B.Tech.

IN

BIOTECHNOLOGY

CURRICULUM

AND

SYLLABI

(Applicable from 2023 Admission onwards)

Department of Bioscience and Engineering
NATIONAL INSTITUTE OF TECHNOLOGY CALICUT
Kozhikode - 673601, KERALA, INDIA

The Program Educational Objectives (PEOs) of B.Tech. in Biotechnology

PEO1	Achieve success in industry, technical profession and/or higher education with a strong foundation in mathematics, basic sciences, applied biology and engineering fundamentals
PEO2	Implement the proficient scientific knowledge in biological sciences coupled with an engineering expertise to comprehend, analyze, design and create novel products and solutions to biological problems that are technically sound, economically feasible and socially acceptable.
PEO3	Exhibit professionalism, ethical attitude, communication skills, team work in their profession, multidisciplinary approach and excellent leadership for promoting science, technology and social development for the benefit of mankind.

Programme Outcomes (POs) of B.Tech. in Biotechnology

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, 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 modelling 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.

Programme Specific Outcomes (PSOs) of B.Tech. in Biotechnology

PSO1	Apply the knowledge to formulate, analyze and comprehend biotechnology problems which are of paramount significance in health, food processing, and agricultural sectors.
PSO2	Conceive, Design and Manipulate biological systems to produce products that improve healthcare, medicine, agriculture, food, pharmaceuticals and the environment.
PSO3	Develop the capacity to become independent thinker for carrying out any challenging project in the field of biotechnology.

CURRICULUM

Total credits for completing B.Tech. in Biotechnology is 150.

COURSE CATEGORIES AND CREDIT REQUIREMENTS:

The structure of B.Tech. programmes shall have the following Course Categories:

Sl. No.	Course Category	Number of Courses	Minimum Credits
1.	Institute Core (IC)	8	22
2.	Program Core (PC) and Program Electives (PE)	28	82
3.	Open Electives (OE)	8	24
4.	Institute Electives (IE) (Entrepreneurship Innovation (EI) + Digital / Automation Technologies (DA) + Humanities, Social Science, Management (HM))	6	18
5.	Activity Credits (AC)	--	4

COURSE REQUIREMENTS

The effort to be put in by the student is indicated in the tables below as follows:
L: Lecture (One unit is of 50-minute duration)
T: Tutorial (One unit is of 50-minute duration)
P: Practical (One unit is of one-hour duration)
O: Outside the class effort / self-study (One unit is of one-hour duration)

1. INSTITUTE CORE (IC)

a) Mathematics

Sl. No.	Course Code	Course Title	L	T	P	O	Credits
1.	MA1001E	Mathematics I	3	1*	0	5	3
2.	MA1011E	Mathematics II	3	1*	0	5	3
3.	MA2006E	Mathematics III	3	1*	0	5	3
4.	MA2016E	Mathematics IV	3	1*	0	5	3
		Total	**12**	**4***	**0**	**20**	**12**

*Optional for Students (can be replaced by self-study)

b) Basic Sciences and Drawing

Sl. No.	Course Code	Course Title	L	T	P	O	Credits
1.	BT1005E	Biology for Engineers	3	0	0	6	3
2.	CY1003E	General Chemistry	3	0	0	6	3
		Total	**6**	**0**	**0**	**12**	**6**

c) Professional Communication and Professional Ethics

Sl. No.	Course Code	Course Title	L	T	P	O	Credits
1.	MS1001E	Professional Communication	3	1*	0	5	3
2.	BT2001E	Professional Ethics	1	0	0	2	1
		Total	**4**	**1***	**0**	**7**	**4**

*Optional for Students (can be replaced by self-study)

2A. PROGRAMME CORE (PC)

Sl. No.	Course Code	Course Title	L	T	P	O	Credits
1	BT1002E	Unit Operations	3	0	0	6	3
2	BT1003E	Microbiology	3	0	0	6	3
3	BT1004E	Biochemistry	3	0	0	6	3
4	BT1091E	Microbiology Laboratory	0	0	4	2	2
5	BT1092E	Biochemistry Laboratory	0	0	4	2	2
6	BT1011E	Cell Biology and Genetics	3	0	2	7	4
7	BT1012E	Process Calculations	3	0	0	6	3
8	BT1013E	Environmental Bioengineering	3	0	0	6	3
9	BT2002E	Bioprocess Engineering	3	0	0	6	3
10	BT2003E	Molecular Biology & Genetic Engineering	3	0	0	6	3
11	BT2091E	Bioprocess Laboratory	0	0	4	2	2
12	BT2092E	Molecular Biology Laboratory	0	0	4	2	2
13	BT2011E	Bioinformatics	3	0	0	6	3
14	BT2012E	Downstream Process Engineering	3	0	0	6	3
15	BT2013E	Biopharmaceutical Technology	3	0	0	6	3
16	BT2093E	Bioinformatics Laboratory	0	0	4	2	2
17	BT2094E	Downstream Process Laboratory	0	0	4	2	2
18	BT3001E	Analytical Techniques & Instrumentation	3	0	0	6	3
19	BT3002E	Immunotechnology	3	0	0	6	3
20	BT3003E	Biosafety and Bioethics	3	0	0	6	3
21	BT3091E	Immunology Laboratory	0	0	4	2	2
22	BT3011E	Plant Biotechnology	3	0	0	6	3
23	BT3092E	Plant Biotechnology Laboratory	0	0	4	2	2
24	BT3093E	Project-Part-I	0	0	6	3	3
25	BT4091E	Internship	0	0	4	2	2
26	BT4092E	Project-Part-II	0	0	6	3	3
Total			**45**	**0**	**50**	**115**	**70**

2B. LIST OF ELECTIVES

Following elective courses may be credited under the categories mentioned in the table below.

