B.TECH. BIOTECHNOLOGY

COURSE STRUCTURE

Department of Biotechnology & Bioinformatics

PROGRAM OUTCOMES

Engineering Graduates will be able to:

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, SOLAN

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B. TECH (BIOTECHNOLOGY) 1st SEMESTER

S. No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	HSS	18B11HS111	English and Technical Communication	2	0	0	**2**	**2**
2		18B1HS171	English and Technical Communication Lab	0	0	2	**1**	**2**
3		18B11MA112	Basic Mathematics -1 OR	3	1	0	**4**	**4**
4	Basic Sciences	18B11BT111	Fundamental Biology	3	0	0	**3**	**3**
5		18B17BT171	Fundamental Biology lab	0	0	2	**1**	**2**
6	Basic Sciences	18B11PH112	Basic Engineering Physics-I	3	1	0	**4**	**4**
7	Engg Science	18B11CI111	Programming for Problem Solving-2	2	0	0	**2**	**2**
8	Engg Science	18B17GE173	Engineering Graphics	0	0	3	**1.5**	**3**
9	Basic Sciences	18B17PH172	Basic Engineering Physics Lab-I	0	0	2	**1**	**2**
10	Engg Science	18B17CI171	Programming for Problem Solving Lab-2	0	0	4	**2**	**4**
						Total	**17.5**	**22**

B. TECH (BIOTECHNOLOGY) 2nd SEMESTER

S.No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	Basic Sciences	18B11MA212	Basic Mathematics-II	3	1	0	**4**	**4**
2	Basic Sciences	18B11PH212	Bioinstrumentation Techniques	3	1	0	**4**	**4**
3	Engg Science	18B11EC212	Basic Electrical Sciences	3	1	0	**4**	**4**
4	Engg Science	18B17EC272	Basic Electrical Sciences lab	0	0	2	**1**	**2**
5	Engg Science	18B11CI211	Data Structure & Algorithms	3	1	0	**4**	**4**
6	Engg Science	18B17CI271	Data Structure & Algorithms Lab	0	0	4	**2**	**4**
7	Engg Science	18BI7GE171	Workshop Practices	0	0	3	**1.5**	**3**
						Total	**20.5**	**25**

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B. TECH (BIOTECHNOLOGY) 3rd SEMESTER

S. No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	HSS	18B11HS311	Interpersonal Dynamics Values and Ethics	3	0	0	**3**	**3**
2	Basic Sciences	18B11MA312	Probability & Statistical Techniques	3	1	0	**4**	**4**
3	Professional Core	18B11BT311	Genetics	3	1	0	**4**	**4**
4	Professional Core	18B11BT312	Biochemistry	3	0	0	**3**	**3**
5	Engg Science	18B11BT313	Thermodynamics & Chemical Processes	3	1	0	**4**	**4**
6	Basic Sciences	18B11BT314	General Chemistry	3	0	0	**3**	**3**
7	Professional Core	18B17BT371	Genetics Lab.	0	0	2	**1**	**2**
8	Basic Sciences	18B17BT372	Biochemistry Lab	0	0	2	**1**	**2**
9	Engg Science	18B17BT373	Thermodynamics & Chemical Processes lab	0	0	2	**1**	**2**
10	Basic Sciences	18B17BT374	General Chemistry Lab	0	0	2	**1**	**2**
						Total	**25**	**29**

B. TECH (BIOTECHNOLOGY) 4th SEMESTER

S.No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	HSS	18B11HS411	Finance and Accounts	3	0	0	**3**	**3**
2	Professional Core	18B11BT411	Cell Biology and Culture Technologies	3	1	0	**4**	**4**
3	Professional Core	18B11BT412	Molecular Biology	3	0	0	**3**	**3**
4	Professional Core	18B11BT413	Introduction to Bioinformatics	3	1	0	**4**	**4**
5	Professional Core	18B11BT414	Microbiology	3	1	0	**4**	**4**
6	Professional Core	18B17BT471	Cell Biology and Culture Technologies lab	0	0	2	**1**	**2**
7	Professional Core	18B17BT472	Molecular Biology Lab	0	0	2	**1**	**2**
8	Professional Core	18B17BT473	Introduction to Bioinformatics lab	0	0	2	**1**	**2**
9	Professional Core	18B17BT474	Microbiology Lab	0	0	2	**1**	**2**
10	Mandatory Course	18B11GE411	Environmental Studies	2	0	0	Audit	2
						Total	**22**	**28**

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B. TECH (BIOTECHNOLOGY) 5th SEMESTER

S. No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	HSS	18B11HS511	Project Management and Entrepreneurship	3	0	0	**3**	**3**
2	Engg Science	18B11BT511	Bioprocess Engineering	3	1	0	**4**	**4**
3	Professional Core	18B11BT512	Genetic Engineering	3	1	0	**4**	**4**
4	Professional Core	18B11BT513	Immunology	3	1	0	**4**	**4**
5	Engg Science	18B17BT571	Bioprocess Engineering Lab	0	0	2	**1**	**2**
6	Professional Core	18B17BT572	Genetic Engineering Lab	0	0	2	**1**	**2**
7	Professional Core	18B17BT573	Immunology Lab	0	0	2	**1**	**2**
8	Professional Elective		Departmental Elective-I	3	0	0	**3**	**3**
9	Project	18B19BT591	Minor Project Part-I	0	0	2	**1**	**2**
						Total	**22**	**26**

B. TECH (BIOTECHNOLOGY) 6th SEMESTER

S.No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	Professional Core	18B11BT611	Downstream Processing	3	1	0	**4**	**4**
2	Professional Core	18B11BT612	Food and Agricultural Biotechnology	3	0	0	**3**	**3**
3	Professional Core	18B17BT671	Downstream Processing Lab.	0	0	2	**1**	**2**
4	Professional Core	18B17BT672	Food and Agricultural Biotechnology Lab	0	0	2	**1**	**2**
5	Professional Elective		Departmental Elective- II	3	0	0	**3**	**3**
6	Professional Elective		Departmental Elective-III	3	0	0	**3**	**3**
7	Open Elective		Open Elective-I	3	0	0	**3**	**3**
8	Open Elective		Open Elective-II	3	0	0	**3**	**3**
9	Project	18B19BT691	Minor Project Part-II	0	0	4	**2**	**4**
10	Mandatory Course		Industrial Training				**Audit**	
						Total	**23**	**27**

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B. TECH (BIOTECHNOLOGY) 7th SEMESTER

S. No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	Professional Elective		Departmental Elective- IV	3	0	0	**3**	**3**
2	Open Elective		Open Elective - III	3	0	0	**3**	**3**
3	Open Elective		Open Elective - IV	3	0	0	**3**	**3**
4	Project	18B19BT791	Major Project Part I	0	0	10	**5**	**10**
5	HSS		Indian Constitution	1	0	0	**Audit**	**1**
						Total	**14**	**20**

B. TECH (BIOTECHNOLOGY) 8th SEMESTER

S.No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	Professional Elective		Departmental Elective- V	3	0	0	**3**	**3**
2	Professional Elective		Departmental Elective- VI	3	0	0	**3**	**3**
3	Open Elective		Open Elective-V	3	0	0	**3**	**3**
4	Project	18B19BT891	Major Project Part II	0	0	14	**7**	**14**
						Total	**16**	**23**
			TOTAL CREDITS				**160**	
			TOTAL HOURS				**200**	
			HSS				**12**	
			Basic Science				**25**	
			Engg Science				**28**	
			Professional CORE				**47**	
			Professional Elective				**18**	
			OE				**15**	
			PROJECT				**15**	
			TOTAL CREDITS				**160**	**160**

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B. TECH (BIOTECHNOLOGY)

PROFESSIONAL ELECTIVE-I

S. No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	Professional Elective	18B1WBT531	Phytopharmaceuticals and Biologicals	3	0	0	**3**	**3**
2	Professional Elective	18B1WBT532	Comparative & Functional Genomics	3	0	0	**3**	**3**
						Total	**3**	**3**

PROFESSIONAL ELECTIVE-II

S.No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	Professional Elective	18B1WBT631	Peptide Therapeutics	3	0	0	**3**	**3**
2	Professional Elective	18B1WBT632	Infectious Diseases	3	0	0	**3**	**3**
						Total	**3**	**3**

PROFESSIONAL ELECTIVE-III

S.No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	Professional Elective	18B1WBT633	Nano-Biotechnology	3	0	0	**3**	**3**
	Professional Elective	18B1WBT634	Bioenergy & Biofuels	3	0	0	**3**	**3**
						Total	**3**	**3**

PROFESSIONAL ELECTIVE-IV

S.No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	Professional Elective	18B1WBT733	Industrial Enzymes Technologies	3	0	0	**3**	**3**
	Professional Elective	18B1WBT734	Intellectual Property Rights & Commercialization	3	0	0	**3**	**3**
						Total	**3**	**3**

PROFESSIONAL ELECTIVE-V								
S. No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	Professional Elective	18B1WBT831	Genetic Counselling	3	0	0	**3**	**3**
2	Professional Elective	18B1WBT832	Traditional Bioprocessing & Their Up Scaling	3	0	0	**3**	**3**
						Total	**3**	**3**

PROFESSIONAL ELECTIVE-VI								
S.No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	Professional Elective	18B1WBT833	Diagnostics & Vaccine Manufacture	3	0	0	**3**	**3**
2	Professional Elective	18B1WBI834	NGS Data Analysis & Applications	3	0	0	**3**	**3**
						Total	**3**	**3**

OPEN ELECTIVE-I								
S.No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	Open Elective	18B1WBT635	Biology for Engineers	3	0	0	**3**	**3**
						Total	**3**	**3**

OPEN ELECTIVE-II								
S.No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	Open Elective	18B1WBT636	Industrial Chemistry	3	0	0	**3**	**3**
						Total	**3**	**3**

OPEN ELECTIVE-III								
S.No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	Open Elective	18B1WBT733	Sustainable Technologies for Waste Management	3	0	0	**3**	**3**
						Total	**3**	**3**

OPEN ELECTIVE-IV								
S.No.	Category Code	Subject Code	Name of the Subjects	Course Hours			Credits	Total Hours
				L	T	P		
1	Open Elective	18B1WBT734	Food Nutrition & Health Care	3	0	0	**3**	**3**
						Total	**3**	**3**

B.TECH. BIOTECHNOLOGY

SYLLABUS

Fundamental Biology

COURSE CODE: 18B11BT111
COURSE CREDITS: 1
CORE/ELECTIVE: CORE
L-T-P:0-0-2

Pre-requisite:Xth Class Biology

Course Objectives:

1. This is basic foundation biology course for the students having mathematics background.
2. The objectives are to familiarize students with basics of biology.
3. Learn about various living organism.
4. Learn about different biological at molecular or celluar level.

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Overview of living system, different life forms and Maintenance of Life.	Familiarity
CO-2	Fundamental understanding of Bio-molecules: Building blocks of living system	Assessment
CO-3	Understanding of structure and function of cell: Prokaryotic and Eukaryotic cells system.	Assessment
CO-4	Understanding the Basic of cellular transport system and cellular inheritance.	Assessment
CO-5	Flow of information in biological system- Central Dogma, DNA replication, Transcription, and Translation	Usage

Course Contents:

Unit	Contents	Lectures required
1	**General Biology:**The nature of life, Characteristics of living organisms, Concept and use of a classification system, brief of five Kingdome and three domain classification system.Concepts of species and hierarchical taxa, biological nomenclature, classical and quantititative methods of taxonomy of plants, animals and microorganisms.	**5**
2	**Introduction to bio-molecule: Structure and function relationship** Structure, chemical reactions and biological functions of carbohydrate, lipid, protein and nucleotides.Stablizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc	**8**
3	**Cell: Basic structure and functions**Unicellular, colonial and multicellular forms; levels of organization of tissues systems; comparative anatomy Structural and biochemical organization of cell. Prokaryotic and Eukaryotic cells. Cell organelles, their molecular composition, structure and functions.	**6**

4	**Basic of cellular transport system** Diffusion , Osmosis, Active transport	**4**
5	**Cellular inheritance** Cell division, cell cycle, Mitosis, Meiosis and Inheritance	**6**
6	**Flow of genetic information**The DNA, Search for Genetic Material, RNA World, Genetic Code, Central Dogma, replication, transcription and translation, (initiation, elongation and termination).	**8**
7	**Maintenance of Life:Adjustment and control.**Homeostasis, thermoregulation, and osmoregulation, Speciation and selection.	**5**
	Total Number of Lectures	**42**

Suggested Text Book(s):

1. Stryer, Lubert (2002). Biochemistry; Fifth edition. W. H. Freeman and Company.
2. Principles of Biochemistry [5th edition], Lehninger.
3. NCERT –XII class Biology

Suggested Reference Book(s):

1. Neill, Campbell (1996). Biology; Fourth edition.The Benjamin/Cummings Publishing Company. p. 309,310. ISBN 0-8053-1940-9.
2. A. W. Haupt, Fundamental of Biology, 3rd ed. McGRAW-HILL

Other useful resource(s):

1. https://nptel.ac.in/courses/122103039/
2. https://nptel.ac.in/syllabus/122103039/

Evaluation Scheme:

S. No.	Exam	Marks	Duration	Coverage/Scope of Examination
1	T-1	15	1 Hour	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Quiz, Assignment, Attendance, etc.

Course Outcomes (COs) contribution to the programme Outcomes (POs):

Course outcomes (Fundamental Biology)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	Average
CO-1	3	2	2	2	1	3	3	1	1	2	1	2	3	2	**1.8**
CO-2	2	2	3	2	1	3	3	-	1	2	1	3	3	2	**1.8**
CO-3	2	3	3	2	2	2	2	-	-	2	2	3	3	2	**1.8**
CO-4	3	2	2	2	3	2	2	1	-	1	2	3	3	2	**2.0**
CO-5	3	3	3	3	3	3	2	1	2	2	3	3	2	3	**2.5**
Average	**2.6**	**2.4**	**2.6**	**2.2**	**2.0**	**2.6**	**2.4**	**1.8**	**1.6**	**1.8**	**1.8**	**2.8**	**2.8**	**2.2**	

Fundamental Biology Lab

COURSE CODE: 18B17BT171
COURSE CREDITS: 1
CORE/ELECTIVE: CORE
L-T-P:0-0-2

Pre-requisite: Xth class biology

Course Objectives:

1. The objective of this course is to familiarize the students with basic biology laboratory techniques specifically used in modern biotechnology area.
2. Learn handling of microorganism
3. To learn about safe laboratory practices
4. To learn ethics, team work and discipline

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	Introduction to basic laboratory practices, microscopy, Bio-safety cabinet and sterilization.	Familiarity
CO2	Fundamental understanding of Biological buffers preparation and application.	Familiarity
CO3	Introduction to microscopic examination of different biological system.	Assessment
CO4	Introduction to analytical technique and application in macromolecular estimation.	Assessment
CO5	Able to understand ethics, team work and discipline.	Usage

List of Experiments

S. No.	Description	Hours
1	**Laboratory safety and basic laboratory Instrumentation** Basic laboratory operation: safety procedure, general safety practice and awareness. (personal safety, eye safety, handling of biologically hazardous material, handling of needles, sharps and chemicals)	2
	To study the different parts and application of simple and compound microscope	2
	To study the fundamental component and application of the Bio-safety cabinet (BSL) in biotechnology.	2
	To study the fundamental of different sterilization method in laboratory practices (Autoclave, Radiation sterilization)	2
2	**Biological buffers: (Preparation and application)**Hands on training on different buffer preparation, purification and pH measurement.	2
	Application of purified buffer in different biotechnology experiment.	2
	Collect water from two different water bodies around you and study them for pH, clarity and presence of any living organism.	2

3	**Microscopic Analysis of biological sample** To perform simple and differential staining of given microorganism and classify them (gram staining) Isolation and identification of microbe from given sample: Microscopic examination and motility test. To perform microscopic examination of unicellular eukaryote organism: identification and characterization	2 2 2
4	**Analytical estimation of bio-molecule** Estimation of Different macromolecules by visible spectrophotometer. To study the basic of standard curve preparations and application in biotechnology experiments.	2 2
Total Lab hours		24

Suggested/Resources:

1 Lab manual
2 Laboratory exercises in Microbiology – Harley Prescott
3 Biotechnology Lab Course: Jeffery M.Becker, Guy A. Caldwell, Eve Ann Zachgo
4 Biology 6thedition : Raven - Johnson

EvaluationScheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	2	2	3	2	1	3	3	1	2	2	3	3	**2.3**
CO2	2	2	2	3	2	2	3	2	2	-	1	1	**1.9**
CO3	3	3	2	3	2	2	2	2	1	2	1	2	**2.1**
CO4	2	3	2	3	3	2	2	2	2	2	2	2	**2.3**
CO5	1	1	1	2	1	1	-	3	3	2	3	3	**1.8**
Average	**2.0**	**2.2**	**2.0**	**2.6**	**1.8**	**2.0**	**2.0**	**2.0**	**2.0**	**1.6**	**2.0**	**2.2**	

General Chemistry Lab

COURSE CODE:18B17BT374

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

L-T-P: 0-0-2

Pre-requisite: XIIth Standard practical chemistry

Course Objectives:

1. To learn lab safety techniques, importance of personnel protective equipment and Enable students to link the theoretical knowledge of chemistry with the experiments.
2. To learn identification of unknown organic compounds and their purification at small scale using chromatography and crystallization techniques.
3. To learn how to perform assay of inorganic salts

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	Able to understand proper procedures and regulations for safe handling and use of chemicals	Familiarity
CO2	Able to apply knowledge of functional groups in identification of unknown compounds	Assessment
CO3	Able to understand the use of stereo models	Assessment
CO4	Able to do purification at small scale using chromatography and crystallization techniques.	Usage
CO5	Able to do titrations for various analytical purposes	Usage

List of Experiments

S.No	Description	Hours
1	A. Lab safety techniques, importance of personnel protective equipment and introduction of chemical apparatus, chemical calculations B. To determine melting point of given organic compound	1
2	Separation of mixtures by Chromatography: Measure the Rf value in each case (combination of two compounds to be given) **a)** Identify and separate the components of a given mixture of 2 amino acids (Glycine, Aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography	1

3	Purification of organic compounds by crystallization (from water and alcohol).	1
4	To chemical identify following organic functional groups in given organic compounds **a.** Test for aldehydes, ketones, carboxylic acids and phenol **b.** Test for carbohydrates and amino acids **c.** Test for esters, nitro and amines (Primary amines, Secondary amines and tertiary amines)	2
5	To identify functional group present in given unknown organic compounds	3
6	Isolation of caffeine from tea leaves.	1
7	**A.** To prepare standard solution of 1 M HCl **B.** To prepare standard solution of 1 M NaOH	2
8	Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture	2
9	To prepare Oxime of 2,4 dinitrophenylhydrazone of aldehyde/ketone	1
10	Virtual lab experiment A. To detect the halogens, nitrogen and sulphur in an organic compound B. To separate Organic compounds with the help of Column Chromatographic technique.	1
Total Lab hours		**14**

Suggested/Resources:

1. A.I Vogel, "Elementary practical organic chemistry" 2nd ed., Prentice Hall 2006
2. D.L. Pavia G. Lampman and G.D. kriz, "Introduction to organic laboratory techniques"2nd ed., Brooks Cole 2004

EvaluationScheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	3	1	2	2	1	3	-	2	1	3	3	**2.18**
CO2	3	3	1	2	2	1	-	3	1	3	2	3	**2.18**
CO3	3	3	1	1	2	2	-	2	3		2	3	**2.2**
CO4	3	3	1	2	3	1	-	1	3	2	2	3	**2.18**
CO5	3	3	1	1	3	1	-	-	3		2	3	**2.2**
Average	**3.0**	**3.0**	**1**	**1.6**	**2.4**	**1.2**	**3.0**	**2.0**	**2.4**	**2.0**	**2.2**	**3.0**	

General Chemistry

COURSE CODE:18B11BT314

COURSE CREDITS: 3

CORE/ELECTIVE: Core

L-T-P: 3-0-0

Pre-requisite: XIITH Standard Chemistry

Course Objectives:

1. To develop the chemistry foundation required for understanding the various processes involved in biological system
2. To provide an insight into mechanism of organic reaction.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Able to understand the fundamental chemistry of various functional group	Familiarity
CO-2	Able to understand the principles of stereochemistry	Familiarity
CO-3	Able to understand organic reaction mechanisms that impact on biochemical processes.	Assessment
CO-4	Able to recall the characteristics of important bio-molecules and be able to discuss the relationships between structure properties and functions	Usage
CO-5	Able to design experiments and interpret numerical, chemical and general scientific information	Usage

Course Contents:

Unit	Contents	Lectures required
1	Chemical calculations, mole calculations, Atomic and molecular structure, Chemical bonding, molecular shape and structures, Acid-base chemistry & resonance, pH, buffer solution, Acid base titration, redox titration Organic Functional group and their nomenclature	**6**
2	Stereochemistry of organic compounds, optical activity; stereoisomerism; specifications of configurations. Bayers strain theory Cyclo hexane and its confirmation,	**8**
3	alcohols, ethers, epoxide, aldehydes, ketones, enols, enones, carboxylic acid, and aromaticity, Chemistry of carboxylic acid and their derivatives, Chemistry of Nitro group and amines,	**8**

4	Introduction of chemical thermodyanamics, reaction kinetics, Chemical equilibrium and aqueous equilibria,	**4**
5	General introduction of structure, function & properties of various bio-molecules of living organisms, Mono-saccharides and their inter relationship, structure of sugar, Important derivatives of monosaccharide, disaccharides and trisaccharides. Building block of lipids - fatty acids, glycerol, sphingosine. Definition and classification of lipids. Classification of fatty acids, physio-chemical properties of fatty acids, saponification and iodine number. Properties of glycerol, fats and oils. Properties and function of phospholipids and Prostaglandins. Structure of sterols with special reference to cholesterol. Classification of amino acids. Physical, chemical and optical properties of amino acids. Introduction to biologically active peptides e.g. Glutathione, Oxytocin, Insulin, basics of enzymes,	**12**
6	Classification of polymers, mechanism of synthesis of polymerization, application of various polymers, Co-ordination compounds and their biological importance	**4**
Total lectures		**42**

Suggested Text Book(s):

1. Robert Thornton Morrison, Robert Neilson Boyd, SaibalKanti Bhattacharjee "Organic Chemistry" 7th ed., Pearson India, 2011
2. Jonathan Clayden, Nick Geeves, Stuart Warren, "Organic Chemistry" 2nd ed., Oxford University Press, 2012
3. J. D. LEE , "Concise Inorganic Chemistry" 5th ed., Wiley-Blackwell, 2004

Suggested Reference Book(s):

1. Peter Sykes, "A Guide Book to Mechanism in Organic Chemistry" 6th ed., Prentice Hall.
2. E.L. Eliel, "Stereochemistry of carbon compounds" 1st ed., Mcgraw-Hill Education, 2001

EvaluationScheme:

Assessment	Max. marks	Duration	Course Covered
T1 Test	15	1 hr.	Syllabus covered upto T-1
T2 Test	25	1.5 hrs.	Syllabus covered upto T-2
End Term Test	35	2 hrs.	Entire Syllabus
Teacher Assessment	25	Entire Sem	Based on Assignments, quizzes etc.

