome						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	3	2	0	3	2
CO2	3	1	2	1	1	3	2
CO3	3	2	1	2	1	3	3
CO4	3	2	2	2	1	3	2
CO5	3	3	2	2	3	2	2

3 = Highly Related; 2 = Medium; 1 = Low

BBI200A: Research Methodology Credit(s): 3

Unit-I
Introduction to Research Methodology and Research Problem Meaning of Research; Objectives of Research; Motivation in Research; Types of Research; Research Approaches; Significance of Research; Research Methods versus Methodology; Research Process; Criteria of Good Research; Problems Encountered by Researchers in India.

Unit II
What is a Research Problem? Selecting the Problem; Necessity of Defining the Problem; Technique Involved in Defining a Problem. Research Design Need for Research Design; Features of a Good Design; Important Concepts Relating to Research Design; Different Research Designs; Basic Principles of Experimental Designs.

Unit III
Developing a Research Plan Collection of Primary Data; Observation Method; Interview Method; Collection of Data through Questionnaires; Collection of Data through Schedules; Other Methods of Data Collection, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Case Study Method.

Unit IV
Interpretation and Report Writing Meaning of Interpretation, Why Interpretation? Technique of Interpretation, Precautions in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports.

Unit V
Synopsis Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports. Internal Evaluation Submission of Research Report/ Project/ Case Study/Assignment.

Suggested Readings

1. Kothari, C. R. - Research Methodology: Methods and Techniques
2. Ranjit Kumar - Research Methodology: A Step-by-Step Guide for Beginners

SEMESTER VIII

S. No.	Semester	Course code	Course	Course Type	Lecture Hours	Tutorial Hours	Practical Hours	Total Hours	Lecture Credit	Tutorial Credit	Practical Credit	Total Credits
1	8		Major DSE 6	Major DSE	3	0	0	3	3	0	0	3
2	8		Major DSE Lab 6	Major DSE Lab	0	0	2	2	0	0	1	1
3	8		Major DSE 7	Major DSE	3	0	0	3	3	0	0	3
4	8		Major DSE Lab 7	Major DSE Lab	0	0	2	2	0	0	1	1
5	8	BBI206 A	Dissertation (In house)	Major core	0	0	24	24	0	0	12	12
			Total		**6**	**0**	**28**	**34**	**6**	**0**	**14**	**20**
			OR									
6	8	BBI204 C	Industry Internship / Dissertation (Experimental Research Outside Campus)	Major core	**0**	**0**	**40**	**40**	**0**	**0**	**20**	**20**

Course- Environmental Biology
Course code- BBI128A
Lectures: 3 Hrs/week

Course Outcome

CO-1 Students will be able to explain wastewater treatment and

CO-2 Students will be able to gain the knowledge about the biogas production and usages of composting.

CO-3 Students will be able to understand biological monitoring of hazardous wastes

CO-4 Students will be able to explain Biomining, bioleaching

CO-5 Students will be able to explain biosensors.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course Outcome	Program Outcome						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	1	2	2	1	2	2
CO2	2	1	1	2	0	1	1
CO3	3	2	2	1	2	2	2
CO4	3	2	1	0	0	2	1
CO5	3	2	1	1	0	1	1

3 = Highly Related; 2 = Medium; 1 = Low

BBI128A: Environmental Biology Credit(s): 3

Unit-I

Waste Water Treatment- Sources and classification of pollutants, BOD, COD, DO, TDS, Biological wastewater treatment, sewage treatment, primary treatment, secondary treatment, anaerobic digestion, tertiary treatment reuse of sewage.

Unit-II

Usages of waste- Biogas, Microbial hydrogen Production, Conversion of sugar to alcohol Gasohol, Anaerobic and aerobic composting.

Unit-III

Biological monitoring of hazardous wastes: degradation of Xenobiotic compounds, degrading agents, superbug, construction of superbug, bioremediation, In situ and Ex situ bioremediation, phytoremediation.

Unit-IV

Biomining definition bioleaching, microorganisms involved in bioleaching, in situ bioleaching, removal of metal from water, microbial enhancement of oil recovery, advantages of Biomining.

Unit V

Definition, Biosensors, types of biosensors, application of biosensors, Bioleaching, Enrichment of ores by microorganisms (Gold, Copper and Uranium) Environmental significance of genetically modified microbes, plants and animals.

Text / Reference Books

1. Fundamentals of Ecology: E. Odum, G. Barrett, 2004, Brooks/Cole
2. Wastewater Engineering – Treatment, Disposal and Reuse: Metcalf & Eddy, 2017, Tata McGrawhill
3. Environmental Pollution Control Engineering: Rao, C.S. 1999 New Age International,
4. Wastewater treatment for pollution control and reuse: S. R. Asolekar Arceiwala, S.J. Arceival, 2006, McGraw-Hill Professional.

BBI129A: Environmental Biology Lab Credit(s): 1

Course Outcomes

Students will able to

CO1- Understand the different methods of water sampling.
CO2- Understand the different methods to determine impurities of water samples.
CO3- students will be able to familiarize quantitative and qualitative estimation of sample.
CO4- to understand the mathematical calculations.
CO5- also able to understand characteristics of water.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course Outcome	Program Outcome						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	2	2	1	1
CO2	3	2	1	3	1	0	0
CO3	2	2	1	2	1	1	0
CO4	3	2	1	0	1	0	1
CO5	3	3	1	1	0	0	1

3 = Highly Related; 2 = Medium; 1 = Low

1. To determine temporary hardness.
2. To determine permanent hardness.
3. To determine total hardness.
4. To determine Alkalinity and Acidity of water.
5. To determine BOD in different water samples.
6. To determine COD in different water samples.
7. To determine DO of different water samples.
8. To determine Total Salts and Total Dissolved Salts of water.
9. To Estimate chloride in water.
10. To perform IMVIC Test.
11. To perform MPN test.

Course – Solid Waste Management
Course code –BBI130A
Lectures: 3 Hrs/week

Course Outcome

Student will able to

CO1-Understand the sources, types, and characteristics of solid waste.

CO2-Learn methods of waste collection, segregation, and transport.

CO3-Apply biological and physicochemical methods for waste treatment.

CO4-Interpret policies and laws related to solid waste management.

CO5-Use biotechnology-based solutions for sustainable solid waste treatment.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	3	2	1	1
CO2	2	3	2	2	2	2	1
CO3	2	3	3	3	3	2	2
CO4	2	2	1	3	2	3	2
CO5	2	3	3	3	3	3	3

3 = Highly Related; 2 = Medium; 1 = Low

Unit 1

Definition and types of solid waste: municipal, industrial, biomedical, agricultural, electronic. Sources and composition of solid waste. Impact of solid waste on human health and the environment

Unit 2

Waste collection methods and tools. Segregation at source. Storage and transport of waste. Transfer stations and route optimization

Unit 3

Physical, chemical, and biological processing of waste. Composting, vermicomposting, and anaerobic digestion. Incineration, pyrolysis, and gasification. Landfilling and landfill engineering

Unit 4

National and international laws and policies (e.g., SWM Rules 2016, CPCB guidelines). Role of municipal corporations and NGOs. Extended Producer Responsibility (EPR)

Unit 5

3Rs: Reduce, Reuse, Recycle. Circular economy concept. Biotechnological tools for waste management (e.g., microbial degradation, enzyme applications). Waste to energy technologies

Reference books

1. Solid and Hazardous Waste Management – M.N. Rao & Razia Sultana, BS Publications
2. Environmental Biotechnology – S.N. Jogdand
3. Solid Waste Management: Principles and Practice – Ramesha Chandrappa & Das
4. Manual on Municipal Solid Waste Management – Ministry of Urban Development, Government of India
5. CPCB & MOEFCC Guidelines and Rules (SWM Rules 2016, Bio-medical Waste Rules) – [official documents]

BBI131A: Solid Waste Management Lab **Credit(s): 1**

Course Outcomes

Student will able to

CO1-Identify and classify different types of solid waste through physical and chemical analysis.

CO2-Demonstrate segregation, collection, and composting techniques for biodegradable waste.

CO3-Analyze leachate and microbial content from landfill/waste samples using lab techniques.

CO4-Evaluate the effectiveness of biological waste treatment methods like vermicomposting.

CO-5-Interpret lab and field data related to solid waste and propose sustainable management solutions.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	3	2	2	1	1
CO2	2	3	3	3	2	2	2
CO3	3	3	3	3	3	2	2
CO4	2	3	3	3	2	2	2
CO5	2	3	2	3	3	3	3

3 = Highly Related; 2 = Medium; 1 = Low

List of practicals

1. Physical and chemical characterization of municipal solid waste
2. Hands-on activity: segregating biodegradable and non-biodegradable waste
3. Setup of aerobic composting using organic waste
4. Construction of small-scale vermicomposting setup
5. Comparison of biodegradable vs non-biodegradable materials using microbial activity
6. Field visit to municipal solid waste processing plant or landfill site
7. Microbial Isolation from Decomposing Waste
8. Enzyme Extraction from Waste Degrading Microorganisms *(optional)*

Course name– Environmental Pollution
Course code –BBI132A
Lectures: 3 Hrs/week

Course Outcome

Student will able to

CO1- Understand types, causes, and consequences of different types of environmental pollution

CO2- Analyze physical, chemical, and biological properties of polluted air, water, and soil

CO3- Apply standard methods for pollution monitoring and treatment

CO4- Explain the role of regulatory bodies, laws, and sustainable practices in pollution control

CO4-Evaluate environmental management strategies, laws, and regulatory frameworks.

CO5- Demonstrate laboratory skills and field techniques in environmental monitoring and assessment.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	3	2	1	1
CO2	2	3	3	2	3	2	2
CO3	2	3	3	3	3	2	2
CO4	2	2	2	3	2	3	2
CO5	2	3	3	3	3	3	3

3 = Highly Related; 2 = Medium; 1 = Low

Unit 1:

Definition and types of environmental pollution. Classification: Air, Water, Soil, Noise, Radiation, Thermal pollution. Causes and consequences of pollution. Global environmental issues: acid rain, ozone depletion, eutrophication, smog

Unit 2:

Major air pollutants (CO_2, SOx, NOx, PM, hydrocarbons). Sources: natural and anthropogenic. Effects on health, vegetation, climate. Monitoring and control: scrubbers, electrostatic precipitators, catalytic converters

Unit 3:

Sources: domestic sewage, industrial discharge, agricultural runoff. Water quality indicators: BOD, COD, DO, pH, coliform count. Eutrophication and algal blooms. Wastewater treatment methods (primary, secondary, tertiary)

Unit 4:

Soil pollution: heavy metals, pesticides, land degradation. Soil remediation: bioremediation, phytoremediation. Noise pollution: sources, decibel scale, health impacts. Control measures and legal limits

Unit 5:

Environmental Protection Act (1986), Water Act (1974), Air Act (1981). Pollution control boards (CPCB, SPCB). Environmental Impact Assessment (EIA). Biotechnology approaches in pollution control. Role of individuals, NGOs, and industry in environmental protection

Reference books:

1. Environmental Pollution Control Engineering by C.S. Rao (New Age International)
2. Environmental Studies by Erach Bharucha
3. Environmental Biotechnology by S.N. Jogdand
4. Principles of Environmental Science by William P. Cunningham & Mary Cunningham
5. CPCB & MOEFCC Guidelines by Govt. of India (Online resources)

BBI133A: Environmental Pollution Lab Credit(s): 1

Course Outcomes

Student will able to

CO1-Determine physicochemical properties (pH, DO, BOD, COD, TDS) of water samples.

CO2-Analyze air and noise pollution using basic monitoring techniques.

CO3-Assess soil quality and identify heavy metal contamination.

CO4-Demonstrate microbial remediation and interpret biological responses to pollutants.

CO5-Compile and report field-based environmental data from pollution-affected sites.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	2	2	1	1
CO2	2	3	3	3	2	2	2
CO3	2	3	3	3	2	2	2
CO4	2	3	3	3	3	2	2
CO5	2	2	2	3	3	3	3

3 = Highly Related; 2 = Medium; 1 = Low

1. Determination of pH, DO, BOD, and COD in water samples
2. Estimation of total dissolved solids (TDS) in water
3. Collection and analysis of air particulate matter (suspended solids)
4. Estimation of noise levels using decibel meter
5. Demonstration of microbial degradation (bioremediation) using oil/organic waste
6. Qualitative and quantitative analysis of soil properties (pH, texture, moisture)
7. Detection of heavy metals (e.g., lead, cadmium) in soil/water samples
8. Visit to a local pollution control facility or sewage treatment plant (STP)

9. Preparation of a field report on a local environmental issue

Course – Environmental Microbiology
Course code–BBI134A
Lectures: 3 Hrs/week

Course Outcome

Student will able to

CO1-Understand microbial diversity and ecological roles in different environments

CO2-Explain microbial roles in biogeochemical cycles and ecosystem functioning

CO3-Describe the principles and processes of water, soil, and wastewater microbiology

CO4-Apply knowledge of microbial interactions for ecological applications

CO5-Evaluate microbial techniques for bioremediation and pollution control

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	3	2	1	1
CO2	3	3	2	3	2	1	2
CO3	3	3	3	3	3	2	2
CO4	2	3	2	3	2	2	2
CO5	2	3	3	3	3	3	3

3 = Highly Related; 2 = Medium; 1 = Low

Unit 1:

Scope and importance of environmental microbiology. Microbial diversity in natural environments: soil, water, air. Extremophiles: thermophiles, halophiles, acidophiles, methanogens

Unit 2:

Microbial interactions: mutualism, commensalism, parasitism, syntrophy. Role of microbes in nitrogen, carbon, sulfur, and phosphorus cycles, Microbial ecology concepts: habitat, niche, population, community

Unit 3:

Microorganisms in drinking water and wastewater. Indicator organisms: coliforms, fecal streptococci. Wastewater treatment: primary, secondary, tertiary treatment. Microbial biofilms and their role in wastewater treatment

Unit 4:

Microbial flora of rhizosphere, phyllosphere, and mycorrhizae. Nitrogen-fixing bacteria: *Rhizobium*, *Azotobacter*, *Frankia*. Decomposition of organic matter: role of bacteria and fungi

Unit 5: Bioremediation and Environmental Monitoring

Microbial degradation of pesticides, hydrocarbons, and xenobiotics. Bioremediation and phytoremediation strategies. Biosensors in environmental monitoring. GMOs and biosafety concerns in environmental applications

Reference books:

1. Environmental Microbiology by R.M. Maier, I.L. Pepper, C.P. Gerba (Elsevier)
2. Microbiology: An Introduction by Gerard J. Tortora, Berdell Funke
3. Environmental Biotechnology by S.N. Jogdand
4. Industrial and Environmental Microbiology by Patel and Patel

BBI135A: Environmental Microbiology Lab **Credit(s): 1**

Course Outcomes

Student will able to

CO1- Isolate and identify microorganisms from environmental samples.

CO2-Quantify microbial populations using culture-based techniques.

CO3-Detect indicator organisms in water samples for pollution assessment.

CO4-Demonstrate the use of microbes in bioremediation and biodegradation.