2B.1 BIOSCIENCES AND TECHNOLOGY

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Additional Categories			
								PE	EI	DA	HM
1.	BT2026E	Advanced Cytogenetics	3	0	0	6	3	Y	N	N	N
2.	BT3022E	Structural Biology	3	0	0	6	3	Y	N	N	N
3.	BT3025E	Marine Biotechnology	3	0	0	6	3	Y	N	N	N
4.	BT3028E	Animal Biotechnology	3	0	0	6	3	Y	N	N	N
5.	BT4021E	Synthetic Biology	3	0	0	6	3	Y	N	N	N
6.	BT4024E	Cancer Biology	3	0	0	6	3	Y	N	N	N
7.	BT4025E	Infection Biology	3	0	0	6	3	Y	N	N	N
8.	BT4026E	Agricultural Biotechnology	3	0	0	6	3	Y	N	N	N
9.	BT4093E	Project-Part-III	0	0	12	6	6	Y	N	N	N

2B.2 COMPUTATIONAL BIOTECHNOLOGY

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Additional Categories			
								PE	EI	DA	HM
1.	BT2071E	Python for Biologists	2	0	2	5	3	Y	N	Y	N
2.	BT3024E	Drug Discovery & Development	3	0	0	6	3	Y	N	N	N
3.	BT3030E	Systems Biology	3	0	0	6	3	Y	N	N	N
4.	BT3032E	Genomics & Proteomics	3	0	0	6	3	Y	N	N	N
5.	BT3071E	Artificial Intelligence & Machine Learning in Life Sciences	3	0	0	6	3	Y	N	Y	N
6.	BT4029E	Programming for Biologists	3	0	0	6	3	N	N	Y	N
7.	BT4030E	Artificial Intelligence in Computational Biology	3	0	0	6	3	N	N	Y	N

2B.3 BIOENGINEERING

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Additional Categories			
								PE	EI	DA	HM
1.	BT2021E	Enzyme Kinetics and Technology	3	0	0	6	3	Y	N	N	N
2.	BT2022E	Biophysics	3	0	0	6	3	Y	N	N	N
3.	BT3023E	Biomechanics	3	0	0	6	3	Y	N	N	N
4.	BT3027E	Metabolic Engineering	3	0	0	6	3	Y	N	N	N

5.	BT3029E	Nanobioengineering	3	0	0	6	3	Y	N	N	N
6.	BT3033E	Biosensors & Diagnostics	3	0	0	6	3	Y	N	N	N
7.	BT3034E	Biomaterials & Artificial Organs	3	0	0	6	3	Y	N	N	N
8.	BT4022E	Biochemical Thermodynamics	3	0	0	6	3	Y	N	N	N
9.	BT4023E	Tissue Engineering	3	0	0	6	3	Y	N	N	N

2B.4 INDUSTRIAL BIOTECHNOLOGY

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Additional Categories			
								PE	EI	DA	HM
1.	BT2023E	Bioenergy and Biofuels	3	0	0	6	3	Y	N	N	N
2.	BT2024E	Food Process Technology	3	0	0	6	3	Y	N	N	N
3.	BT2025E	Integrated Physiology and Pharmacology	3	0	0	6	3	Y	N	N	N
4.	BT3021E	Bioreactor Design and Analysis	3	0	0	6	3	Y	N	N	N
5.	BT3026E	Bioconjugate Technology & Applications	3	0	0	6	3	Y	N	N	N
6.	BT3031E	Pharmacology & Toxicology	3	0	0	6	3	Y	N	N	N
7.	BT4027E	Herbs & Nutraceuticals	3	0	0	6	3	Y	N	N	N
8.	BT4028E	Blood Substitutes	3	0	0	6	3	Y	N	N	N

2B.5 HUMANITIES, MANAGEMENT & ENTREPRENEURSHIP

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Additional Categories			
								PE	EI	DA	HM
1.	BT2061E	Innovation Entrepreneurship & IPR	3	0	0	6	3	N	Y	N	N
2.	BT3081E	Mastering Scientific Communication: Effective Writing & Presentation Skills	3	0	0	6	3	N	N	N	Y
3.	BT3082E	Economics for STEM (Science, Technology, Engineering & Mathematics)	3	0	0	6	3	N	N	N	Y

3. OPEN ELECTIVES (OE)

Courses offered by Other Departments/Schools/Centres or Approved Online Platforms, with a limit on the maximum number of courses from such platforms specified as per BTech Ordinances and Regulations. In addition, PE courses offered by the Parent department shall be included in this category for students of the Parent department.