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Chemistry)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	-	3	2	2	2	-	2	-	2	2	-	2	2.1
CO-2	3	3	2	3	3	-	2	-	3	2	-	-	2.3
CO-3	3	3	2	3	3	2	2	-	3	2	-	-	2.3
CO-4	3	3	3	3	3	2	2	-	3	1	-	-	2.5
CO-5	3	3	3	2	2	2	2	2	3	1	2	3	2.3
Average	3.0	3.0	2.4	2.6	2.6	2.0	2	2	2.8	1.6	2.0	2.5	

BIOCHEMISTRY LAB

COURSE CODE: 18B17BT372

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

L-T-P: 0-0-2

Pre-requisite: Cell biology, basic chemistry

Course Objectives:

1. The objective of this course is to familiarize the students with laboratory techniques related to identification and quantification of various biomolecules required to meet the metabolic needs of body.
2. To develop basic practical biochemical skills for the handling and analysis of biomolecules.

Course Outcomes:

S.N.	Course Outcomes	Level of Attainment
CO I	to familiarize with introduction to basic biochemistry laboratory practices and safety.	Familiarity
CO II	to calculate different identities in terms of molarity, normality and independently handle different instruments utilized in a biochemistry lab.	Familiarity
CO III	to identify qualitatively the biomolecules in given solution.	Assessment
CO IV	to estimate the concentration of a biomolecules in given solution.	Assessment
COV	to understand ethics, team work and discipline	Usage

List of Experiments

S.No.	Description	Hours
1	Basic guidelines for safety measures to avoid hazards in biochemistry lab.	1
2	To prepare buffer solution of varying pH by using Henderson-Hasselbalch equation and pH meter.	1
3	To identify and classify sugars into various categories based upon	2

	qualitative methods.	
4	To determine concentration of carbohydrates by Anthrone method: a quantitative approach.	2
5	To identify a given sample for protein by using qualitative methods.	2
6	To estimate concentration of proteins by quantitative methods: Biuret method, Lowry's method, and Bradford's method.	2
7	To isolate plasma and serum from blood and visualize different proteins present in serum sample by SDS PAGE technique.	2
8	To perform the isoelectric precipitation of casein present in milk.	2
9	To determine presence of lipid in a given sample through qualitative method.	2
10	To estimate the amount of cholesterol present in the serum sample by ZAK's method.	2
11	To quantify the concentration of nucleic acid through spectrophotometer.	2
12	To determine uric concentration in a given serum sample.	2
13	To determine blood sugar concentration in a serum sample.	2
	Total Lab hours	**24**

Suggested books /Resources:

1. Lab manual
2. An Introduction to Practical Biochemistry - David T Plummer
3. Practical Biochemistry, Principles and Techniques - Keith Wilson and John Walker
4. Practical Biochemistry-Geetha Damodaran K
5. E-portal of V-labs by Amrita University (vlab.amrita.edu)

Evaluation Scheme:

Mid Term Test	20
End Term Test	20
Teacher Assessment (Based on day to day work, performance in experiments, lab notebook etc.)	60
Total	100

Course Outcomes (COs) contribution to the Programme Outcomes (POs):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	1	2	2	1	1	1	-	-	1	-	3	**1.25**
CO2	2	3	2	1	2	1	1	1	-	2	3	3	**1.75**
CO3	2	2	2	2	1	2	2	1	1	1	2	2	**1.67**
CO4	2	2	2	2	2	1	2	-	2	2	2	2	**1.75**
CO5	1	1	2	1	1	2	1	3	1	2	2	3	**1.67**
Average	**2.00**	**1.80**	**2.00**	**1.60**	**1.40**	**1.40**	**1.40**	**1.00**	**0.80**	**1.60**	**1.80**	**2.60**	

BIOCHEMISTRY

COURSE CODE: 18B11BT312

COURSE CREDITS: 3

ELECTIVE/CORE: CORE

L-T-P: 3-0-0

Pre-requisite: Cell Biology, Chemistry

Course Objectives:

1. To provide an understanding of the basic bio-molecule structures, their origin and their involvement in life processes.
2. To provide an insight into the main metabolic pathways of living organisms and their integration with other biological pathways.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	to understand the structural fundaments of various biochemical present in organisms.	Familiarity
CO-2	to understand the principles of structural-functional relationship of biomolecules.	Familiarity
CO-3	to understand primary metabolic pathway of energy production in organism.	Assessment
CO-4	to understand the regulation of various metabolic pathway of organism.	Assessment
CO-5	to integrate knowledge of biochemical pathways for understanding the various disorders and their rectification.	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Bio-molecules and their bi role in metabolism:** Biological importance structural polysaccharides, Properties and function of lipids in fat metabolis enzymatic regulation in metabolism, Importance of nucleic acids in liv system,	8
2	**Carbohydrate Metabolism:** Introduction to Intermediary metabolism, central role of glucose in metabolism of plants, animals. Glycolysis, reactions of glycolysis. Fermentation: anaerobic fate of pyruvate. Regulation of glycolytic pathway. Overview of TCA, Metabolic sources of Acetyl-Coenzyme A. TCA Cycle	8

	inhibitors. Gluconeogenesis and its Regulation, Glyoxalate Cycle reactions. Glycogen metabolism, Synthesis and breakdown, glycogen synthetase and phosphoryllase and their regulation, Glycogen Storage diseases.	
3	**Lipid Metabolism:** Biosynthesis of lipids, fatty acid synthesis and its regulation, biosynthesis of triacylglycerols, phospholipids. Lipid digestion, absorption and transport. Fatty acids oxidation, oxidation of saturated, unsaturated fattys in mitochondria, transport of fatty acids to mitochondria. Ketone Bodies synthesis and degradation.	**8**
4	**AminoAcids metabolism:**Overview; assimilation of inorganic nitrog in biomolecules.Positive and negative nitrogen balance, Protein calo malnutrition, Kwashiorkor and Marasmus. Glucogenic and ketogenic amino acids, catabolic pathways for the 20 standard amino acids; Metabolism of one-carbon units. Disorders of amino acid metabolism:Phenylketonuria, Alkaptonuria, Maple syrup urine disease etc.	**7**
5	**Purine andPyrimidinemetabolism:** Biosynthesis of IMP; pathwa from IMP to AMP and GMP; conversion to triphosphates; regulation purine nucleotide biosynthesis, salvage pathways. Inhibitors of nucleotide metabolism and their use as anti bacterial / anticancer drugs.Degradation of purine and pyrimidine nucleotides. Disorders of nucleotide metabolism: LeschNyhan syndrome, Gout, SCID, Adenosine deaminase deficiency.	**7**
6	**Vitamins:**Structure of fat soluble vitamins A, D, E & K. Water soluble vitamins, their co- enzyme forms and deficiency disorders, Thiamine, riboflavin, pantothenic acid, niacin, pyridoxine, biotin, cobalamine, folic acid and ascorbic acid.	**4**
	Total	**42**

Suggested Text Book(s):

1. Lehninger Principles of Biochemistry Cox, M.M. and Nelson, D.L. and Lehninger A. L. 4th edition.
2. Biochemistry- J.M. Berg, J.L.Tymoczko, and LubertStryer; 5th edition W.H. Freeman and Company, New York, USA.
3. Voet, D. and Voet, J.G.(2011), 4th edition. Biochemistry, John Wiley & Sons, Inc. USA.
4. Robert Murray, David Bender, Kathleen M. Botham, Peter J. Kennelly, Victor Rodwell, P. Anthony Weil Rodwell, (2012) 29th edition. Harper's Illustrated Biochemistry, Lange, McGrawHill.

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes & Attendance

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	1	2	2	-	1	1	-	-	1	-	3	**1.17**
CO2	2	2	2	1	1	3	1	1	-	2	1	3	**1.58**
CO3	2	2	2	1	1	2	2	1	1	1	2	2	**1.58**
CO4	2	2	2	2	2	1	2	-	2	2	2	2	**1.75**
CO5	2	2	2	2	1	2	2	2	1	2	2	3	**1.92**
Average	**2.20**	**1.80**	**2.00**	**1.60**	**1.00**	**1.80**	**1.60**	**0.80**	**0.80**	**1.60**	**1.40**	**2.60**	

Genetics

COURSE CODE: 18B11BT311

COURSE CREDITS: 4

ELECTIVE/CORE: CORE

L-T-P: 3-1-0

Pre-requisite: Knowledge of Biology (10+2)

Course Objectives

1. Genetics is a core course designed to cover both basic and advanced concepts in classical genetics.
2. A good understanding on this subject will help the students to think analytically on other areas of modern biology and medicine.
3. After completing this course the students would acquire a good understanding of Mendelian analysis, linkage analysis, gene mutation and genetics of model organisms, genetic diseases, ethical issues and population genetics.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO I	Students will combine their knowledge of probability theory with the rules of inheritance to do pedigree analysis and accurately predict genetic outcomes.	Assessment & Analytical Skills
CO II	Students will be able to interpret pedigrees and phenotypic ratios to determine if genes are autosomal or sex-linked, linked or sorting independently, and genotypes of parents	Analytical & Technical Skills
CO III	Students will develop an appreciation of how genes work within organisms.	Familiarity
CO IV	Students will develop an understanding and ramifications of gene mutations	Awareness
CO V	Students will be able to recognize real-world examples of genetics topics and demonstrate the interaction of genetics in society.	Assessment & Analytical Skills
CO VI	Students will develop an understanding of the ethical issues related to genetic research and its applications.	Analytical & Technical Skills

Course Contents:

Unit	Contents	Lecture required
1	**Introduction to Genetics**Background and revision of concepts of mitosis &meosis,Terminology and relevance of the subject.	2

2	**Mendelian Genetics** Basic principles of Mendelian experiments. Mendel's laws and its extension, Model systems in genetic analysis – Drosophila, Pea, Arabidopsis.	6
3	**Chromosomes and Chromosome theory of inheritance**Nucleic Acids, Chromosomes, Chromosomal abnormalities: polyploidy, Lampbrush and Polytene chromosomes, The Chromosome Theory of Heredity, Sex Chromosomes and Sex- Linkage	6
4	**Gene interaction**Genes, Alleles, Lethal alleles, Multiple alleles and their interaction, Pleiotropism, Penetrance and expressivity, Transposable Elements	5
5	**Linkage and chromosome mapping**The Discovery of Linkage,Linkage and Recombination, Linkage of Genes on the X- chromosome, Linkage maps, Three-Point Testcross, Interference, Calculating Recombinant Frequencies, Examples of Linkage Maps, Chi-square test, The Nature of Crossing-Over, Linkage Mapping by Recombination in Humans.	6
6	**Gene mutation** Somatic versus germinal Mutation, Mutant Types, Mutation Induction, Gene Mutation, The Molecular Basis of Gene Mutations, Spontaneous Mutations, Induced Mutations, Reversion Analysis, The Relationship between Mutagens and Carcinogens, Luria Delbruck fluctuation test,	6
7	**Extra Chromosomal Inheritance**Extra nuclear Inheritance in Higher Plants, Overview of the Mitochondrial Genome, Overview of the Chloroplast Genome	3
8	**Population Genetics**Darwin's Revolution, Variation and Its Modulation, The Effect of Sexual Reproduction on Variation, The Sources of Variation, Selection, balanced Polymorphism, Quantitative genetics	5
9	**Genetic Diseases & Ethics**Genetic Diseases and Protein malfunctioning, ethical issues related to Genetics	3
Total Lectures		**42**

Suggested Text Books:

1. Concept of genetics by William S Klug and M.R. Cummings
2. Principles of Genetics. D P Snustad, M J Simmons

Suggested Reference Books:

1. An Introduction to Genetic Analysis. Griffiths et al.
2. Genetics, from Genes to Genomes L.H. Hartwell et al,
3. Genetics by Strickberger
4. Genetics by Peter J. Russell
5. Principles of Population Genetics by Daniel L. Hartl and Andrew G. Clark

Other Useful Links:

1. https://nptel.ac.in/

2. http://www.dnaftb.org/1/bio.html Developed by Cold Spring Harbor Laboratory
3. http://www.dnaftb.org/1/bio.html Developed by Cold Spring Harbor Laboratory

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes & Attendance

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Genetics)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	1	2	2	2	1	1	2	1	3	3	**1.8**
CO-2	3	3	3	2	3	2	3	2	2	2	1	2	**2.2**
CO-3	3	2	2	3	1	2	3	2	2	2	1	2	**2.08**
CO-4	2	2	2	3	2	2	1	2	1	2	1	2	**1.8**
CO-5	2	2	1	2	1	2	1	2	1	1	1	2	**1.5**
CO-6	1	2	2	1	2	2	1	3	-	1	-	2	**1.7**
Average	**2.1**	**2.1**	**1.8**	**2.1**	**1.8**	**2**	**1.6**	**2**	**1.3**	**1.5**	**1.1**	**2.1**	

Genetics Lab

COURSE CODE:18B17BT371

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

L-T-P: 0-0-2

Pre-requisite: Knowledge of Biology (10+2)

Course Objectives:

1. Genetics is a core course designed to cover both basic and advanced concepts in classical genetics.
2. A good understanding on this subject will help the students to think analytically on other areas of modern biology and medicine.

Course Outcomes

S.No.	Course Outcomes	Level ofAttainment
CO1	To acquaint the students with methods and techniques used in experimental genetics.	Familiarity
CO2	Obtain hands-on experience in performing fundamental genetics experiment including working safely and efficiently in a modern laboratory setting.	Assessment & Analytical Skills
CO3	Correctly analyze and interpret experimental results within the limitations of the experimental design	Assessment&Analytical Skills
CO4	Students will be trained students with genetics experiments related to Model Organism Drosophila	Assessment & Analytical Skills
CO5	They will develop a statistical analysis of genetic data relevant to forensic, conservation and evolutionary genetics, and summarize and interpret the outcomes along with ethical issues.	Analytical & Technical Skills
CO6	Students will develop an understanding and importance of Virtual Genetics Labs.	Assessment & Analytical Skills

List of Experiments

S.NO.	Description	Hours
1	Course orientation and Lab safety along with a preview of instruments.	2
2	Study of human karyotype – Study of chromosome structure, morphology, number and types.	2

3	Cell division (Mitosis and Meiosis) – Basis of Genetics	2
4	Study of co-dominance using ABO and Rh blood typing and Ishihara test for colourblindness and its associated Genetics.	2
5	Calculation of allelic and genotypic frequencies as per Hardy-Weinberg Law – Free ear lobes, Hitchhikers, Widow's peak, Dimpled chin, Taste allele frequencies	2
6	DNA isolation from *E.coli* strain. Agarose gel formation, PCR basics.	2
7	DNA quantification and amplification.	2
8	Virtual Lab. 1 on Classical Genetics and Mendel's experiments.	2
9	Virtual Lab. 2 on Buffers like TBE, TE, TAE. Relevance of various buffers will be explained. Their composition and preparation will also be studied.	2
10	Virtual Lab. 3 on Nucleic acid molecules are separated by agarose gel electrophoresis. Factors related to separation and its preparation, loading etc. will be studied through it.	2
11	Handling Drosophila, identifying mutants, and scoring flies.	2
12	Drosophila genetics and recombination Analysis of Drosophila recombinants using probability and Chi-Square test.	2
13	Dissect the Drosophila larvae and bring out the salivary gland and polytene chromosomes from *Drosophila melanogaster*	2
14	Survey of DNA polymorphism using Dominant and Co-dominant molecular markers (RAPD,ISSR and SSR)	2
Total Lab Hours28		

Suggested Reference(s):

1. Genetics Lab manual
2. http://vlab.amrita.edu
3. https://nptel.ac.in/

EvaluationScheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Genetics Lab)	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**Average**
CO1	2	2	2	2	3	1	1	2	2	1	-	2	**1.8**
CO2	2	2	3	2	3	2	2	2	2	2	2	3	**2.2**
CO3	2	3	3	3	3	2	1	2	2	-	1	2	**2.1**
CO4	1	2	2	2	2	1	-	2	2	1	-	2	**1.7**
CO5	3	3	3	3	2	1	2	1	3	1	1	2	**2**
CO6	1	3	3	2	3	2	1	1	2	2	1	3	**2**
Average	**1.8**	**2.5**	**2.6**	**2.3**	**2.6**	**1.5**	**1.1**	**1.6**	**2.1**	**1.1**	**1**	**2.3**	

Thermodynamics and chemical processes

COURSE CODE:18B11BT313

COURSE CREDITS: 4

CORE/ELECTIVE: CORE

L-T-P: 3-1-0

Pre-requisite: General Chemistry and Basic Physics

Course Objectives:

1. Learn the concept of thermodynamics, bioenergetics.
2. Learn Reaction kinetics, mass and energy balances as well as fluid flow mechanics.
3. Learn heat transfer and mixing equipments.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Use of correct Thermodynamical terms to describe &analyze phenomena/problems in physico-chemical processes	Familiarity
CO-2	Understanding the concept of thermodynamics for biological processes as in bioenergetics.	Assessment
CO-3	Understanding basic reaction theory and general reaction kinetics for biological systems in terms of Michaelis – Menten Kinetics.	Assessment
CO-4	To familiarize basic principles for macroscopic analysis of cell growth and product formation. Calculation of nutrient and oxygen requirements during various fermentation processes for both material balances and energy balances.	Familiarity and Usage
CO-5	To know the flow behaviour of different fermentation fluids, their Classification, flow curves for Non- Newtonian fluids with examples from biotechnology as well as Rheological properties of fermentations Broths.	Assesment
CO-6	Understanding the principles governing heat transfer with applications in bioprocess design. Modes of heat transfer, Heat - Transfer equipmentsand Heat transfer coefficients.	Familiarity and Usage

Course Contents:

Unit	Contents	Lectures required
1	**Introduction andfundamentalconceptsofthermodynamics:** Processes, Components (single/multi), Phases(G/L/S), ideality, Concept of continuum for biological processes, Entropy, enthalpy, Gibbs Free energy, Specific heats /heat capacity. Laws of Thermodynamics and its applications.	3
2	**Bioenergetics (Biological Thermodynamics):** Principles of bioenergetics. Energetics of metabolic pathways by metabolic flux, Energy coupling (ATP and NADH), Biological oxidation and reduction reactions. Understanding thequantitative relationships among free energy, enthalpy and entropy. Concept of G_o, $G_{o'}$ to biochemical reactions, Endergonic and exergonic reactions, Catabolic and anabolic mechanisms.	5
3	**Homogenoeus Reactions/Reaction kinetics:** Basic reaction theory, Reaction Thermodynamics, Calculation of reaction rates from experimental data, General reaction kinetics for biological systems, Michaelis – Menten Kinetics, Kinetics of enzyme deactivation.	6
4	**MaterialBalances ofBiochemicalProcesses:** Aspects of metabolic stoichiometry, principlesfor macroscopic analysis of cell growth and product formation. Calculation of nutrient and oxygen requirements during various fermentation processes. Analysis of batch culture of growing cells. Stochiometric coefficients for cell growth, Elemental and electron balances, Biomass yield, Product stochiometry, Theoretical oxygen demand, Thermodynamic maximum biomass and product yields.	7
5	**Energy Balancesof BiochemicalProcesses:** Stochiometric and energetic analysis of cell growth and product formation, elemental study of energy flow within the living systems. Enthalpy calculations for reactive and nonreactive biological processes, Heat of reaction for the process of biomass production, Thermodynamics of microbial growth, Energy balance equation for aerobic and anaerobic cell culture and various other fermentation processes.	7
6	**Fluid mechanics:** Flow behavior of different fermentation fluids. Introduction, Classification of fluids, Newton's Law of viscosity, flow curves for Non- Newtonian fluids with examples from biotechnology, Reynolds number, Boundary layer separation, Fluids in motion, flow patterns– Laminar, turbulent and transition flow, Rheological properties of fermentations Broths, properties of Fluids (Viscosity, Surface Tension), Factors affecting broth viscosity, cell morphology.	7
7	**Heat Transfer:** Principles governing heat transfer with applications in bioprocess design. Modes of heat transfer, Heat - Transfer equipments. Analogy between Heat and momentum transfer, Heat transfer between fluids, Heat transfer coefficients, Design equations for heat transfer systems and its application.	7
	Total lectures	**42**

Suggested Text Book(s):

4. Heat Thermodynamics and Statistical Physics: By B. Lal, N. Subramanyam and P. S. Hemne
5. Biochemistry : By Jeremy M. Berg, John L. Tymoczkao, L. Stryer; .
6. Bioprocess Engineering Principles: By P.M. Doran.

Suggested Reference (s):

1. Thermodynamics: A Core Course By: R. C. Srivastava, S.K.Saha and A.K.Jain
2. Engineering Thermodynamics, By: Lynn D. Russsell and George A. Adebiyi
3. Lehninger's Principles of Biochemistry 4th Editoin : By D L Nelson, Cox Lehninger
4. Himmelblau, D.M., "Basic Principles and Calculations in Chemical Engineering", 6th ed.