CO5- Record, analyze, and report environmental microbiological data.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	3	2	2	1	1
CO2	2	3	3	2	2	1	2
CO3	2	3	3	3	3	2	2
CO4	2	3	3	3	3	2	2
CO5	2	2	2	2	3	3	3

3= Highly Related; 2= Medium; 1=Low

1. Isolation of microorganisms from soil, air, and water samples
2. Enumeration of bacteria by serial dilution and plate count method
3. Detection of coliforms in water by MPN and confirmed test
4. Estimation of microbial population in rhizosphere soil
5. Study of nitrogen-fixing bacteria (*Rhizobium*, *Azotobacter*)
6. Biodegradation assay of organic waste (e.g., oil, detergent)

7. Winogradsky column preparation and microbial diversity observation
8. Effect of pollutants (e.g., heavy metals) on microbial growth
9. Visit to wastewater treatment plant or composting facility
10. Preparation of report on case studies in microbial bioremediation

Course name– Biodiversity
Course code –BBI136A
Lectures: 3 Hrs/week

Course Outcome

Students will able to

CO1 Understand the scope, significance, and levels of biodiversity
CO2 Classify and identify various species and taxonomic groups
CO3 Analyze the ecological roles and values of biodiversity in ecosystems
CO4 Assess the threats to biodiversity and interpret IUCN Red List
CO5 Evaluate conservation strategies and biodiversity-related laws

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	1	2	2	3	2
CO2	3	3	2	2	2	1	2
CO3	3	2	3	2	2	2	3
CO4	3	3	3	3	3	3	3
CO5	3	2	3	3	3	3	3

3= Highly Related; 2= Medium; 1=Low

Unit 1:

Definition, scope and importance of biodiversity, Types of biodiversity: Genetic, species, ecosystem, Levels of biodiversity: Alpha, beta, gamma, Global and Indian biodiversity statistics, Biodiversity hotspots in India

Unit 2:

Species concepts: Morphological, biological, phylogenetic, Taxonomic hierarchy: Kingdom to species, Classification systems: Artificial, natural, phylogenetic, Major biodiversity groups: Microbial, Plant, Animal

Unit 3:

Ecosystem diversity: Forest, grassland, desert, aquatic, Ecological interactions: Mutualism, competition, predation, Keystone species, indicator species, endemic and invasive species, Ecosystem services and their valuation

Unit 4:

Natural vs anthropogenic threats, Habitat loss, fragmentation, pollution, overexploitation, Climate change and biodiversity, IUCN Red List categories and examples

Unit 5:

In-situ conservation: National parks, wildlife sanctuaries, biosphere reserves, Ex-situ conservation: Botanical gardens, zoos, gene banks, Biodiversity laws and policies: CBD, CITES, National Biodiversity Act (India), Role of organizations: UNEP, WWF, IUCN

Reference books

1. **"Biodiversity"** – Edward O. Wilson
2. **"Global Biodiversity Assessment"** – UNEP
3. **"Fundamentals of Ecology"** – Odum, E.P.
4. **"Conservation Biology"** – Andrew Pullin
5. **"Biodiversity and Conservation"** – M.P. Arora
6. **"Environmental Biology"** – P.D. Sharma
7. **"Textbook of Biodiversity"** – K.V. Krishnamurthy

BBI137A: Biodiversity Lab **Credit(s): 1**

Course Outcomes

Students will able to

CO1 Understand the scope, significance, and levels of biodiversity

CO2 Classify and identify various species and taxonomic groups

CO3 Analyze the ecological roles and values of biodiversity in ecosystems

CO4 Assess the threats to biodiversity and interpret IUCN Red List

CO5 Evaluate conservation strategies and biodiversity-related laws

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	2	3	2	3	2
CO2	2	2	3	3	2	3	3
CO3	3	3	3	3	3	3	2
CO4	2	2	2	2	3	3	3
CO5	3	2	3	2	1	2	2

List of practicals

1. Study and identification of local flora and fauna (through field visit or digital resources)
2. Preparation of herbarium and museum specimen (demo/simulation)
3. Survey and documentation of biodiversity in a selected area
4. Identification of indicator species and invasive species (local examples)
5. Study of biodiversity hotspots and mapping exercises
6. Analysis of IUCN Red List categories using selected species
7. Visit report to a biodiversity park, botanical garden, or conservation site

Course– Microbial and Industrial Application
Course code –BBI138A
Lectures: 3 Hrs/week

Course Outcome

Students will able to

CO1 Understand the basic principles and applications of industrial microbiology

CO2 Describe microbial production of primary and secondary metabolites

CO3 Explain fermentation technology, process optimization, and bioreactor designs

CO4 Perform isolation, screening, and assays of industrial microbes and products

CO5 Evaluate microbial processes in sustainable and environmental industrial uses

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	1	1	1	2	3
CO2	3	3	3	3	3	2	2
CO3	3	3	3	2	3	3	3
CO4	3	2	2	1	2	3	3
CO5	2	2	3	3	3	2	2

3= Highly Related; 2= Medium; 1=Low

Unit 1:

Scope and history of industrial microbiology, Primary and secondary metabolites, Microorganisms used in industrial processes, Types of fermentation: submerged and solid-state fermentation

Unit 2:

Types of fermenters (batch, continuous, fed-batch), Design and operation of fermenters,Sterilization processes and inoculum development, Downstream processing: extraction, purification, product recovery

Unit 3:

Production of ethanol, citric acid, lactic acid, acetic acid, Microorganisms involved and process conditions

Unit 4:

Antibiotics: penicillin, streptomycin, Vitamins: B12, riboflavin, Enzymes: amylase, protease, cellulase, Industrial production and optimization

Unit 5:

Wastewater treatment using microbes, Biogas production, Microbial enhanced oil recovery, Biosurfactants and bioplastics

Reference books

1. **Agricultural Biotechnology** – Arie Altman & Paul M. Hasegawa, CRC Press
2. **Plant Biotechnology and Genetics** – C. Neal Stewart, Wiley-Blackwell
3. **Principles of Plant Biotechnology** – S. H. Mantell, J. R. Matthews, E. J. McKee
4. **Plant Tissue Culture: Theory and Practice** – S.S. Bhojwani & M.K. Razdan
5. **Biotechnology in Agriculture and Forestry** – Y.P.S. Bajaj (Series)

BBI139A: Industrial Microbial Lab **Credit(s): 1**

Course Outcome

Students will be able to

CO1 Isolate and identify industrially important microorganisms from natural sources

CO2 Demonstrate fermentation techniques for the production of industrially relevant metabolites

CO3 Analyze microbial production of enzymes and determine their activity through assays

CO4 Operate basic fermentation equipment and understand the principle of downstream processing

CO5 Apply microbiological techniques in biotechnological industries for environmental and product use

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
PCO1	3	2	2	3	2	2	3
PCO2	3	3	3	3	3	1	2
PCO3	2	3	3	3	3	1	1
PCO4	3	2	3	3	3	2	1
PCO5	2	2	2	3	2	3	2

1. Isolation of industrially important microorganisms from soil
2. Screening of antibiotic-producing microorganisms
3. Production and estimation of ethanol by fermentation
4. Determination of citric acid production using Aspergillus niger
5. Enzyme assay: amylase and protease from microbial cultures
6. Demonstration of fermenter setup and operation
7. Downstream processing techniques (e.g., filtration, centrifugation)
8. Visit to an industrial fermentation unit (if possible)

Course – Bioremediation
Course code –BBI140A
Lectures: 3 Hrs/week

Course Outcome:

Students will able to:

CO1 Understand the basic principles and types of bioremediations.
CO2 Identify the role of microbes in detoxification and environmental cleanup
CO3 Explain techniques and tools used in various bioremediation strategies
CO4 Evaluate bioremediation of specific pollutants with real-life applications
CO5 Analyze the effectiveness and limitations of bioremediation technologies

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	-	1	-	3	2
CO2	3	3	2	2	-	3	2
CO3	3	2	3	3	2	3	-
CO4	2	3	3	3	3	3	2
CO5	2	2	2	3	2	3	3

3= Highly Related; 2= Medium; 1=Low

Unit 1:

Definition, scope and importance, Types: in situ and ex situ bioremediation, Advantages and limitations, Factors affecting bioremediation

Unit 2:

Role of bacteria, fungi, and algae, Metabolic pathways in pollutant degradation, genetically engineered microbes (GEMs) for bioremediation

Unit 3:

Hydrocarbons (oil spills), Heavy metals, Pesticides and herbicides, Industrial effluents and dyes

Unit 4:

Bioventing, biosparging, bioaugmentation, biostimulation, Land farming and composting, Phytoremediation, Biosorption and bioaccumulation

Unit 5:

Biosensors and monitoring tools, Case studies of successful bioremediation projects, Environmental laws and regulations, Future perspectives of bioremediation

BBI141A: Bioremediation Lab Credit(s): 1

Course Outcome:

Students will able to

CO1 Isolate and evaluate pollutant-degrading microorganisms
CO2 Perform degradation assays for pollutants like hydrocarbons and dyes
CO3 Demonstrate biosorption and metal tolerance tests using microbes or plants
CO4 Analyze remediation potential using phytoremediation techniques
CO5 Apply microbial consortia and biostimulation for enhanced degradation studies

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

PCOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7
PCO1	3	2	2	3	2	3	1
PCO2	3	3	3	3	3	3	2
PCO3	2	3	3	3	3	3	1
PCO4	2	2	2	2	2	3	2
PCO5	2	2	2	3	3	3	2

1. Isolation of hydrocarbon-degrading bacteria from contaminated soil
2. Assay for biodegradation of dyes by microbial cultures
3. Detection and estimation of heavy metal tolerance in microbes
4. Microbial biosorption assay using algae or fungi
5. Phytoremediation setup using common plants (e.g., *Eichhornia*)
6. Bioaugmentation experiment: enhancement of degradation using consortia
7. Oil spill remediation simulation in lab
8. Visit to industrial effluent treatment plant (if possible)

Reference books

1. **R.M. Atlas and R. Bartha** – *Microbial Ecology: Fundamentals and Applications*
2. **Martin Alexander** – *Biodegradation and Bioremediation*, Academic Press
3. **G.M. Evans and J.C. Furlong** – *Environmental Biotechnology: Theory and Application*
4. **R.C. Dubey** – *A Textbook of Environmental Biotechnology*
5. **B.D. Singh** – *Environmental Microbiology and Biotechnology*
6. **Mohapatra, P.K.** – *Environmental Biotechnology: Industrial Pollution Management*, I.K. International

Course –Plant Biotechnology
Course code –BBI042C
Lectures: 3Hrs/week

Course Outcome

CO-1 Students will be able to understand different plant tissue culture, the history, and the laboratory requirement in plant tissue culture.
CO-2 Students will be able to describe the different sterilization techniques involved in tissue culture.
CO-3 Students will be able to describe and compare different type's tissue culture media, cell and suspension cultures, genetic transformation and micro-propagation techniques
CO-4 Students will be able to distinguish different plant tissue culture techniques and able to raise callus and also able to acquire skills to analyze the critical problems related to plant tissue culture
CO-5 Students will define and explain the protoplast techniques including the applications of protoplast.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course Outcome	Program Outcome						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	1	2	1	2
CO2	3	2	3	2	2	1	1
CO3	3	3	3	2	2	2	2
CO4	3	2	3	1	1	2	1
CO5	2	2	1	1	0	0	1

3 = Highly Related; 2 = Medium; 1 = Low

BBI042C: Plant Biotechnology Credit(s): 3

Unit-I

History: Milestones in the history of plant tissue culture, Cellular totipotency: 'Explant' for plant tissue culture: Laboratory Requirements for plant tissue culture laboratory different work areas, equipment & instruments required, techniques, other requirements.

Aseptic techniques: Washing & preparation of glassware, packing & sterilization, media sterilization, surface sterilization, aseptic work station, precautions to maintain aseptic conditions.

Unit-II

Tissue Culture Media: Introduction, nutritional requirements of the explants, PGR's and their *in vitro* roles, media constituents, media selection, media preparation; Callus culture technique, Micropropagation of medicinal plants found in Rajasthan

Cell and Suspension Culture: Introduction, principle, isolation of single cells, suspension cultures, culture of single cells, types, growth & growth measurement, synchronization.

Unit-III

Protoplast Technology: Protoplast isolation, culture and regeneration of cell wall, Somatic hybridization Protoplast fusion techniques, selection of hybrids, production of symmetric & asymmetric hybrids & cybrid production. Application of protoplast culture

Unit-IV

Genetic transformations –*Agrobacterium* mediated transformations, direct DNA transfer methods – electroporation, microprojectile bombardment, and microinjection, use of marker genes, integration & expression of foreign DNA. Somatic embryogenesis, organogenesis, Haploid Plant Production: Anther, pollen, ovule and ovary culture, artificial seed, types, uses and advantages.

Unit-V

Somaclonal variation and micropropagation Embryo rescue, embryo culture, Transgenic plant-Herbicide resistance plant, insect resistant plants, improving the quality of oils and fats, biodegradable plastic, Edible vaccine, Stress tolerance plants. Germplasm.

Conservation: Introduction, long-term storages, short- or medium-term storage, cryopreservation, Gene Bank.

Text / Reference Books

1. Experiments in Plant Tissue Culture: John H. Dodds, Lorin W. Robert, 1985, Cambridge University Press.
2. Plant tissue Culture: Theory and Practice, S.S. Bhojwani and M.K. Razdan, 1996, Elsevier,
3. An Introduction to Plant Biotechnology: H S Chawla, 2002, Oxford and IBH.

BBI043C: Plant Biotechnology Lab Credit(s): 1

Course Outcomes

CO1- Understand the micro and macronutrients of plant tissue culture media and different methods of tissue culture.

CO2- Understand the different methods of cell plating.

CO3- students will be able to familiarize with synthetic seed formation.

CO4- to understand the role of plant growth hormones

CO5- also able to understand characteristics of the plants.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course Outcome	Program Outcome						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	2	2	1	1
CO2	3	2	1	3	1	0	1

CO3	2	3	1	1	1	1	0
CO4	2	2	1	0	1	1	1
CO5	3	3	1	1	0	1	1

3 = Highly Related; 2 = Medium; 1 = Low

1. To Prepare Stock Solutions for M.S. media.
2. To prepare and inoculate node and inter-node.
3. To culture callus.
4. To perform suspension culture.
5. To prepare media and inoculate shoot tip.
6. To prepare media and inoculate root tip.
7. To prepare media and inoculate anther.
8. To Prepare the synthetic seeds.
9. To perform Bergmann's cell plating technique for single cell culture.
10. To determine the Composition of various plant tissue culture media.
11. To Prepare stock solution for various growth hormones.
12. To Prepare M.S. media for seed inoculation.
13. To Inoculate seed in M.S. media for micropropagation.
14. Preparation of Herbarium sheet using medicinal plants found in Rajasthan

Course name – Agriculture microbiology
Course code –BBI116A
Lectures: 3 Hrs/week

Course outcome

CO-1 Students will be able to understand the basics agricultural microbiology
CO-2 Students will be able to illustrate different type of metabolism in bacteria
CO-3 Students will be able to explain soil microflora useful for crops
CO-4 Students will be able to evaluate the uses of different types of biofertilizer
CO-5 Students will able to analyze and use the gain knowledge for the higher education.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	2	2	2	1
CO2	3	3	3	1	1	2	2
CO3	3	3	3	2	2	1	1
CO4	3	3	3	1	2	2	2
CO5	2	2	3	3	3	2	2

1-LOW, 2-MEDIUM, 3-HIGH

Unit I:

Scope and importance of agricultural microbiology, Soil as a habitat for microorganisms, Classification and types of soil microorganisms (bacteria, fungi, actinomycetes, protozoa, algae) Rhizosphere and phyllosphere microorganisms, Microbial interactions in soil (mutualism, commensalism, antagonism)

Unit II:

Microbial role in biogeochemical cycles: Carbon cycle, Nitrogen cycle (nitrogen fixation, nitrification, ammonification, denitrification), Phosphorus and sulfur cycles, Biofertilizers: types, applications, and production

Unit III:

Symbiotic and asymbiotic nitrogen fixation, Mycorrhizal associations: types and benefits, Rhizobium-legume symbiosis, Cyanobacteria in agriculture, PGPR (Plant Growth-Promoting Rhizobacteria)

Unit IV:

Biopesticides and biofungicides, Mechanisms of biological control, Examples: *Trichoderma*, *Bacillus thuringiensis*, *Pseudomonas fluorescens*, Role of antagonistic microorganisms in disease suppression

Unit V:

Composting and vermicomposting, Green manuring, Role of microbes in organic farming, Bioremediation in agriculture (pesticide degradation, oil spill cleanup), Genetically modified microbes in agriculture

BBI117A: Agricultural Microbiology Lab **Credit(s): 1**

Course outcome

Students will be able to

CO1 Identify and isolate major groups of soil microorganisms using standard microbiological techniques.

CO2 Assess microbial activity in soil through biochemical tests and soil enzyme assays.

CO3 Perform nitrogen fixation and phosphate solubilization tests to evaluate beneficial microbes.

CO4 Prepare and evaluate compost/vermicompost using microbial inoculants.