4. INSTITUTE ELECTIVES (IE)

In case of the Institute Electives, courses in the appropriate categories offered by other departments/schools/centres also can be credited instead of the courses offered by the School of Biotechnology subject to the approval from the Course Faculty and Faculty Advisor.

a) Entrepreneurship / Innovation Basket (EI):

Courses proposed by the Departments/Schools/Centres and approved by Institute Innovation Council. Total credits required is 3.

b) **Digital Automation Technologies (DA):**

Courses related to programming / automation tools & techniques / Industry 4.0. Total credits required is 6.

c) **Humanities, Social Science, Management (HM):**

Courses such as Indian and Foreign languages, Economics, Engineering Management, Financial Management and Design Thinking. Total credits required is 9.

5. ACTIVITY CREDITS (AC)

A minimum of 80 Activity Points is to be acquired for obtaining the 4 Activity Credits required in the curriculum.

Activity points acquired should be a minimum of 20 at the end of S4.
Activity points acquired should be a minimum of 40 at the end of S6.

PROGRAMME STRUCTURE

Semester I

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	MA1001E	Mathematics I	3	1*	0	5	3	IC
2.	BT1005E	Biology for Engineers	3	0	0	6	3	IC
3.	BT1002E	Unit Operations	3	0	0	6	3	PC
4.	BT1003E	Microbiology	3	0	0	6	3	PC
5.	BT1004E	Biochemistry	3	0	0	6	3	PC
6.	BT1091E	Microbiology Laboratory	0	0	4	2	2	PC
7.	BT1092E	Biochemistry Laboratory	0	0	4	2	2	PC
		Total	**15**	**1***	**8**	**33**	**19**	**--**

Semester II

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	MA1011E	Mathematics II	3	1*	0	5	3	IC
2.	CY1003E	General Chemistry	3	0	0	6	3	IC
3.	MS1001E	Professional Communication	3	1*	0	5	3	IC
4.	BT1011E	Cell Biology & Genetics	3	0	2	7	4	PC
5.	BT1012E	Process Calculations	3	0	0	6	3	PC
6.	BT1013E	Environmental Bioengineering	3	0	0	6	3	PC
		Total	**18**	**2***	**2**	**35**	**19**	**--**

Semester III

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	MA2001E	Mathematics III	3	1*	0	5	3	IC
2.	BT2001E	Professional Ethics	1	0	0	2	1	IC
3.		Digital Automation Elective - 1	3	0	0	6	3	DA
4.	BT2002E	Bioprocess Engineering	3	0	0	6	3	PC
5.	BT2003E	Molecular Biology & Genetic Engineering	3	0	0	6	3	PC
6.		Open Elective - 1	3	0	0	6	3	OE
7.	BT2091E	Bioprocess Laboratory	0	0	4	2	2	PC
8.	BT2092E	Molecular biology Laboratory	0	0	4	2	2	PC
		Total	**16**	**1***	**8**	**35**	**20**	**--**

Semester IV

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	MA2011E	Mathematics IV	3	1*	0	5	3	IC
2.		Entrepreneurship / Innovation Elective	3	0	0	6	3	EI
3.	BT2011E	Bioinformatics	3	0	0	6	3	PC
4.	BT2012E	Downstream Process Engineering	3	0	0	6	3	PC
5.	BT2013E	Biopharmaceutical Technology	3	0	0	6	3	PC
6.	BT2093E	Bioinformatics Laboratory	0	0	4	2	2	PC
7.	BT2094E	Downstream Process Laboratory	0	0	4	2	2	PC
8.		Open Elective - 2	3	0	0	6	3	OE
9.		Minor Course - 1	3	0	0	6	3#	MC
Total (Excluding the Minor Courses)			**18**	**1***	**8**	**39**	**22**	**--**

Semester V

Sl. No	Course Code	Course Title	L	T	P	O	Credits	Category
1.		Humanities Elective - 1	3	0	0	6	3	HM
2.	BT3001E	Analytical Techniques and Instrumentation	3	0	0	6	3	PC
3.		Digital Automation Elective – 2	2	0	2	5	3	DA
4.	BT3002E	Immunotechnology	3	0	0	6	3	PC
5.	BT3003E	Biosafety and Bioethics	3	0	0	6	3	PC
6.	BT3091E	Immunology Laboratory	0	0	4	2	2	PC
7.		Open Elective - 3	3	0	0	6	3	OE
8.		Minor Course - 2	3	0	0	6	3#	MC
Total (Excluding the Minor Courses)			**17**	**0**	**6**	**37**	**20**	**--**

Semester VI

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.		Humanities Elective - 2	3	0	0	6	3	HM
2.	BT3011E	Plant Biotechnology	3	0	0	6	3	PC
3.	BT3092E	Plant Biotechnology Laboratory	0	0	4	2	2	PC
4.	BT30**E	Programme Elective - 1	3	0	0	6	3	PE
5.		Open Elective - 4	3	0	0	6	3	OE
6.		Open Elective - 5	3	0	0	6	3	OE
7.	BT3093E	Project-Part-I	0	0	6	3	3	PC
8.		Minor Course - 3	3	0	0	6	3#	MC
Total (Excluding the Minor Courses)			**15**	**0**	**10**	**35**	**20**	**--**

Semester VII

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.		Humanities Elective - 3	3	0	0	6	3	HM
2.	BT40**E	Programme Elective - 2	3	0	0	6	3	PE
3.		Open Elective - 6	3	0	0	6	3	OE
4.		Open Elective - 7	3	0	0	6	3	OE
5.		Open Elective - 8	3	0	0	6	3	OE
6.	BT4091E	Internship	0	0	4	2	2	PC
7.	BT4092E	Project-Part-II	0	0	6	3	3	PC
8.		Minor Course - 4	3	0	0	6	3[#]	MC
Total (Excluding the Minor Courses)			**15**	**0**	**10**	**35**	**20**	--