Other useful resource(s):

1.Link to NPTEL course contents:https://nptel.ac.in/courses/106104019/

2.Link to topics related tocourse:

i. https://nptel.ac.in/courses/102104063
ii. https://nptel.ac.in/courses/102106069/
iii. https://nptel.ac.in/courses/102106026/

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	Average
CO1	3	3	2	-	2	-	1	1	-	1	2	-	1.25
CO2	-	2	-	2	2	1	-	1	2	3	-	-	1.08
CO3	2	3	-	2	3	1	1	1	3	3	3	2	2
CO4	2	-	3	3	3	1	-	1	2	-	3	2	1.66
CO5	3	2	3	-	2	-	1	1	-	2	-	-	1.16
CO6	3	3	-	3	2	-	1	1	3	2	1	3	1.91
Average	2.1	2.1	1.33	1.66	2.33	0.5	0.66	1	1.66	1.8	1.5	1.1	

Thermodynamics and chemical processes Lab

COURSE CODE:18B17BT373

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

L-T-P: 0-0-2

Pre-requisite: None

Course Objectives:

1. Learn enthalpy calculations
2. Learn to calculate enzyme activity
3. Analyzing the Michael Menton kinetic constants.
4. Measurement of viscosity and surface tension of various biological liquids

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	Able to familiar with the various experiments involved with the flow of heat in terms of water equivalent/heat capacity, enthalpy calculation of various biological compounds as well as energy calculation of different food items.	Familiarity
CO2	Able to correlate the activity with the thermodynamic parameters: ΔH, ΔG, ΔS, and Cp	Assesment
CO3	To understand the variation of activity of enzymes with different physical parameters as pH, Temp. and concentration	Assesment
CO4	Able to correlate the chemical processes with reaction kinetics as well as Michael - Menton kinetics	Usage
CO5	Able to enhance practical skills related to all the measurements of different parameters of liquids as viscosity, surface tension.	Usage
CO6	Able to enhance practical skills related to all the measurements of fluid flow mechanics in order to check the flow patterns with the help of Reynolds number.	Familiarity

List of Experiments

S.No	Description	Hours
1	To determine Heat Capacity or Water equivalent of given thermos/ Dewar flask used as calorimeter	2

2	To determine enthalpy/heat of solution of some biological important compound	2
3	To determine heat of neutralization of strong acid and strong base media	2
4	Determination of the thermodynamic parameters: ΔH, ΔG, ΔS, and Cp of the protein lysozyme	2
5	To measure the energy in different food samples.	2
6	To determine the activity of amylase by spectrophotometric method.	2
7	To study the effect of different temperature on amylase activity	2
8	To study the effect of different pH on amylase activity	2
9	To calculate Km and Vmax of the amylase	2
10	To determine viscosities of various fluids: Glucose, Biological fluids and culture.	2
11	To determine surface tension of various fluids: Glucose, Biological fluids and Culture.	2
12	To study the flow pattern by changing the RPM.	2
Total Lab hours		**24**

Suggested/Resources:

1. Lab Manual : \\172.16.73.6/BT/BI
2. https://www.bvrit.ac.in/Freshman_Lab_Manuals/freshman_engineering_chemistry/Engineering%20Chemistry.pdf

EvaluationScheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	2	2	1	2	1	1	--	-	-	2	-	**1.16**
CO2	2	3	3	3	3	-	-	1	2	2	2	-	**1.83**
CO3	3	3	3	3	3	-	-	2	3	1		2	**1.9**
CO4	1	3	1	3	1	-	1	1	2	-	2	-	**1.25**
CO5	1	3	1	1	1	1	-	-	2	1	2	-	**1.08**
CO6	3	3	3	3	3	-	-	-	3	2	3	-	**1.91**
Average	**2.5**	**2.83**	**2.83**	**2.83**	**2.83**	**1**	**1**	**1.33**	**2.4**	**1.5**	**2.2**	**2.0**	

Cell Biology & Cell Culture Technologies

COURSE CODE:18B11BT411

COURSE CREDITS: 3

ELECTIVE/CORE: CORE

L-T-P: 3-0-0

Pre-requisite: Basic Understanding of Biology

Course Objectives:

1. The objective of this course is to introduce the student to basic cell biology, animal & plant tissue culture techniques and their application.
2. In cell biology component, the course is designed to understand fundamental concepts of cell and how it functions at the cellular level.
3. In animal tissue culture component, the course is designed to impart an understanding pertaining to why one needs animal cell cultivation, the basic ATC set-up, the biology of cultured cells, techniques to establish and propagate cell cultures of animal origin.
4. In plant tissue culture component, the course is designed to develop an understanding about the morphology of plant cell and its utilization through different techniques of plant tissue culture for propagation, conservation and production of different plant species and their products

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Successful student will understand fundamental concepts of cellular function.	Familiarity
CO-2	Be able to critically analyze, the scientific evidence underlying current understanding of cellular processes.	Assessment& Analytical Skills
CO-3	To enable students for applying the knowledge about basic techniques of plant tissue culture.	Technical Skills
CO-4	They will learn the strategies for analyzing, upscaling and commercialization of plant based products.	Technical Skills
CO-5	Basic understanding of animal tissue culture, Maintain aseptic condition, primary and continuous culture of cell lines, suspension and adherent cells, cryopreservation and revival of cell lines.	Awareness
CO-6	To understand functional assay at cellular level, cell morphology and survival, immunolabeling.	Analytical & Technical Skills

Course Contents:

Units	Contents	Lectures required
1	Introduction to the cell Prokaryotic and Eukaryotic cell; Animal and Plant cell, Structure of cell, cellular organelles and their structure and function. Biological membranes – Overview of Membrane structure and function - Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, membrane pumps, Protein Sorting, Intracellular Vesicular Traffic and regulation of intracellular transport, electrical properties of membranes.	**3**
2	Cell signalling - Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers and regulation of signaling pathways. The Cytoskeleton, Cell Cycle and Programmed Cell Death, Cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation. Methods and techniques - Manipulating proteins, DNA and RNA. Visualizing cells.	**8**
3	Plant structure, growth and development Introduction, definitions and history of plant cell and tissue culture Organization of tissue culture laboratory Cellular totipotency and cell differentiation, factors affecting differentiation	**8**
4	Isolation of single plant cells, suspension cultures, types of suspension cultures, Measurement of the growth in suspension cultures, Assessment of Viability of the cultured cells, bioreactors used for plant cell cultures	**8**
5	Type of cultures and their applications: Direct and indirect methods of culture; seed culture, embryo culture, organ culture, callus culture, somaclonal variation and applications	**7**
6	Somatic embryogenesis Micro-propagation and its applications, Advances in acclimatization of tissue cultured plants. Haploid and triploid production and applications Protoplast isolation and fusion and application Production of virus free plants through cell and tissue culture	**4**
7	Secondary metabolite production and bioconversions /biotransformation through plant cell cultures and plant stem cells	**4**
8	Introduction to human anatomy and Physiology, An overview of different Systems, organs and tissues of human body. Basics terms and definitions, historical background, Importance of animal cell culture technology, laboratory facilities-design, equipments and safety parameters, waste disposal in a cell culture set-up. Aseptic techniques for animal cell cultivation.	
9	Cell culture technology: Basic requirement for growing animal cells - Cell culture reagents, media, media supplements, media preparation and sterilization, Defined-Undefined media, Complete-Incomplete media, Importance of Serum and Serum free Media, culture conditions. Maintenance of cell culture: Culturing, sub-	

	culturing, passaging.	
10	Studying biological system using cell culture techniques: Functional assays based on cell culture: Cell morphology, Quantitation, Growth pattern, Cytotoxicity assays, Study of Cell Death: senescence, apoptosis and necrosis, Cell proliferation, Cell viability measurements, FISH. Immunolabeling of cells to study molecular expression pattern–Microscopy, Flow cytometry, Immunohistochemistry, etc. Application of Cell culture Technology Hybridoma technology for monoclonal antibody production.	
Total Lectures		**42**

Suggested Text Book(s):

1. Michael Butler, "Animal Cell Culture and Technology", BIOS Scientific Publishers
2. John R.W. Masters, " Animal Cell Culture-A Practical Approach", Oxford University Press
3. R. Ian Freshney, "Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications".
4. Introduction to Plant biotechnology H S Chawala
5. Plant tissue culture: theory and Practice S.S.Bhojwani and M K Razadan
6. Plant tissue culture S.S.Bhojwani and M K Razadan
7. Elements of Biotechnology P K Gupta
8. Plant cell and tissue culture Narayan Swamy

Suggested Reference Book(s)

1. Molecular Biology of the Cell: by Bruce Alberts, 4th Edition 2002.
2. Lodish, et al. Molecular Cell Biology. 5th ed. New York, NY: W.H. Freeman and Company, 2003.

Other useful resource(s):

1. Link to NPTEL course contents:https://nptel.ac.in/
2. https://nptel.ac.in/courses/102103012/
3. https://nptel.ac.in/courses/102104059/
4. https://nptel.ac.in/courses/102103016/

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

Course outcomes (Cell Biology & Cell Culture Technologies)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	2	2	2	2	2	1	1	1	2	2	**1.75**
CO-2	2	2	2	2	2	2	1	1	1	1	2	2	**1.66**
CO-3	3	3	3	3	2	1	2	1	1	1	2	2	**2**
CO-4	3	3	3	3	2	1	2	1	1	1	2	2	**2**
CO-5	2	2	2	2	2	2	1	1	1	1	2	2	**1.66**
CO-6	3	3	3	3	2	2	1	1	1	1	2	2	**2**
Average	**2.5**	**2.5**	**2.5**	**2.5**	**2**	**1.6**	**1.5**	**1**	**1**	**1**	**2**	**2**	

Cell Biology & Cell Culture Technologies Lab

COURSE CODE: 18B17BT471

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

L-T-P: 0-0-2

Pre-requisite: Basic Biology

Course Objectives:

4. The objective is to familiarize students with the various Cell biology and cell culture techniques.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	To understand, design, analyze and interpret experiments related to cell biology and link practical knowledge to theoretical.	Familiarity
CO2	To understand, design, analyze and interpret experiments related to Animal cell culture and link practical knowledge to theoretical	Analytical Skills
CO3	To understand, design, analyze and interpret experiments related to Plant tissue Culture and link practical knowledge to theoretical	Analytical Skills
CO4	Able to perform cell count using haemocytometer and maintain aseptic condition.	Technical Skills
CO5	To understand team work, ethics and work discipline.	Use

List of Experiments

S.No	Description	Hours
1	Laboratory Safety and To Study various parts of compound microscope	2
2	To prepare and study temporary or permanent slides of mitosis, meiosis, stem and root cells/sections and differentiate the plant cells and animal cells	2
3	To study the effect of salinity on biological membranes of cells	2

4	To prepare the blood smear slides, visualization and cell count of the components of blood using light microscopy	2
5	Introduction to ATC, Fluid Transfer using aseptic technique, Preparation of stock media from powder and filter sterilization	2
6	Sub culturing, Cryopreservation and Revival of Cell culture	2
7	Assessment of cytotoxicity using MTT assay/Biological screening of herbal/synthetic molecules.	2
8	Introduction to various equipments and their working in plant tissue culture lab setup and Preparation of stocks solutions, hormones culture medium	2
9	Establishment of Callus and Suspension cultures and measuring cell growth	2
10	Plant regeneration from callus and somatic embryogenesis	2
11	Microproapagation of different plant species by axillary shooting	2
12	Hardening or Acclimatization of cultured plantlets to field conditions	2
13	Meristem culture for virus elimination. Anther and pollen culture for haploid production	2
14	Protoplast isolation and determining the protoplast viability	2
Total Lab hours		**28**

Suggested/Resources:

1. Lab Manual
2. Plant Cell and Tissue Culture - A Tool in Biotechnology: Basics and Application (Principles and Practice) by: Karl-Hermann Neumann publisher: Springer
3. Tissue Culture for Plant Propagators by R.A. de Fossard
4. Plant Culture Media, Volume 1,Formulations and Uses by E.F. George
5. Micropropagation: Technology and Application by P.C. Debergh and R.H. Zimmerman Kluwer

Academic Publishers

6. Virtual Lab. (http://vlab.amrita.edu)

EvaluationScheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	3	3	3	2	2	1	1	1	1	1	1	**1.83**
CO2	3	3	3	3	3	1	1	1	1	1	1	3	**2.00**
CO3	3	3	2	3	2	3	2	1	1	1	2	1	**2.00**
CO4	3	3	3	2	3	2	1	1	1	1	1	1	**1.83**
CO5	2	2	3	3	3	3	1	1	1	1	1	1	**1.83**
Average	**2.8**	**2.8**	**2.80**	**2.80**	**2.60**	**2.20**	**1.20**	**1.00**	**1.00**	**1.00**	**1.20**	**1.40**	

Molecular Biology

COURSE CODE: 18B11BT412

COURSE CREDITS: 3

CORE/ELECTIVE: CORE

L-T-P: 3-0-0

Pre-requisite: Fundamental biology Cell biology, Biochemistry

Course Objectives:

1. This course covers the basic principles of molecular biology and its practical applications.
2. The main objective of the course is to equip students with a detailed knowledge of molecular biology in the context of human diseases.
3. To prepare students for future research and also enhance their career prospects in the expanding life sciences sector including public-funded research laboratories or private industry.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	To understand the basic structures of various genetic materials of cells.	Familiarity
CO-2	To understand the structural-functional relationship of genetic material with other biomolecules of cells.	Familiarity
CO-3	To understand foundational genetic processes of molecular biology.	Familiarity
CO-4	To Understand how molecular machines within the cell are regulated so that they can accurately copy, repair, and interpret genomic information.	Assessment
CO-5	To integrate knowledge of molecular biology principles for understanding the various disorders and their rectification.	Usage

Course Contents:

Units	Contents	Lectures required
1	**Basics of Molecular Biology:** Why Molecular Biology? How molecular biology came about? Major events in molecular biology, Nucleic acids; DNA and RNA and their structure and function in detail, Protein structure, basic functions, DNA-Protein interactions, molecular details of protein purification ,	4

	DNA structures and their implication in diseases	
2	**Molecular Biology Techniques and their Applications:**Polymerase chain reaction, DNA sequencing, Western blot Southern and northern blotting, DNA foot-printing, Immuno-fluorescence	**8**
3	**DNA replication:**Avery Mcleod and Mccarty experiments, Hershey Chase Experiment, Maintenance of DNA sequence, Linking number of DNA, Forces which stabilize the DNA secondary structure, DNA polymerase,Replication process: Initiation, Extension, leading strand, lagging strand, Dynamics at the replication fork, termination, DNA replication protein,DNA replication regulation: Eukaryotes and prokaryotes	**8**
4	**DNA transcription and RNA processing:**History, RNA polymerases, Major steps in transcription: Pre-initiation, Initiation, promoter, elongation,termination mRNA splicing mechanisms, rRNA modifications Reverse transcription, Transcription inhibitor, Post-transcription modification	**8**
5	**Translation:** Basic mechanism-Eukaryotic and Prokaryotic translations,composition of Ribosomes, Genetic codes; Role of tRNA in translation, mRNA translation mechanisms: initiation, elongation and termination process	**8**
6	**Gene regulation and Post-translational modification:**Why cells need to regulate genes, control of gene regulation, Operon (TrpOperon,Lac operon), Regulatory proteins; Helix turn-helix, Leucine Zipper, Zinc finger; Post translational modifications, Effects of post-translational modifications, Why protein post-translational modification are made , Types of post-translational modifications, Methods used to study post-translational modifications	**6**
Total Hours		**42**

Suggested Text books:

1. Stryer, Lubert (2002). Biochemistry; Fifth edition. W. H. Freeman and Company.
2. Lehninger “Principles of Biochemistry”.

Suggested Reference books:

1. Lodish H, Berk A, Zipursky LS, Matsudaira P, Baltimore D, Darnell J (2000). *Molecular Cell Biology*. W. H. Freeman and Company
2. Lewin's GENES XI
3. Molecular Cell Biology Damell Jr. J., Lodish, H and Baltimore, D. Scientific American Inc., New York
4. Neill, Campbell (1996). Biology; Fourth edition. The Benjamin/Cummings Publishing Company. p. 309,310. ISBN 0-8053-1940-9.

EvaluationScheme:

Exam	Max. marks	Duration	Course Covered
T1 Test	15	1 hr.	Unit 1-2
T2 Test	25	1.5 hrs.	Unit 1-4
End Term Test	35	2 hrs.	Whole Syllabus
Teacher Assessment(Based on Assignments, quizzes etc.)	25	Whole Semester(Quiz, short presentations)	Inform class time to time
Total	**100**		

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	1	1	1	1	1	1	1	0	0	0	2	1.00
CO2	1	2	3	1	1	1	1	0	0	2	2	2	1.33
CO3	1	2	2	2	1	2	1	1	1	2	2	1	1.50
CO4	2	2	2	3	1	1	3	1	1	1	1	3	1.75
CO5	1	2	3	2	2	2	1	2	2	2	2	3	2.00
Average	1.60	1.80	2.20	1.80	1.20	1.40	1.40	1.00	0.80	1.40	1.40	2.20	

Molecular Biology Lab

COURSE CODE: 18B17BT472

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

L-T-P: 0-0-2

Pre-requisite: Fundamental biology Cell biology, Biochemistry

Course Objectives:

3. The objective of this course is to familiarize the students with laboratory techniques related to isolation and quantification of various biomolecules required to maintain the cellular processes at molecular level.
4. To develop basic practical skills for the handling and analysis of biomolecules.

Course Outcome:

S.N.	Course Outcomes	Level of Attainment
CO1	Able to understand the fundamental procedures of isolation, visualization of various biomolecules from cellular or tissue organization.	Familiarity
CO2	Able to understand, and perform, molecular biology techniques accurately and safely.	Familiarity
CO3	Able to isolate, quantify and visualize various biomolecules having application in the field of biotechnology.	Assessment
CO4	Able to report experimental results in a standard written format and to write coherently and persuasively about conclusions from such results and their significance.	Assessment
CO5	Able to interpret experimental results and conclusions for understanding various biological processes and their abnormalities.	Usage

List of Experiments

S.No.	Description	Hours
1	Good Lab Practice and Calculations of molarity and normality of the solutions	2
2	To isolate genomic DNA from *E. coli* (DH5-α) using heat boiling method.	2
3	Quantification of DNA concentration and purity by nanodrop method.	2
4	To perform agarose gel electrophoresis.	2
5	To isolate *E. coli* (DH5-α) genomic DNA using phenol chloroform method.	2

6	Isolation of genomic DNA from human blood sample.	2
7	To isolate plant genomic DNA using CTAB method.	2
8	To isolate *E. coli* (DH5-α) plasmid DNA by alkaline lysis method.	2
9	To isolate RNA from bacterial cell.	2
10	Introduction to Polymerase Chain Reaction and to amplify gene using genomic DNA of *E. coli*.	2
11	To perform restriction digestion using *E. coli* plasmid DNA.	2
12	To separate serum and plasma proteins from human blood.	2
13	To visualize human serum and plasma proteins using SDS-PAGE technique.	2
	Total	**26**

Suggested Resource(s):

1. Lab manual
2. Michael R. Green and Joseph Sambrook. Molecular Cloning, A Laboratory Manual. fourth edition.
3. Keith Wilson and John Walker (2010).Principles and Techniques of Biochemistry and Molecular Biology, seventh edition.

Evaluation Scheme:

Mid Term Test	20
End Term Test	20
Teacher Assessment (Based on day to day work, performance in experiments, lab notebook etc.)	60
Total	100

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Molecular Biology Lab)	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**Average**
CO1	3	2	3	2	3	1	1	3	3	2	3	3	**2.4**
CO2	3	2	2	3	2	1	-	2	3	2	2	2	**2.18**
CO3	3	3	1	3	3	1	-	1	3	1	3	3	**2.27**
CO4	2	2	1	3	2	1	-	1	3	1	2	2	**1.8**
CO5	2	1	1	2	2	1	-	1	3	1	2	2	**1.6**
Average	**2.6**	**2**	**1.6**	**2.6**	**2.4**	**1**	**1**	**1.6**	**3**	**1.4**	**2.4**	**2.4**	

Introduction to Bioinformatics

COURSE CODE:18B11BT413

COURSE CREDITS: 4

CORE/ELECTIVE: CORE

L-T-P: 3-1-0

Pre-requisite: Molecular Biology, Biochemistry

Course Objectives:

5. Background and need for bioinformatics
6. Learn sequence analysis techniques.
7. Learn sequence alignment-pairwise and multiple.
8. Apply phylogenetic analysis.
9. Application of bioinformatics in modern day research.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Knowledge of bioinformatics databases and resources	Familiarity
CO-2	Sequence analysis including pairwise sequence alignment	Assessment
CO-3	Sequence analysis using multiple sequence alignment	Assessment
CO-4	Sequence annotation by identifying motifs, domains, conserved regions, predicting secondary structure of protein sequences	Usage
CO-5	Perform phylogenetic analysis of protein sequences and RNA secondary structure prediction	Assessment

Course Contents:

Unit	Contents	Lectures required
1	**Introduction:** Bioinformatics and its role in modern biology, Current scenario of Bioinformatics in India	**3**
2	**Databases:** Biological databases: classification into different types; sequence retrieval and sequence submission PubMED Nucleic acid sequence database (NCBI, EMBL, DDBJ) Genome database (TIGR) Protein sequence database (SWISSPROT) Databases of metabolic pathways (KEGG)	**8**

	ENTREZ, sequence retrieval system (SRS), Protein identification resource (PIR), Expert Protein Analysis System (ExPASY), Ensembl, sequence formats, Seqin, BankIt	
3	**Sequence Alignment:** Sequence Alignment: Dot plots, Alignments (Needleman & Wunsch algorithm, Smith-Waterman algorithm-with simple scoring systems), Multiple sequence alignment, Amino acid distance measures (PAM matrices, Blosum matrices)	**8**
4	**DatabasesearchDatabasesearching** : FASTA, BLAST	**8**
5	**Fundamental of sequence alignment:** Sequence similarity: Basic concepts, similarity scores	**7**
6	**Primer design:** Principles, Programs for Primer Design	**4**
7	**Distance measures:** Nucleotide distance measures (simple counts method, Jukes-Cantor correction, Kimura 2 parameter correction);	**4**
8	**Phylogenetic reconstruction:** Introduction, distance method (UPGMA, NJ), parsimony method	**7**
9	**Gene prediction:** Principles and programs for Gene prediction.	**2**
10	**Molecular modelling:** Homology modeling, docking, energy field calculations, molecular dynamics	**2**
11	**Protein sequence analysis:** Primary sequence analysis, protein structure visualization and Secondary structure prediction	**7**
12	**RNA secondary structure prediction:** Principles and programs for RNA secondary structure prediction	**3**
	Total lectures	**42**

Suggested Text Book(s):

1. Bioinformatics: D.W. Mount
2. Introduction to Bioinformatics by Arthur Lesk
3. Bioinformatics: Databases, tools and Algorithms by OrpitaBosu and Simminder Kaur Thukral
4. Knowledge discovery in Bioinformatics: Xiaouha Hu, Yi Pan

Suggested Reference (s):

5. Sousa et al., Bioinformatics Applications in Life Sciences and Technologies, 2016. PubMed PMID: PMC4870335

Other useful resource(s):

1. https://www.hindawi.com/journals/isrn/2013/615630/
2. https://www.sciencedirect.com/science/article/pii/S0888754317300551

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Introduction-to-BI)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	2	2	2	2	2	2	2	2	1	2	1.92
CO-2	2	2	2	2	2	1	1	2	2	2	1	2	1.75
CO-3	2	2	2	2	2	1	1	1	2	-	2	2	1.73
CO-4	2	2	2	2	2	1	1	1	2	2	-	2	1.73
CO-5	2	2	2	2	2	1	1	1	-	-	-	2	1.67
Average	2.0	2.0	2.0	2.0	2.0	1.25	1.25	1.4	2.0	2.0	1.33	2.0	

Introduction to Bioinformatics Lab

COURSE CODE:18B17BT473

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

L-T-P: 0-0-2

Pre-requisite: None

Course Objectives:

10. Understand the importance of bioinformatics
11. Application of various bioinformatics tools
12. Understand the connection of bioinformatics and biotechnology

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	Understand the use of common bioinformatics resources (NCBI)	Usage and familiarity
CO2	Understand various databases and tools in NCBI (PubMed, Nucleotide, gene)	Assessment
CO3	Understand various databases and tools in Expasy (Swissprot, PROSITE)	Assessment
CO4	Hands-on of pairwise sequence alignment tools-global and local	Assessment
CO5	Hands-on of multiple sequence alignment tools-global and local	Assessment
CO6	Hands-on of phylogenetic analysis tools and visualization	Assessment

List of Experiments

S.No	Description	Hours
1	Retrieval of sequences from NCBI and hands-on of EMBOSS software for various types of sequence analysis	2
2	BLAST program in online page and standalone package	2
3	Use of expasy resource for sequence retrieval and analysis	2

4	Multiple sequence alignment (MSA) programs and viewers: ClustalW, Jalview in online mode	2
5	Use of MSA programs (ClustalW) as a standalone package	2
6	Use of structural databases like PDB and structure visualization using Pymol and Rasmol	2
7	Use of structural classification databases like SCOP, CATH, FSSP	2
8	Gene prediction methods- GENPRED, GenePred	2
9	Phylogenetic analysis methods and tree viewers: Phylip and Archaeopteryx	2
10	Use of Phylip software as standalone package, MrBayes etc.	2
11	KEGG and GO database	2
12	Homology modeling in MODELLER, Docking in PatchDock	2
13	Prediction of RNA secondary structure	2
14	EMBOSS, STADEN and STAMP packages for sequence analyses	2
Total Lab hours		**28**

Suggested/Resources:

3. Pevsner J.:Bioinformatics and Functional Genomics; Cold Spring Harbor Laboratory Press, New York.
4. Baxevanis AD &Oulette BFF: Bioinformatics – A practical guide to the Analysis of Genes and Proteins, Willey International publishers.

EvaluationScheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	3	3	3	2	2	1	1	1	1	1	1	**1.83**
CO2	3	3	3	3	3	1	1	1	1	1	1	3	**2.00**
CO3	3	3	2	3	2	3	2	1	1	1	2	1	**2.00**
CO4	3	3	3	2	3	2	1	1	1	1	1	1	**1.83**
CO5	2	2	3	3	3	3	1	1	1	1	1	1	**1.83**
CO6	2	3	3	3	2	2	2	2	2	2	2	2	**2.25**
Average	**2.67**	**2.83**	**2.80**	**2.80**	**2.60**	**2.20**	**1.20**	**1.00**	**1.00**	**1.00**	**1.20**	**1.40**	

Microbiology

COURSE CODE: 18B11BT414

COURSE CREDITS: 4

ELECTIVE/CORE: CORE

L-T-P: 3-1-0

Pre-requisite: Knowledge of Biology (10+2)

Course Objectives:

1. To provide an understanding of the principles of microbiology and techniques that can serve as a platform for other courses built on microbiological concepts**.**
2. Scientific evaluation of role of microorganisms in various situations like health, industry, agriculture, environment.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Exhibit competence in fundamental aspects of Microbiology (e.g. Microbial Genetics, Classification, functions	Familiarity
CO-2	Scientifically test the hypothesis provided under a given situation involving microbial world and demonstrate practical skills in basic microbiological techniques	Assessment & Analytical Skills
CO-3	Designate vital role of the microorganisms in the environment and their association with human beings.	Awareness
CO-4	Analyze and interpret the experiments/pathways relevant to Microbes	Analytical & Technical Skills
CO-5	Retrieve and use cotemporary information related to microbial world.	Assessment & Analytical Skills

Course Contents:

Unit	Contents	Lectures required
1	**History of Microbiology:** Discovery of microbial world, A timeline with emphasis on Pasteur's experiments disproving spontaneous generation, Koch's postulates.	3
2	**Microbial diversity, taxonomy and phylogeny:** Taxonomic ranks, classificati systems (phonetic, numerical, phylogenetic), major characteristics used for classification (classical and molecular approaches), the three domain syster	6
3	**Methods in microbiology:** Pure culture techniques, theory and practice of sterilization, Principles of microbial nutrition, culture media and types	6

	(simple, complex, enriched, enrichment, selective & differential), replica plating techniques, Preservation of Cultures, Microscopy	
4	**Growth of microorganisms:** Media & their types, Growth curve; Mathematical expression of exponential growth phase; Measurement of growth and growth yields; Synchronous growth; Continuous culture; Effect of environmental factors on growth. conditions on growth, preservation techniques	5
5	**Microbial metabolism:** Photosynthetic mechanisms, CO_2 fixation mechanisms, fermentation, anaerobic respiration	4
6	**Microbial Ecology and Extremophiles:** Carbon, sulphur and nitrogen cycles, Thermo & hyperthermophiles, alkaliphiles, acidophiles, halophiles, psychrophiles, radiophiles	3
7	**Pathogenic microbes and Control Measure :**(Bacteria, fungi, protozoa and viruses), host-pathogen interactions - defense mechanisms against microbes, control of microbes, antimicrobial agents (physical, chemical and biological), Bioterrorism	6
8	**Microbial genetics:** Types of mutations; UV and Chemical mutagenesis, Ames test for mutagenesis, Conjugation, Transformation, Transduction, plasmids, transposons, Operon Model, Bacterial genome with special reference to *E. coli*	5
9	**Industrial applications with case studies:** Biofertilizers, Biopesticides, Biofilms, Biosensors, Fermented foods and beverages, Medicines, Single cell protein.	4
	Total lectures	**42**

Suggested Text Books:

1. Prescott, Harley and Klein: Microbiology, 6th Edition, McGraw Hill 2005.
2. Gerard J. Tortura, Berdell R. Funke, and Christine L: Microbiology An Introduction: Case. 8th Ed., Pearson/Benjamin Cummings, 2004.
3. Pelczar, Chan and Krieg: Microbiology by; Tata McGraw Hill.

Suggested Reference Books:

1. Madigan, M.T., Martinko, J.M., Parker, J: Brock Biology of Microorganisms. 10th Edition.: Publisher: Prentice Hall 2003
2. Nester : Microbiology Study Guide McGraw Hill.
3. Black : Microbiology : Principles and Applications Prentice Hall

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes & Attendance

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Microbiology)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	1	2	2	3	2	3	2	2	3	1	1	3	2.18
CO-2	3	3	3	2	2	2	2	2	3	2	2	3	2.4
CO-3	2	1	2	3	2	2	3	3	2	1	2	2	2
CO-4	2	2	2	3	3	3	2	2	3	2	1	3	2.3
CO-5	3	2	2	3	3	3	2	2	2	1	1	3	2.25
Average	2.2	2	2.2	2.8	2.4	2.6	2.2	2.2	2.6	1.4	1.4	2.6	

Microbiology lab

COURSE CODE: 18B11BT414

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

L-T-P: 0-0-2

Pre-requisite: None

Course Objectives:

13. To gain experience in microbiological techniques used in study of microbes
14. To familiarize the students with basics of methods with experimental analysis

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	To familiarize the students with basic microbiology instruments in the lab and basic precautions to be taken.	Familiarity
CO2	To aware the students about basic microbiological techniques to study the microorganisms.	Assessment
CO3	Able to analyze bacterial growth kinetics (homogeneous reaction) in the laboratory	Assessment
CO4	Able to understand the basis of microbial resistance against antibiotics and growth of pathogenic organisms.	Usage
CO5	To develop a strong foundation about microbes and their applications	Usage

List of Experiments

S.No	Description	Hours
1	**Microscopy and Instrumentation** **1.** To study the construction and working of compound microscope.	2 2

	2. Study of microbiology-lab instruments. (Operation of autoclave, LAF, hot air oven, Culture room fumigation using formalin).	
2	**Staining techniques** **3.** Gram's staining and test for differentiation of bacteria. **4.** To perform acid fast staining. **5.** To perform Lacto phenol Cotton Blue slide mounts for fungal culture.	 2 2 2
3	**6.** Preparation and sterilization of bacterial and fungal culture media (Nutrient broth, nutrient agar slant, potato dextrose agar)	2
4	7. Streaking and plating methods for isolation of axenic culture of bacteria. **8.** Isolation and enumeration of bacteria from soil, water and air using serial dilution technique	2 2
5	**9.** Study of bacterial growth kinetics using Turbidometry, **10.** Cell count using haemocytometer. **11**. Effects of various environmental factors such as the presence or absence of oxygen, temperature and pH on growth of microbes. **12.** Physical and chemical methods used to control the growth of microbes and the growth of microbes on various selective and differential media. **13.** Filter paper disc method for evaluation of antibiotic resistant activity of bacteria. Antimicrobial Sensitivity Testing – The Kirby-Bauer Method	2 2 2 2 2
6	**14.** Preparation of nutrient agar slants and glycerol stocks for preservation. **15.** Lyophilization and Glycerol stock of bacteria for long term preservation	2 2
Total Lab hours		30

Suggested/Resources:

1. Introduction to Microbiology : A Case-History Study Approach by John L. Ingraham, Catherine A. Ingraham, Hardcover: 816 pages, Publisher: Brooks Cole

2. Microbiology : A Laboratory Manual (7th Edition) by James Cappuccino, Natalie Sherman, Paperback: 544 pages, Publisher: Benjamin Cummings
3. Microbiology: A Laboratory Experience; Holly Ahern
4. Creative Commons License: Attribution-NonCommercial-ShareAlike CC BY-NC-SA
5. Willey, Joanne, Linda Sherwood, Chris Woolverton. Prescott's Microbiology, 8th edition. New York: McGraw Hill, 2011. Print.
6. Willey, Joanne, Linda Sherwood, Chris Woolverton. Lab Excercises in Microbiology, 8th edition. New York: McGraw Hill, 2011. Print
7. James G. Cappuccino and Natalie Sherman. Microbiology: A Laboratory Manual, 7th edition. Benjamin Cummings, 2004. Print.

EvaluationScheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	2	2	2	1		2	3	3	3		1	3	**1.83**
CO2	3	2	2	2	2	2	1	2	3		2	3	**2.00**
CO3	2	3		2	2	1	2	3	3	2	1	2	**2.00**
CO4	3	3	3	2	1	1	3		2	2	2	2	**1.83**
CO5	2	2	3	3	3	2	2	3		3	3	3	**1.83**
Average	**2.4**	**2.6**	**2.2**	**2.6**	**2.5**	**2.6**	**2.6**	**2.7**	**2.7**	**2.8**	**2.6**	**2.6**	

Environmental Studies

COURSE CODE:18B11BE411

COURSE CREDITS: 2

CORE/ELECTIVE: Audit

L-T-P: 2-0-0

Pre-requisite: None

Course Objectives:

15. Identify environmental problems arising due to engineering and technological activities and the science behind those problems.
16. Estimate the population- economic growth, energy requirement and demand.
17. Analyze material balance for different environmental systems
18. Realize the importance of ecosystem and biodiversity for maintaining ecological balance.
19. Identify the major pollutants and abatement devices for environmental management and sustainable development.
20. Recognizing the major concepts of environmental studies, developing problem solving ability, forecasting the global climate change

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Introducing basic concept of environmental studies, interdisciplinary nature and scope of the subject	Familiarity
CO-2	Understanding ecosystem services and its functioning as well as equitable use of natural resources.	Assessment
CO-3	Understanding Pollution, A threat to the environment and finding its solutions, Pollutant sampling and monitoring of samples.	Assessment
CO-4	Correlating the concept of Biodiversity and its importance to human mankind	Usage
CO-5	Understanding social issues and their impact on environment.	Usage
CO-6	Role of Information Technology in environment and human health	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Unit 1: Multidisciplinary nature of environmental studies:** The Multidisciplinary nature of environmental studies: Definition, scope and importance, Need for public awareness, Types of Ecosystems, World Biomes, Ecosystem functioning, Biogeochemical cycles.	3
2	**Unit 2: Natural resources, their consumption & Protection:** Natural resources, their consumption & Protection: Water, Land Energy (Renewable, non-renewable, wind, solar, hydro, Biomass), Mineral, Forest, & Food resources, Role of an individual in conservation of natural resources, Equitable use of resources.	4
3	**Unit 3: Pollution- a threat to environment:** Pollution- a threat to environment: Air, Water & Land pollution, sources & causes, Space pollution, causes & effects, toxicity limits of pollutants. Critical issues concerning global Environment (Urbanization, population growth, global warming, climate change, acid rain, ozone depletion etc.) and the Roots in: Cultural, Social, Political, Commercial, industrial, territorial domains	4
4	**Unit 4: Environmental standards &Quality:**Environmental standards & Quality: Air, Water & Soil Quality, Pollutant sampling, pollution control systems. Green Chemistry and its applications	3
5	**Unit 5: Biodiversity and its conservation:**Biodiversity loss: Diversity of flora and fauna, species and wild life diversity, Biodiversity hotspots, threats to biodiversity	4
6	**Unit 6: Social Issues and the Environment:** Waste land reclamation, consumerism and waste products, eco-consumerism, dematerialization, green technologies, eco-tourism. Water conservation, rain water harvesting, watershed management. Environment protection act, Air (prevention and control of population) act; Water (prevention and control of pollution) act, Wildlife protection act, Forest conservation act, Issues involved in enforcement of environmental legislation National Environmental Policy; Function of pollution control boards (SPCB and CPCB), their roles and responsibilities.	4
7	**Unit 7: Human Population and the environment:** Population growth, variation among nations. Population explosion—Family Welfare Programme. Environment and human health. Humanrights. Value education.HIV/AIDS. Women and Child Welfare. Role of Information Technology in environment and humanhealth. Case Studies.	4
8	**Unit 8: Field work:** Field Work: Explore the surrounding flora & fauna (Study of common plants, insects, birds document environmental assets), documentation of industries in local region and their possible effects, measure of water, air and land quality, Visit to a local polluted site-Urban/Rural /Industrial / Agricultural, Study of simple ecosystems-pond, river, hill slopes etc	4
Total lectures		**30**

Suggested Text Book(s):

7. Environmental Studies By: M. P. Poonia and S.C. Sharma, Khanna Publishers
8. Textbook of Environmental Studies for UG Courses - ErachBharucha, University Press
9. Joseph, B., 2005, Environmental Studies, Tata McGraw Hill, India.

Suggested Reference Book(s):

3. Nebel, B.J. & Wright, R.T., 1993, Environmental Science, 8th Edition, Prentice Hall, USA.
4. Chiras D D.(Ed.). 2001. Environmental Science – Creating a sustainable future. 6th ed. Jones &Barlett Publishers.
5. David Laurance. 2003. Environment Impact assessment, Wiley publications.
6. Chhokar KB, Pandya M & Raghunathan M. 2004. Understanding Environment. Sage publications, NewDelhi.

Other useful resource(s):

1. Issues of the journal: Down to Earth, published by Centre for Science and Environment.
2. Audio visuals from: Discovery, National Geographic etc.
3. https://nptel.ac.in/courses/120108002/
4. https://nptel.ac.in/courses/120108005

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered up to T-1
2	T-2	25	1.5 Hours	Syllabus covered up to T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes, Attendance.

Course Outcomes (COs) contribution to the ProgrammeOutcomes (POs)

Course outcomes (EVS)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	2	2	2	1	1	1	2	2	2	2	1.75
CO-2	2	3	3	3	3	1	1	1	2	2	1	2	2
CO-3	2	2	2	2	3	1	1	1	2	2	1	2	1.75
CO-4	2	3	3	3	2	1	1	1	2	3	2	2	2.08
CO-5	2	3	3	2	2	1	1	1	1	1	3	2	1.83
CO-6	2	2	2	2	1	1	1	2	2	2	2	2	1.75
Average	2	2.5	2.5	2.33	2.16	1	1	1.1	1.5	2	1.8	2	

Bioprocess Engineering

COURSE CODE:18B11BT511

COURSE CREDITS: 4

CORE/ELECTIVE: CORE

L-T-P: 3-1-0

Pre-requisite: Thermodynamics and Chemical Processes, Microbiology, Biochemistry

Course Objectives:

1. Learn various bioprocess related terms and principles
2. Learn about microbial growth kinetics in various mode of fermentation
3. Learn about the principles and application of Mass transfer and Sterilization
4. Develop an understanding of important concepts and design aspects of bioreactors
5. Learn about the functioning of various bioreactors
6. Learn about the principle of scaling up and scaling down of bioprocesses

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Able to use correct biological terms to describe & analyze phenomena/ problems in bioprocesses	Familiarity
CO-2	Able to apply engineering principles to address issues in various bioprocesses	Assessment
CO-3	Able to analyze bacterial growth kinetics (homogeneous reaction) in batch /continuous/ Fed-batch reactor and sterilization	Assessment
CO-4	Able to understand and to solve problems related to bioprocess phenomena including mixing, Mass transfer and sterilization	Assessment
CO-5	To develop a strong foundation about bioreactor designs and their applications	Usage
CO-6	Able to understand the basis of bioprocess scale up and the related basic design calculations	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Introduction:**Role of bioprocess engineer, Microbial process development, Quality control management, Fermentation Economics	**3**
2	**Kinetics of Microbial growth:**Batch culture, Kinetic implications of endogenous and maintenance metabolism. Continuous culture, Modifying continuous reactors: Chemostat with recycle and multistage Chemostat Systems. Modifying batch reactors: Fed-batch operation, Perfusion systems.	**7**
3	**Sterilization:**Design of batch and continuous sterilization processes, kinetics of thermal death of cells and spores.	**2**
4	**Mixing:**Mixingequipments, flow patterns in reactors, mixing mechanism, power consumption and shear properties of sparged and agitated vessels and various mixing agitators.	**4**
5	**Mass Transfer:**Role of diffusion in bioprocessing, film theory, convective mass transfer, oxygen uptake in cell cultures. Oxygen transfer in fermenters: measuring dissolved-oxygen concentration, estimating oxygen solubility, mass transfer correlation, measurement of k_La, oxygen transfer in large vessels.	**7**
6	**Strain Improvement and Media Formulation:**Strain improvement of industrially important microorganisms, Media formulation industrial fermentations.	**5**
7	**Immobilized Cell Systems (ICS):** Immobilization and its limitations, Active and passive immobilization, applications of immobilized cell biocatalysts. Diffusional limitations in ICS. Bioreactor considerations.	**3**
8	**Bioreactor design and analysis:**Bioreactor configurations and its utilities, Analysis of ideal and non-ideal reactors. Multiphase reactors: packed-bed reactors, bubble-column bioreactors, fluidized bed bioreactors, trickle-bed reactors. Practical considerations for bioreactor construction, Bioreactors instrumentation and control. Bioprocess Considerations: Animal cell cultures & plant cell cultures	**6**
9	**Scale up and Scale down:**Scale up of bioprocesses and its difficulties. Scale up criteria for bioreactors based on oxygen transfer, power consumption and impeller tip speed. Scale down.	**5**
Total Lectures		**42**

Suggested Text Book(s):

1. Pauline M. Doran, “Bioprocess Engineering Principles”, 8th ed., Academic press, New York, 2003.
2. M.L. Shuler and F. Kargi, "Bioprocess Engineering--basic Concepts", 2nd Edn. Prentice-hall Of India Pvt Ltd (2008).
3. Peter F. Stanbury, Stephen J. Hall & A. Whitaker, "Principles of Fermentation Technology", Â Elsevier India Pvt Ltd. (2007).

Suggested Reference (s):

1. KlaasVan’t Riet, Johannes Tramper, “Basic Bioreactor Design”, 2nd ed., Marcel Dekker, Inc., New York, 1991.
2. Bailey and Ollis, “Biochemical Engineering Fundamentals”, 2nd ed., McGraw-Hill Book Company, New York, 1986.
3. MccabeL.Warren, Smith C. Julian and Peter Harriott, “Unit Operations of Chemical Engineering”, 6th ed., McGraw Hill International Edition, New York, 2001.
4. Abhilasha S. Mathuriya, “Industrial Biochnology” 1st ed., Ane Books Pvt. Ltd., New Delhi, 2009.