CO5 Demonstrate the use of biocontrol agents against plant pathogens in controlled experiments.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	2	2	2	2	1
CO2	3	3	2	2	2	3	1
CO3	3	3	3	3	3	3	2
CO4	3	3	2	2	2	3	2
CO5	3	3	3	3	3	3	2

1- Familiarization with instruments, materials, glassware etc. in a microbiology laboratory
2- Methods of Sterilization and Preparation of media

3- Plating methods for Isolation and Purification of bacteria
4- Morphological examination of bacteria by Simple and Differential staining
5- Different biochemical tests for identification of bacterial culture

Reference Books

1. Agricultural Microbiology. 1998. G. Rangaswani and D.J. Bagyraj. Prentice Hall of India., New Delhi.
2. An Introduction to Microbiology. 1996. P. Tauro, K.K. Kapoor and K.S. Yadav. Wiley Eastern Ltd., New Delhi.
3. Microbiology, 1986. M. J. Pelczar, E.C.S. Chan and N.L. Krieg. Mc Graw Hill 5th Edition, New York, USA.
4. Soil microorganisms and plant growth. 1977. N. S. Subbarao Oxford & IBH Publ. Co. New Delhi.

Course name – Molecular Plant Breeding
Course code –BBI118A
Lectures: 3 Hrs/week

Course outcome

CO-1 Students will be able to understand the basics of molecular plant breeding
CO-2 Students will be able to illustrate different type of pollination in crops
CO-3 Students will be able to explain Heterosis in crops
CO-4 Students will be able to evaluate different type of seed production
CO-5 Students will be able to analyze real-world applications, risks, and ethical aspects of molecular plant breeding

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	2	2	2	1
CO2	3	3	3	1	1	2	2
CO3	3	3	3	2	2	1	1
CO4	3	3	3	1	2	2	2
CO5	3	2	2	2	2	2	3

1-LOW, 2-MEDIUM, 3-HIGH

Unit 1

Historical milestones in plant breeding, Aims and objectives of plant breeding Significance of plant breeding in crop development.

Unit 2

Various methods of plant breeding in self- and cross-pollinated crops, acclimatization, selection, pure line theory, Reproductive systems of plants, Flora biology, flower parts, Self- and cross-pollinated crops. Genetic consequences and differences between self- and cross-pollinated crops

Unit 3

Clonal selection, population improvement program, Heterosis, Genetics and physiological basis. Male sterility Types of male sterility combining ability-general and specific, its exploitation. Interspecific/ Intergeneric hybridization, Heterosis inbreeding depression, Polyploidy its types

Unit 4

Mutation breeding Gene actions, heritability, genotype and environmental interactions, its importance in plant breeding, Introduction to seed production (Nucleus, breeder, foundation, certified), Maintenance of genetic purity during seed production, Molecular markers and their application

Unit 5

Breeding for disease and pest resistance, Breeding for abiotic stress tolerance (drought, salinity, heat), Biofortification through molecular breeding, IPR, biosafety, and ethical issues

BBI119A: Molecular Plant Breeding Lab **Credit(s): 1**

Course outcome

Students will able to

CO1-Isolate and quantify high-quality plant DNA suitable for molecular breeding applications.
CO2-Perform PCR amplification and assess DNA polymorphisms using molecular markers.
CO3-Analyze gel electrophoresis results and interpret genotyping data.
CO4-Construct linkage maps and understand QTL mapping through software and data interpretation.
CO5-Understand and simulate molecular breeding strategies such as MAS and genome editing.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	3	3	2	1
CO2	3	3	2	3	3	2	2
CO3	2	3	2	3	3	2	2
CO4	3	3	3	3	3	2	3
CO5	3	3	3	2	3	3	3

1-LOW, 2-MEDIUM, 3-HIGH

a. DNA isolation from plant tissues using CTAB method
b. Quantification and quality check of DNA using spectrophotometer and gel electrophoresis
c. PCR amplification of DNA using gene-specific or SSR primers
d. Analysis of polymorphism using molecular markers (SSR/RAPD)
e. Gel electrophoresis and scoring of marker data
f. Linkage map construction and QTL analysis (simulation/data analysis using software)
g. Study of Marker-Assisted Selection (MAS) using case studies
h. Demonstration of CRISPR/Cas9 constructs and genome editing approaches (if available)
i. Visit to a plant genomics lab or molecular breeding center and report preparation

Reference books:

1. Principles of Plant Breeding by Allard R W 1960. Kalyani Publishers, New Delhi
2. Principles of Plant Breeding by Singh B.D 1983. Kalyani Publishers, New Delhi.
3. Principles of Genetics by Gardner E. J, M. J Simons and D. P Sanstad 1991.John Wiley and Sons Inc New York.
4. Plant Breeding by Lamkey and Lee 2006, Panima, New Delhi.
5. Breeding Field Crops by Sleper and Poehlman 2007, Panima New Delhi.

Course – Principles of Plant Physiology
Course code–BBI120A
Lectures: 3 Hrs/week

Course Code: BBI120A

Course Name: Principles of Plant Physiology **Credit(s): 3**

Course outcome

CO-1 Students will be able to understand the basics of different plant-water relations and nutrition
CO-2 Students will be able to discuss the Photosynthesis and their role in crop productivity
CO-3 Students will be able to explain different plant hormones
CO-4 Students will be able to evaluate different stress related resistant mechanism in plants
CO-5 Students will be able to see the effects of different plant hormone.

Mapping of PO/CO

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	2	2	2	1
CO2	3	3	3	1	1	2	2
CO3	3	3	3	2	2	1	1
CO4	3	3	3	1	2	2	2
CO5	3	2	3	2	2	3	3

1-LOW, 2-MEDIUM, 3-HIGH

Unit 1

Definition, scope and introduction in agriculture, Osmosis, DPD, TP. Water absorption by plants; Ascent of sap. Transpiration-Mechanism, factors affecting it, Structure and function of stomata. Osmotic pressure, guttation. Plant Nutrition: Major and minor nutrients; their roles and deficiency symptom; Active and passive mineral uptake mechanisms.

Unit 2

Photosynthesis Structure and function of chloroplast; Light and dark reactions; Cyclic and non-cyclic electron transfer; C3, C4, Crassulacean acid metabolism and photorespiration.

Unit 3

Respiration types; R.Q. Hormones: types and role in agriculture biotechnology. Growth phases, photoperiodism, and vernalization.

Unit 4

Stress physiology (Drought, heat, frost and salinity); mechanism of resistance to above types. Physiological aspects and problems of cereals, pulses, oilseeds, cotton and sugarcane.

Unit-5

Phases and measurement of growth, Plant growth regulators (auxins, gibberellins, cytokinins, ABA, ethylene), Seed dormancy and germination, Senescence and abscission

Reference books

a. Plant Physiology – Lincoln Taiz & Eduardo Zeiger
b. Plant Physiology and Biochemistry – S. S. Bhojwani & Bhatnagar
c. Introduction to Plant Physiology – William G. Hopkins
d. Physiology of Plants – Salisbury & Ross
e. Laboratory Manual of Plant Physiology – P.C. Trivedi
f. ICAR Practical Manual on Plant Physiology

Course Code: BBI121A
Course Name: Plant Physiology Lab **Credit(s):1**

Course Outcome:

Students will able to
CO1-Demonstrate experiments related to osmosis, transpiration, and water potential.
CO2-Perform pigment extraction and chromatography of chloroplast pigments.
CO3-Analyze the effects of environmental factors on photosynthesis and respiration.
CO4-Evaluate plant hormone effects through bioassays.
CO5-Identify nutrient deficiency symptoms in plants and understand their physiological impact.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

PCOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7
PCO1	3	2	2	3	3	2	2
PCO2	3	2	2	3	3	2	1
PCO3	3	3	2	3	3	2	2
PCO4	3	2	3	2	2	3	2
PCO5	3	2	2	2	2	2	3

1-LOW, 2-MEDIUM, 3-HIGH

a. Study of **imbibition and osmosis** using seeds and potato osmometer
b. Determination of **water potential** using plasmolysis experiment
c. Measurement of **transpiration** by potometer
d. Extraction and separation of **chlorophyll pigments** by paper chromatography
e. Determination of **rate of photosynthesis** under varying light and CO_2 conditions

f. Demonstration of **aerobic and anaerobic respiration** in germinating seeds
g. Bioassay of **auxins/gibberellins** using plant growth techniques
h. Study of **mineral deficiency symptoms** in hydroponic culture or charts

Reference Books:

1. A Text Book Plant Physiology by Verma V 1973 M.K publication house New Delhi
2. An Introduction to Plant Physiology of Field Crops by Shivraj A 1978 Oxford and I.B.H publishing Co-operative PVT Ltd, New Delhi
3. Plant Physiologists by Pande S.N and Sinha B.K 1978 Vikas publishing house New Delhi.
4. Practical Plant Physiology by Amar Singh 1982 Kalyani publisher New Delhi
5. Useful techniques for plant scientist by Dhopte A.N and Levra N 1989 Publication of forum of plant physiologist Akola
6. Plant Physiology by Salisbury F and C. Ross 1990, Prentice Hall of India New Delhi

Course – Biotechnology for Biotic and Abiotic Stress Tolerance
Course code –BBI122A
Lectures: 3 Hrs/week

Course Outcome:

Students will able to

CO1 Understand the types and effects of biotic and abiotic stress on plant systems.
CO2 Describe plant defense mechanisms and molecular responses to stresses.
CO3 Apply knowledge of biotechnology tools to develop stress-tolerant crops.
CO4 Evaluate transgenic and genome editing strategies for improving stress resistance.
CO5 Interpret omics data and molecular markers for stress breeding programs.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	2	1	2	1
CO2	3	2	3	3	2	3	1
CO3	3	3	3	3	3	2	2
CO4	3	2	3	3	3	2	2
CO5	3	3	3	3	3	3	2

Unit I: Introduction to Plant Stress Biology

Definition and types of plant stresses: biotic and abiotic, General plant responses to stress (morphological, physiological, biochemical), Concept of stress tolerance, avoidance, resistance, and susceptibility

Unit II: Biotic Stress and Plant Defense Mechanisms

Types of biotic stress: pathogens (fungi, bacteria, viruses), insects, nematodes, Plant defense mechanisms: constitutive and induced, Molecular basis of plant–pathogen interactions, Gene-for-gene hypothesis, R genes, PR proteins, Biotechnological approaches to develop disease-resistant crops (e.g., Bt crops, virus-resistant plants)

Unit III: Abiotic Stress and Tolerance Mechanisms

Types of abiotic stress: drought, salinity, heat, cold, heavy metals, oxidative stress, Molecular and physiological responses to abiotic stress, Role of stress proteins (e.g., HSPs, LEA proteins), Osmo protectants, antioxidants, Signal transduction pathways (ABA, ROS, MAPK)

Unit IV: Genetic Engineering for Stress Tolerance

Gene identification and cloning for stress tolerance, Promoters and gene expression systems, Transgenic plants for abiotic stress tolerance, CRISPR/Cas and other genome editing tools in stress tolerance

Unit V: Omics and Molecular Breeding Approaches

Use of transcriptomics, proteomics, and metabolomics in stress research, Marker-assisted selection and QTL mapping for stress traits, Case studies of successful stress-tolerant GM crops, Biosafety and regulatory aspects

Course Code: BBI123A
Course Name: Plant Stress Lab **Credit(s):1**

Course outcome

Students will able to

CO1 Demonstrate physiological and biochemical methods to study stress responses.

CO2 Estimate molecular and enzymatic markers under stress conditions.

CO3 Perform basic gene-based analysis related to stress tolerance (PCR, ELISA).

CO4 Analyze case studies of transgenic crops for stress tolerance.

CO5 Develop experimental strategies for screening or engineering stress tolerance.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	2	2	2	2	1
CO2	3	3	3	3	3	2	1
CO3	3	3	3	3	3	2	2
CO4	3	2	3	3	2	3	2

CO5	3	3	3	3	3	3	2

1. Study of morphological changes in plants under drought and salinity stress
2. Assay of antioxidant enzymes (SOD, catalase, peroxidase) in stressed plants
3. Estimation of proline content under abiotic stress
4. Detection of PR proteins by SDS-PAGE or ELISA
5. PCR amplification of R gene or stress-related gene
6. Design and interpretation of transgenic approaches for stress tolerance (virtual simulation or case study)
7. Visit to a biotech institute/agriculture field demonstrating stress-tolerant crops

Reference books

1. **Ashraf, M. & Harris, P. J. C.** (2013). *Abiotic Stress Tolerance in Plants: Toward the Improvement of Global Environment and Food*. Springer.
2. **Hirt, H. & Shinozaki, K.** (2003). *Plant Responses to Abiotic Stress*. Springer.
3. **Choudhary, D. K., Varma, A.** (2016). *Plant-Microbe Interaction: An Approach to Sustainable Agriculture*. Springer.
4. **Pareek, A. et al.** (2010). *Abiotic Stress Adaptation in Plants: Physiological, Molecular and Genomic Foundation*. Springer.
5. **Datta, S. K.** (2008). *Role of Biotechnology in Enhancing Biotic and Abiotic Stress Tolerance in Plants*. NIPA.
6. Scientific research papers and reviews from journals like *Plant Physiology*, *BMC Plant Biology*, *Frontiers in Plant Science*, and *Molecular Plant*.

Course – Advances in Agriculture Biotechnology
Course code–BBI114A
Lectures: 3 Hrs/week

Course outcome

CO-1 Students will be able to understand the basics agricultural microbiology
CO-2 Students will be able to illustrate different type of metabolism in bacteria
CO-3 Students will be able to explain soil microflora useful for crops
CO-4 Students will be able to evaluate the uses of different types of biofertilizer
CO-5 Students will able to analyze and use the gain knowledge for the higher education.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	2	2	2	1
CO2	3	3	3	1	1	2	2
CO3	3	3	3	2	2	1	1
CO4	3	3	3	1	2	2	2
CO5	2	2	3	3	3	2	2

1-LOW, 2-MEDIUM, 3-HIGH

Unit 1

History of Microbiology: Spontaneous generation theory, Role of microbes in fermentation, Germ theory of disease, Protection against infections, Applied areas of Microbiology

Unit 2

Metabolism in bacteria: ATP generation, chemoautotrophy, photo autotrophy, respiration, fermentation. Bacteriophages: structure and properties of Bacterial viruses – Lytic and Lysogenic cycles: viroids, prions.

Unit 3

Microbial groups in soil, microbial transformations of carbon, nitrogen, phosphorus and sulphur, Biological nitrogen fixation. Microflora of Rhizosphere and Phyllosphere microflora, microbes in composting. Microbiology of food: microbial spoilage and principles of food preservation.

Unit 4

Beneficial microorganisms in Agriculture: Biofertilizer (Bacterial Cyanobacterial and Fungal), microbial insecticides, Microbial agents for control of Plant diseases, Biodegradation, Biogas production, Biodegradable plastics, Plant – Microbe interactions.

Unit 5

Bioinoculants and microbial consortia, Genomics and metagenomics in soil microbiology, Microbial formulations and shelf-life, Regulatory and quality control aspects of biofertilizers

BBI115A: Agriculture Biotechnology Lab Credit(s): 1

Course Outcomes

Students will be able to

CO1- Demonstrate preparation and sterilization of culture media and tools for plant tissue culture.
CO2-Perform micropropagation techniques and study somaclonal variation in vitro.
CO3-Isolate DNA from plant tissues and carry out PCR amplification and electrophoresis.
CO4-Analyze genetically modified (GM) crops using molecular marker techniques.
CO5-Demonstrate gene transfer techniques (e.g., Agrobacterium-mediated transformation).

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7
PCO1	3	2	2	3	3	3	2
PCO2	3	2	3	3	3	2	2
PCO3	3	2	2	3	3	2	1
PCO4	3	3	3	3	3	3	2
PCO5	3	3	3	3	3	3	2

a. Media preparation for plant tissue culture
b. Micropropagation of selected plant species
c. Demonstration of Agrobacterium-mediated gene transfer
d. DNA isolation from plant tissue
e. PCR and gel electrophoresis techniques
f. Analysis of GM crops through molecular markers
g. Visit to an agricultural biotech company or plant tissue culture lab

h. Report writing on case studies of GM crops

Course – Techniques in Biochemistry and Molecular Biology
Course code –BBI126A
Lectures: 3 Hrs/week

Course Code: BBI126A
Course Name: Techniques in Biochemistry and molecular biology
Credit(s): 3

Course Outcome:
Students will able to

CO1: Understand key techniques in biochemistry, biophysics, and molecular biology

CO2: Apply methods such as centrifugation, chromatography, electrophoresis effectively

CO3: Characterize macromolecules using biochemical and biophysical approaches

CO4: Analyze experimental outcomes critically and interpret results using biochemical reasoning.