Semester VIII

Sl. No.	Course Code	Course Title	L	T	P	O	Credits	Category
1.	BT4093E/ BT****E BT****E	Project-Part-III/ Programme Elective – 3, Programme Elective – 4	0/ 3 3	0 0 0	12/ 0 0	6/ 6 6	6	PE
2.		Activity Credits (minimum of 80 points)				12	4	AC
Total			**0/6**	**0**	**12/0**	**18/24**	**10**	--

MA1001E MATHEMATICS I

L	T	P	O	C
3	1*	0	5	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Formulate some engineering problems as ODEs and hence solve such problems.
CO2: Solve linear ODEs with constant coefficients.
CO3: Find the limits, check for continuity and differentiability of real valued functions of two variables.
CO4: Test for the convergence of sequences and series.
CO5: Find the Fourier series representing periodic functions.

Existence and uniqueness of solution of first order ODE, methods of solutions of first order ODE, linear ODE, orthogonal trajectories, linear homogeneous second order ODEs with constant coefficients, fundamental system of solutions, existence and uniqueness of solutions, Wronskian, method of undetermined coefficients, solution by variation of parameters, Euler-Cauchy equations, applications of first and second order ODEs, system of linear ODEs with constant coefficients.

Function of several variables: Limit, continuity, partial derivatives, partial differentiation of composite functions, directional derivatives, gradient, local maxima and local minima of functions of two variables, critical point, saddle point, Taylor's formula for two variables, hessian, second derivative test, method of Lagrange multipliers. Parameterised curves in space, arc length, tangent and normal vectors, curvature and torsion.

Sequences, Cauchy sequence, convergence of sequences, series, convergence of series, tests for convergence, absolute convergence, sequence of functions, power series, radius of convergence, Taylor series, periodic functions and Fourier series expansions, half-range expansions, Fourier integral, Fourier transforms and their properties.

References:

1. H. Anton, I. Bivens and S. Davis, Calculus, 10th edition, New York: John Wiley & Sons, 2015.
2. G. B. Thomas, M.D. Weirand J. Hass, Thomas' Calculus, 12th edition, New Delhi, India: Pearson Education, 2015.
3. E. Kreyszig, Advanced Engineering Mathematics, 10th edition, New York: John Wiley & Sons, 2015.
4. Apostol, Calculus Vol 1, 1st ed. New Delhi: Wiley, 2014.

BT1002E UNIT OPERATIONS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Describe the basic concepts and equations in fluid mechanics, heat transfer and vapor liquid equilibrium
CO2: Illustrate the design of equipment used for flow measurement, heat exchange, evaporation, distillation and mechanical operations and describe their functioning.
CO3: Analyze and solve a variety of problems in fluid statics, fluid dynamics, heat transfer and mass transfer.
CO4: Identify the relationship between physical quantities and develop equations to solve complex problems.

Basic Concepts and Equations in Fluid Mechanics
Fluid definition and classification, rheological behaviour of fluids & Newton's Law of viscosity; Fluid statics- Pascal's law, hydrostatic equilibrium, Barometric equation and pressure measurement (problems), Reynolds experiment, Types of flow - laminar and turbulent; Basic equations of fluid flow - Continuity equation, Euler's equation and Bernoulli equation; Flow through circular conduits - Hagen Poiseuille equation; Dimensional analysis, Conceptual numerical problems.

Flow Measurements & Mechanical Operations
Different types of flow measuring devices (Orifice meter and Venturimeter) with derivations, flow measurements; Pumps – types of pumps (Centrifugal & Reciprocating pumps), Energy calculations and characteristics of pumps; Significance of size reduction, equipment used for size reduction and sieve analysis, sedimentation equipment, types of different mixers; Conceptual numerical problems.

Heat Transfer
Modes of heat transfer; Conduction - Fourier's law of heat conduction, steady-state heat conduction through walls, cylinder and sphere; Convection - Concepts of heat transfer by convection, principles of heat transfer co-efficient, log mean temperature difference, individual and overall heat transfer co-efficient; Heat transfer equipment, Counter-current and parallel flow heat exchangers, Single pass and multi-pass heat exchangers, Theory of evaporation, Single effect and multiple effect evaporation, Design calculation for single and multiple effect evaporation; Conceptual numerical problems.

Mass Transfer
Diffusion-Fick's law of diffusion; Types of diffusion; Steady state molecular diffusion in fluids at rest and laminar flow; Measurement of diffusivity, Mass transfer coefficients and their correlations; Distillation – Methods of distillation, distillation of binary mixtures using McCabe Thiele method; Drying - drying operations, batch and continuous drying; Conceptual numerical problems.