Other useful resource(s):

1. NPTEL Course Content:
   - i) Bioreactors by Prof. Suraish Kumar, IIT Madras https://nptel.ac.in/courses/102106053/
   - ii) Industrial Biotechnology by Prof. Debabrata Das, IIT Kharagpur…. https://nptel.ac.in/courses/102105058/
   - iii) Aspects of Biochemical Engineering by Prof. Debabrata Das, IIT Kharagpur https://nptel.ac.in/courses/102105064/

2. Link to topics related tocourse:
   - i) Mass Transfer by Prof. Bishnupada Mandal, IIT Guwahati https://nptel.ac.in/courses/103103034/13#

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Unit 1-2
2	T-2	25	1.5 Hours	Unit 1-5
3.	T-3	35	2 Hours	Whole Syllabus
4.	Teaching Assessment	25	Entire Semester	Inform class time to time (Quizzes, Presentation, Assignments)

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Bioprocess Engineering)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	-	1	1	1	-	-	2	1	3	2	-	3	1.75
CO-2	3	2	2	1	-	-	-	1		1	-	3	1.86
CO-3	3	3	3	3	2	-	2	1	2	1	-	2	2.20
CO-4	3	3	3	1	-	-	-	1	2	1	-	1	1.88
CO-5	3	1	2	1	2	2	-	1	-	2	-	1	1.67
CO-6	3	3	3	3	-	2	2	1	3	1	2	2	2.27
Average	3.00	2.17	2.33	1.67	2.00	2.00	2.00	1.00	2.50	1.33	2.00	2.00	

Bioprocess Engineering Lab

COURSE CODE:18B17BT571

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

L-T-P: 0-0-2

Pre-requisite: Microbiology Lab, Biochemistry Lab

Course Objectives:

21. Provide exposure to the students with hands on experience on various practices in Bioprocess Engineering.
22. Enable students to link the theoretical knowledge of bioprocess engineering with the experiments.
23. Learn how to operate bench scale fermentor
24. Learn how to determine various Monod's Kinetics parameter

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	Able to apply practical knowledge to understand the various important process engineering aspects involved in biotechnology industries	Familiarity
CO2	Able to design experiments and analyze various data related to various practices in bioprocess engineering	Assessment
CO3	Ability to apply theoretical concepts for data analysis and interpretation and their documentation	Assessment and Usage
CO4	Able to run fermenter and also to analyze their results	Usage
CO5	Able to understand and determine various growth kinetics parameters in a batch culture	Assessment and Usage
CO6	Able to work in a team to accomplish the experiments and to document the experiments properly in lab note books	Assessment

List of Experiments

S.No.	Description	Hours
1	Introduction of Lab and lab safety	1
2	Describe the various parts of the bench-top fermenter (bioreactor) along with their functions.	1
3	To determine the thermal death point of a microbial culture.	2
4	To determine the thermal death time of a microbial culture.	2
5	To estimate the reducing sugar concentration in a given sample using DNS method.	2
6	To estimate the sugar concentration in fresh and spent media using DNS method.	2
7	To establish the correlation between OD and dry cell weight.	2
8	To study the different phase of microbial growth.	2
9	To study growth kinetics parameters of *E. coli*. a) Specific growth rate (μ) h^{-1} b) Maximum specific growth rate (μ_m) h^{-1} c) Saturation constant (K_s) gm/l d) Growth yield coefficient ($Y_{x/s}$) gm cell/gm substrate. e) Productivity of biomass gm cell/litre/h.	4
10	To study the effect of varying carbon substrate on specific growth rate	2
11	Determination of Volumetric mass transfer coefficient (K_La) using dynamic gassing out method (Virtual Lab)	2
12	Preparation of Immobilized yeast cells in calcium alginate beads	2
Total Lab hours		**24**

Suggested/Resources:

5. M.L. Shuler and F. Kargi, "Bioprocess Engineering--basic Concepts", 2nd Edn. Prentice-hall Of India Pvt Ltd (2008).
6. Lab Manual
7. Pauline M. Doran, “Bioprocess Engineering Principles”, 8th ed., Academic press, New York, 2003.
8. Peter F. Stanbury, Stephen J. Hall & A. Whitaker, "Principles of Fermentation Technology", Â

Elsevier India Pvt Ltd. (2007).

9. http://iitd.vlab.co.in/?sub=63

EvaluationScheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the Programme Outcomes(POs):

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	3	3	3	1	3	1	2	1	2	1	3	**2.17**
CO2	3	3	3	3	2	2	1	2	1	2	-	3	**2.27**
CO3	3	3	3	3	2	2	1	2	1	2	-	3	**2.27**
CO4	3	3	3	3	1	2	2	3	2	2	2	3	**2.42**
CO5	3	3	3	3	1	2	3	3	3	2	2	3	**2.58**
CO6	-	-	-	-	-	-	-	-	3	3	1	3	**2.5**
Average	**3.00**	**3.00**	**3.00**	**3.00**	**1.40**	**2.20**	**1.60**	**2.40**	**1.83**	**2.17**	**1.50**	**3.00**	

Genetic Engineering Lab

COURSE CODE:18B17BT572

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

L-T-P: 0-0-2

Pre-requisite: None

Course Objectives:

1. The objective of the course is to give practical exposure to student about basic tools and techniques employed in recombinant DNA technology and genetic engineering.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	Students will be able to isolate and analyze plasmid vectors.	Technical
CO2	Students will be cut and ligate DNA fragments/vectors with help of restriction enzymes and ligase.	Technical
CO3	The students will be able to prepare competent cells and demonstrate bacterial transformation with given vectors	Technical
CO4	The students will be able to amplify specific DNA fragment and cloning it in T vectors demonstrate bacterial transformation.	Technical
CO5	Student will acquire proficiency in designing and conducting experiments involving genetic manipulation.	Strategies and Application

List of Experiments

S.No	Description	Hours
Lab-I	Introduction to rDNA laboratory, w.r.t. working bench, types of instruments and their handling, lab. Preparation of stock solutions of buffers for use in gel running, gel loading, their autoclaving; preparation of working buffers, antibiotic stocks, and storage of buffers required in rDNA practicals with detailed methodology. (Theory and Virtual)	4
Lab 2-3	Plasmid DNA Preparation: Preparation of LB medium with and without antibiotics for the growth of bacterial cultures, Growth of *E. coli*, Isolation of Plasmid DNA, Electrtrophoresis of Plasmid DNA and Interpretation of results	4
Lab 4	Restriction of given plasmid or λ DNA with the restriction enzyme *Eco*RI and HindIII or any other Restriction Enzymes,	4
Lab 4 -5	To perform ligationof λ/*Eco*R I digest using T4 DNA Ligase Electrophoresis of the uncut and digested DNA and Interpretation of the results Electrophoresis of ligated samples by agarose gel electrophoresis, Interpretation of the results	4

Lab 6	Setting up a PCR reaction to amplify a gene or a DNA fragment using gene specific primers	2
Lab 7	Preparation of competent cells of *E. coli* transformation	4
Lab 8	To insert the PCR product into T vector by TA-cloning, and confirmation	4
Lab 9-10	Transformation of E.coli. DH5 α cells with Empty puc/ pcambia1301/and Confirmation of transformed cells by scoring the expression of LacZ gene.	4
Lab 10-11	Transformation of E.coli. DH5 α cells with Recombinant T- vector/puc vector Confirmation of transformed cells by scoring the expression of LacZ gene.	4
Lab 12-13	RNA isolation and to synthesize cDNA from total RNA preparation using reverse transcriptase and oligod T primer (Virtual)	2
Lab 12-14	Mini Project for lab evaluation and Exam	4
Total Lab hours Total Contact Hours (Students are required to devote some extra time for some experiments		**40**

Suggested/Resources:

10. Lab Manual
11. Molecular Cloning: A Laboratory Manual 2nd Edition Cold Spring Harbour Laboratory Press
12. Virtual Lab

EvaluationScheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	3	3	3	3	2	2	2	3	3	2	3	**2.67**
CO2	3	3	3	3	3	2	2	3	3	3	2	3	**2.75**
CO3	3	3	3	3	3	2	2	3	3	3	2	3	**2.75**
CO4	3	3	3	3	3	2	2	3	3	3	2	3	**2.75**
CO5	3	3	3	3	3	2	2	3	3	3	2	3	**2.75**
Average	**3.00**	**3.00**	**3.00**	**3.00**	**3.00**	**2.00**	**2.00**	**2.80**	**3.00**	**3.00**	**2.00**	**3.00**	

Genetic Engineering

COURSE CODE: 18B11BT512

COURSE CREDITS: 4

CORE/ELECTIVE: CORE

L-T-P: 3-1-0

Pre-requisite: Genetics, Molecular Biology

Course Objectives:

25. Familiarize the students with the basic concepts in genetic engineering;
26. Acquaint the students to versatile tools and techniques employed in genetic engineering and recombinant DNA technology
27. Apprise students about applications genetic engineering

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Students will become aware of concept of genetic engineering and its applications	Familiarity and Basics
CO-2	Students will have knowledge of tools and strategies used in genetic engineering	Technical and strategies
CO-3	Student will acquire knowledge about gene libraries and isolation of genes, DNA and genome sequencing technologies	Technical and application
CO-4	Student will have acquaintance about protein expression hosts and genetic manipulation of plants and animals	Familiarity and Basics
CO-5	Can use and apply the knowledge of genetic engineering in problem solving and in practice from academic and industrial perspective	Application

Course Contents:

Unit	Contents	Lectures required
1	**Introduction:** Genetic engineering, Recombinant DNA technology: gene cloning - concept and basic steps - rDNA Glossary	2
2	**DNA modifying enzymes and cloning techniques:** Restriction Endonucleases, DNA Ligation Enzymes and, DNA, Gene cloning methods and strategies: Cloning of PCR products, TA and TOPO TA cloning, Gateway cloning, DNA Modifying Enzymes: Nucleases, Kinases, phosphatases, Reverse transcriptase, RFLP and AFLP	8
3	**Cloning and Expression Vectors:** Plasmid Vectors, Vectors based on Lambda Bacteriophage, Cosmids, M13 Vectors, Vectors for Cloning	10

	Large DNA Molecules, Expression Vectors, Transcriptional & Translational Fusions, Adding Tags and Signals overproducing Proteins.	
4	**Construction & Screening of genomic libraries:** Genomic library, cDNA library, Growing& Storing Libraries, cDNA Cloning (5'&3' RACE)	5
5	**Identification and isolation of genes:** Screening Libraries with Gene Probes, Screening Expression Libraries with Antibodies, Susbtacrtive hybridization, DDRT-PCR, Positional Gene Cloning, Functional Complementation	4
6	**DNA and Genome Sequencing:** Basics fo DNA Sequencing, Next generation sequencing technologies, Whole genome sequencing	6
7	**Gene Expression in Microbial and Eukaryotic Systems:** Microbial, Yeast *Saccharomyces Cerevisiae* and Other Fungi as heterologoues protein expression platforms	3
8	**Genetic Manipulation of Plants and Animals:** Gene transfer methods, Application of Genetically Engineered Strains of Plants and Animals	4
Total lectures		**42**

Suggested Text Book(s):

10. Principles of Gene Manipulation and Genomics SEVENTH EDITION S.B. Primrose and R.M. Twyman.
11. Recombinant DNA: A Short Course by JD Watson, J. Tooze and DT Kurtz.
12. Genetic Engineering :Amita Rastogi and Neelam Pathak

Suggested Reference Book(s):

7. From Genes to Genomes: Concepts and Applications of DNA Technology by JW Dale and M Schantz
8. Molecular Biotechnology: Principles & Applications of Recombinant DNA Glick BR and Pasternak JJ
9. Genetic Engineering :Amita Rastogi and Neelam Pathak

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes & Attendance

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

Course outcomes (Genetic Engineering)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	3	3	3	2	2	2	3	3	2	3	**2.67**
CO-2	3	3	3	3	3	2	2	2	3	3	2	3	**2.67**
CO-3	3	3	3	3	3	2	2	2	3	3	2	3	**2.67**
CO-4	3	3	3	3	3	2	2	2	3	3	2	3	**2.67**
CO-5	3	3	3	3	3	2	2	2	3	3	2	3	**2.67**
Average	**3.00**	**3.00**	**3.00**	**3.00**	**3.00**	**2.00**	**2.00**	**2.00**	**3.00**	**3.00**	**2.00**	**3.00**	

Immunology Lab

COURSE CODE:18B17BT573
COURSE CREDITS: 1
CORE/ELECTIVE: CORE
L-T-P: 0-0-2

Pre-requisite: Immunology/Basic Biology

Course Objectives:

1. The objective is to familiarize students with the various immunological techniques that include antigen-antibody interactions, quantitation of antigens or antibody, ELISA, agglutination reactions etc.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	To understand, design, analyze and interpret experiments related to immunology and link practical knowledge to theoretical.	Familiarity
CO2	To detect antigen and check quality of antigen.	Assessment
CO3	To quantitate antigen using techniques various techniques.	Assessment
CO4	To check changes in the number of leucocytes and their isolation from the blood.	Assessment
CO5	To understand team work, ethics and work discipline.	Usage

List of Experiments

S.No.	Description	Hours
1	To perform Radial Immunodiffusion (RID) by Mancini's technique.	2
2	To perform Double Immunodiffusion (DID) by using Ouchterlony method.	2
3	To perform the Quantitative precipitation assay-test.	2
4	To perform hemagglutination assay for ABO blood group typing determination of and Rh factor.	2
5	To perform Immuno-electrophoresis of given sample.	2

6	To perform Immuno-electrophoresis of given sample.	2
7	To determine the concentration of antigen by sandwich ELISA method.	2
8	To determine Total Leukocytes Count (TLC) of the given sample.	2
9	To determine Differential Leukocytes Count (DLC) of the given sample.	2
10	Isolation of lymphocytes from peripheral blood by ficoll method and check the viability of isolated lymphocytes.	2
11	Amplification of Interleukin-28b gene using Polymerase Chain Reaction assay.	2
12	Lysis of red blood cells (hypotonic lysis with H_2O and ammonium chloride)	2
13	To isolate the lymphocyte from whole blood by density gradient centrifugation method. (Virtual Lab)	2
14	To understand the concepts of mouse Euthanasia. To learn the basic procedures involved in rodent dissection and how to identify and remove lymphoid organs. (Virtual Lab)	2
Total Lab hours		**28**

Suggested/Resources:

1.Lab Manual

2. Hay FC and Westwood OMR (2003) Practical Immunology, 4th Ed., Blackwell Publishing.
3. Virtual Lab. (http://vlab.amrita.edu/?sub=3&brch=70)

EvaluationScheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	3	3	3	2	2	1	2	3	2	2	3	**2.4**
CO2	3	1	2	2	1	1	-	2	1	1	1	2	**1.5**
CO3	3	2	2	2	2	1	-	2	1	1	1	2	**1.7**
CO4	3	2	2	2	2	1	-	2	1	1	1	2	**1.7**
CO5	1	1	2	1	1	2	1	3	3	3	2	3	**1.9**
Average	**2.6**	**1.8**	**2.2**	**2**	**1.6**	**1.4**	**1**	**2.2**	**1.8**	**1.6**	**1.4**	**2.4**	

Immunology

COURSE CODE:18B11BT513

COURSE CREDITS: 4

CORE COURSE

L-T-P: 3-1-0

Pre-requisite: Basic Biology

Course Objectives:

1. Basics of Immunology: types of immunity, T-cells and B-cells, antigen-antibody reaction and major histocompatibility complex (MHC).
2. Mechanisms of regulation of immune responses and immunological tolerance.
3. Role played by immune response in: infectious diseases, autoimmunity, hypersensitivity reactions, immunodeficiency diseases and vaccines.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	To understand and apply basic concepts of immunology.	Familiarity
CO-2	To understand the role of immune cells, major histocompatibility complex, antigen-antibody interactions in diagnostics.	Assessment
CO-3	To understand the mechanisms of regulation of immune responses and immunological tolerance.	Assessment
CO-4	To understand the roles played by immune response in: infectious diseases, autoimmunity.	Assessment/ Usage
CO-5	To understand hypersensitivity reactions, immunodeficiency diseases and vaccines.	Assessment/Usage

Course Contents:

Unit	Contents	Lectures required
1	**Basic immunology:** Historical perspectives, Cells and organs of the immune system	**3**
2	**Types of immunity:** innate and acquired immunity	**3**
3	**Antigens:** Immunogenicity, antigenicity, epitopes, haptens, mitogens	**2**
4	**Immunoglobins : structure and function:** Basic structure and fine structure of Igs, immunoglobin classes, hybridoma technology, antibody engineering	**4**
5	**Antigen- antibody interactions:** Theory, cross reactivity, precipitation reactions, agglutination reactions, RIA, ELISA, Western blotting, immunofluorescence	**4**
6	**B cell and T cell receptor:** Organization and expression of	**4**

	immunoglobulin genes : Generation of antibody diversity, class switching, T cell receptor complex, TCR coupled signaling pathways, co-stimulatory signals	
7	**Major histocpmatibility complex (MHC) and HLA:** General organization and inheritance of MHC, structure of MHC class I and II molecules, peptide binding by MHC molecules, MHC and susceptibility to disease, Tissue and organ transplantation	**3**
8	**Regulation of immune response and immunological tolerance:** Cytosolic and endocytic pathway, Responses in humoral and cell mediated branch and immunological tolerance	**2**
9	**Immune effector mechanisms:**Complement system, Cytokines	**3**
10	**Autoimmunity:** Types of autoimmune diseases (organ specific and systemic), Mechanisms of autoimmunity.	**2**
11	**Hypersensitivity reactions:** Type I, II, II and IV, hypersensitivity reactions	**2**
12	**Tumor immunity:** Malignant transformation of cells and immune responses, tumor antigens, tumor evasion of the immune system, cancer immunotherapy.	**2**
13	**Vaccines:** Types, active and passive immunization	**3**
14	**Immune response to infectious diseases and tumor immunity:** Viral, bacterial, protozoan diseases, parasitic infections	**3**
15	**Immunodeficiency diseases:** Primary and secondary immunodeficiency diseases, Acquired immunodeficiency syndrome (AIDS)	**2**
	Total lectures	**42**

Suggested Text Book(s):

1. Kindt TJ, Goldsby RA and Osborne BA (2007) KubyImmunology .W.H. Freeman and Co., New York, 6th Ed.
2. Abbas AK, Lichtman AH and Pillai S (2011) Cellular and Molecular Immunology. Elsevier, USA, 7th Ed.
3. Coico R and Sunshine G (2009) Immunology: A Short Course. Wiley – Liss, 6th Ed.
4. Delves PJ, Martin SJ, Burton DR and Roitt IM (2011) Roitt's Essential Immunology. Wiley-Blackwell, 12th Ed.

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Immunology)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	3	3	3	2	2	1	2	2	2	1	3	2.25
CO-2	2	2	3	2	2	1	-	2	2	2	1	3	2.0
CO-3	2	1	2	3	1	1	-	2	2	2	1	2	1.72
CO-4	2	1	2	2	1	2	2	3	1	1	1	2	1.6
CO-5	2	3	3	2	1	2	3	3	1	1	1	3	2.0
Average	2.2	2	2.6	2.4	1.4	1.6	2	2.4	1.6	1.6	1	2.6	

Downstream Processing

COURSE CODE:18B11BT611

COURSE CREDITS: 4

CORE/ELECTIVE: CORE

L-T-P: 3-1-0

Pre-requisite: Thermodynamics and Chemical Processes, Biochemistry, Bioprocess Engineering

Course Objectives:

1. Learn about the financial importance of Downstream Processing of bioproducts
2. Learn about the differences in recovery processes of intracellular and extracellular products
3. Learn about the principles and application of various separation techniques involved in bioproducts recovery
4. Learn about the recovery of various products through case studies

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Able to understand the importance and financial considerations of downstream processing in compare to upstream processing	Familiarity
CO-2	Conceptually sound in understanding about the difference between the downstream processing of intracellular and extracellular products	Assessment
CO-3	Able to understand various separation techniques used in downstream processes	Assessment
CO-4	Able to apply principles of various unit operations in designing and optimization of downstream processes	Assessment
CO-5	Able to understand the requirements for successful operation of downstream processes	Usage
CO-6	Able to apply the principles of major unit operations used in downstream processing for the purification and formulation of final products obtained from Fermentation Technology.	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Scope of Downstream processing:** Importance of DSP in biotechnology, characteristics of bioproducts, Criteria for selection of bio-separation techniques, Role of DSP methods in bioprocess economics	**4**
2	**Cell Disruption:** Various cell disruption methods: Mechanical viz; sonicators, dyno mill, homogenizer, chemical and biological methods.	**4**
3	**Solid-Liquid Separation:** Centrifugation: Principles, Centrifuges viz; basket centrifuge, tubular centrifuge, disc-bowl centrifuge. Filtration: Principles, Filter units viz; filter press, Applications.	**6**
4	**Membrane Technology:** Merits and Demerits, Reverse osmosis, Ultrafiltration, Microfiltration, Dialysis, Electrodialysis	**3**
5	**Separation of soluble products:** Liquid-liquid extraction, Aqueous two-phase extraction, Adsorption, Precipitation	**6**
6	**Chromatographic Techniques:** Gel filtration, Ion-exchange, Hydrophobic Interaction and Affinity Chromatography, HPLC, FPLC, Applications	**5**
7	**Finishing steps for purification:** Crystallization, Drying, Lyophilization	**4**
8	**Stabilization of bioproducts:** Formulation. Integration of reaction and separation	**2**
9	**Case-Studies:**Process design of Industrial Bio-products **Anaerobic bioprocesses:** Ethanol, Lactic acid production	**4**
	Aerobic bioprocesses: Citric acid, Gluconic acid, Penicillin production	**4**
	Total lectures	**42**

Suggested Text Book(s):

1. Raja Ghosh, “Principles of Bioseparation Engineering”, World Scientific Publishing Co. Pte. Ltd., Singapore, 2006.
2. Pauline M. Doran, “Bioprocess Engineering Principles”, 8th ed., Academic press, New York, 2003.
3. Peter F. Stanbury, Stephen J. Hall & A. Whitaker, "Principles of Fermentation Technology", Â Elsevier India Pvt Ltd. (2007).
4. Wulf Crueger, Anneliese Crueger, K.R. Aneja, “A Textbook of Industrial Microbiology”, Medtech,Scientific International Pvt. Ltd. 3rd Ed. (2017)
5. M.L. Shuler and F. Kargi, "Bioprocess Engineering--basic Concepts", 2nd Edn. Prentice-hall Of India Pvt Ltd (2008).

Suggested Reference (s):

5. P.A. Belter, E. L. Cussler, and W.S. Hu, “Bioseparations: Downstream Processing in Biotechnology”, John Wiley and Sons, New York, 1998.
6. B. Sivasankar, “Bioseparations : Principles and Techniques”, PHI Learning Private Limited, New Delhi, 2009.
7. Roger G. Harrison, Paul W. Todd, Scott R. Rudge, Demetri Petrides, “Bioseparations Science and Engineering”, 1st Edn. Oxford University Press, 2002
8. Abhilasha S. Mathuriya, “Industrial Biochnology” 1st ed., Ane Books Pvt. Ltd., New Delhi, 2009.