CO5: Apply advanced biophysical and analytical techniques (e.g., spectroscopy, immunoassays, radiolabeling) in experimental design and problem-solving.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	2	2	2	1
CO2	3	3	2	2	2	2	1
CO3	3	3	3	3	3	2	2
CO4	3	3	3	3	3	2	2
CO5	3	2	2	2	3	3	3

Unit I: Foundational Biochemical Techniques

Centrifugation (differential and density-gradient), electrophoresis (agarose, SDS-PAGE), spectroscopic methods (UV-Vis, fluorescence), Hands-on: Protein/DNA quantification, mini-spin protocols.

Unit II: Nucleic Acid Techniques

DNA & RNA extraction (bacterial, plant, animal), nucleic acid purification, theoretical principles of extraction methods.

Unit III: Molecular Biology Methods

Topics: PCR (regular, RT-PCR, qPCR), molecular cloning basics, gel electrophoresis analysis.

Practical: PCR amplification, gel visualization.

Unit IV: Protein Analysis and Enzyme Assays

Topics: Protein purification strategies (salt precipitation, chromatography), enzyme kinetics, Bradford assay.

Unit V: Advanced Analytical & Functional Techniques

Topics: Immunochemical assays (e.g. ELISA), radiolabeling basics and detection (radiobiology techniques including scintillation, autoradiography), advanced spectroscopy.

Course Code: BBI127A
Course Name: Molecular Biology Lab **Credit(s): 1**

Course Outcome:

Students will be able to

CO1: Understand foundational principles of biochemistry and molecular biology techniques (e.g., centrifugation, electrophoresis, spectroscopy).

CO2: Perform DNA, RNA, and protein extraction, purification, and quantification accurately.

CO3: Execute molecular biology methods such as PCR, cloning, and gel electrophoresis.

CO4: Analyze experimental outcomes critically and interpret results using biochemical reasoning.

CO5: Apply advanced biophysical and analytical techniques (e.g., spectroscopy, immunoassays, radiolabeling) in experimental design and problem-solving.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

PCOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7
PCO1	3	2	2	3	2	2	2
PCO2	3	3	2	3	3	2	2
PCO3	3	3	3	3	3	2	2
PCO4	3	2	2	2	2	3	3
PCO5	3	3	3	2	3	2	2

1. Hands-on: Protein/DNA quantification, mini-spin protocols.
2. Extraction and estimation of nucleic acids.
3. PCR amplification, gel visualization.
4. Purification from crude extracts; activity assays.
5. ELISA and, if feasible, radioisotope-based detection

Reference Books

- **Krishnamurthy, K.V. (2004)**: *An Advanced Textbook on Biodiversity – Principles and Practice*. Oxford and IBH Publishing Co. Pvt. Ltd.
- **Primack, R. (2014)**: *Essentials of Conservation Biology*. Sinauer Associates, Inc.

- **Groom, M.J., Meffe, G.R., & Carroll, C.R. (2006)**: *Principles of Conservation Biology*. Sinauer Associates, Inc.
- **Sodhi, N.S., & Ehrlich, P.R. (2010)**: *Conservation Biology for All*. Oxford University Press.
- **Bharucha, E. (2013)**: *Textbook of Environmental Studies for Undergraduate Courses*. University Press.

Course – Fundamental of industry Biotechnology
Course code –BBI100A
Lectures: 3 Hrs/week

Course Code: BBI100A

Course Name: Fundamental of industry Biotechnology **Credit(s): 3**

Course Outcome:

Students will able to

CO1-Understand the role and scope of microorganisms in industrial biotechnology.

CO2-Explain fermentation types, growth kinetics, and bioreactor design.

CO3-Describe the production and applications of industrial metabolites and enzymes.

CO4-Illustrate techniques involved in downstream processing and product recovery.

CO5-Assess current applications and ethical regulations in industrial biotechnology.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	1	1	2	1	2
CO2	3	3	3	2	3	2	2
CO3	3	2	2	2	2	2	2
CO4	3	2	2	3	3	2	2
CO5	3	2	2	2	2	3	3

1-LOW, 2-MEDIUM, 3-HIGH

Unit 1

Scope and significance of industrial biotechnology, Types of microbial fermentation: batch, fed-batch, continuous, industrially important microorganisms and strain improvement, Concepts of upstream and downstream processing

Unit 2

Microbial growth kinetics, Factors affecting microbial growth, Design and components of a bioreactor (stirred tank, airlift, packed bed), Sterilization techniques: batch and continuous

Unit 3

Production processes: ethanol, citric acid, lactic acid, Antibiotics: penicillin and streptomycin, Amino acids and vitamins: lysine, vitamin B12, Enzymes and biopolymers: amylase, protease, xanthan gum

Unit 4

Cell separation: centrifugation, filtration, Cell disruption methods, Purification: precipitation, chromatography, Drying and formulation of final products

Unit 5

Industrial enzymes and recombinant proteins, Biorefineries and bioplastics, Waste management using microbes, Good Manufacturing Practices (GMP), biosafety, and regulations

Course Code: BBI101A
Course Name: Industrial Biotechnology Lab **Credit(s):1**

Course Outcome

Students will able to

CO1-Isolate and identify microbes used in industrial fermentation.

CO2-Study microbial growth kinetics and assess product yield.

CO3-Perform and interpret small-scale fermentations and enzyme activity assays.

CO4-Demonstrate downstream processing methods used for industrial products.

CO5-Relate theoretical knowledge to industrial practices through case studies or visits.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

PCOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7
PCO1	3	2	2	3	2	2	2
PCO2	3	3	2	3	2	2	2
PCO3	3	2	3	3	3	2	2
PCO4	3	2	3	3	3	2	2
PCO5	3	2	2	2	2	3	3

1-LOW, 2-MEDIUM, 3-HIGH

1. Isolation from soil, water, or industrial samples
2. Screening for **amylase, protease, lipase** producers using plate assays
3. Inoculation in nutrient broth
4. Optical density (OD) measurement at regular intervals
5. Plotting growth curve and calculating growth rate
6. Gravimetric method for biomass measurement
7. Product estimation (e.g., ethanol via potassium dichromate method)
8. Setup of fermentation process in flask or mini-fermenter
9. Substrate inoculation and monitoring over 2–5 days
10. Estimation of fermentation yield
11. Solid-state or submerged fermentation for **amylase/protease**
12. Enzyme activity measurement (DNS assay for amylase, casein digestion for protease)

13. Demonstration of **autoclave, filtration, UV sterilization**
14. Sterility testing of media and equipment
15. Study of components of a **lab-scale fermenter**

Course – Microbial Physiology
Course code –BBI102A
Lectures: 3 Hrs/week

Course Code: BBI102A

Course Name: Microbial Physiology **Credit(s): 3**

Course Outcome:

Students will able to

CO1-Describe the structure and function of microbial cells and their components.

CO2-Classify microorganisms based on nutritional requirements and culture conditions.

CO3-Explain the metabolic pathways involved in microbial growth and energy generation.

CO4-Analyze enzyme kinetics and bioenergetic principles in microbial physiology.

CO5-Discuss microbial adaptations and stress responses at physiological levels.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	1	2	1	2
CO2	3	3	2	2	2	2	2
CO3	3	3	3	2	3	2	2
CO4	3	3	3	3	3	2	2
CO5	3	2	2	2	2	2	3

1-LOW, 2-MEDIUM, 3-HIGH

Unit 1

Prokaryotic vs eukaryotic microbial cell structure, Cell wall architecture (Gram-positive and Gram-negative), Cytoplasmic membrane, flagella, pili, capsules, Cell division and growth

Unit 2

Nutritional classification: phototrophs, chemotrophs, autotrophs, heterotrophs, Macronutrients and micronutrients, Culture media: defined, complex, selective, differential, Uptake of nutrients: passive, active, group translocation

Unit 3

Overview of catabolism and anabolism, Energy generation pathways: glycolysis, TCA cycle, oxidative phosphorylation, Fermentation: types and industrial applications, Photosynthetic and chemolithotrophic pathways

Unit 4

Enzyme classification, coenzymes, cofactors, Enzyme kinetics: Michaelis-Menten, Lineweaver-Burk plot, Factors affecting enzyme activity, ATP generation and electron transport systems

Unit 5

Stress responses: temperature, pH, osmotic, oxidative, Sporulation and germination, Regulation of gene expression in microbes Quorum sensing and signal transduction

Course Code: BBI103A

Course Name: Practicals of Microbial Physiology **Credit(s):1**

Course outcome

Students will able to

CO1-Prepare sterile media and culture microbes under various conditions.

CO2-Monitor and analyze microbial growth and environmental influences.

CO3-Perform fermentation and enzyme assays relevant to microbial metabolism.

CO4-Identify physiological responses such as sporulation and stress tolerance in microbes.

CO5-Interpret experimental results and represent data graphically for physiological parameters.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

PCOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7
PCO1	3	2	2	3	2	2	2
PCO2	3	3	2	3	3	2	2
PCO3	3	3	3	3	3	2	2
PCO4	3	2	2	2	2	3	3
PCO5	3	3	3	2	3	2	2

1. Preparation and sterilization of media for microbial growth
2. Measurement of microbial growth: OD method, viable count (CFU)
3. Study of effect of pH, temperature, and salt on bacterial growth
4. Estimation of bacterial respiration rate
5. Demonstration of fermentation by yeast and product estimation (ethanol or acid)
6. Enzyme activity assay (e.g., amylase/protease)
7. Observation of sporulation and germination under the microscope
8. Study of cell membrane permeability (e.g., salt/sugar solution effect)
9. Graphical plotting of bacterial growth curve

Course – Microbial genetics and r-DNA technology

Course code –BBI102A

Lectures: 3 Hrs/week

Course Code: BBI104A

Course Name: Microbial genetics and r-DNA technology **Credit(s): 3**

Course Outcome

Students will able to

Understand molecular structure and functions of nucleic acids in microbes.

Explain gene expression, regulation, and mutation mechanisms.

Describe genetic transfer mechanisms and their role in microbial evolution.

Apply the principles and tools of recombinant DNA technology.
Analyze the ethical, legal, and societal aspects of GMOs and rDNA technology.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	2	2	2	1
CO2	3	3	2	2	2	2	1
CO3	3	3	3	3	3	2	2
CO4	3	3	3	3	3	2	2
CO5	3	2	2	2	3	3	3

Unit 1

Structure and function of DNA, RNA, DNA replication, transcription, translation, Genetic code and regulation of gene expression, Mutation: types, mutagens, DNA repair mechanisms

Unit 2

Horizontal gene transfer: conjugation, transformation, transduction, Plasmids: types, properties, significance, Transposable elements and IS elements, Bacteriophage life cycles (lytic and lysogenic)

Unit 3:

Restriction enzymes, ligases, polymerases, Cloning vectors: plasmids, cosmids, phages, BACs, YACs, Host cells: E. coli and other bacterial systems, Techniques for making competent cells

Unit 4

Gene cloning strategies, cDNA and genomic library construction, PCR and blotting techniques (Southern, Northern, Western), DNA sequencing and analysis

Unit 5

GMOs: production and applications, Gene therapy basics, Biosafety levels and ethical concerns, Patents in biotechnology

Reference books

1. Molecular Biology of the Gene – Watson et al.
2. Gene Cloning and DNA Analysis – T.A. Brown
3. Principles of Gene Manipulation and Genomics – Primrose & Twyman
4. Molecular Genetics of Bacteria – Snyder and Champness
5. Recombinant DNA – Watson, Gilman, Witkowski, Zoller

6. Laboratory Manual in Molecular Biology – Sambrook & Russell

7. University/ICAR Practical Manuals (for lab work)

BBI105A: Microbial genetics Lab **Credit(s):1**

Course outcome

Students will able to

CO1-Extract and analyze genomic and plasmid DNA using electrophoresis techniques.
CO2-Perform restriction digestion and transformation in bacterial cells.
CO3-Screen and identify recombinant clones using blue-white selection and antibiotic markers.
CO4-Amplify DNA fragments using PCR and assess results using gel electrophoresis.
CO5-Demonstrate biosafety procedures and maintain lab records effectively.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

PCOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7
PCO1	3	2	2	3	3	2	1
PCO2	3	3	3	3	3	2	2
PCO3	3	3	3	3	3	3	2
PCO4	3	3	3	3	3	2	2
PCO5	3	2	2	2	2	3	3

1. Isolation of genomic DNA from bacteria
2. Isolation of plasmid DNA from E. coli
3. Agarose gel electrophoresis of DNA
4. Restriction digestion of DNA
5. Preparation of competent cells ($CaCl_2$ method)
6. Bacterial transformation using plasmid DNA
7. Blue-white screening for recombinant selection
8. Antibiotic resistance screening
9. PCR amplification of target DNA
10. Demonstration of Southern blotting

Course – Pharmaceutical chemistry
Course code –BBI106A
Lectures: 3 Hrs/week

Course Code: BBI106A

Course Name: Pharmaceutical chemistry **Credit(s): 3**

Course outcome

Students will able to

CO1-Understand the scope, nomenclature, and classification of pharmaceutical compounds.
CO2-Describe drug actions, pharmacokinetics, and pharmacodynamics.
CO3-Analyze the chemical nature of therapeutic agents and their synthesis.
CO4-Evaluate drug formulation strategies and quality control parameters.
CO5-Recognize emerging trends and ethical issues in pharmaceutical chemistry.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	2	2	2	1
CO2	3	3	2	3	2	2	2
CO3	3	3	3	3	2	2	2
CO4	3	2	3	3	3	3	2
CO5	2	3	2	2	3	3	3

Unit 1

Scope and importance, Sources of drugs (natural, synthetic, semi-synthetic), Drug nomenclature: generic, chemical, brand names, Routes of drug administration, Pharmacokinetics: Absorption, distribution, metabolism, excretion (ADME)

Unit 2

Drug–receptor interactions, Dose–response relationships, Therapeutic index and drug potency, Drug antagonism and synergism, Side effects, toxicity, and drug tolerance

Unit 3

Analgesics and antipyretics (aspirin, paracetamol), Antibiotics: Penicillin, streptomycin, tetracyclines, Sulfa drugs and antiseptics, Antimalarials and antifungal agents, Chemotherapy of cancer

Unit 4

Tablets, capsules, suspensions, emulsions formulation, Quality control and stability testing, Role of excipients and preservatives, pharmaceutical additives and binders, Good Manufacturing Practices (GMP)

Unit 5

Drug discovery and development, High-throughput screening, Computer-Aided Drug Design (CADD), Nanomedicine and targeted drug delivery, Intellectual Property Rights (IPR) in pharmaceuticals

Reference books

1. “Textbook of Pharmaceutical Chemistry” – Jayashree Ghosh
2. “Pharmaceutical Chemistry” – V.K. Ahluwalia and Madhu Chopra
3. “Remington: The Science and Practice of Pharmacy” – David B. Troy

4. “Pharmaceutical Organic Chemistry” – B. S. Rathi
5. “Medicinal Chemistry” – Ashutosh Kar
6. Practical Manual of Pharmaceutical Chemistry – University-level manuals or AICTE/UGC-approved lab guide.