References:

1. W. L. McCabe, J. Smith, and P. Harriott, Unit Operations of Chemical Engineering, 7th Edn., McGraw-Hill Education, New York, 2017.
2. R. K. Rajput, A Textbook of Fluid Mechanics, S. Chand & Company Limited, New Delhi, 2019.
3. J.M. Coulson and J.F. Richardson, Chemical Engineering, Vol. IA Fluid Flow: Fundamentals and Applications, Editors: R. P. Chhabra, V. Shankar 7th Edn., Butterworth - Heinemann 2017
4. J.M. Coulson and J.F. Richardson, Chemical Engineering, Vol. 2A Particulate Systems and Particle Technology, Editor: R. P. Chhabra 6th Edn., Butterworth - Heinemann, 2019.
5. J.P. Holman, Heat Transfer, 8th Edn., McGraw Hill, 2010.
6. W. L. Badger and J. T. Banchero, Introduction to Chemical Engineering, 1st Edn., McGraw- Hill Education, NewYork, 1997

BT1003E MICROBIOLOGY

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Identify the microbial diversity and apply basic knowledge to culture, enumerate, visualize, and classify different types of microorganisms using various techniques and tools.
CO2: Explain the structure, reproduction of bacteria, fungi, and viruses and demonstrate their growth control using different physical and chemical means.
CO3: Describe both aerobic and anaerobic microbial metabolic processes.
CO4: Assess the beneficial and harmful effects of microbes in medical, industrial, agricultural and environmental aspects of Microbiology

General Microbiology
Introduction to Microbiology, Prokaryotes and eukaryotes, Types of microbes, General introduction to viruses, bacteria, fungi, algae, and protozoa. Staining techniques. Study of microbes using microscopes- bright field, dark field, phase contrast, fluorescent, and electron microscopy - Control of microorganisms by physical and chemical methods.

Microbial Physiology
Nutritional requirements for microbial growth, growth curve, culture, and enumeration methods of microbes - Biochemical and molecular characterization of microbes - Structure and reproduction of bacteria, fungi, and viruses.

Microbial Genetics and Metabolism
Introduction to genetics of viruses and bacteria, introduction to microbial metabolism: Aerobic and anaerobic processes, Heterotrophic metabolism, Photophosphorylation in bacteria, Secondary metabolism.

Medical, Environmental Industrial & Agricultural Aspects of Microbiology
Brief introduction to beneficial and harmful effects of microbes: Infections and emerging infections; examples malaria, Tuberculosis and Typhoid; Cryptococcosis and Aspergillosis; AIDS, COVID-19, and Nipah - Antibiotic resistance - Microbial interactions - Introduction to industrial, agricultural and environmental applications of microbes; examples: biomass, alcohols, acids, enzymes, bioinsecticides, biofertilizers, biofuels, and bioremediation.

References:

1. Joanne Willey, Linda Sherwood, and Christopher J. Woolverton, Prescott's Microbiology, 11th Edition, McGraw-Hill Education, 2021
2. M.J. Pelczar, E.C.S. Chan, and N.R. Krieg, Microbiology, 5th edition, McGraw-Hill, 2021
3. Gerard J. Tortora, Berdell R. Funke, and Christine L. Case, Microbiology: An Introduction,13th Edition, Addison-Wesley, 2018
4. Roger Y Stanier, John L Ingraham, Mark L Wheelis, Page R Painter, General Microbiology, 5th edition, Palgrave Macmillan, 1999
5. Michael Madigan, Kelly S. Bender, Daniel Buckley, W. Matthew Sattley, and David A. Stahl, Brock Biology of Microorganisms, 16th edition, Pearson, 2020

BT1004E BIOCHEMISTRY

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Describe the genetic, chemical and physical fundamentals of biochemistry.
CO2: Explain the importance of biomolecules and apply their structural basis to perceive the biological functions.
CO3: Interpret the bioenergetic principles behind the metabolism of carbohydrates, lipids, proteins, and nucleic acids.
CO4: Analyze the biosynthetic pathway for synthesis of different biological macromolecules.

Fundamentals of Biochemistry
Foundations of biochemistry: Cellular, Chemical, Physical, Genetic and Evolutionary Foundations; Importance of water: Weak interactions, Ionization in water, Acids, Bases; Physiological buffers: Henderson-Hasselbalch Equation, pKa and pH, isoelectric point.

Biological Macromolecular Structures
Proteins: Amino acids, Peptides, Quantification, Purification, Structural hierarchy (Primary, Secondary, Tertiary & Quaternary), Folding & Denaturation; Carbohydrates: mono-, di- and polysaccharides, Glycoconjugates; Nucleotides and Nucleic Acids: Purines, Pyrimidines, Structure and types of DNA and RNA, Methylation; Lipids: Storage lipids (Fatty acids), Structural lipids (Phospholipids and sterols); Hormones: Insulin, Glucagon & Epinephrine.

Cellular Metabolism and Bioenergetics
Introduction to metabolism: Bioenergetics & Thermodynamics, Redox reactions; Metabolism of carbohydrates: Glycolysis, Gluconeogenesis, Pentose Pyruvate pathway; Citric Acid Cycle; Glyoxylate Cycle; Metabolism of lipids: Oxidation of Fatty Acids, Ketone bodies; Metabolism of amino acids: Fates of Amino groups, Urea Cycle, Pathways of amino acid degradation; Oxidative phosphorylation: Electron Transport Chain, ATP synthesis.

Biosynthesis of Macromolecules
Carbohydrate Biosynthesis: In Plants and Bacteria, Starch, Sucrose, Cellulose and Peptidoglycan Synthesis; Lipid Biosynthesis: Fatty Acid, Eicosanoids, Triacylglycerol, Phospholipid & Cholesterol synthesis; Amino Acid Biosynthesis: Nitrogen metabolism, Nonessential and Essential amino acid synthesis; Nucleotide Biosynthesis: De Novo Pathway, Salvage Pathway.