Other useful resource(s):

2. NPTEL Course Content:

iv) Downstream Processing by Prof. Mukesh Doble, IIT Madras
https://nptel.ac.in/courses/102106022/
v) Industrial Biotechnology by Prof. Debabrata Das, IIT Kharagpur
https://nptel.ac.in/courses/102105058/
vi) Principles of Downstream Techniques in Bioprocess by Prof. Mukesh Doble, IIT Madras
https://nptel.ac.in/courses/102106048/

2. Link to topics related tocourse:
ii) Aspects of Biochemical Engineering by Prof. Debabrata Das, IIT Kharagpur
https://nptel.ac.in/courses/102105064/

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Unit 1-2
2	T-2	25	1.5 Hours	Unit 1-5
3.	T-3	35	2 Hours	Whole Syllabus
4.	Teaching Assessment	25	Entire Semester	Inform class time to time (Quizzes, Presentation, Assignments)

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Bioprocess Engineering)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1		2	1	1			2	1		1	3	3	1.75
CO-2	2	2	2	1	2	1	2	1		2		3	1.80
CO-3	2	2	2	2	2	2	2	1	2	1		3	1.91
CO-4	3	3	3	2	2	2	2	1	2	2		3	2.27
CO-5	2	3	3	2	2	1	1	1	1	2	2	3	1.92
CO-6	3	3	3	3	2	2	2	1	2	2	2	3	2.33
Average	2.40	2.50	2.33	1.83	2.00	1.60	1.83	1.00	1.75	1.67	2.33	3.00	

Downstream Processing Lab

COURSE CODE:18B17BT671

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

L-T-P: 0-0-2

Pre-requisite: Microbiology Lab, Biochemistry Lab, Bioprocess Engineering

Course Objectives:

28. Provide exposure to the students with hands on experience on various practices in Fermentation Technology.
29. Enable students to link the theoretical knowledge of Downstream Processing with the experiments.
30. Learn how to recover the various bioproduct after their production
31. Learn how to characterize the products after their recovery

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	Able to set up of different kind of fermentation processes for biomass and product production	Familiarity
CO2	Able to describe and to apply the principles of various unit operations such as sonication, centrifugation, filtration, precipitation etc. used in DSP	Assessment
CO3	Able to strategize the downstream processes for the purification of various bioproducts such as enzymes, wine etc.	Assessment and Usage
CO4	Able to design experiments and analyze various data related to various practices in DSP	Usage
CO5	Able to analyze and characterize the synthesized bioproducts for further applications	Assessment and Usage
CO6	Able to work in a team to accomplish the experiments and to make proper documentation of lab experiments carried out in the lab	Assessment

List of Experiments

S.No.	Description	Hours
1	Introduction to DSP Lab and related lab safety	2
2	Setting up of yeast fermentation processes using fruit juice	2
3	Downstream processing of the yeast fermented product (Sedimentation, Filtration, Bottling, Pasteurization)	2
4	Quality analysis of the yeast fermented product i) pH, TSS content ii) Sugar content using DNS method iii) Anti-oxidant content iv) Phenolic content v) Alcohol content using alcoholometer	2
5	To determine the effect of speed and time of exposure over the settling of the cells during centrifugation	2
6	Disruption of yeast cells using sonication to recover intracellular Invertase enzyme	2
7	Determination of protein and enzyme content in the cell lysate after the cell disruption	2
8	Setting up of a fermentation process for production of extracellular industrial enzyme (Amylase) from *Bacillus licheniformis*	2
9	Clarification of the fermentation broth & Estimation of the yield of the industrial enzyme produced by the fermentation process.	2
10	Concentration of invertase/amylase using salt-induced precipitation	2
11	Organic Solvent Precipitation	2
12	Set up of dialysis to remove the additional salt from the enzyme solution	2
Total Lab hours		**24**

Suggested/Resources:

13. Keith Wilson, John Walker, "Principles and Techniques of Biochemistry and Molecular Biology, 7th ed., Cambridge University Press, Singapore, 2010.
14. Lab Manual
15. Raja Ghosh, "Principles of Bioseparation Engineering", World Scientific Publishing Co. Pte. Ltd., Singapore, 2006.
16. Pauline M. Doran, "Bioprocess Engineering Principles", 8th ed., Academic press, New York, 2003.
17. Peter F. Stanbury, Stephen J. Hall & A. Whitaker, "Principles of Fermentation Technology", Â

Elsevier India Pvt Ltd. (2007).

18. Downstream Processing by Dr. Mukesh Doble, IIT Madras
https://nptel.ac.in/courses/102106022/

EvaluationScheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	2	2	3	2	3	1	2	2	2	2	2	3	**2.17**
CO2	3	2	3	2	2	2	2	2	2	2	1	3	**2.17**
CO3	2	2	2	3	2	3	3	2	2	2	2	3	**2.33**
CO4	2	3	3	3	2	2	2	2	2	2	2	3	**2.33**
CO5	1	2	2	3	2	2	2	2	2	2	3	3	**2.17**
CO6						1	1	2	3	3	1	3	**2.00**
Average	**2**	**2.20**	**2.60**	**2.60**	**2.20**	**1.83**	**2.00**	**2.00**	**2.17**	**2.17**	**1.83**	**3.00**	

Food and Agricultural Biotechnology

COURSE CODE: 18B11BT612

COURSE CREDITS: 4

CORE/ELECTIVE: CORE

L-T-P: 3-1-0

Pre-requisite: Molecular Biology, Biochemistry

Course Objectives:

32. Learn about different processes employed in the manufacture of food products.
33. Learn about different techniques used for the production and improvement of agricultural crops.
34. Apply basic knowledge for developing food and agricultural products through biotechnological interventions.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Able to learn the mechanisms of preservation methods applied to different food products.	Familiarity
CO-2	To understand different bioprocesses involved in food production.	Technical skills
CO-3	To provide knowledge of different streams of agriculture having biotechnological interventions.	Assessment and Analytical skills
CO-4	Able to apply knowledge and analyze the problems associated with food and agricultural biotechnology	Usage
CO-5	Able to apply these methodologies and techniques for developing modified crops and agricultural products	Technical skills
CO-6	To provide insight about ethical ,legal and public aspects associated with food and agricultural biotechnology.	Assessment and Analytical skills

Course Contents:

Unit	Contents	Lectures required
1	**Basics of food components:**Macronutrients and micronutrients, Composition and metabolism of Carbohydrates, proteins and fats. Phytochemicals in foods: Occurrence and characteristics of dietary fibres, polyphenols in foods	5
2	**Food Preservation Technology :** Role and significance of microorganisms in foods: Intrinsic and Extrinsic Parameters of Foods that affect microbial growth Hurdle Technology: Principles and applications Physical methods of sterilization: Heat treatments (Pasteurization, blanching, canning), Low temperature, dehydration, ultrafiltration, sterilization, irradiation Chemical methods of sterilization: Salting, Smoking, Curing, preservatives Biological methods of sterilization: Biopreservation, Fermentation.	8
3	**Food Production technology:** Concept of Starter cultures, Microorganisms as foods: Single cell protein, baker's yeast, mushroom, Production of Fermented Foods: Indigenous fermented foods, Lactic acid fermented foods, Production of food additives: Organic acids, Vitamins, Pigments, Flavors	8
4	**Recent advances in Food Biotechnology:** Nutraceuticals and Probiotics: concepts and application in foods, Food packaging systems	4
5	**Quality assurance in Food Industries:** Food Standards and Specifications, GMP, HACCP, Quality systems.	3
6	**Introduction Agricultural Biotechnology:** Agricultural Biotechnology, Conventional method of crop improvements vs. Biotechnological interventions, Prospects of Agricultural biotechnologies	4
7	**Techniques of crop improvement:** Different Crop improvement by genetic manipulation taking case studies for herbicide tolerance ,pest resistance etc. Production of phytochemicals and foreign compounds Plant disease resistance ,natural Disease resistance pathways, Biotechnological approaches to disease resistance Case studies	6

8.	**Agroindustrial resources:** Transgenic livestocks Transgenic fish technology and products from Macro –Micro algae in agro industry Important crops with their pattern of harvesting and Organic farming	6
9	**Microbial Agro- Biotechnology:** Bio fertilization and Bioremediation of pesticides and agricultural chemicals	2
10	**Ethical Legal and public aspects:** Cartagena protocol ,CBD and Plant Varieties and Farmer's Right Act 2001 Prospects and limitations of Agricultural Biotechnology	3
Total lectures		**42**

Suggested Text Book(s):

13. Plant Biotechnology- Adrian Slater, Nigel W. Scott and Mark R. Fowler (Text Book).
14. Biotechnology- Expanding Horizons by B.D. Singh.
15. Food Microbiology: Fundamentals and frontiers - M.P. Doyle

Suggested Reference Book(s):

10. Agricultural Biotechnology by Arie Altman.
11. Modern Food Micro-Biology - James M. Jay.

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes & Attendance

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Food and Agricultural Biotechnology)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	2	2	2	2	1	1	2	1	2	2	**1.9**
CO-2	2	2	1	3	2	2	1	1	2	1	1	2	**1.6**
CO-3	2	2	2	2	3	1	1	1	2	2	1	2	**1.7**
CO-4	2	2	3	3	2	1	1	1	2	1	1	2	**1.8**
CO-5	2	1	1	1	2	1	2	1	1	1	1	1	**1.2**
CO-6	2	1	1	2	2	2	1	1	2	2	2	2	**1.6**
Average	**3.4**	**2.8**	**1.6**	**2**	**2.1**	**1.3**	**1.1**	**1**	**1.6**	**1.6**	**1.5**	**1.8**	

Food and Agricultural Biotechnology Lab

COURSE CODE:18B17BT672

COURSE CREDITS: 1

CORE/ELECTIVE: CORE

L-T-P: 0-0-2

Pre-requisite: Microbiology, Agriculture Science

Course Objectives:

35. To gain experience in manufacturing and preservation techniques used in food manufacturing units
36. To familiarize the students with basics of biotechnological interventions in food and agricultural sector linked with experimental analysis

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	To enable students for apply basic knowledge of techniques used for food and agricultural biotechnology	Awareness
CO2	Apply practical knowledge to understand the various important parameters involved in food production and preservation	Technical skills
CO3	Able to conceptualize experimental setups related to various practices in food and agriculture	Technical and Analytical skills
CO4	To enable students for exploring their avenues for entrepreneurship and social welfare through projects	Usage
CO5	Able to use different techniques for the development of different food and agricultural products	Technical skills
CO6	Able to apply biotechnological techniques for the development of improved products	Analytical and Technical skills

List of Experiments

S.No	Description	Hours
1	Basic guidelines for safety measures to avoid hazard in laboratory.	2
2	To determine the quality of a milk sample by methylene blue reduction test (MBRT)	2
3	To estimate total phenolic content by a modified Folin-Ciocalteu assay	2
4	Preparation of Mozzarella cheese using direct acidification method	2
5	To estimate antioxidant activity in foods by DPPH and ABTS assay	3
6	To estimate the reducing sugars in the given food samples.	2
7	Effect of physical parameters on food spoiling microorganisms	2
8	Preparation of Yoghurt using defined strain starters	3
9	To study different concentrations of kanamycin/ hygromycin sensitivity test on selected plant leaf discs	3
10	To perform method of *Agrobacterium tumefaceins* transformation by using toacco leaf disc or seedimbibitions technique, along with molecular analysis of putative transformed plants by GUS assays	3
11	Demonstration of suspension cell cultures for metabolites production and HPLC Quantification	3
12	Artificial seed production through somatic embryos of medicinal plants, cryopreservation and regeneration into plants.	3
Total Lab hours		**28**

Suggested/Resources:

19. Lab manual
20. Plant Biotechnology- Adrian Slater, Nigel W. Scott and Mark R. Fowler (Text Book)
21. Biotechnology- Expanding Horizons by B.D. Singh
22. Agricultural Biotechnology by Arie Altman ,Israel
23. Modern Food Micro-Biology - James M. Jay, (2000), An Aspen Publication, Maryland, USA.

EvaluationScheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	3	2	2	2	2	1	1	1	1	1	1	**1.7**
CO2	3	2	2	3	3	1	1	2	1	1	1	2	**1.8**
CO3	3	3	2	3	2	2	2	1	1	1	2	1	**1.8**
CO4	3	2	3	2	2	2	1	1	1	1	1	1	**1.7**
CO5	2	2	3	2	3	3	1	1	1	1	1	1	**1.83**
CO6	2	3	2	3	2	2	2	2	2	2	2	2	**2.25**
Average	**2.6**	**2.6**	**2.60**	**2.80**	**2.60**	**2.20**	**1.20**	**1.00**	**1.00**	**1.00**	**1.20**	**1.40**	

Phytopharmaceuticals and Biologicals

COURSE CODE: 18B1WBT531

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Basic understanding of biology

Course Objectives:

37. The objective of the course is to develop an understanding and basic knowledge on Indian medicinal herbs, its commercial value, quality control and industrial standards for commercialisation of phytopharmaceuticals and biologicals.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Able to understand pharmacopoeial standards of ayurvedic products	Familiarity
CO-2	Able to understand the phytopharmaceuticals, monographs and quality control of medicinal herbs	Usage
CO-3	Able to understand the extraction and evaluation process of phytopharmaceuticals	Technical
CO-4	Able to understand pharmacopoeial standards of Indian Pharmacopoeia	Familiarity
CO-5	Able to understand the monographs, specifications and quality control of biologicals	Usage

Course Contents:

Unit	Contents	Lectures required
1	Intoduction to phytopharmaceuticals – medicinal herbs & its importance and biologicals. Over view of Ayurvedic and Indian Pharmacopoeia	**4**
2	Pharmacopoeial standards of Ayurvedic (Used by manufacturers, regulators and other stakeholders for quality control of medicinal herbs and finished products against internationally recommended specifications).	**7**
3	Monographs of medicinal herbs, specifications and standards for identification, evaluation, processes and clinical applications	**8**
4	Evaluation of physiochemical parameters of herbal drugs, extraction, Identification & Assay of Herbals Drugs	**6**

5	Pharmacopoeial standards of Indian Pharmacopoeia (Used by manufacturers, regulators and other stakeholders for quality control of active pharmaceutical ingredients (APIs) and finished products against internationally recommended specifications).	**3**
6	Monographs on Blood and Blood related products, Monographs on Human Vaccines (The specifications cover the various tests for critical quality parameters of the vaccine, procedures and acceptance criteria)	**7**
7	Monographs of Erythropoietin Injection, Interferon Injection, streptokinase solution, Human Insulin, etc. Bacterial Endotoxin Test, Sterility Test, Test for Microbial Contamination, etc.	**7**
Total lectures		**42**

Suggested Text Book(s):

1. The Ayurvedic Pharmacopoeia Of India, First Edition, Published By Pharmacopoeia Commission For Indian Medicine & Homoeopathy Ghaziabad (2016)
2. Indian Pharmacopoeia published by the Indian Pharmacopoeia Commission (IPC)

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

Course outcomes (Phytopharmaceuticals and Biologicals)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	2	2	2	2	2	2	2	2	1	2	1.9
CO-2	2	2	2	2	2	1	1	2	2	2	1	2	1.75
CO-3	2	2	2	2	2	1	1	1	2	2	2	2	1.75
CO-4	2	2	2	2	2	1	1	1	2	2	1	2	1.6
CO-5	2	2	2	2	2	1	1	2	2	2	1	2	1.75
Average	2.0	2.0	2	2	2	1.25	1.25	1.5	2.0	2	1.25	2.0	

Bioenergy and Biofuels

COURSE CODE: 18B1WBT634

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Microbiology, Bioprocess Engineering, Downstream Processing, Bioresource Technology

Course Objectives:

The shortage of fossil fuels and its environmental consequences, Bioenery and Biofuel technology seems to be a alternative for generation of energy and fuels. This sector facing various technical, process and social problems for implementation. Based on these aspects the objectives of the course are framed as

1. Introduction of existing and possible Bioenergy and Biofuels technoloies
2. Discussion of technical, process and economic issues related to first, second and third generation biofuels along with Physico chemical techniques

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Advantages and disadvantages of Bioenergy and Biofuels over fossil fuels	Familiarity
CO-2	Technical barriers in Bioenergy and Biofuel Technology	Assessment
CO-3	Whole biorefinery approaches for economical implementation into the market	Usage
CO-4	Conversion technologies of waste to Biofuels, Bioproducts, and Bioenergy	Usage
CO-5	Conversion of waste and Mixed feedstock to Biofuels, Bioenergy and Bioproducts	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Introduction to Biofuels and Bioenergy:** Definition, Global Energy Outlook, Sustainability, Biomass Feedstocks, Processes and Technologies, Environment and Ecology	**4**
2	**Crop Oils, Biodiesel, and Algae Fuels:** Vegetable Oils, Algae Oil Extraction of Straight Vegetable Oil, Manufacture of Biodiesel	**12**

3	**Ethanol from Corn and Lignocellulosics:** Fuel Ethanol from Corn, Corn Ethanol as Oxygenated Fuel, Chemistry of Ethanol Fermentation, Corn-to-Ethanol Process Technology, By-Products/Coproducts of Corn Ethanol, Ethanol as Oxygenated and Renewable Fuel, Ethanol Vehicles, Lignocellulose and Its Utilization, Lignocellulose Conversion, Agricultural Lignocellulosic Feedstock, Cellulosic Ethanol Technology; Energy Balance for Ethanol Production from Biomass, Process Economics and Strategic Direction.	**12**
4	**Fast Pyrolysis and Gasification of Biomass:** Biomass and Its Utilization, Analysis and Composition of Biomass, Chemistry of Biomass Gasification, Fast Pyrolysis of Biomass, Biomass Gasification Processes, Utilization of Biomass Synthesis Gas	**7**
5	**Conversion of Waste to Biofuels, Bioproducts, and Bioenergy & Mixed Feedstock:** Types of Waste and Their Distributions, Strategies for Waste Management, Waste Preparation and Pretreatment for Conversion, Technologies for Conversion of Waste to Energy and Products, Economic and Environmental Issues Related to Waste Conversion, Future of the Waste Industry, Advantages and Disadvantages of Mixed Feedstock, Transportation, Storage, and Pretreatment, Gasification Technologies, Liquefaction Technologies, Future of Mixed Feedstock.	**7**
Total Lectures		**42**

Suggested Text Book(s):

1. Biofuels and Bioenergy: Processes and Technologies by Sunggyu Lee and Y. T. Shah, CRC Press

2. Bioenergy and Biofuel from Biowastes and Biomass by Samir K. Khanal, Rao Y. Surampalli, Tian C. Zhang, Buddhi P. Lamsal, R. D. Tyagi and C.M. Kao, ASCE Publishers .

Suggested Reference Book(s):

1. Review and research articles from Science Direct, Springer, Wiley and PubMed Publishers

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	3	3	3	1	3	1	2	1	2	1	3	2.17
CO2	3	3	3	3	2	2	1	2	1	2	-	3	2.27
CO3	3	3	3	3	2	2	1	2	1	2	-	3	2.27
CO4	3	3	3	3	1	2	2	3	2	2	2	3	2.42
CO5	3	3	3	3	1	2	3	3	3	2	2	3	2.58
Average	3.00	3.00	3.00	3.00	1.40	2.20	1.60	2.40	1.60	2.00	1.00	3.00	

Intellectual Property Rights and Commercialization

COURSE CODE: 18B1WBT734

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: None

Course Objectives:

38. To provide an insight and understanding about different aspects of protection of inventions and research developments
39. Learn about procedures for filling protection through Intellectual Property Rights.
40. To provide scopes of protection of diverse intellectual properties and its commercialization for socio-economic improvement.

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Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	To enable students with basic concepts and knowledge of intellectual property rights.	Awarness
CO-2	To apply and execute different types of IP protection in research and academics.	Assessment and technical skills
CO-3	Able to understand about the mechanisms of different IP protections, registrations and applications	Technical
CO-4	To be capable of tackling issues related to IP and its commercialization	Assessment
CO-5	Able to learn the strategies for effective IP management and commercialization	Analytical skills
CO-6	To apply the knowledge of IPR for the benefit generation and for mass utilization	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Introduction**:Introduction of Intellectual properties and rights conferred . Integration of Intellectual Property, Bioethics and Biosafety for biological and applied sciences in research and academia.	4
2	**Types of IP tools**:Different types of IPR(Patents, copyrights and related rights, Trademark, Tradesecret, Integrated circuit layout, Geographical indications, Traditional knowledge, Industrial designs and PBR) Drafting Patent Application and Documentation Revocation of Patent, Litigation and Infringement Rationale of different IPR ,their mechanism of protection and provisions in Law	10
3	**International Agreements** and Treaties:International IP treaties (Madrid Agreement, Trademark law treaty, Patent Law treaty etc.) WIPO, EPC, WTO, and TRIPS. International agreements relevant to biotechnology-associated IP	8
4	**Commercialization**: Methods of commercialization,Impact of commercialization. Financing	6
5	**IP Management for value addition:** Strategies for IP Management and commercialization. IP audit, IP insurance Bioentreprenuership management	4
6	**Licensing/Assignment** :Types of licensing and modes to carry out, Assignments and its benefits, Compulsory Licensing Commercialization for social and economic prosperity with case studies	8
Total lectures		**42**

Methodology

The course will be covered through lectures, presentations and vedios. Apart from discussions on topics covered through lectures and assignments, students have to carry out research paper analysis.

Suggested Text Book(s):

1. Intellectual Property Rights & Copyright By Bouchoux.
2. Intellectual Property Licensing Strategies by Thompson Reuters

Suggested Reference Book(s):

1. Intellectual Property Rights, the WTO and Developing Countries: The TRIPS ...Book by Carlos María Correa
2. Perspectives on Commercializing Innovation by F. Scott Kieff (Editor), Troy A. Paredes (Editor

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes & Attendance

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Intellectual Property Rights & Commercialization)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	2	2	2	1	1	1	1	1	2	2	**15**
CO-2	2	2	1	2	2	2	1	1	1	1	1	2	**1.5**
CO-3	2	2	2	2	3	1	1	1	2	2	1	2	**1.7**
CO-4	2	2	3	3	2	1	1	1	2	2	2	2	**1.9**
CO-5	2	2	2	2	2	1	2	1	1	2	1	2	**1.6**
CO-6	2	2	2	2	2	2	1	1	2	2	2	2	**1.8**
Average	**3.4**	**3.4**	**2**	**2.1**	**2.1**	**1.3**	**1.1**	**1**	**1.5**	**1.6**	**1.5**	**2**	

Peptide Therapeutics

COURSE CODE: 18B1WBT631

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: General Chemistry

Course Objectives:

3. To develop an understanding of important concepts and design aspects of peptides
4. To learn various therapeutic applications of peptides.
5. Apply basic knowledge to design peptides for various therapeutic purposes

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Able to understand various peptide design consideration and other important structural aspects of peptides	Familiarity
CO-2	Able to understand and learn the concept of solid phase peptides synthesis	Familiarity
CO-3	To develop methods of peptides and proteins for their quality control and apply them in handling Therapeutic peptides and proteins	Assessment
CO-4	To understand the mechanism of action of Antibiotic, Anticancer, Antihypertensive and Opioid peptides	Usage
CO-5	To develop a strong foundation therapeutic peptide design and their applications	Usage

Course Contents:

Unit	Contents	Lectures required
1	Peptides, synthetic peptides & their classification based on structure, engineering bioactive peptide based therapeutic molecules,	**7**
2	Principle and practice of solid phase peptide synthesis, solid support, protection scheme, peptide acid and amide, Purification of peptides, quality control of peptides	**7**

3	Antimicrobial host defense peptides, Anticancer peptides, Opioid Peptides, Antihypertensive Peptides, Peptides in clinical trial ,chemical biology of Oxytocin, valinomycin and enkephalins	**18**
4	Preformulationstudies, Formulation development, Aggregation in protein formulation, novel formulation approaches, Lyophilization, Pharmaceutical Processing, and Handling of Therapeutic Peptides and Proteins	**6**
5	Circular dichroism, UV, IR, Mass and fluorescence spectroscopy of peptides	**4**
	Total lecture	**42**

Suggested Text Book(s):

3. Ajay K Banga, "Therapeutic peptides and protein: formulation processing and delivery system, Second edition, Taylor and Francis.
4. Lehninger Principles of Biochemistry Cox, M.M. and Nelson, D.L. and Lehninger A. L. 4th edition.
5. Biochemistry- J.M. Berg, J.L.Tymoczko, and LubertStryer; 5th edition W.H. Freeman and Company, New York, USA.