BBI107A: Pharmaceutical chemistry Lab **Credit(s):1**

Course outcome

Students will able to

CO1-Perform basic synthesis and testing of pharmaceutical compounds.
CO2-Evaluate physicochemical properties and purity of drugs using standard techniques.
CO3-Formulate simple pharmaceutical preparations and test their quality.
CO4-Apply spectrophotometric and chromatographic methods in drug analysis.
CO5-Demonstrate safe laboratory practices and documentation skills.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

PCOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7
PCO1	3	3	3	2	2	2	1
PCO2	3	3	3	3	2	2	2
PCO3	3	2	3	3	3	3	2
PCO4	3	3	3	3	3	2	2
PCO5	3	2	2	2	2	3	3

1. Preparation of aspirin and its purity test
2. Identification of common pharmaceutical compounds (paracetamol, caffeine, urea, etc.)
3. Determination of physical constants (melting/boiling point) of drug samples
4. UV-Vis spectrophotometric assay of a drug
5. Limit test for heavy metals and chloride
6. Determination of pKa and partition coefficient
7. Qualitative analysis of some drugs using TLC
8. Preparation of a simple pharmaceutical formulation (ointment/syrup)
9. Study of drug solubility and pH dependence
10. Study of antimicrobial activity of a drug (disc diffusion method)

Course – Bioprocess Engineering
Course code –BBI108A
Lectures: 3 Hrs/week

Course Code: BBI108A

Course Name: Bioprocess Engineering **Credit(s):3**

Course Outcomes:

Students will able to

CO1: Explain principles of microbial nutrition, media design, and sterilization for industrial bioprocesses.
CO2: Analyze performance and design parameters of various bioreactors (including non-ideal).
CO3: Apply kinetic models and scale-up methodologies to engineer effective bioprocesses.
CO4: Design and execute downstream processing protocols for product recovery.
CO5: Implement process control and modeling tools to monitor and predict bioprocess behavior.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

CO	PO1	PO2	PO3	PO4	PO5	PO7
CO1	3	2	2	1	1	1
CO2	3	3	3	2	2	2
CO3	2	3	2	2	3	2
CO4	2	2	3	2	2	1
CO5	1	3	2	2	3	3

Unit 1

Microbial Cultivation & Media Optimization
Basics of microbial growth, designing and optimizing media, sterilization techniques (as in Bioprocess Technology syllabi)

Unit 2

Bioreactor Design & Operation
Types of bioreactors, mass and energy balances, reactor modeling, residence time distribution, and control loops

Unit 3

Bioprocess Kinetics & Scale-up
Reaction kinetics, effectiveness factors, scale-up principles, and optimization strategies

Unit 4

Downstream Processing & Separation Techniques
Downstream processing methodologies—extraction, purification, chromatography,

Unit 5

Process Control, Monitoring & Modeling
Control strategies, instrumentation for monitoring bioreactors, mathematical modeling, and simulation

Course Code: BBI109A
Course Name: Bioprocess Engineering Lab **Credit(s):1**

Course Outcomes:
Students will able to
CO1 Master practical lab equipment and control systems in bioprocessing
CO2 Carry out control system experiments using real-world setups
CO3 Follow protocols to design and operate process control systems
CO4 Analyze data, interpret results, and document findings professionally

CO5 Lead and collaborate within quasi-GMP laboratory settings

Mapping of PO/CO

CO	PO1	PO2	PO3:	PO4	PO5:	PO7:
CO1	3	2	2	1	1	1
CO2	3	3	3	2	2	2
CO3	2	3	2	2	3	2
CO4	2	2	3	2	2	1
CO5	1	3	2	2	3	3

1. Media preparation and sterilization protocols; monitoring microbial growth.
2. Setting up and operating lab-scale bioreactors; measuring parameters (pH, DO, temperature, agitation).
3. Conducting scale-up experiments; performing mass/energy balance calculations.
4. Downstream processing exercises—e.g., separation, purification trials.
5. Using simulation software for modeling bioprocesses; evaluating control strategies

Reference books

1. **Bioprocess Engineering: Basic Concepts** by Michael L. Shuler – accessible for undergrad/postgrad students
2. **Biochemical Engineering Fundamentals** by Bailey & Ollis – classic text on theoretical foundations
3. **Biotechnology Engineering: A Practical Approach on Bioprocess Development** – includes case studies, software tools, modern applications
4. From Sanfoundry's curated list – covers other standard textbooks widely used in bioprocess engineering education

Course – Enzyme technology and Biotransformation
Course code –BBI110A
Lectures: 3 Hrs/week

Course Code: BBI110A
Course Name: Enzyme technology and Biotransformation **Credit(s):3**

Course Outcomes:
Students will able to

CO1: Describe enzyme mechanisms, classifications, and analytical characterization techniques.

CO2: Apply enzyme kinetics principles to determine reaction parameters and inhibition modes.

CO3: Understand and implement immobilization strategies and biosensor design.

CO4: Execute enzyme-mediated biotransformation, including functional group conversions and drug biotransformation.

CO5: Analyze and illustrate enzyme applications across diagnostics, industry, and environmental biotechnology.

Mapping of PO/CO

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	3	1	1	2
CO2	2	3	2	3	1	2	2
CO3	2	2	3	3	1	2	2
CO4	2	2	3	3	1	2	3
CO5	3	2	3	3	2	2	3

Unit I – Introduction & Enzyme Fundamentals
Enzyme classification, catalytic mechanisms, active site energetics, specificity, catalysis (collision and transition state theories), entropy effects, purity criteria, enzyme characterization (e.g., molecular weight)

Unit II – Enzyme Kinetics & Regulation
Single/multi-substrate kinetics, Michaelis–Menten parameters (Km, Vmax), turnover number (kcat), inhibition types (competitive, non-competitive, uncompetitive, allosteric), Monod–Wyman–Changeux model, pH/temperature effects, deactivation kinetics

Unit III – Immobilization Techniques & Biosensors
Approaches: adsorption, matrix entrapment, encapsulation, covalent linking, cross-linking; design of immobilized enzyme reactors; biosensor construction and applications

Unit IV – Biotransformation & Functional Group Transformations
Enzyme-catalyzed conversion of functional groups (hydrolysis, oxidation/reduction, C–C bond formation), retrosynthetic biocatalysis, chemoenzymatic synthesis, catalytic antibodies, artificial enzymes, drug biotransformation processes

Unit V – Industrial & Analytical Applications
Enzyme applications across diagnostics, biosensors, food, textiles, pulp and paper, pharmaceuticals; environmental uses, molecular biology tools

Course code: BBI111A
Course name- Enzyme technology Lab
Credit(s):1

Course outcomes:

Students will bale to

CO1: Employ appropriate techniques for enzyme isolation, purification, and characterization in laboratory settings.

CO2: Conduct enzyme kinetics studies—including determination of Km, Vmax, and types of inhibition—through hands-on experimental methods.

CO3: Implement enzyme immobilization methods and compare activities between free and immobilized enzymes.

CO4: Perform biotransformation processes and evaluate their effectiveness using analytical techniques.

CO5: Develop teamwork, data analysis, and scientific reporting aptitudes through collaborative practical experiments.

Mapping of PO/CO

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	0	2	0	1	1
CO2	3	3	2	1	1	0	1
CO3	2	2	3	2	1	0	0
CO4	3	2	3	2	3	1	1
CO5	3	3	2	2	1	1	0

Enzyme Activity Assays

Measure enzyme-specific activity, Km, and Vmax via spectrophotometric or fixed-time methods.

Effects of pH & Temperature

Study enzyme stability and activity across pH/temperature gradients, determine deactivation kinetics.

Enzyme Immobilization

Immobilize enzymes using techniques like adsorption or cross-linking; compare activity with free enzymes.

Biosensor Demonstrations

Design or test enzyme-based sensors (e.g., glucose electrodes); measure analytical response.

Biotransformation Reactions

Conduct enzyme-mediated conversion of model substrates, e.g., chiral compound synthesis or drug-like molecules.

Industrial Application Modules

Perform assays relevant to food or environmental industries, such as amylase activity or pollutant degradation.

Reference books

1. **Enzyme Technology** — Messing, Wiley
2. **Fundamentals of Enzymology** — Price & Stevens, Oxford
3. **Enzymes – Biochemistry, Biotechnology, Clinical Chemistry** — Trevor Palmer, Horwood
4. **Biotransformations in Organic Chemistry** — Kurt Faber, Springer
5. **Enzymes in Industry: Production and Applications** — W. Gerhartz, VCH
6. Additional references: **Biochemical Engineering Fundamentals** (Bailey & Ollis), etc., if deeper engineering focus required.

Course – Industrial Manufacturing
Course code –BBI112A
Lectures: 3 Hrs/week

Course Code: BBI112A
Course Name: Industrial Manufacturing **Credit(s):3**

Course Outcomes:
Students will able to

CO1: Understand and differentiate between manufacturing systems, automation strategies, and production types.

CO2: Develop and apply production planning tools including inventory models, MRP interpretations, and scheduling heuristics.

CO3: Analyze, operate, and evaluate machining and rapid prototyping technologies.

CO4: Apply principles of automation—like robotics, CIM, and PLC—to real-world manufacturing setups.

CO5: Execute industrial problem-solving using ergonomics, layout analysis, and quality control techniques.

Mapping of PO/CO

PCOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7
PCO1	3	2	2	3	2	2	2
PCO2	3	3	2	3	2	2	2
PCO3	3	2	3	3	3	2	2
PCO4	3	2	3	3	3	2	2
PCO5	3	2	2	2	2	3	3

Unit I

Fundamentals of Manufacturing Systems & Automation
Covers production types, automation approaches, concepts of Flexible Manufacturing Systems (FMS), and group technology (fabrication and part families).

Unit II

Production Planning & Control
Includes inventory control, MRP, scheduling, Lean Manufacturing methods like value-stream mapping.

Unit III

Manufacturing Processes & Technologies
Studies casting, welding, forming, machining, additive manufacturing, CNC, and rapid prototyping.

Unit IV

Industrial Automation & Control
Focuses on robotics, PLCs, computer-integrated manufacturing (CIM), instrumentation, and Industry 4.0 applications.

Unit V

Quality, Layout & Ergonomics
Teaches statistical quality control, facility layout, ergonomic design, metrology, and measurement systems.

Course code: BBI113A

Course name: Industrial Manufacturing Lab
Credit(s):1

Course Outcome:

Students will be able to:

CO1: Demonstrate proficiency in conventional (lathe, milling) and CNC machining tools and operations.

CO2: Develop and evaluate robotic sequences and automation workflows.

CO3: Apply inventory planning and scheduling tools for effective production control.

CO4: Identify and eliminate process inefficiencies via lean manufacturing techniques.

CO5: Use quality measurement tools and statistical approaches for manufacturing accuracy and control.

Mapping of PO/CO

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7

CO1	3	2	3	2	1	1	2
CO2	2	3	3	2	1	1	2
CO3	3	2	3	2	2	1	3
CO4	3	2	3	2	2	2	2
CO5	3	3	3	3	2	2	3

1. **Machining Fundamentals**
2. Operations: turning (lathe), milling, drilling, Focus: tool setup, cutting parameters, surface finish evaluation
3. **CNC Programming & Operation**
4. Learning G-code basics, programming, simulation, and execution on CNC machines
5. **Casting & Forming Workshops**
6. Hands-on with sand casting and basic metal forming techniques
7. **Robotics & Automation Simulation**
8. Programming pick-and-place tasks; simulation of robotic movements and sequences
9. **Production Planning Tools**
10. Exercises: Inventory control (ABC analysis), basic MRP, production scheduling using analytical tools
11. **Lean Manufacturing Activities**
12. Value-stream mapping, simulation of cellular layouts, identifying waste and improvement opportunities
13. **Quality & Metrology Sessions**
14. Measurement techniques, capability studies, use of gauges and CMM (Coordinate Measuring Machine) if available

Reference books

1. **Manufacturing Engineering and Technology** (Kalpakjian, Schmid)
2. **Fundamentals of Modern Manufacturing** (Groover)
3. **CNC Programming Techniques – An Insider's View** (Milholland)
4. **Introduction to Robotics: Analysis, Systems, Applications** (Craig)
5. **Production Planning and Control** (Joseph G. Monks)

Course – BASICS OF BIOINFORMATICS
Course code – BBI157A
Lectures: 3 Hrs/week

Course Code: BBI157A
Course Name: BASICS OF BIOINFORMATICS **Credit(s):3**

Course Outcomes:
CO-1: Student will able to understand the basic concept of Bioinformatics.
CO-2: Student will able to acquire the basic concepts of biological databases and their file format.
CO3: Student will able to determine identity between the biological sequences by similarity alignments.
CO4: Students will be able to understand the gene expression of the organisms.
CO5: Use gene and protein prediction tools and understand their relevance in genome annotation.

Mapping of PO/CO

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	0	2	0	1	1
CO2	3	3	2	1	1	0	1
CO3	2	2	3	2	1	0	0
CO4	3	2	3	2	3	1	1
CO5	3	2	2	1	0	1	1

1-LOW, 2-MEDIUM, 3-HIGH

Unit I

What is Bioinformatics and its relation with molecular biology Examples of related tools (FASTA, BLAST, BLAT, RASMOL), databases (GENBANK, Pubmed, PDB) and software (RASMOL, Ligand Explorer), Data generation; Generation of large-scale molecular biology data. (Through Genome sequencing, Protein sequencing, Gel electrophoresis, NMR Spectroscopy, X-Ray Diffraction, and microarray). Applications of Bioinformatics.

Unit II

Biological Database and its Types, Introduction to data types and Source. Population and sample, Classification and Presentation of Data. Quality of data, private and public data sources. General Introduction of Biological Databases; Nucleic acid databases (NCBI, DDBJ, and EMBL). Protein databases (Primary, Composite, and Secondary). Specialized Genome databases: (SGD, TIGR, and ACeDB). Structure databases (CATH, SCOP, and PDBsum).

Unit III

Data storage and retrieval and Interoperability, Flat files, relational, object-oriented databases and controlled vocabularies. File Format (Genbank, DDBJ, FASTA, PDB, SwissProt).

Unit IV

Sequence Alignments and Visualization, Introduction to Sequences, alignments and Dynamic Programming, Local alignment and Global alignment (algorithm and example), Pairwise alignment (BLAST and FASTA Algorithm) and multiple sequence alignment (Clustal W algorithm). Methods for presenting large quantities of biological data: sequence viewers (Artemis, SeqVISTA), 3D structure viewers (Rasmol, SPDBv, Chime, Cn3D, PyMol), Anatomical visualization.

Unit V

Gene Expression and Representation of patterns and relationship, General introduction to Gene expression in prokaryotes and eukaryotes, transcription factors binding sites. SNP, EST, STS. Introduction to Regular Expression, Hierarchies, and Graphical models (including Marcov chain and Bayes notes). Genetic variability and connections to clinical data.

References:

1. David W. Mount - Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor Laboratory, 2004.

Course code: BBI158A
Course name: Bioinformatics Lab **Credit(s): 1**

Course Outcome:
Students will able to

CO1 Retrieve biological sequence data from online databases like NCBI, UniProt, and EMBL.
CO2 Perform and interpret pairwise and multiple sequence alignments using tools like BLAST and ClustalW.
CO3 Identify open reading frames and predict genes using tools like ORF Finder and GENSCAN.
CO4 Utilize tools for protein structure and function prediction (e.g., ExPASy, Swiss-Model).
CO5 Demonstrate basic phylogenetic analysis using tools like MEGA or Phylogeny.

CO/PO Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	2	2	3	1	1	2
CO2	2	3	3	3	1	2	2
CO3	2	2	3	3	1	1	2
CO4	2	2	2	3	1	2	2
CO5	2	3	2	2	1	2	3

1. To Characterize of a Known Gene.
2. To Find out open reading frames (ORF) through NCBI ORF finder.
3. To Identify a gene using BLAST program.
4. To Find the conserved Domains in Protein Sequences.
5. To find the sequence similarity between sequence by using nucleotide BLAST.
6. To find the sequence similarity between sequence by using protein BLAST.
7. To perform Sequence alignment through FASTA.
8. To perform multiple alignment with T-coffee.
9. To perform agarose gel electrophoresis.

Course Code: BBI159A
Course Name: Structural Bioinformatics
Lectures: 3 Hrs/week

Course Code: BBI159A
Course Name: Structural Bioinformatics **Credit(s):3**

Course Outcomes:
CO-1: Student will able to understand the basic concept of protein structures.
CO-2: Student will able to acquire the basic concepts of protein databases and their file format.