References:

1. Nelsen, David L., and Michael M. Cox. *Lehninger principles of biochemistry*. Macmillan Learning, 2021.
2. Berg, Jeremy M., John L. Tymoczko, and Lubert Stryer. Biochemistry. Macmillan, 2007.
3. Voet, Donald, Judith G. Voet, and Charlotte W. Pratt. *Fundamentals of biochemistry: life at the molecular level*. John Wiley & Sons, 2016.
4. Rodwell, Victor W., David Bender, and Kathleen M. Botham. Harper's illustrated biochemistry. McGraw-Hill, 2018.
5. Garrett, R. H., and C. M. Grisham. "Biochemistry; Cengage Learning: Boston." *MA, USA* (2016).

BT1005E BIOLOGY FOR ENGINEERS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Explain the evolutionary basis of life and the structure-function relationship of biomolecules.
CO2: Describe the characteristics of the cellular composition, communication, and principles of genetics.
CO3: Evaluate and apply the biological principles to solve real-world problems related to food, agriculture, and environmental sciences
CO4: Illustrate biocatalysis and the basic concepts in energy transformation.

Exploring Biology
Origin of life, Darwinian Evolution, historical perspectives – Structure and function of Biomolecules: carbohydrates (mono-, di-, and poly- saccharides), lipids, proteins (amino acids, peptides), and nucleic acids (DNA & RNA) - central dogma of molecular biology and gene regulation.

Cell Biology & Genetics
Cell structure and function: Prokaryotic & Eukaryotic cells - Cell communication: Signal Transduction - Cell division: Cell Cycle, Binary fission, Mitosis & Meiosis - Genetics & inheritance: Mendelian Genetics, Chromosomal Aberrations.

Enzymes and Bioenergetics
Enzymes: Classification, Catalysis, Steady-state kinetics, Enzyme Inhibition, Regulatory Enzymes, Co-Enzymes, Vitamins – Basic concepts in the energy transformation & photosynthesis: Photosystem I, Photosystem II.

Global Challenges in Medicine, Agriculture and Environment
Human Diseases, Disorders & Drugs, Biosensors, Biomedical Diagnostics, Vaccines & Antibiotics - Genetic modification of crops, precision farming and sustainable agriculture - Biodegradation and bioremediation of pollutants, biofuels - Recent advances in biology.

References:

1. L. A. Urry, M. L. Cain, S. A. Wasserman, P. V. Minorsky, J. B. Reece, & N. A Campbell. Campbell biology. 2017, Eleventh edition. New York, NY, Pearson Education, Inc.
2. S. Thyagarajan, N. Selvamurugan, M P. Rajesh, R. A. Nazeer, Thilagaraj, W. Richard, S. Bharathi, M. K Jaganathan, Biology for Engineers. McGraw Hill Education, 2013
3. Klug, W. S., Cummings, M. R., Spencer, C. A., Palladino, M. A., & Killian, D. Concepts of Genetics, Global Edition. Person, 2019
4. Nelsen, David L., and Michael M. Cox. Lehninger principles of biochemistry. Macmillan Learning, 2021.
5. Fox, Stuart Ira. "Human physiology. 13th." New York, NY: McGraw--Hill,2011
6. Webb, Andrew G. Principles of biomedical instrumentation. Cambridge University Press, 2018.
7. Johnson, Arthur T. *Biology for engineers*. CRC Press, 2018.

BT1091E MICROBIOLOGY LABORATORY

L	T	P	O	C
0	0	4	2	2

Course Outcomes:

CO1: Practice different standard Microbiology Lab practices and apply proper practices in appropriate situations
CO2: Apply basic knowledge of the preparation of different types of culture media and various sterilization techniques in necessary microbiological situations
CO3: Demonstrate different techniques of staining, culturing, isolation, identification, enumeration, storage and preservation of microbes from various sources.
CO4: Design an experimental setup for the detection of bacterial products of industrial & agricultural importance.

Syllabus / List of Experiments:

1. Sterilization techniques.
2. Preparation of culture media (I) broth type of media (II) agar.
3. Culturing of microorganisms.
4. Isolation of pure culture using streak plate and pour plate methods.
5. Storage/preservation of microorganisms
6. Isolation of microbes from soil/mouth flora/water samples.
7. Identification of microorganisms – (I) staining techniques (simple, negative, Gram, and spore staining) (II) hanging drop (III) biochemical testing (Indole test, methyl red test, Voges-Proskauer test, citrate utilization, starch hydrolysis, urease test, catalase test, oxidase test, coagulase test) (IV) antibiotic sensitivity.
8. Bacterial enumeration – (I) nephelometry – turbidometry (II) wet and dry weight (III) colony forming unit.
9. Growth curve measurement of bacterial population by turbidometry/Colony Forming Unit methods.
10. Isolation of microbes from (I) milk (II) fermented food.
11. Detection of microbial products- acids and enzymes
12. Isolation of *Rhizobium leguminosarum*

References:

1. Heidi Smith, Alfred E. Brown., Benson's Microbiological Applications Laboratory Manual 15th Edition McGraw-Hill 2021.
2. James G. Cappuccino and Natalie Sherman, Microbiology: A Laboratory Manual 12th edition, Pearson Benjamin Cummings, 2021.
3. Jeffrey C. Pommerville, Laboratory Fundamentals of Microbiology,12th edition, Jones & Bartlett Learning, 2021.
4. Michael J. Leboffe and Burton E. Pierce, Microbiology Laboratory Theory & Application, 5th edition, Morton Publishing Company, 2019
5. Neusely da Silva, Marta H. Taniwaki, Valéria C.A. Junqueira, Neliane Silveira, Margarete Midori Okazaki, Renato Abeilar Romeiro Gomes. Microbiological Examination Methods of Food and Water 2nd Edition CRC Press, 2018

BT1092E BIOCHEMISTRY LABORATORY

L	T	P	O	C
0	0	4	2	2

Course Outcomes:

CO1: Apply theoretical knowledge and demonstrate proficiency to design, execute, and analyze experiments in biochemistry
CO2: Perform a variety of biochemical assays, and analyze and interpret biochemical data
CO3: Develop experimental skills and understand the importance of good laboratory practice in biochemistry
CO4: Communicate scientific findings effectively through reports and presentations and collaborate effectively in the lab, demonstrating good scientific practices and teamwork

Syllabus / List of Experiments:

1. Introduction to Biochemistry Laboratory: Safety precautions and laboratory rules, Basic laboratory skills, Spectrophotometry, Units, volume/weight measurements, concentration units, pH measurements, preparation of buffers.
2. Qualitative tests for carbohydrates and amino acids.
3. Quantitative determination of carbohydrates.
4. Quantitative determination of proteins.
5. Paper chromatography of amino acids.
6. Basics of Cell Culture technique: cell culture media and sterile techniques.
7. Separation of proteins by SDS-PAGE electrophoresis.

References:

1. Benjamin F. Lasseter. Biochemistry in the Lab: A Manual for Undergraduates. CRC Press, 2020.
2. K. Wilson, J. Walker, and J. M. Walker, Principles and Techniques of Biochemistry and Molecular Biology, 8th Edn., Cambridge University Press, 2018.
3. D. L. Nelson and M. M. Cox, Lehninger Principles of Biochemistry, 4thEdn, WH Freeman and Company, 2005.
4. S. Rao and V. Deshpande, Experimental Biochemistry, 1st Edn., I K International Publishing House, 2005.

MA1011E MATHEMATICS II

L	T	P	O	C
3	1*	0	5	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Find the parametric representation of curves and surfaces in space and evaluate integrals over curves and surfaces

CO2: Use Laplace transform and its properties to solve differential equations and integral equations.

CO3: Test the consistency of the system of linear equations and solve it.

CO4: Diagonalise symmetric matrices and use it to find the nature of quadratic forms.

Vector field, divergence, curl, identities involving divergence and curl, scalar potential, line integral, independence of path, conservative field, evaluation of double integral, change of variables, Jacobian, polar coordinates, Green's theorem for plane, finding areas using Green's theorem, triple integral, cylindrical and spherical coordinates, mass of a lamina, centre of gravity, moments of inertia, parameterized surface, surface area and surface integral, flux, Gauss' divergence theorem, Stokes' theorem.

Laplace transform, sufficient condition for existence, linearity, inverse Laplace transform, Dirac delta function, transforms of derivatives and integrals, shifting theorems, convolution, differentiation and integration of transform, solution of differential equations and integral equations using Laplace transform.

System of linear equations, augmented matrix, existence and uniqueness of solution, Gauss elimination method, Elementary row operations, LU decomposition, Row-equivalent systems, Row echelon form, Rank of a matrix, Linear dependence, Consistency of linear system, Linear combination of solutions, General solution. Types of matrices and their properties, Eigenvalues, Eigen vectors, Eigenvalue problems, Cayley- Hamilton theorem, Similarity of matrices, Diagonalisation, Quadratic form, Reduction to canonical form.

References:

1. E. Kreyszig, Advanced Engineering Mathematics, 10th edition, New Delhi, India: Wiley, 2015.
2. H. Anton, I. Bivens and S. Davis, Calculus, 10th edition, New York: John Wiley & Sons, 2015.
3. V. I. Arnold, Ordinary Differential Equations, New York: Springer, 2006.
4. P. Dyke, An Introduction to Laplace Transforms and Fourier Series, New York: Springer,2014.

CY1003E GENERAL CHEMISTRY

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Apply the concepts of acid-base chemistry to bioactive molecules
CO2: Demonstrate the principles of stereochemistry for organic synthesis
CO3: Construct the fundamental concepts of reaction mechanisms in synthetic chemistry
CO4: Utilize the basic concepts of essential metal ions in biological systems

Acid-Base Chemistry - Bronsted acid-base chemistry, Aqueous solutions, Non-aqueous systems, Predicting acid strength in solution, Acids and bases of biological interest, Lewis acids/bases and Electrophiles/Nucleophiles.
Stereochemistry - Basic concepts and terminology, Stereochemical descriptors, Distinguishing enantiomers and diastereomers, Symmetry and stereochemistry, Topicity relationships, Stereo-selective and Stereo-specific reactions.