Suggested Reference Book(s):

1. Gregory A. Grant, "Synthetic peptides A Users Guide" 2nd ed. W. H. Freeman and Company

EvaluationScheme:

Assessment	**Max. marks**	**Duration**	**Course Covered**
T1 Test	15	1 hr.	Syllabus covered upto T-1
T2 Test	25	1.5 hrs.	Syllabus covered upto T-2
End Term Test	35	2 hrs.	Whole Syllabus
Teacher Assessment (Based on Assignments, quizzes etc.)	25	Whole Sem	Inform class time to time
Total	**100**		

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

Peptide Therapeutics	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**	**PO-9**	**PO-10**	**PO-11**	**PO-12**	**Average**
CO-1	2	3	2	2	2	1	-	-	2	3	3	3	1.92
CO-2	2	3	3	3	2	2	-	-	2	3	3	3	2.17
CO-3	3	3	3	3	3	2	-	-	2	3	3	3	2.33
CO-4	3	3	2	3	3	2	-	-	2	3	3	3	2.25
CO-5	3	3	2	3	2	2	-	-	2	3	3	3	2.17
Average	2.60	3.00	2.40	2.80	2.40	1.80	0.00	0.00	2.00	3.00	3.00	3.00	

Nano-Biotechnology

COURSE CODE: 18B1WBT633

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Basic of Physics, Chemistry and Biology

Course Objectives:

1. Introduction to Nanomaterial and various material used for obtaining nano-materials
2. Learn various approaches or methods used for nanomaterial synthesis.
3. To learn various analytical techniques used for nanomaterial characterization.
4. Learn various applications of nanomaterial in health care, agriculture and environmental monitoring

Course Outcomes

S. No.	Course Outcomes	Level of Attainment
CO-1	Introduction to Nano (Basics to Nanoscience and Nanotechnology)	Familiarity
CO-2	Introduction to the two approaches (bottom up and top down) followed for the synthesis of nanomaterial and fundamental properties of Nano-materials(Nano-effect)	Assessment & Technical
CO-3	Introduction to various technique used for the characterization of nanostructures and nanomaterial.	Assessment & Technical
CO-4	Fundamental understanding of nanomaterial/nano-biotechnological application in health and disease.	Usage
CO-5	Fundamental understanding of nanomaterial/nano-biotechnological application in Environment and food - detection and mitigation	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Introduction, History &Applications:**Various definitions and Concept of Nano-biotechnology & Historical background. Fundamental sciences and broad areas of Nano-biotechnology. Various applications of Nano-biotechnology, Cell – Nanostructure interactions	**6**
2	**Synthetic methodologies:**Introduction to the two approaches (bottom up and top down) followed for the synthesis of nanomaterials: Lithography method, Electrochemical method, Mechanical Method, Chemical Synthesis, Chemical vapour deposition, Molecular self-assembly, Laser Induced assembly.	**10**
3	**Techniques used for the characterization of nanoparticles:**Principles of microscopy-light, electron, fluorescent confocal, scanning and	**13**

	transmission microscopes, different fixation and staining techniques for EM. Principles of spectroscopy-UV, visible, CD, FTIR, NMR, and ESR spectroscopy, structure determination using X-ray diffraction, analysis using light scattering.	
4	**Nano-biotechnologicalapplications in health and disease:**Properties of different types of nanoparticles normally used in health and disease. Diagnostics and theranostics application of nanomaterials in health sciences.	**6**
5	**Nanobiotechnological applications in Environment andfood - detection and mitigation:**Properties of different types of nanoparticles normally used in environmental and food sciences. Detection and removal of toxic metal ion from polluted sample and detection and removal of pathogen form food sample.	**7**
Total Lectures		**42**

Suggested Text Book(s):

1. C. A. Mirkin and C. M. Niemeyer. Nanobiotechnology - II more concepts and applications. (2007) - Wiley VCH.
2. P. Boisseau, P. Houdy, M. Lahmani, Nanoscience: Nanobiotechnology and Nanobiology

Suggested Reference Book(s):

1. A. Nouailhat, An Introduction to Nanoscience and Nanotechnology, Wiley
2. D.A Phoenix, W. Ahmed, Nanobiotechnology, One Central Press Ltd, UK
3. L. Filipponi, D. Sutherland, Nanotechnologies: Principles, Applications, Implications and Hands-on Activities.Directorate- European commission

Other useful resource(s): Link to NPTEL course contents

- https://nptel.ac.in/courses/118107015/
- https://onlinecourses.nptel.ac.in/noc17_bt17/preview
- http://videos.gitam.edu/nptel/nano.html

Evaluation Scheme:

S. No.	Exam	Marks	Duration	Coverage/Scope of Examination
1	T-1	15	1 Hour	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Quiz, Assignment, Attendance, etc.

Course Outcomes (COs) contribution to the programme Outcomes (POs):

Course outcomes (NanoBiotech.)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	1	1	2	3	2	1	1	1	2	2	1.7
CO-2	2	3	2	2	3	2	2	2	1	1	3	2	2.1
CO-3	3	3	2	2	3	2	2	2	1	1	3	2	2.2
CO-4	2	2	3	3	2	3	2	2	2	2	3	2	2.3
CO-5	2	2	3	3	2	3	3	2	2	1	3	2	2.3
Average	2.2	2.4	2.2	2.2	2.4	2.6	2.2	1.8	1.4	1.2	2.8	2.0	

Infectious diseases

COURSE CODE: 18B1WBT632

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Microbiology, Immunology

Course Objectives:

1. Learn to define the basic concepts related to infectious diseases, immunology and epidemiology.
2. Able to understand the basic forms, functions, behaviour, and diversity of infectious agents and their interactions with the host
3. Able to analyse the underlying principles of mode of action and resistance towards the agents used to treat infectious diseases

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	The students would have knowledge of infectious diseases for practical use in medicine and biotechnology.	Familiarity
CO-2	The students would have in-depth knowledge of basic concepts related to infectious diseases, immunology and epidemiology.	Assessment
CO-3	The students would develop knowledge and understanding of the basic form, function, behavior, and diversity of infectious agents and their interaction with the host.	Assessment
CO-4	The students would develop knowledge and skill about important techniques used to study host –pathogen interactions.	Assessment/Usage
CO-5	The students would have sound knowledge of mode of action and resistance towards the agents used to treat infectious diseases.	Assessment/Usage

Course Contents:

Unit	Contents	Lectures required
1	Introduction to infectious diseases Infectious and non-infectious diseases, Epidemiology of infectious diseases. Infectious agents, socio economic impact of infectious diseases	**6**
2	Host response to infections Bacterial, mycobacterial, viral, helminth, fungal	**3**
3	Biology of infectious agents Morphology, classification, life	**5**

	cycle, pathogenecity, mechanism of replication in bacteria, viruses, protozoa and fungal pathogens	
4	Pathology of Infectious diseases Pathogenesis, Clinical pathology, Gross pathology, Microscopic pathology.	**4**
5	Biology of major Infectious diseases HIV/AIDS, Tuberculosis, malaria, dengue, West Nile virus, chikungunya virus, diarrheal diseases, sexually transmitted infections, influenza, viral hepatitis, Ebola	**8**
6	Diagnostic techniques for infectious diseases Immunohistology, Immunohistochemistry/In situ hybridization, Polymerase chain reaction based methods, Flow Cytometry.	**5**
7	Antimicrobials against infectious agents Antimicrobial agents, mechanism of action, Antibiotic resistance, various mechanisms of antibiotic resistance	**5**
8	Emerging infectious diseases and their Social Impact Emergenceof SARS, Zika virus, Ebola and other newly reported diseases along with their Social and Scientific Impact.	**4**
9	Biological Weapons Introduction, Concept and examples	**2**
Total Lectures		**42**

Suggested Text Book(s):

1. Evolution of infectious disease. Ewald PW. Oxford University Press, New York.1994. ISBN 0-19-511139-7.
2. Emerging Infections 1. Scheld WM, Armstrong D and Hughes JM, Editors. ASM Press, Washinton, DC. 1998. ISBN 1-55581-123-3
3. Emerging Infections 2. Scheld WM, Craig WA and Hughes JM, Editors. ASM Press, Washington, DC. 1998. ISBN 1-55581-141-8.
4. Emerging Viruses. Morse SS, Editor. Oxford University Press, New York. 1993. ISBN 0-19-510-484-6.
5. Modern Infectious Disease Epidemiology: Concepts, Methods, Mathematical Models, and Public Health (Statistics for Biology and Health) Kramer; 2010

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

Course outcomes (Infectious diseases)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	3	3	3	3	3	3	3	2	2	1	3	2.6
CO-2	3	3	3	3	3	3	3	3	3	2	-	3	2.9
CO-3	1	3	3	3	1	1	3	3	3	3	-	3	2.5
CO-4	3	1	3	3	3	3	2	1	-	-	3	2	2.4
CO-5	1	2	3	3	-	-	3	3	2	2	2	2	2.3
Average	2	2.4	3	3	2.5	2.5	2.8	2.6	2.5	2.25	2	2.6	

Genetic Counselling

COURSE CODE: 18B1WBT831

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Molecular Biology, Genetics

Course Objectives:

1. To provide an understanding of the basis of genetic counseling, diagnostic testing and management for a variety of types of disorders and also the ethical and legal considerations.
2. The students will understand the nature of the non-directive counseling process and the need to educate the patient and family to make informed decisions relating to complex genetic situations.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	To understand basics of genetic counselling, the nature of the directive and non-directive genetic counselling process and to counsel the patients with genetic diseases and help them in decision making.	Familiarity
CO-2	To understandgenetic basis of various diseases (Chromosomal, monogenic and oligogenic disorder).	Assessment
CO-3	To understand gene therapy, its role in genetic disorders and recent developments in gene therapy.	Assessment
CO-4	To understand risk assessment in genetic counseling and ethical issues in genetic counselling.	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Genetic Counselling an overview:**Counseling, diagnostic testing and management of genetic disorders.	**2**
2	**Human chromosomal disorders:** mutations, types of mutations, chromosomal aberrations, quad screen test, Amniocentesis, karyotyping, Down's syndrome, Patau's syndrome, Edward's syndrome, Turner's syndrome, X-chromosome related syndromes.	**6**
3	**Human allelic diseases (monogenic and oligogenic):** Cystic fybrosis. Glucose-6-phospho dehydrogenase deficiency Bradet-Biedl syndrome and some important autosomal recessive and	**6**

	dominant disorders	
4	**Muscle disorders:** Duchenne muscular dystrophy, Becker's muscular dystrophy, limb-girdle muscular dystrophies and cardiac muscle disorders.	**4**
5	**Neurological disorder:** Alzheimer, Hutington, Parkinson, Lewy body dementia and Schizophrenia	**4**
6	**Genetic basis of neoplastic disorders:** Retinoblastoma, Wilms tumor, Colectral cancer, and Blooms syndrome	**6**
7	Prenatal Genetic counseling	**2**
8	**Gene therapy:** Principles of molecular genetic-based therapies and treatment with recombinant proteins or genetically engineered vaccines The technology of classical gene therapy Gene therapy for inherited disorders Gene therapy for neoplastic disorders The ethics of human gene therapy	**7**
9	**Genetic counseling risk assessment**	**3**
10	**Genetic counseling and ethical issues**	**2**
Total Lectures		**42**

Suggested Text Book(s):

6. Strachan T and Read AP (2010) Human Molecular Genetics -4, Garland Science, 4th Ed.
7. Pasternak JJ (2005) An introduction to Human Molecular Genetics: Mechanisms of Inherited Diseases. *Hoboken (New Jersey): John Wiley & Sons*, 2nd Ed.
8. Evans C (2006) Genetic Counselling A psychological approach. New York, NY, US: Cambridge, 1St Ed.

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes (Genetic Counseling)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	3	3	2	2	2	1	3	2	2	1	3	2.1
CO-2	2	2	3	2	2	1	-	3	2	2	1	3	2
CO-3	2	3	2	2	2	1	-	3	2	3	1	2	2
CO-4	2	3	2	2	2	2	-	3	2	3	1	2	2
Average	2.0	2.75	2.5	2	2	1.5	1	3	2	2.5	1	2.5	

Comparative and Functional Genomics

COURSE CODE: 18B1WBT532

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Molecular Biology, Biochemistry

Course Objectives:

1. The course is intended to provide thorough understanding of the genomics i.e. modern technologies in whole genome sequencing, genome mining, comparative genomics, global gene function technologies, protein structure & function technologies at the genome level, etc.
2. The course will explore that how technological innovations fostered by the Human Genome Project, will lead to significant advances in our understanding of diseases that have a genetic basis and, more importantly, how health care will be delivered from this point forward

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Students will have a thorough understanding of various genomic technologies such as whole genome mapping & sequencing, genome annotation, global gene cloning and gene expression technologies, comparative genomics, introduction to pharmacogenomics	Familiarity
CO-2	The students will know the vast amount of genome information in publically available databases and how to access and best utilize for practical purposes.	Assessment
CO-3	Able to analyze the gene expression data sets to derive the biologically meaning information	Assessment
CO-4	Able to apply the knowledge of function genomics in public health	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Introduction to genomics:**Genome organization of Model organism- E. coli, Yeast, Mice, A. thaliana, Human etc. Genome statistics	**3**
2	**First and 2nd generation sequencing:**Sanger sequencing and next generation sequencing; Reverse termination sequencing, Single cell RNA sequencing or single cell RNA sequencing and Applications	**8**
3	**Comparative genomics:**Genome Annotation i.e. Mining Genomic Sequence Data, gene prediction methods, Physical mapping, Metagenomics, evolutionary relationship, Genome Analysis, Functional	**8**

	maps (Transcriptome, proteome, metabolome) Metabolic network maps	
4	**Functional genomics tools:**Hybridization and sequencing based approaches. Serial Analysis of Gene Expression-SAGE, DNA-Microarray, Application of DNA Microarray, cDNA-PCR, etc.	**8**
5	**SNP:**SNP Technologies: Platforms & Analysis Haplotyping: Concepts and Applications and relevance in cancer Biology	**7**
6	**Regulation of gene expression:**Gene Function Technologies (Gene Targeting, Gene Silencing (RNAi), micro RNA-human and Drosophila	**4**
7	Biomarkers Pharmacogenomics: Concepts and Applications in Healthcare Role of genotype in drug metabolism Identification & Utilisation of cancer bio-marker	**4**
Total Lectures		**42**

Suggested Text Book(s):

9. Discovering Genomics, proteomics & bioinformatics. Second edition by A Malcolm Campbell, Davidson College; Laurie J. Heyer Davidson College ; With Foreword by Francis S. Collins
10. Molecular Biology of the Gene (1987) Watson J. D., Hopking N., Robast J. and Steiz, J.
11. BIOINFORMATICS: A Practical Guide to the Analysis of Genes and Proteins (Third edition) Andreas D. Baxevanis& B. F. Francis Ouellette

Suggested Reference Book(s):

6. Ronaghi M. Pyrosequencing sheds light on DNA sequencing. Genome Res. 2001
7. Jan;11(1):3-11. Review. PubMed PMID: 11156611
8. Schulze A, Downward J. Navigating gene expression using microarrays—a technology review. Nat Cell Biol. 2001 Aug;3(8):E190-5. Review. PubMed PMID: 11483980
9. Kim JB, Porreca GJ, Song L, Greenway SC, Gorham JM, Church GM, Seidman CE, Seidman JG. Polony multiplex analysis of gene expression (PMAGE) in mouse hypertrophic cardiomyopathy. Science. 2007 Jun 8;316(5830):1481-4. PubMed PMID: 17556586
10. MacBeath G, Schreiber SL. Printing proteins as microarrays for high-throughput function determination. Science. 2000 Sep 8;289(5485):1760-3. PubMed PMID: 10976071.
11. Shankar J, Wu TD, Clemons KV, Monteiro JP, Mirels LF, et al. (2011) Influence of 17b-Estradiol on Gene Expression of Paracoccidioides during Mycelia-to- Yeast Transition. PLoS ONE 6(12): e28402. doi:10.1371/journal.pone.0028402
12. Mary V. Relling, William E. Evans Nature. Author manuscript; available in PMC 2016 Jan 13.
13. Published in final edited form as: Nature. 2015 Oct 15; 526(7573): 343–350. doi: 10.1038/nature15817

Other useful resource(s):

1. Link to NPTEL course contents:https://nptel.ac.in/courses/102104056/

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Course outcomes	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	2	2	2	2	2	2	2	2	1	2	1.9
CO-2	2	2	2	2	2	1	1	2	2	2	1	2	1.75
CO-3	2	2	2	2	2	1	1	1	2	-	2	2	1.7
CO-4	2	2	2	2	2	1	1	1	2	2	-	2	1.7
Average	2.0	2.0	2	2	2	1.25	1.25	1.5	2.0	2	1.33	2.0	

Computational Molecular Evolution

COURSE CODE: 18B1WBI831

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Basic knowledge of computational biology, evolutionary biology, and functional genomics

Course Objectives:

1. The objective of the course is to develop functional and evolutionary genomic understanding of biological entities for various kinds of lineages for biological data types such as DNA, RNA, Genes, and Proteins etc.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Able to understand the holistic approaches of molecular evolution	Familiarity
CO-2	Combining acquisition, integration and management of experimental evolutionary data with computer aided analysis	Assessment
CO-3	Use various methods from computational genomics and proteomics to learn their functional aspects of controlling biological processes by incorporating evolutionary information	Assessment
CO-4	Able to analyze various kind of biological sequence data and identify their limiting factors to propose new design principles for the analysis of biological data	Assessment and Usage
CO-5	Applications of evolutionary analysis through various available approaches	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Introduction:**Introduction to molecular evolution and its role in the regulation of various biological processes. Introduction to evolutionary biology, functional genomics, basics of data types for biological sequences their importance and applications in further analysis.	**6**
2	**Biomolecules:**To understand various entities and their role in evolution: Genes, operons, regulons, stimulons, genomes, proteins, proteomes etc.	**6**
3	**Codon usage and patterns:**Patterns of base composition and codon usage, gene duplication, pseudogenes, orphan genes, gene gain and gene loss processes, overlapping and nested genes, exonization, intron and RNA editing, functional convergence, hypothetical proteins and their	**6**

	annotations.	
4	**Mutation and selection:**Various kinds of mutations and selection pressure and related theories.	**6**
5	**New data and evolution:**Description of models, methods and algorithms that are most useful for analysing the ever-increasing supply of molecular sequence data, with a view to furthering our understanding of the evolution of genes, proteins, and genomes.	**10**
6	**Models of evolution:**Models of nucleotide substitution, models of amino acid and codon substitution, phylogeny reconstruction: Overview, Maximum Likelihood methods, Bayesian methods, comparison of methods and tests on trees, molecular clock and estimation of species divergence times, neutral and adaptive protein evolution, simulating molecular evolution	**8**
Total Lectures		**42**

Suggested Text Book(s):

1. Molecular Evolution by Dan Graur and Wen-Hsiung Li, Sinauer Associated Inc. Pub., USA .
2. Computational Molecular Evolution by Ziheng Yang, Oxford Series in Ecology and Evolution.
3. Molecular Evolution: A phylogenetic approach Rodric DM Page and Edward C Holmes, Blackwell Science Ltd.

Suggested Reference Book(s):

1. Inferring Phylogenies J. Felsenstein, . Sinauer Associated Inc. Pub., USA.
2. Bioinformatics and Molecular Evolution by Paul G Higgs, Blackwell Publishing.
3. Molecular Evolution and Phylogenetics Masatoshi Nei and Sudhir Kumar, Oxford University Press.