CO3: Student will able to determine homology between the biological sequences by similarity alignments.
CO4: Students will be able to understand the structural features of RNA of the organisms.
CO5: Evaluate structure-function relationships in biomolecules and their implications in drug discovery and disease.

Mapping of PO/CO

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	0	2	0	1	1
CO2	3	3	2	1	1	0	1
CO3	2	2	3	2	1	0	0
CO4	3	2	3	2	3	1	1
CO5	3	2	1	1	3	1	0

1-LOW, 2-MEDIUM, 3-HIGH

Unit I

Fundamentals of X-ray diffraction, NMR spectroscopy of macromolecules, Protein Structure: Primary, Secondary, Super Secondary, Domains, Tertiary, Quaternary, Ramachandran plot.

Unit II

Protein secondary structure classification databases: HSSP, FSSP, CATH, SCOP, Protein secondary structure prediction methods: GOR, Chou-Fasman, PHD, PSI- PRED, J-Pred.

Unit III

Protein Tertiary structure prediction methods: Homology Modeling, Fold Recognition, Ab- intio Method, Protein folding, Molecular Dynamics of Protein, Molecular Docking of Protein, Small molecule and Nucleotide, Concepts of Force Field

Unit IV

Motif and Domain: Motif databases and analysis tools, Domain databases (CDD, SMART, ProDom) and Analysis tools. HMM (Hidden Markov Model): Introduction to HMM, its application in Sequence alignment and Structure prediction, HMM based Softwares (HMMER and HMMSTR)

Unit V

Structural features of RNA: Primary, Secondary, Tertiary. Introduction to RNA Secondary structure prediction, Methods for RNA Secondary structure prediction, Limitation of RNA Secondary structure prediction.

References:

1. David W. Mount - Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor Laboratory, 2004.

Course code: BBI160A
Course name- Practical of structural bioinformatics **Credit(s):1**

Course Outcome

Students will able to

CO1 Retrieve and analyze 3D structures of proteins and nucleic acids from structural databases such as PDB.

CO2 Visualize and interpret structural features of biomolecules using tools like PyMOL, Chimera, or RasMol.

CO3 Compare and classify protein structures using SCOP, CATH, and related classification systems.

CO4 Perform homology modeling and validate predicted structures using tools like SWISS-MODEL and PROCHECK.

CO5 Identify structure-function relationships and binding sites relevant to drug design and protein engineering.

CO/PO Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	3	1	1	2
CO2	2	3	2	3	1	2	2
CO3	2	2	3	3	1	2	2
CO4	2	2	3	3	1	2	3
CO5	3	2	3	3	2	2	3

1-LOW, 2-MEDIUM, 3-HIGH

1. To retrieve the protein sequences from NCBI database and to interpret the results.
2. To Study protein X-ray diffraction data by using Protein Structure Database.
3. To Find the conserved Domains in Protein Sequences.
4. To analyse the retrieve protein sequence for Ramachandran Plot by using PSVS.
5. To study structural features of RNA by using different RNA database and softwares.
6. To determine the motifs, present in your target proteins.
7. To perform homology alignment by using pdb-BLAST.
8. To analyse the secondary structural elements of the given target proteins.

Course Name: Informatics in Omics and its application

Course Code: BBI161A

Credit(s):3

Course Outcomes:

CO-1: Student will able to understand the basic concept of genomics.

CO-2: Student will able to acquire the basic concepts of system biology and metagenomic.

CO3: Student will able to understand metabolic pathway database and drug designing.

CO4: Students will be able to understand the structural features of compound library.

CO5: Evaluate the applications of omics in personalized medicine, diagnostics, and drug discovery.

Mapping of PO/CO

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	0	2	0	1	1
CO2	3	3	2	1	1	0	1
CO3	2	2	3	2	1	0	0
CO4	3	2	3	2	3	1	1
CO5	3	2	3	2	1	1	0

1-LOW, 2-MEDIUM, 3-HIGH

Unit I

Genomics: Genome Annotation, Genome Assembly, Structural and Functional Genomics. Comparative Genomics, Microarray: technique, Design, Analysis, Drug target identification.

Unit II

System biology: Introduction, Associated disciplines, Interactomics (PPI), Fluxomics, Biomics. Metagenomics: Introduction, metagenome, shotgun metagenomics (pyrosequencing). Tool's in metagenomics, MEGAN, MG- RAST, and SEED. Application: Gene survey, Environmental genomes, Microbial diversity.

Unit III

Metabolic pathway database (KEGG pathway database), Concept of metabolome and metabolomics. Drug Discovery and design: Target identification, Target Validation, Lead Identification, lead optimization, preclinical Pharmacology & Taxology.

Unit IV

Chemoinformatics: Cheminformatics tools for drug discovery. Chemical Structure Representation (SMILE & SMART). Chemical databases: CSD, ACD, WDI, ChemBank, hazardous chemical database, PUBCHEM.

Unit V

Quantitative Structure Activity Relationship (2D & 3D). Combinatorial libraries & their design. High throughput screening, virtual screening, Lipinski's rule of five.

Reference:

1. D. Baxivanis and Foulette - Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Wiely Indian Edition, 2001.
2. David W. Mount - Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor Laboratory, 2004.

Course Code: BBI162A
Course Name - Practical of omics and its application **Credit(s):1**

Student will be able to:

CO1 Retrieve and interpret omics datasets (genomics, transcriptomics, proteomics) from public repositories like NCBI GEO, ENA.

CO2 Perform CADD databases and ADMET analysis

CO3 Analyze transcriptomic (RNA-seq) or proteomic data using pipelines such as MG-RAST

CO4 Use databases and tools (KEGG, STRING, Reactome) for pathway and functional enrichment analysis.

CO5 Interpret integrated omics results for biological significance in disease, drug response, or metabolic regulation.

CO/PO Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	3	1	1	2
CO2	2	3	2	3	1	1	2
CO3	3	3	3	3	1	2	2
CO4	2	2	2	3	1	2	3
CO5	3	2	3	3	2	2	3

1. To retrieve the genomics and proteomics data from biological databases.
2. To study CADD (computer added drug designing) database.
3. To perform ADMET analysis of chemical compounds by using computational tools.
4. To study the installation of the softwares.
5. To retrieve the chemical compounds from different chemical databases.
6. To study the Lipinski's rule of five with respect to chemical compounds.
7. To perform metagenomic analysis by using MG-RAST.
8. To perform string analysis for protein-protein interaction studies.
9. To retrieve the whole genome sequences from ncbi database and study the containing ORF regions in particular genome.
10. Find out the number of entries in SWISSPROT for Serine kinase in PIG.

Course Code: BBI163A

Course Name: Molecular Modelling and molecular mechanics

Credit(s):3

Course Outcomes:

CO-1: Student will able to understand the basic concept of molecular modelling.

CO-2: Student will able to acquire the basic concepts of biomolecules.

CO3: Student will able to understand the concept of molecular dynamic.

CO4: Students will be able to understand the structural features of compound library and drug designing.

CO5: Evaluate the role of molecular modeling and mechanics in drug design and structure-based functional prediction.

Mapping of PO/CO

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	0	2	0	1	1
CO2	3	3	2	1	1	0	1
CO3	2	2	3	2	1	0	0
CO4	3	2	3	2	3	1	1
CO5	3	3	2	2	1	1	0

1-LOW, 2-MEDIUM, 3-HIGH

Unit I

Molecular Modeling and Molecular Mechanics: Introduction to Molecular Modelling, Protein Secondary and Tertiary structure elements, Empirical Force Fields for Molecular Mechanics: bond stretching, angle bending, torsion, improper torsion, Lennard-Jones potential and van der waals interactions.

Unit II

Macromolecules: Study of self-organized assemblies, bio-molecules like peptides, proteins, membranes and ion channels through simulations. Concept of hydrophobic and hydrophilic interactions. Use of molecular modelling in drug design.

Unit III

Molecular Dynamics and Monte Carlo simulation: 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.

Unit IV

Homology Modelling – steps to get a model, Refinement of the model, Comparative modeling of proteins – comparison of 3D structure – Homology – steps in homology modeling – tools – databases – side chain modeling – loop modeling.

Unit-V

Drug design: General approach to discovery of new drugs - lead discovery – lead modification – physiochemical principles of drug action – drug stereo chemistry –drug action - 3D database search – computer aided drug design – docking - molecular modeling in drug design – structure-based drug design – pharmacophores - QSAR.

TEXT BOOKS:

1. A. R.Leach - Molecular Modeling Principles and Application, 2nd edition, Longman Publications, 1996.

2. D. Baxivanis and Foulette - Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Wiely Indian Edition, 2001.

REFERENCE BOOK:

1. T K Attwood, D J parry-Smith, Introduction to Bioinformatics, Pearson Education, 1st Edition, 11th Reprint 2005.

Course code: BBI164A

Course name: Practical on Molecular Modelling and molecular mechanics Credit(s):1

Students are able to:

CO1: Visualize and analyze molecular structures using molecular modeling software.
CO2: to generate the 3 D conformations of biological macromolecules.
CO3: to evaluate molecular energy between the atoms and residues of modeled structures.
CO4: familiar to install softwares used for molecular modeling and dynamics studies.
CO5: generate and draw chemical structure of compounds or chemical entities.

Mapping of PO/CO

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	3	2	3	1	2	2
CO2	3	3	3	3	1	2	2
CO3	3	2	3	3	1	2	2
CO4	3	3	3	3	2	3	3
CO5	2	3	3	3	2	2	3

1. To install modeller for homology modelling
2. To compare the predicted model with homologous protein structure with respect to Ramachandran plot and Z-score.
3. To visualize the predicted homology model by the help of Pymol viewer.
4. To perform loop modelling of generated 3D model of target proteins.
5. To perform threading modelling by using different computational tools.
6. To install GROMACS a molecular dynamics platform.
7. To perform 3D-QSAR by using online 3D-QSAR tool.
8. To draw a chemical entity by using chemdraw.

Course Name: Genomics analysis

Course Code: BBI165A

Credit(s): 3

Course Outcomes:

CO-1: Student will able to understand the basic concept of genome sequencing.
CO-2: Student will able to acquire the basic concepts of bioinformatics databases.
CO3: Student will able to understand the concept of gene expression.
CO4: Students will be able to understand the different types of genomics.
CO5: Design and implement basic genomics analysis pipelines and report results in a scientific format.

Mapping of PO/CO

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	1	1	1	2
CO2	2	3	3	2	2	1	2
CO3	3	3	3	2	2	1	2
CO4	2	2	3	2	1	1	3
CO5	2	2	3	3	2	2	3

1-LOW, 2-MEDIUM, 3-HIGH

Unit I

Large scale genome sequencing strategies, Genome assembly and annotation, Genome databases of Plants, animals and pathogens, Metagenomics, Gene networks: basic concepts, computational Model such as Lambda receptor and lac operon, Prediction of genes, promoters, splice sites, Regulatory regions: basic principles, application of methods to prokaryotic and eukaryotic Genomes and interpretation of results.

Unit II

Basic concepts on identification of disease genes, role of bioinformatics-OMIM database, reference genome sequence, integrated genomic maps, gene expression profiling; identification of SNPs, SNP database (DbSNP). Role of SNP in Pharmacogenomics, SNP arrays,

Unit III

DNA microarray: database and basic tools, Gene Expression Omnibus (GEO), ArrayExpress, SAGE databases, DNA microarray: understanding of microarray data, normalizing microarray data, detecting differential gene expression, correlation of gene expression data to biological process and computational analysis tools (especially clustering approaches).

Unit IV

Comparative genomics: Basic concepts and applications, BLAST2, MegaBlast algorithms, PipMaker, AVID, Vista, MUMmer, applications of suffix tree in comparative genomics, synteny and gene order comparisons, Comparative genomics databases: Clusters of Orthologous Groups (COGs)

Unit V

Functional genomics: Application of sequence based and structure-based approaches to

assignment of gene functions – e.g., sequence comparison, structure analysis (especially active sites, binding sites) and comparison, pattern identification, etc.

Reference:

1. D. Baxivanis and Foulette - Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Wiely Indian Edition, 2001.

Course Code: BBI166A

Course name: Practicals on Genomics analysis **Credit(s): 1**

Students will able to
CO1 Retrieve and analyze whole genome sequences using public databases like NCBI and visualize using tools like ENTEZ Map Viewer.
CO2 Perform quality control of genomic data using tools such as FASTQC.
CO3 Apply metagenomic tools like MG-RAST to analyze microbial community structure and functions.
CO4 Analyze protein-protein interaction networks using STRING database and interpret biological significance.
CO5 Demonstrate skills in gene prediction, genome assembly, and gene annotation.

CO/PO Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	3	2	1	1	2
CO2	2	3	3	2	1	1	2
CO3	3	2	3	2	2	1	3
CO4	3	2	3	2	2	2	2
CO5	3	3	3	3	2	2	3

1. To retrieve whole genome from genome database.
2. To perform FASTQC analysis with reference to given genomic sequences.
3. To perform metagenomic analysis by using MG-RAST.
4. To perform string analysis for protein-protein interaction studies.
5. To retrieve the whole genome sequences from ncbi database and study the containing ORF regions in particular genome.
6. Identify the Genes present if any in the given genomic sequence NC_010456.
7. To study genome assembly and gene annotation tools.
8. To view human genome in ENTEZ map viewer.

Course Name: Advance in Bioinformatics

Course Code: BBI167A

Credit(s): 3

Course Outcomes:

CO-1: Student will able to understand the basic concept of SNPs.
CO-2: Student will able to acquire the basic concepts of proteomics.
CO3: Student will able to understand the concept of drug designing and drug development.
CO4: Students will be able to understand the structure-based drug designing
CO5: Students will be able to understand how computational studies used in vaccine designing.

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	1	1	1	2
CO2	3	3	2	1	1	1	2
CO3	3	3	3	2	2	2	3
CO4	3	3	3	2	2	2	3
CO5	3	3	3	2	2	2	3

1-LOW, 2-MEDIUM, 3-HIGH

Unit I

Use of various derived databases in function assignment, use of SNPs for identification of genetic traits, Gene/Protein function prediction using Machine learning tools: supervised/unsupervised learning, Neural network, SVM etc.

Unit II

Proteomics Protein arrays: basic principles, Computational methods for identification of polypeptides from mass spectrometry, Protein arrays: bioinformatics-based tools for analysis of proteomics data (Tools available at ExPASy Proteomics server); databases (such as InterPro) and analysis tools Protein-protein interactions: databases such as STRINGS, DIP, PPI server and tools for analysis of protein-protein interactions,

Unit III

Modeling biological systems, Systems biology – Use of computers in simulation of cellular subsystems, Metabolic networks, or network of metabolites and enzymes, Signal transduction networks, Gene, regulatory networks, Metabolic pathways: databases such as KEGG, EMP , MetaCyc, AraCyc Drug design Drug discovery process, Role of Bioinformatics in drug design, Target identification and validation and lead optimization, Different systems for representing chemical structure of small molecules like SMILES etc, Generation of 3D coordinates of small

molecules,

Unit IV

Structure-based drug design: Identification and Analysis of Binding sites and virtual screening, Ligand based drug design: Structure Activity Relationship – QSARs and QSPRs, QSAR Methodology, Pharmacophore mapping, In silico prediction ADMET properties for Drug Molecules.

Unit V

Vaccine design: Reverse vaccinology and immunoinformatic, Databases in Immunology, Principles of B-cell and T-cell epitope prediction.

Course Code: BBI168A

Course Name: Advance in Bioinformatics practical lab **Credit(s):1**

Course Outcomes

Students will be able to

CO1 Understand and utilize biological databases such as NCBI and Expasy for protein and gene information retrieval.
CO2 Analyze genetic variations and immune epitopes using in silico tools such as PredictSNP and MHC/B-cell epitope prediction servers.
CO3 Apply ADMET and QSAR approaches to evaluate pharmacokinetic and pharmacodynamic properties of drug-like molecules.
CO4 Perform in silico cloning and analyze gene constructs using molecular biology software like SnapGene.
CO5 Predict active sites and analyze protein–protein interactions using STRING and structural modeling tools.