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes & Attendance

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

Course outcomes (Computational Molecular Evolution)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	2	3	2	3	1	1	3	2	3	2	2.17
CO-2	2	2	3	2	2	-	-	-	1	1	2	2	1.89
CO-3	3	3	2	2	2	2	1	1	3	2	1	3	2.08
CO-4	2	2	3	1	1	-	-	-	2	2	2	1	1.78
CO-5	3	2	3	2	2	3	-	-	-	2	-	1	2.25
Average	2.4	2.2	2.6	2	1.8	2.67	1	1	2.25	1.8	2	1.8	

Diagnostics & Vaccine Manufacturing

COURSE CODE: 18B1WBT833

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Immunology

Course Objectives:

1. To familiarize the students with the principles & applications of the latest state-of-the-art bio-molecular diagnostic techniques/technology used in laboratories the world over.
2. The safety aspects, quality control, quality assurance and validation of PCR based diagnostics and laboratory safety.
3. Knowledge of various technologies employed in vaccine production and examine their use in developing vaccines against human and animal pathogens. The safety aspects, quality control, quality assurance and validation of vaccine production and will also be covered.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	The students would be able to identify and analyze what DNA based approach and methodology should be used for diagnostic purpose in different settings, their comparative advantages and limitations.	Usage
CO-2	The students would be able to identify and analyze what antigen - antibody based approach and methodology should be used for diagnostic purpose in different settings, their comparative advantages and limitations.	Usage
CO-3	The students would have in-depth knowledge of various types of vaccines and approaches used for their production.	Familiarity
CO-4	The students would have in-depth knowledge of quality control and assurance considerations used in the industry for diagnostics.	Assessment & Technical
CO-5	The students would have in-depth knowledge of antimicrobial susceptibility and its application in the industry for diagnostics.	Assessment & Technical

Course Contents:

Unit	Contents	Lectures required
1	**General Introduction**: Biotechnology in the diagnosis of infectious diseases and vaccine development, Biotechnology in Vaccine production, Recent developments in vaccine technology.	2
2	**Immunodiagnostics:** Antigen – Antibody Interaction, Lattice Theory, Precipitin Curve, Simple Immunodiffusion (Radial Immunodiffusion – Qualitative, Quantitative); Double Diffusion (Mechanism of Reaction of Identity, Partial – Identity, and Non-Identity); Immunoelectrophoresis; Rocket Electrophoresis, Western Blot, Immunofluorescence, Agglutination – Antibody titer, Prozone Phenomenon, Direct and Indirect Agglutination, Hemagglutination, ABO Blood typing, Agglutination Inhibition; Immunofluorescence, Radioimmunossay (including advantages and disadvantages).	10
3	**ELISA:** Theory, Designing an ELISA method, Types – Direct, Indirect, Sandwich, Competitive, Dot ELISA.	2
4	**PCR:** concept, protocol, strategy. Types of PCR – Strategy and Applications - Nested, Semi-nested, Real time, RT-PCR, Asymmetric PCR, Inverse PCR, Multiplex PCR.	3
5	**QC & QA of PCR and Real Time based diagnostics**: Theory, Application, and Trouble shooting. Importance of controls. Best Fit Assay, Optimization and Standardization of PCR based diagnostics.	3
6	**AST**: Concept, KB Method. Laboratory methodologies for bacterial antimicrobial susceptibility testing – concepts, antibiotics –, resistance, mechanism. Disk diffusion, tube dilution, microbroth dilution methods.	4
7	Biosafety and biosecurity in the medical microbiology laboratory and animal facilities.	2

8	Different types of vaccines, i.e., sub-unit vaccines, recombinant vaccines, synthetic vaccines, idiotypic based - vaccines, DNA vaccines, glycoconjugate vaccines, deletion vaccines.	**3**
9	Examples of different vaccines - Rabies vaccines, PPRV vaccines, Chimeric vaccines – JEV/DENV/Westnile, Meningococcal conjugate & protein based vaccines, Oral B subunit + whole cell cholera vaccine, Multicellular Parasite vaccines, Novel Vaccines against *Mycobacterium tuberculosis,* Mycoplasma vaccines, Protozoal &rickettsial vaccines.	**8**
10	Genetic basis of attenuation, vaccine vectors, large-scale production of vaccines and automation. . Vaccine delivery system and approaches to enhance immunogenicity - immunomodulators and, immunomodulation adjuvant. Delivery of particulate antigens through liposomes, microspheres etc.	**5**
Total lectures		**42**

Suggested Text Book(s):

1. Burtis, C. A., Ashwood, E. R.,:Tietz textbook of Clinical Chemistry &Bruns, D. E. Molecular Diagnostics, Saunders, 2006
2. World Organization for: Manual of Diagnostic Tests and Vaccines for Animal Health Terrestrial Animals, Volumes I & II, 6th Edition, 2010.
3. Rao, J. R.:Molecular Diagnostics: current technology and Applications, Horizon Bioscience, U. K., 2006.
4. Review and Research Publications available on-line
5. Immunology: Kuby

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

Course outcomes (Diagnostics & Vaccine Manufacturing)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	3	1	1	1	1	1	1	1	0	0	0	2	1
CO-2	1	2	3	1	1	1	1	0	0	2	2	2	1.33
CO-3	1	2	2	2	1	2	1	1	1	2	2	1	1.5
CO-4	2	2	2	3	1	1	3	1	1	1	1	3	1.75
CO-5	1	2	3	2	2	2	1	2	2	2	2	3	2
Average	1.6	1.8	2.2	1.8	1.2	1.4	1.4	1	0.8	1.4	1.4	2.2	

Traditional Bioprocesses & their upscaling

COURSE CODE: 18B1WBT832

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Microbiology, Bioprocess Engineering, Downstream Processing

Course Objectives:

Traditional bioprocess gives the lying fundamentals of the pre-historic bioprocess technologies and its scaleup studies on the industrial sectors. Moreover, these gives insights about the technological developments till the existing industrial bioprocesses. Bioprocessing of biopharmaceuticals and immobilization technology also gives an opportunity to study the recent advancements in this field. By keeping the mentioned points, the course objectives were framed as follows

1. Introduction of traditional bioprocesses and its upscaling
2. Discussion of bioprocessing of biopharmecuticals, recent advances in Immobilization technology and Fermentation technology

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Introduction to Traditional Bioprocesses and its production technologies	Familiarity
CO-2	Bioprocessing of Biopharmaceuticals	Assessment
CO-3	Recent trends in Immobilization technology and bioreactor technology	Assessment
CO-4	Upscaling studies of bioprocess products	Usage
CO-5	Scale up considerations of different bioprocess commodities	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Traditional Bioprocesses: Introduction and Technology Advancemnets:** Industrial production of organic acids (Citric acid; Glutamic acid; Lactic acid; Kojic acid; Ascorbic acid) ; Industrial	14

	production of Antibiotics (Pencillins; Cephalosporins; Tetracyclins); Industrial production of Amino acids (Lysine; Threonine; Aspartate)	
2	**Bioprocessing of Biopharmaceuticals:** Overview of USP and DSP aspects of Biopharmaceuticals; Upstream processing of Mab production; Downstream Processing of Mab's ; Process optimization for Mab production; Protein therapeutics	**6**
3	**Recent advances in Reactor technology:** Bioreactors for solid state fermentation ; Photobioreactors for microalgal products; Bioreactors for pharmaceuticals	**9**
4	**Advances of enzyme immobilization techniques:**Sol-gel chemistry and immobilization; Immobilization on nano-particles; Cross-linked Enzyme Aggregates; Surface analysis technology of Immobilized Enzymes	**5**
5	**Scale up considerations of different bioprocess commodities:** Bioprocess aspects of sugar alcohols; Production of flavours in food industries; Flavour production in fermented foods; Bioprocess aspects of Nutraceuticals; Probiotics, Prebiotics and Synbiotics;	**8**
Total lectures		**42**

Suggested Text Book(s):

1. Microbial Technology: Microbial processes by Henry J. Peppler, D. Perlman
2. Microbial Biotechnology by Alexander N. Glazer and Hiroshi Nikaido
3. Industrial Biotechnology by Wim Soetaert and Erick J. Vandamme
4. Immobilization of Enzymes and Cells by Jose M.Guisan
5. Biofilms in Medicine, Industry and Environmental Biotechnology by Piet Lens et al.

Suggested Reference Book(s):

1. Review / Research articles from Science Direct, Springer, Wiley and Pub Med

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	3	3	3	1	3	1	2	1	2	1	3	2.17
CO2	3	3	3	3	2	2	1	2	1	2	-	3	2.27
CO3	3	3	3	3	2	2	1	2	1	2	-	3	2.27
CO4	3	3	3	3	1	2	2	3	2	2	2	3	2.42
CO5	3	3	3	3	1	2	3	3	3	2	2	3	2.58
Average	3.00	3.00	3.00	3.00	1.40	2.20	1.60	2.40	1.60	2.00	1.00	3.00	

Structural Bioinformatics

COURSE CODE: 18B1WBI531

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Structural Biology

Course Objectives:

1. To develop the ability to design, predict, analyze and compare the protein structures as well as predict the function of target proteins.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Understanding the fundamental concepts of structural biology (chemical building blocks, structure, superstructure, folding, etc.)	Familiarity
CO-2	To Understand and use structural databases and software for structure visualization	Familiarity
CO-3	To understand the algorithms used in Structure determination and quality assessment	Assessment
CO-4	To perform protein structure comparison and the hierarchical nature of biomacromolecular structure classification	Usage
CO-5	To understand the methodology of protein structure prediction and assessment	Assessment
CO-6	To understand the methodology of sequence- and structure-based functional site prediction	Assessment

Course Contents:

Unit	Contents	Lectures required
1	**Introduction of protein structure:**Overview of syllabus and protein structure (amino acids and peptide bonds; primary, secondary, super-secondary, tertiary and quaternary structure	3

	of proteins).	
2	**Fundamental concepts of structural biology:**Chemical building blocks, structure, superstructure, folding, etc.; the physical forces that shape macromolecules; structural databases (protein data bank, SCOP database, CATH database and other structure based databases)	**6**
3	**Secondary structure of protein:**Computational methods for prediction of secondary structure of protein sequences (Chou-Fasmann, GOR and Neural Networks) and reliability (Q3 value and SOV score)	**3**
4	**Tertiary structure of protein:**Prediction of tertiary structures of protein sequences (Homology and Threading methods); structure quality assessment.	**6**
5	**Protein structures comparison and alignment:**General approach of alignment and comparison, comparison algorithm & optimization, statistical analysis of results, multiple structural alignment.	**3**
6	**Analysis of 3D structures:**Secondary structure assignment, assignment of hydrogen bonds, coulomb hydrogen bond calculation, empirical hydrogen bond calculation, assignment methods of secondary structure (DSSP, STRIDE, DEFINE, P-Curve)	**3**
7	**Identifying structural domains in protein:**How structural domains are defined? First and second generation algorithms for domain assignments, domain assignment based on graph theoretical methods, prediction of binding sites and characterization.	**3**
8	**Ab initio protein structure prediction:**Empirical force field for biomolecular simulations, Potential Energy Function (bond length potential, bond angle potential, torsional potential, van der Waals potential and coulomb potential), classical representations of electrostatics (Poisson-Boltzmann, Generalized Born and Colombic).	**6**
9	**Energy minimization techniques:**Concept of local and global minima, energy minimization protocol, energy minimization algorithms (steepest descent, conjugate gradient, Newton Raphson)	**3**
10	**Molecular Dynamics simulations:**Monte Carlo Simulations, Techniques for efficient conformational search: Simulated Annealing, Calculation of Free energy using simulation techniques.	**6**
Total Lectures		**42**

Suggested Text Book(s):

1. Structural Bioinformatics (2nd Edition), Jenny Gu (Editor), Philip E. Bourne (Editor)
2. D.W. Mount Bioinformatics: Genome and Sequence Analysis: (2001) Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York.
3. Molecular Modeling: Principles & Applications, Andrew R. Leach, Prentice Hall

Evaluation Scheme:

Assessment	Max. marks	Duration	Course Covered
T1 Test	15	1 hr.	Syllabus covered up to Test-1
T2 Test	25	1.5 hrs.	Syllabus covered up to Test-2
End Term Test	35	2 hrs.	Whole Syllabus
Teacher Assessment (Based on Assignments, quizzes etc.)	25	Whole Semester	Inform class time to time
Total	**100**		

Course Outcomes (COs) contribution to the Programme Outcomes (POs)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Average
CO1	3	3	3	3	2	2	1	1	1	1	1	1	1.83
CO2	3	3	3	3	3	1	1	1	1	1	1	3	2.00
CO3	3	3	2	3	2	3	2	1	1	1	2	1	2.00
CO4	3	3	3	2	3	2	1	1	1	1	1	1	1.83
CO5	2	2	3	3	3	3	1	1	1	1	1	1	1.83
CO6	2	3	3	3	2	2	2	2	2	2	2	2	2.25
Average	2.67	2.83	2.80	2.80	2.60	2.20	1.20	1.00	1.00	1.00	1.20	1.40	

Advanced Algorithms for Bioinformatics

COURSE CODE: 18B1WBI631

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Basics of data structures, algorithms, and basic methods in computational biology

Course Objectives:

1. The overall objective of the course is to develop an understanding of algorithms implementation for solving problems in biology.
2. To evaluate existing algorithms, possible improvements and for their implementations.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Able to apply algorithmic principles to address problems in biology	Analytical
CO-2	Use various methods from computational biology to implement their algorithmic versions	Usage
CO-3	Analyze problems in biology and able to design new protocols and algorithms for biological data analysis	Analytical
CO-4	Able to analyze the algorithms in computational biology and identify their limiting factors to propose new design principles	Analytical
CO-5	Assessment of biological complexity through algorithmic principles	Analytical

Course Contents:

Unit	Contents	Lectures required
1	**Introduction:**An overview of Algorithms, Sequence and String search algorithms with mathematical formulations for similarity and distance scoring systems with their algorithmic implementations.	**6**
2	**Genome Assembly:**Complexity of DNA problems and their simulatory solutions. Genome assembly algorithms, their computational	**7**

	implications and applications.	
3	**Graph based Algorithms:**Graph algorithms in bioinformatics and their applications to fragment assembly, Eulerian and Hamiltonian Cycle Problem, Interval graph algorithm, shortest superstring problem and its mapping with traveling salesman problem.	**4**
4	**Motif and Regulatory element's Algorithms:**Algorithms for finding regulatory motifs in genomic sequences through profiles and consensus approaches. Brute Force Motif Search, Median String Search algorithms and their refinements. Algorithms for Sequencing by hybridization (SBH), use of spectrum approach to solve SBH problem.	**5**
5	**Gene prediction:**Algorithmic approaches for Contig assembly to super-contigs. Computational challenges for gene prediction, popular algorithms and their implementations for gene prediction. Exon chaining and Spliced Alignment Problems.	**7**
6	**Brute Force and branch and bound algorithms:**Brute Force and branch and bound algorithms for Partial Digest Problem, restriction mapping, partial digest and double digest problems and their solutions through multiset and homometric sets.	**5**
7	**MSA advancedments:**Progresssive and iterative refinements of MSA algorithms, Barton-Sternberg Iterative Refinement Algorithm, STAR and TREE alignment approaches, Greedy and Entropy approach for MSA.	**5**
8	**Graph based MSA advancements:**Partial Order (PO)-MSA, and A-Bruijn Alignment (ABA) algorithm for MSA. Combinatorial dynamic programming approach for MSA.	**3**
Total Lectures		**42**

Suggested Text Book(s):

1. Computational Molecular Biology: An algorithmic approach (2004), P.A. Pevzner, PHI.
2. An Introduction to Bioinformatics Algorithms (2004) N.C. Jones and P.A. PevznerAne Books.
3. Algorithms in Bioinformatics (2004), G. Benson and R. Page (Eds): Springer Verlag.

Suggested Reference Book(s):

1. Bioinformatics Algorithms: Techniques and Applications, I.I. Mandoiu and A Zelikovsky,

   Wiley Interscience Press.

2. Biological Sequence Analysis: Probabistic models of proteins and nucleic acids (1998) Durbin R., et al, Cambridge University press.

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes & Attendance

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

Course outcomes (Advanced Algorithms for Bioinformatics)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	3	1	3	2	2	2	1	3	2	3	3	2.25
CO-2	3	2	2	1	-	1	-	-	-	1	2	3	1.88
CO-3	3	3	3	3	2	2	2	1	2	-	-	2	2.30
CO-4	3	3	3	1	-	-	-	-	2	1	2		2.14
CO-5	3	1	2	2	2	2	-	1	-	2	-	1	1.78
Average	2.8	2.4	2.2	2	2	1.75	2	1	2.33	1.5	2.33	2.25	

Datawarehousing and Mining for Bioinformatics

COURSE CODE:18B1WBI632

COURSE CREDITS: 3

ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Molecular Biology, Biochemistry

Course Objectives:

41. Learn to develop and use datawarehouse
42. Learn feature selection methods
43. Learn methods for data mining.
44. Apply data mining techniques in biological datasets.
45. Learn and apply cross-validation.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Students will have a thorough understanding of various datawarehousing components and architecture.	Familiarity
CO-2	Students will understand various types of data models.	Assessment
CO-3	Students will understand how to perform feature selection and derive association rules	Assessment
CO-4	Students will understand how to perform various types of data mining, including clustering, neural networks etc.	Usage

Course Contents:

Unit	Contents	Lectures required
1	**Knowledge Discovery Process -** Understanding the business intelligence cycle	**2**
2	**Introduction to Data warehousing** – Components of data warehouse, Architecture, lifecycle & related core terms.	**2**
3	**Types of Data warehouse design methodologies** – Top Down Approach, Bottom Down approach, Hybrid design Approach	**3**
4	**Data Models** - Dimensional Data Modeling (Star Schema, Snowflake Schema); Relational Data Modeling; Conceptual, Physical & Logical Data Model.	**3**
5	**Multidimensional Analysis** – OLAP & OLTP Approaches	**2**

6	**Building & Maintaining the data warehouse** – ETL design & development;	**2**
7	**Introduction to Data Mining** - concepts and techniques for the discovery of patterns hidden in large data sets	**2**
8	**Grouping of data** - Classification and Clustering Methods; Decision Tree, Neural Network, Nearest Neighbor, Genetic Algorithm	**7**
9	**Feature Selection Methods** - Wrapper & Filter Approach**,** Correlation analysis,PCA	**7**
10	**Association Rule Learning Based Methods** - Apriori Algorithm	**7**
11	**Statistical techniques involved in data mining** – regression based model development	**1**
12	**Cross Validation Techniques** - Jackkniffing, Bootstrapping, Sensitivity, Specifcity, Accuracy	**2**
	Total Number of Lectures	**42**

Suggested Text Book(s):

12. Kimball, R., Margy, R. : The Data Warehouse Toolkit, 2nd Edition: The Complete Guide to Dimensional Modeling, John Wiley &SonsMolecular Biology of the Gene (1987) Watson J. D., Hopking N., Robast J. and Steiz, J.
13. Inmon, B. :Building the Data Warehouse, John Wiley & Sons.

Suggested Reference Books(s):

14. Pei, Han and Kamber, Data mining: Concepts and techniques third edition, Elsevier, 2011
15. Data Mining: Practical Machine Learning Tools and TechniquesKim JB, Porreca GJ, Song L, Greenway SC, Gorham JM, Church GM, Seidman CE,
16. Introduction to Data Mining, Tan, Steinbach and Vipin Kumar, Pearson Education, 2016

Other useful resource(s):

1. Link to NPTEL course contents:https://onlinecourses.nptel.ac.in/noc18_cs14/preview
2. Link to topics related tocourse:

iv. https://nptel.ac.in/courses/102104063
v. https://nptel.ac.in/courses/102106069/
vi. https://nptel.ac.in/courses/102106026/

EvaluationScheme:

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1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

Course outcomes (Datawarehousing and Mining for BI)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	2	2	2	2	2	2	2	2	1	2	1.9
CO-2	2	2	2	2	2	1	1	2	2	2	1	2	1.75
CO-3	2	2	2	2	2	1	1	1	2	-	2	2	1.7
CO-4	2	2	2	2	2	1	1	1	2	2	-	2	1.7
Average	2.0	2.0	2	2	2	1.25	1.25	1.5	2.0	2	1.33	2.0	

Industrial Enzymes Technologies

COURSE CODE: 18B1WBT733

COURSE CREDITS: 3

CORE/ELECTIVE: ELECTIVE

L-T-P: 3-0-0

Pre-requisite: Enzyme production purification and applications

Course Objectives:

1. The objective of the course is to develop an understanding of important aspects of production and purification of industrially important enzyme and their application in industry.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	To develop an understanding of basic concepts of enzymes.	Familiarity
CO-2	To understand the basic mechanism of action and working behaviour of enzymes	Assessment
CO-3	To familiarize the students with various applications of enzymes in laboratory as well as Industrial scale.	Assessment
CO-4	To conceptualize about immobilized enzyme technology, and other specific enzymes and their applications.	Usage
CO-5	To familiarize the students with present potential of enzyme in industrial application and improved activity of the enzyme using various molecular biology techniques.	Usage
CO-6	To understand the principle and function of enzyme in various adverse conditions like high temperature and pH(s).	Assessment

Course Contents:

Unit	Contents	Lectures required
1	**Enzymes: Basic concepts:**Enzymes as powerful and highly specific catalysts, Classification of enzymes, free energy and enzymes, the formation of the transition state, catalytic strategies. General properties: Enzyme specificity, stability and structure, Factors affecting enzyme activity; effect of pH and Temperature, Substrate and Enzyme concentration.	**5**
2	**Enzyme kinetics**: Michaelis-Menten kinetics, evaluation of parameters in the Michaelis-Menten equation, 3-D structure of active site, Kinetics of single and bi-substrate enzyme catalysed reactions, Inhibition & its kinetics.	**5**

3	**Enzyme preparation techniques:** Sources of enzymes, production,Recovery and purification of intracellular products: cell disruption, chromatographic techniques. Analytical assays of purity level of enzymes.	**3**
4	**Enzyme preparation and application in industries:** Application of enzymes in leather, glucose syrup production, starch and sugar industry, Dairy and food industry, Beverage industry, Textile industry. Hydrolysis of starch and cellulose. Catalytic functions of Cellulase, lipase, esterase laccase amylase, glucose isomerase, protease, xylanase, invertase, peroxidises. Other applications of enzymes in solution: medical applications of enzymes, non-hydrolytic enzymes in current and developing industrial technology.	**10**
5	**Enzyme engineering:** Mechanisms and manifestations of protein denaturation. Strategies for enzyme stabilization: Physical and chemical modifications, Selection, directed evolution and Rational design. design and construction of mutant enzymes, Bifunctional and polyfunctional enzyme, Enzyme in organic solvents.	**5**
6	**Immobilized-enzyme technology**: Introduction, enzyme immobilization method: Entrapment, carrier-binding and cross-linking method. Medical and analytical applications of immobilized enzymes.	**8**
7	**Specified Enzymes and applications:** Thermozymes, Cold adapted enzymes, Ribozymes, Hybrid enzymes, Diagnostic enzymes, Therapeutic enzymes: Characteristics, principles and applications.	6
Total Lectures		**42**

Suggested Text Book(s):

1. Devasena, T., “Enzymology”, 1st ed., Oxford University Press, 2010
2. Berg, J.M., Tymoczko, J.L. and Stryer, L., “Biochemistry”, 5th ed., W.H. Freeman and Company, New York, 2002.
3. Nelson D.L., Cox M.M., “Lehninger Principles of Biochemistry”, 5th ed., W.H. Freeman and Company, New York, 2008.

Suggested Reference Book(s):

1. Pye, E.K. and Wingard, L.B., “Enzyme Engineering II”, Plenum Press, 1974.
2. Illanes A, “Enzyme Biocatalysis”, Springer Science, 2008.

Other useful resource(s):

https://nptel.ac.in/course.php?disciplineId=102

EvaluationScheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes&Attendance

Course Outcomes (COs) contribution to the ProgrammeOutcomes(POs)

Course outcomes (Industrial Enzymes)	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	Average
CO-1	2	2	3	1	1	2	2	3	2	2	1	2	1.9
CO-2	1	2	2	2	2	1	-	2	2	2	1	3	1.8
CO-3	2	2	2	2	2	2	1	1	2	-	2	2	1.8
CO-4	2	3	2	1	2	1	-	1	3	2	-	2	1.9
CO-5	1	3	1	3	2	2	1	2	1	2	1	3	1.8
CO-6	1	1	-	2	2	2	2	1	2	2	1	3	1.7
Average	1.5	2.1	1.6	1.8	1.8	1.6	1	1.6	2	2	1.2	2.5	