CO/PO Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	3	2	1	1	2
CO2	3	2	3	2	1	2	3
CO3	3	3	3	2	1	2	3
CO4	2	3	3	2	1	1	2
CO5	3	2	3	2	2	2	3

1. Biological Databases with Reference to Expasy and NCBI.
2. To find out the SNP information of a given protein sequence by using predictsnp server.
3. To predict MHC and B-cell epitope regions in given protein sequences.
4. To perform ADMET analysis of chemical compounds.
5. To find out the QSAR (quantitative structural relationship) between the pharmacophores.
6. To perform in silico cloning by using snapgene.
7. To analysis the active sites in a given target proteins.
8. To study the metabolic networks by using string.

Course Code: BBI169A

Course Name: In Silico drug designing **Credit(s):3**

Course Outcomes:

CO-1: Student will able to understand the basic concept of CADD.
CO-2: Student will able to acquire the basic concepts of QSAR.
CO3: Student will able to understand the concept of drug designing and drug development.
CO4: Students will be able to understand the molecular modeling and dynamics
CO5: Students will be able to understand the Pharmacophore mapping.

CO/PO Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	3	2	1	1	2
CO2	3	2	3	2	1	1	2
CO3	3	3	3	2	2	2	3
CO4	3	3	3	2	2	2	3
CO5	3	3	3	2	2	2	3

1-LOW, 2-MEDIUM, 3-HIGH

Unit I:

Introduction to Computer Aided Drug Design (CADD) History, different technique sand applications, Quantitative Structure Activity Relationships: Basics History and development of QSAR:Physicochemical parameters and methods to calculate physicochemical parameters: Hammett equation and electronic parameters (sigma), lipophilicity effects and parameters (log P, pi substituent constant), steric effects (Taft steric and MR parameters) Experimental and theoretical approaches for the determination of these physicochemical parameters.

Unit II:

Quantitative Structure Activity Relationships: Applications Hansch analysis, Free Wilson analysis and relationship between them, Advantages and disadvantages; Deriving 2D-QSAR equations 3D-QSARapproaches and contour map analysis Statistical methods used in QSAR analysis and importance of statistical parameters.

Unit III:

Molecular Modeling and Docking: Molecular and Quantum Mechanics in drug design, Energy Minimization Methods: comparison between global minimum conformation and bioactive conformation, Molecular docking and drug receptor interactions: Rigid docking, flexible docking and extra-precision docking. Agents acting on enzymes such as DHFR, HMG-CoA reductase and HIV protease, choline esterase (AchE & BchE).

Unit IV:

Molecular Properties and Drug Design: Prediction and analysis of ADMET properties of new molecules and its importance in drug design. De novo drug design: Receptor/enzyme-interaction and its analysis, Receptor/enzyme cavity size prediction, predicting the functional components of cavities, Fragment based drug design. Homology modelling and generation of 3D-structure of protein.

Unit V:

Pharmacophore Mapping and Virtual Screening 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 In-silico virtual screening protocols.

REFERENCES:

1. Computational and structural approaches to drug discovery, Robert M Stroudand Janet. F Moore, RCS Publishers.

2. Introduction to Quantitative Drug Design by Y.C. Martin, CRC Press, Taylor & Francis group.

3. Drug Design by Ariens Volume 1 to 10, Academic Press, 1975, Elsevier Publishers.

4. Principles of Drug Design by Smith and Williams, CRC Press, Taylor & Francis.

5. The Organic Chemistry of the Drug Design and Drug action by Richard B. Silverman, Elsevier Publishers.

6. Medicinal Chemistry by Burger, Wiley Publishing Co

7. An Introduction to Medicinal Chemistry –Graham L. Patrick, Oxford University Press.

8. Wilson and Gisvold's Text book of Organic Medicinal and Pharmaceutical Chemistry, Ippincott

Williams & Wilkins.

9. Comprehensive Medicinal Chemistry – Corwin and Hansch, Pergamon Publishers.

10. Computational and structural approaches to drug design edited by Robert M Stroudand Janet. F Moore

Course Code: BBI170A

Course Name: Practical on In Silico Drug Designing

Credit(s): 1

Course Outcome:

Students will beable to

CO1 Perform ADMET and QSAR analysis to evaluate drug-likeness and pharmacophore properties.
CO2 Analyze protein–protein interactions and metabolic pathways using STRING.
CO3 Apply computational methods like loop modeling, threading, and molecular docking for protein structure and interaction studies.
CO4 Install and operate molecular dynamics platforms like GROMACS and perform basic simulations.
CO5 Use cheminformatics tools like ChemDraw and perform 3D-QSAR modeling.

CO/PO Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	2	1	2	3
CO2	2	2	3	2	1	1	2
CO3	3	3	3	2	2	2	3
CO4	3	3	3	2	2	2	3
CO5	3	3	3	2	1	1	3

1. To perform ADMET analysis of chemical compounds.
2. To find out the QSAR (quantitative structural relationship) between the pharmacophores.

3. To perform string analysis for protein-protein interaction studies.

4. To perform loop modelling of generated 3D model of target proteins.

5. To perform threading modelling by using different computational tools.

6. To install GROMACS a molecular dynamics platform.

7. To perform 3D-QSAR by using online 3D-QSAR tool.

8. To draw a chemical entity by using chemdraw.

9. To perform molecular docking and dynamics calculation by online servers.

Course- Nanoscience and Nanotechnology
Course Code-BBI171A
Lectures: 3 Hrs/week

Course Code: BBI171A
Course Name: Nanoscience and Nanotechnology **Credit(s):3**

Course outcome

Students will able to
CO-1 Explain the historical development and basic concepts of nanotechnology.
CO-2 Understand nanoscale physics, quantum effects, and surface phenomena
CO-3 Identify and classify nanomaterials based on structure and properties
CO-4 Interpret UV-Vis, FTIR, Raman, and XRD data for nanoparticles
CO-5 Describe principles and applications of SEM, TEM, AFM, DLS

Mapping of PO/CO

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	1	1	1	1	1
CO2	3	3	2	1	1	1	1
CO3	3	2	2	2	2	1	1
CO4	3	3	3	3	1	1	2
CO5	2	3	3	2	1	1	1

1-LOW, 2-MEDIUM, 3-HIGH

Unit 1
Unit I: Introduction to Nanoscience

History, milestones, and scope, Nanoscale dimensions and their significance, Types of nanomaterials (0D, 1D, 2D, 3D)

Unit II: Physical and Chemical Principles

Surface area to volume ratio, Quantum effects and confinement, Surface energy, van der Waals forces with definition

Unit III: Types and Properties of Nanomaterials

Carbon nanostructures (fullerenes, CNTs, graphene), Quantum dots, metal nanoparticles, Magnetic nanoparticles

Unit IV: Characterization Techniques – I

UV-Visible spectroscopy, FTIR, Raman spectroscopy, X-ray diffraction (XRD)

Unit V: Characterization Techniques – II

Scanning electron microscopy (SEM), Transmission electron microscopy (TEM) Atomic Force Microscopy (AFM), Dynamic Light Scattering (DLS)

Course Code: BBI172A
Course Name: Practical of nanotechnology
Credit(s):1

Course Outcome:

CO-1 Students will be able to understand and perform basic nanoparticle synthesis using chemical and biological methods
CO-2 Students will be able to Apply UV-Vis and FTIR spectroscopic techniques for nanoparticle characterization.
CO-3 Students will be able to Analyze morphology and size of nanoparticles.
CO-4 Students will be able to relate surface area, zeta potential, and nano-properties with physical behavior.
CO5- Students will be able to demonstrate awareness of safety procedures and nanomaterial handling ethics.

Mapping of PO/CO

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	3	1	1	2	3	1
CO2	3	2	1	3	2	1	2
CO3	3	2	1	1	2	3	1
CO4	1	2	3	3	2	1	2
CO5	1	1	2	3	3	1	3

1-LOW, 2-MEDIUM, 3-HIGH

1.Synthesis of Silver Nanoparticles
Learn plant reduction techniques to synthesize silver nanoparticles and study their properties by UV-Vis spectroscopy.

2.Nanoparticle Characterization by UV-Vis and DLS
Analyze size and distribution of synthesized nanoparticles using UV-Visible spectroscopy and Dynamic Light Scattering (DLS).

3. Surface Functionalization of silver Nanoparticles
Modify surfaces of silver nanoparticles with biomolecules (e.g., proteins or ligands) and demonstrate changes using spectrophotometry.

4. Thin Film Fabrication by Sol-Gel Technique
Prepare thin nanomaterial films on glass slides using sol-gel and characterize their surface features by microscopy.

5. Transmission Electron Microscopy (TEM) of Nanomaterials
Prepare and examine nanomaterial samples under TEM to observe morphology and particle size.

6. Atomic Force Microscopy (AFM) Analysis
Use AFM to investigate the surface topology of thin film nanomaterials or nanoparticles.

7. Synthesis and Testing of Magnetic Nanoparticles (Ferrofluids)
Synthesize iron oxide magnetic nanoparticles and investigate their response to magnetic fields.

8. Protein-Nanoparticle Conjugation
Conjugate nanoparticles with model proteins (e.g., BSA) and analyze using PAGE/electrophoresis or spectroscopic methods.

9. Assessment of Nanoparticle Cytotoxicity (MTT Assay)
Expose cultured cells to nanoparticles and measure cell viability using MTT assay.

10. DNA-Nanoparticle Interaction Studies
Examine the effect of nanoparticles on DNA structure (e.g., migration shifts in gel electrophoresis post-binding).

Reference Books

1. Nanoscience in Medicine Vol. 1, Springer.
2. Text book of Nanoscience and Nanotechnology by B S Murty, P Shankar, Baldev Raj, B B Rath, James Murday, Springer
3. An Introduction to Nanoscience and Nanotechnology by Alain Nouailhat, Wiley.
4. Nanoscience volume 8 by Royal Society of Chemistry.

Course-Synthesis of nanomaterials
Course Code-BBI173A
Lectures: 3 Hrs/week

Course Code: BBI173A
Course Name: Synthesis of Nanomaterials
Credit(s):3

Course outcome

CO-1 Students will be able to understand the Differentiate between top-down and bottom-up methods
CO-2 Students will be able to explain physical synthesis methods like milling and ablation
CO-3 Students will be able to understand sol-gel, microemulsion, co-precipitation techniques
CO-4 Students will be able to evaluate eco-friendly nanoparticle synthesis using biological systems
CO5- Students will be able to demonstrate knowledge of nano-thin film and patterning techniques

Mapping of PO/CO

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	2	2	2	1
CO2	3	3	3	1	1	2	2
CO3	3	3	3	2	2	1	1
CO4	3	3	3	1	2	2	2
CO5	3	1	2	3	2	3	1

1-LOW, 2-MEDIUM, 3-HIGH

Unit I: Top-Down and Bottom-Up Approaches

Overview of synthesis strategies, Lithography and etching, Self-assembly, molecular fabrication

Unit II: Physical Methods

Ball milling, Laser ablation, Sputtering and evaporation

Unit III: Chemical Methods

Sol-gel synthesis, Microemulsion, Co-precipitation, hydrothermal synthesis

Unit IV: Green and Biological Methods

Plant-mediated synthesis, Microbial synthesis of nanoparticles, Enzyme-assisted methods

Unit V: Fabrication Techniques

Thin film deposition, Electrospinning, Nanopatterning

TEXT BOOKS.

1. Novel Nanocrystalline Alloys and Magnetic Nanomaterials- Brian Cantor
2. Nanoscale materials -Liz Marzan and Kamat.
3. Physical properties of Carbon Nanotube-R Satio.
4. Polymer nanocomposites: Edited by Yiu-Wing Mai and Zhong-Zhen Yu, First published 2006, Woodhead Publishing Limited and CRC Press LLC, USA.
5. Physics of Magnetism - S. Chikazumi and S.H. Charap.
6. Magnetostriction and Magnetomechanical Effects - E.W. Lee.
7. Carbon Nanotubes: Properties and Applications- Michael J. O'Connell.

Course Code: BBI174A
Course Name: Lab of synthesis of nanomaterials
Credit(s):1

Course Outcome

CO-1 Students will be able to explain and compare top-down and bottom-up methods of nanoparticle synthesis.
CO-2 Students will be able to perform synthesis of nanoparticles using chemical methods like sol-gel and co-precipitation.
CO-3 Students will be able to apply biological routes (plant/microbial) for green nanoparticle synthesis
CO-4 Students will be able to demonstrate techniques for nanofilm preparation or surface coating
CO5- Students will follow safe handling practices and evaluate environmental impact of synthesis processes.

Mapping of PO/CO

Course Outcome	Program Outcome						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	3	1	2	0	2	2
CO2	2	1	3	2	3	1	1
CO3	1	2	2	1	2	2	2
CO4	2	2	1	2	0	1	1
CO5	1	0	1	1	1	2	2

1-LOW, 2-MEDIUM, 3-HIGH

1. Chemical Reduction Synthesis of Silver Nanoparticles
Prepare silver nanoparticles via wet-chemical reduction using $AgNO_3$ and a reducing agent, and characterize by UV-Vis spectroscopy.

2. Sol-Gel Synthesis of Metal Oxide Nanoparticles
Synthesize TiO_2 or ZnO nanoparticles using sol-gel chemistry, followed by annealing or drying, and analyze morphology under microscopy.

3. Hydrothermal Synthesis of Nanostructures
Perform synthesis of nanorods or nanowires inside a closed autoclave at elevated temperature and pressure using aqueous precursors.

4. Green Synthesis of Gold Nanoparticles using Plant Extracts
Utilize plant leaf extracts as reducing agents to biosynthesize gold nanoparticles and observe the color change and spectrum.

5. Microbial Synthesis of Nanoparticles
Employ bacteria or fungi to biologically produce silver or iron oxide nanoparticles; characterize using DLS or microscopy.

6. Physical Vapor Deposition (PVD) of Thin Metal Films
Demonstrate PVD—such as thermal evaporation or sputtering—for synthesis of metal nanoparticle films and measure thickness.

7. Ball Milling for Nano-sized Powders
Mechanically grind bulk metal/oxide powders to nano-scale using ball milling and check particle size using SEM/TEM.

8. Reverse Micelle Synthesis of Quantum Dots
Prepare CdS or ZnS quantum dots using a reverse micelle emulsion, and study fluorescence properties.

9. Chemical Vapor Deposition (CVD) of Carbon Nanotubes
Set up CVD for the production of carbon nanostructures on substrates and examine products under optical microscopy.

10. Surface Functionalization of Iron Oxide Nanoparticles
Synthesize superparamagnetic Fe_3O_4 nanoparticles and modify surfaces with ligands, confirming successful functionalization by FTIR.

Course- Surface science in Nanotechnology
Course Code-BBI175A
Lectures: 3 Hrs/week

Course outcome

Students will able to

CO1: Understand the fundamental principles of surface science and their relevance to nanotechnology.

CO2: Demonstrate proficiency in using surface characterization techniques.

CO3: Apply surface modification methods for specific biotechnological applications.

CO4: Analyze the role of surface properties in the functionality of nanobiotechnological devices.

CO5: Evaluate the environmental and ethical considerations in the application of nanomaterials.

Mapping of PO/CO

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	2	2	1	1
CO2	2	3	3	2	2	2	1
CO3	2	2	3	3	2	2	1
CO4	2	2	2	3	3	2	1
CO5	1	1	1	2	2	3	3

1-LOW, 2-MEDIUM, 3-HIGH

Unit I: Fundamentals of Surface Science

Surface energy and surface tension, Surface area to volume ratio in nanomaterials, Surface defects and their implications, Adsorption phenomena: physical vs. chemical

Unit II: Characterization Techniques

Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), X-ray Photoelectron Spectroscopy (XPS)

Unit III: Surface Modification Techniques

Self-assembled monolayers, Langmuir-Blodgett films, Plasma treatment and chemical vapor deposition, Surface functionalization for biocompatibility

Unit IV: Applications in Nanobiotechnology

Biosensors and diagnostic devices, Drug delivery systems, Tissue engineering scaffolds Environmental remediation using nanomaterials

Unit V: Surface-related biosafety, toxicity & ethical considerations

Biocorona formation, dose-dependent surface reactivity, nanoparticle lifecycle, and responsible production practices (green synthesis, biodegradable surface coatings).

Course Code: BBI176A

Course Name: Surface studies in Nanotechnology
Credit(s):1

Course outcome

Students will be able to

CO1- Perform at least two surface-functionalization experiments using ALD, silanization, spin-coating or inkjet deposition

CO2- Operate and obtain reproducible data using AFM/contact-angle goniometer (P2) and SPR sensors (P4).

CO3- Correlate structural/interfacial properties with a downstream application—e.g. superhydrophobicity in biosensing/drug delivery systems (P3) or solar cells

CO4-Evaluate biocompatibility or environmental sustainability (using surface-treated slides/cells or N-of-1 experimental risk test) in one optional micro-study (extend P2–P6).

CO5- Write & present a full analytical lab report or poster, including: objective, reagents/devices_list, controlled variables, data graphs, error-analysis and conclusion.

Mapping of PO/CO

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	1	1	1	3	2	2	1
CO2	1	1	1	3	2	2	1
CO3	1	1	1	2	2	3	2
CO4	1	1	1	2	2	2	3
CO5	2	2	2	2	1	3	1

1-LOW, 2-MEDIUM, 3-HIGH

1. **Contact Angle Goniometry**: Measure surface tension & wettability of glass vs PDMS vs SAM-coated substrates.
2. **Zeta-Potential Analysis & Stability of Colloids**: Use laser-DLS for citrate AuNPs or surfactant-stabilized latex.
3. **Surface Coating with Functional Silanes / ALD**: Measure contact angle before/after silanization; optional ellipsometry thickness.
4. **XPS or X-ray Photoelectron Spectroscopy**: Compare elemental surface composition of treated vs untreated biomaterial (e.g. TiO_2).
5. **Atomic Force Microscopy (AFM)**: Map surface topography and roughness on coated vs uncoated surfaces; 1–2 treated glass slides.
6. **SPR Sensor Fabrication & Real-Time Binding**: Deposit gold or conjugate biotin–streptavidin monolayer; record binding kinetics.

Course- Chemistry of Nanotechnology

Course Code-BBI177A
Lectures: 3 Hrs/week

Course Code: BBI177A

Course Name: Chemistry of Nanotechnology

Credit(s):3

Course outcome

CO-1 Students will be able to understand the physical methods for synthesis of nanomaterials

CO-2 Students will be able to illustrate the chemical methods of nanoparticle synthesis

CO-3 Students will be able to explain the biological methods of nanoparticle synthesis
CO-4 Students will be able to evaluate the lithographic technique for fabrication of nanomaterials
CO5- Students will be able to analyze applications and ethical aspects of nanomaterials in chemical industries and society.

Mapping of PO/CO

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	2	2	2	1
CO2	3	3	3	1	1	2	2
CO3	3	3	3	2	2	1	1
CO4	3	3	3	1	2	2	2

1-LOW, 2-MEDIUM, 3-HIGH

Unit-I:

Atoms, Molecules, Ions, Electrons & Periodic trends Dalton's Atomic theory as foundation for chemistry, Structure of atoms, Ionic compounds and Chemical Nomenclature. Nature of light, Line spectra & Bohr Atom, Matter of Waves,

Unit-II:

Chemical Bonds, Molecular structure and Bonding Theories Lewis symbols, Ionic bonding, Covalent bonding, Formal charges & resonance in Lewis structure, Molecules that do not satisfy the octet rule, Bond energies. Valence –orbitals shell Electron-Pair repulsion Model, Polarity of molecules, Valence bond theory

Unit-III:

Fundamentals of Nanotechnology Introduction to Nano-science and Nano-technology, Nano-scale material, implications for Physics, Chemistry, Engineering & Biology, and Motivation for Nanotechnology study.

Unit-IV:

Structures & Classification of Nanomaterials, Nano-structures: various types of nano-structures and nano-crystals. Classification: of bulk Nanostructured materials, 0D, 1D, 2D structures.

REFERENCES:
1. C. Bre´chignac P. Houdy M. Lahmani, Nanomaterials and Nanochemistry, Springer Berlin Heidelberg, Germany (2006).
2. Kenneth J. Klabunde, Nanscale materials in chemistryЛЪ, Wiley Interscience Publications (2001).
3. Hans Lautenshlager, EmulsionsЛЪ, Kosmetik International, (2002).
4. Roque Hidalgo-Alvarez, Structure and Functional properties of ColloidsЛЪ, CRC Press, (2009).
5. Richard J. Fann, Chemistry and Technology of SurfactantsЛЪ, Wiley-Blackwell, (2006)

Course Code: BBI178A
Course Name: Practical of nanotechnology in chemistry

Credit(s):1

Course outcome

CO1-Synthesize nanoparticles using chemical and green routes.

CO2-Characterize nanoparticles using techniques like UV-Vis and FTIR.

CO3-Analyze SEM/XRD data to determine morphology and particle size.

CO4-Perform chemical procedures with adherence to safety and green chemistry principles.

CO5-Evaluate potential applications of synthesized nanomaterials in chemical products.

Mapping of PO/CO

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	2	2	2	1
CO2	3	3	3	1	1	2	2
CO3	3	3	3	2	2	1	1
CO4	3	3	3	1	2	2	2
CO5	2	3	1	2	2	1	3

1-LOW, 2-MEDIUM, 3-HIGH

1.Visible light photo catalyzed synthesis of metal nanoparticles

2. To study the Optical Characterization of synthesized CdSe nanoparticles.

3. To identify and analyze the given nanomaterial by FTIR spectroscopy.

4. Synthesis and Optical Characterization of Plasmonic Noble Metal Nanoparticles

5. Preparation of Dye-Sensitized TiO2 Solar Cells.

6. Dye degradation using nano particles.: 1 Dye degradation using ZnO 2. Dye degradation using CdSe.

Course-Application of Nanomaterials
Course Code-BBI179A
Lectures: 3 Hrs/week

Course Code: BBI179A
Course Name: Application of Nanomaterials
Credit(s):3

Course Outcome

CO-1 Students will be able to describe nanoparticle-based drug delivery and diagnostics.
CO-2 Students will be able to discuss nanotech applications in soil, plant, and pest management.
CO-3 Students will be able to assess role of nanomaterials in pollution detection/remediation
CO-4 Students will be able to Illustrate industrial uses in food, cosmetics, textiles, and energy.
CO5- Students will able to explain use of nanoscaffolds in regenerative medicine.

Mapping of PO/CO

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	2	2	2	1
CO2	3	3	3	1	1	2	2
CO3	3	3	3	2	2	1	1
CO4	3	3	3	1	2	2	2
CO5	2	3	1	1	2	2	3

1-LOW, 2-MEDIUM, 3-HIGH

Unit I: Nanotechnology in Medicine

Drug delivery systems, Nano-diagnostics and biosensors, Targeted therapy

Unit II: Nanotechnology in Agriculture

Nano-fertilizers and pesticides, Detection of pathogens, Soil quality enhancement

Unit III: Nanotechnology in Environment

Water purification using nanomaterials, Sensors for pollutant detection, Nanoremediation

Unit IV: Industrial Applications

Cosmetics, food packaging, Energy (solar cells, batteries), Paints, textiles, electronics

Unit V: Tissue Engineering and Regenerative Medicine

Scaffolds, nanofibers, Stem cell–nanomaterial interactions, Wound healing applications

References:

1. Nanotechnology: Health and Environmental Risks, Jo Anne Shatkin, CRC Press, 2008

2. Nanotechnology: Environmental Health and Safety, Risks, Regulation and Management,

Matthew Hull and Diana Bowman, Elsevier, 2010

3. Principles and Methods of Toxicology. Edited by A.W. Hayes. Taylor and Francis, 2008.

Course Code: BBI180A
Course Name: Instrumentation in nanotechnology lab
Credit(s):1

Course outcome

CO-1 Students will be able to understand the biological impacts of nanoparticles
CO-2 Students will be able to describe regulatory frameworks and risk analysis methods
CO-3 Students will be able to discuss ethical concerns, public perception, and IP rights
CO-4 Students will be able to propose strategies for nanomaterial disposal and sustainability
CO5- Student will be able to evaluate trends and challenges in emerging nanotechnologies

Mapping of PO/CO

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	2	2	2	1
CO2	3	3	3	1	1	2	2
CO3	3	3	3	2	2	1	1
CO4	3	3	3	1	2	2	2
CO5	2	3	1	2	2	1	3

1-LOW, 2-MEDIUM, 3-HIGH

1. Synthesis of Au/Ag metal nanoparticles by chemical route.
2. Optical properties of Au/Ag nanoparticles by using UV-Vis spectroscopy.
3. Synthesis of transition metal oxide nanoparticles by hydrothermal route.
4. To calculate the absorption coefficient and optical band gap using UV-Vis. Spectroscopy.
5. Synthesis of CNTs BY CVD method.
6. Analysis of CNTs by UV-Vis. and FTIR spectroscopy.
7. Synthesis of CNT nanocomposites.
8. Analysis of CNT nanocomposites by UV-Vis. and FTIR spectroscopy.

Course- Nanotoxicology and Biosafety
Course Code-BBI181A
Lectures: 3 Hrs/week

Course outcome

CO-1 Students will be able to understand the biological impacts of nanoparticles
CO-2 Students will be able to describe regulatory frameworks and risk analysis methods
CO-3 Students will be able to discuss ethical concerns, public perception, and IP rights
CO-4 Students will be able to propose strategies for nanomaterial disposal and sustainability
CO5- Student will be able to evaluate trends and challenges in emerging nanotechnologies

Mapping of PO/CO

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	2	2	2	1
CO2	3	3	3	1	1	2	2
CO3	3	3	3	2	2	1	1
CO4	3	3	3	1	2	2	2
CO5	2	3	1	2	2	1	3

1-LOW, 2-MEDIUM, 3-HIGH

Unit I: Nanotoxicology

Interaction with biological systems, Cytotoxicity, genotoxicity, Ecotoxicity and environmental fate

Unit II: Risk Assessment and Regulation

Exposure pathways, Regulatory bodies (FDA, EPA, REACH), Safety protocols and guidelines

Unit III: Ethical, Legal and Social Issues

Ethics in nanomedicine, public perception and privacy, Legal framework and IP rights

Unit IV: Waste Management and Sustainability

Disposal of nanomaterials, Life cycle analysis, green nanotechnology

Unit V: Future of Nanotechnology

Nano-robotics, Smart materials, Trends in personalized nanomedicine

References/compulsory reading

TEXT BOOKS

1.Handbook of Nanotoxicology, Nanomedicine and Stem Cell Use in Toxicology. Saura C Sahu, Daniel A Casciano.

2.Nanotoxicology - Interactions of Nanomaterials with Biological Systems. Yuliang Zhao and Hari Singh Nalwa.

3.Biointeractions of Nanomaterials. Vijaykumar B. Sutariya, Yashwant Pathak

4.New Technologies for Toxicity Testing. Michael Balls DPhil, Robert D. Combes PhD, Nirmala Bhogal.

Course Code: BBI182A
Course Name: Ethical and Safety Practices

Credit(s):1

Course Outcome:

CO-1 Students will be able to understand the biological impacts of nanoparticles
CO-2 Students will be able to describe regulatory frameworks and risk analysis methods
CO-3 Students will be able to discuss ethical concerns, public perception, and IP rights
CO-4 Students will be able to propose strategies for nanomaterial disposal and sustainability
CO5- Student will be able to evaluate trends and challenges in emerging nanotechnologies

Mapping of PO/CO

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	1	1	2	3	2
CO2	1	2	1	2	3	3	2

CO3	3	2	1	2	3	1	3
CO4	2	1	3	1	2	2	3
CO5	3	2	3	1	2	2	1

1-LOW, 2-MEDIUM, 3-HIGH

1. Study of nanotoxicology case studies of metallic and metal oxide nanoparticles
2. Demonstration of biosafety protocols while working on the nanotechnology laboratory
3. Risk analysis and disposal of nanomaterials by keeping the environmental concern
4. Literature search in the direction of controlling the hazards and bringing the biosafety.
5. Demonstration of 12 principles of green chemistry

Course- Overview of Nanotechnology
Course Code-BBI183A
Lectures: 3 Hrs/week

Course outcome

CO-1 Students will be able to understand the basic of biotechnology
CO-2 Students will be able to illustrate the lipid and DNA technology
CO-3 Students will be able to explain the importance of bio nanocomposites
CO-4 Students will be able to evaluate the characterization methods for nanobiomaterials.
CO5-Students will able to understand and apply the technology in the more advance form.

Mapping of PO/CO

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	2	2	2	1
CO2	3	3	3	1	1	2	2
CO3	3	3	3	2	2	1	1
CO4	3	3	3	1	2	2	2
CO5	3	3	3	1	2	2	2

1-LOW, 2-MEDIUM, 3-HIGH

Unit 1

Background to Nanotechnology Scientific revolution- Atomic structures-Molecular and atomic size-Bohr radius – Emergence of Nanotechnology – Challenges in Nanotechnology - Carbon age– New form of carbon (from Graphene sheet to CNT).

Unit 2

Nucleation Influence of nucleation rate on the size of the crystals- macroscopic to microscopic crystals and nanocrystals - large surface to volume ratio, top-down and bottom-up approaches-self-assembly process-grain boundary volume in nanocrystals-defects in nanocrystals-surface effects on the properties.

Unit 3

Types of Nanostructures Definition of a Nano system - Types of Nanocrystals-One Dimensional (1D)-Two Dimensional (2D) -Three Dimensional (3D) nanostructured materials - Quantum dots - Quantum wireCore/Shell structures.

Unit 4

Nanomaterials and properties Carbon Nanotubes (CNT) - Metals (Au, Ag) - Metal oxides (TiO2, CeO2, ZnO) - Semiconductors (Si, Ge, CdS, ZnSe) - Ceramics and Composites - Dilute magnetic semiconductor- Biological system - DNA and RNA - Lipids - Size dependent properties - Mechanical, Physical and Chemical properties.

Unit 5

Applications of Nanomaterials

Molecular electronics and nanoelectronics – Quantum electronic devices - CNT based transistor and Field Emission Display - Biological applications - Biochemical sensor - Membrane based water purification.

References /compulsory readings

1. M. Wilson, K. Kannangara, G Smith, M. Simmons, B. Raguse, Nanotechnology: Basic science and Emerging technologies, Overseas Press India Pvt Ltd, New Delhi, First Edition, 2005.
2. C.N.R. Rao, A. Muller, A.K. Cheetham (Eds), The chemistry of nanomaterials: Synthesis, properties and applications, Wiley VCH Verlag Gmbh &Co, Weinheim, 2004.
3. Kenneth J. Klabunde (Eds), Nanoscale Materials Science, John Wiley & Sons, InC, 2001.
4. C.S.S.R. Kumar, J. Hormes, C. Leuschner, Nanofabrication towards biomedical applications, Wiley –VCH Verlag GmbH & Co, Weinheim, 2004.
5. W. Rainer, Nano Electronics and information Technology, Wiley, 2003.
6. K.E. Drexler, Nano systems, Wiley, 1992.
7. G. Cao, Nanostructures and Nanomaterials: Synthesis, properties and applications, Imperial College Press, 2004.

Course Code: BBI184A
Course Name: Practical of Different Approaches of Nanotechnology
Credit(s):1

Course Outcome:

Students will able to

CO1-Demonstrate understanding of emerging applications of nanomaterials in medicine, environment, and electronics.
CO2-Design or simulate prototypes integrating nanotechnology for futuristic systems.
CO3-Apply lab-based or simulated techniques to analyze functionality of advanced nanomaterials.
CO4-Assess potential risks and ethical aspects of futuristic nanotech applications.
CO5-Work collaboratively on a problem-based nanotechnology project to address future societal needs.

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES:

Course Outcome	Program Outcome						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	0	0	3	0	1	2
CO2	3	3	1	0	0	0	2

CO3	2	0	1	2	0	1	2
CO4	0	3	3	3	2	0	3
CO5	0	2	3	2	3	0	3

3 = Highly Related; 2 = Medium; 1 = Low

1- Biomedical application of synthesized nanoparticles-antibacterial activity.
2- Biomedical application of synthesized nanoparticles-antifungal activity.
3- Toxicity screening of synthesized nanoparticles
4- Chip technology-Demo
5- Bio-sensor application in disease control.