Reaction Mechanism – Thermodynamic and kinetics data, Substituent effects, Electrophilic and nucleophilic substitution reactions, Stability and reactivity of carbocations, Nucleophilicity and basicity, Leaving group effect, Steric effects in substitution reactions.
Biological reactions mediated by enzymes – Group transfer reactions, Formation/removal of carbon-carbon double bonds, Isomerization reactions, Ligation reactions, Hydrolysis reactions and Oxidation-reduction reactions.
Heterocyclic chemistry – Nomenclature, Importance of heterocyclic compounds in medicinal chemistry.

Essential and trace metal ions in biology and their distribution with function, Thermodynamic and kinetic factors for the presence of selected metal ions, Bio-ligands - amino acids, proteins, nucleic acids, nucleotides and their potential metal-binding sites.
Enzymes – Nomenclature and classification, Chemical kinetics, Free energy of activation, and the effects of catalysts.
Chemical hazards and Toxic substances - Classification, Properties and Control.

References:

1. E. V. Anslyn, D. A. Dougherty, *Modern Physical Organic Chemistry*, University Science Books, USA, 2005.
2. R. Chang, *General Chemistry: The Essential Concepts*, 5th edition, The McGraw-Hill Companies, Inc., New York, 2008.
3. E. L. Eliel and S.H. Wilen. *Stereochemistry of Organic Compounds*. New York: Wiley, 1994.
4. L. G Wade JR., *Organic Chemistry*, 8th edition, Pearson Education, Inc., USA, 2013.
5. F. A. Carey and R. A. Sundberg, *Advanced Organic Chemistry, Part A: Structure and Mechanisms*, 5th edition, Springer, New York, 2007.
6. F.A. Carey and R.J. Sundberg. *Advanced Organic Chemistry. Part B: Reactions and Synthesis*. New York, Springer, 2008.
7. J. E. Huheey, E. A. Keiter, R. L. Keiter and O. K. Medhi, *Inorganic Chemistry – Principles of Structure and Reactivity*, Pearson India Ltd., 2009.
8. W. Kaim and B. Schwederski, *Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life – An Introduction and Guide*, John Wiley & Sons, 1994.
9. S. J. Lippard, and J. M. Berg, *Principles of Bioinorganic Chemistry*, University Science Books, 1994.
10. I. Bertini, H. B. Gray, S. J. Lippard, J. S. Valentine, *Bioinorganic chemistry*, University Science Books, 1994

MS1001E PROFESSIONAL COMMUNICATION

L	T	P	O	C
3	1*	0	5	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Distinguish the role and purpose of communication at the workplace and for academic purposes.
CO2: Decide strategies and modes for effective communication in a dynamic workplace.
CO3: Combine multiple approaches for successful and ethical information exchange.
CO4: Estimate best communication practices to assist productivity and congeniality at the workplace.

Listening and Reading Comprehension

Conversation starters: introductions and small talk - Seek and provide information, clarification, polite enquiries, requests, congratulate people, apologise, give and respond to feedback - Describe graphs, tables, and charts - Words often confused: Lexicon and Meaning - Sense Groups - Listening for specific purposes: Listening to lectures, Summarise academic lectures for note-taking - Appropriate Language to Request and Respond - Public Speaking

Vocabulary and Speaking

Developing professional vocabulary - Basic Sentence Structures from Reading Texts - Concord - Functions of Auxiliary Verbs and Modals - Strategies for Effective Reading - Skimming and Scanning, Determine themes and main ideas, Predicting content using photos, images and titles - Critical Reading: Discussing and Summarising text points - Understanding Text Structures: sequencing, comparing and contrasting, relating cause and effect, problems and problem-solving - Discussing Rhetorical and Cultural Aspects in Texts - Text Appreciation: Drawing inferences, Framing Opinions and Judgments on Reading Text

Effective Writing

Note Making and Summarising: Prepare notes from reading texts, Paraphrasing - Use of Multimedia for Assistive Purposes - Paragraph Writing: cohesive devices to connect sentences in a paragraph - transitional devices - Use Text Structures in Paragraphs: sequencing, comparing and contrasting, relating cause and effect, problems and problem-solving - Avoiding Ambiguity and Cleft Sentences - Applications- Writing Instructions, Descriptions and Explanations - Official Letters of Request and Denial - Official E-mails - Abstract Writing - Digital Resources for Effective Communication

Communication at Workplace

Communication Theory - Process of Communication - Modes of Communication - Verbal and Non-Verbal Communication - Tone in Communication - Formal and Informal Communication at Workplace - Passive, Assertive and Aggressive Styles of Communication - Positive Body Language - Group Discussions - Presentation - Workplace Communication - Active Listening - Giving Feedback - Communication Etiquette - Persuasion - Negotiation - Tone and Voice - Telephone etiquette - Establishing Credibility in Conversations - Digital Communication and Netiquette: Conducting Oneself in Virtual Interactions, Constructive use of Social media - Ethical and Culturally Sensitive Communication: Ethical considerations in professional communication, Addressing diversity, Inclusive Communication Practices

References:

1. Nitin, Bhatnagar. Communicative English for Engineers and Professionals. Pearson Education India, 2010.
2. Foley, M., & Hall, D. Longman advanced learners 'grammar: A self-study reference & practice book with answers. Pearson Education, 2018
3. Garner, Bryan A. HBR guide to better business writing (HBR Guide Series). Harvard Business Review Press, 2013.
4. Hewings, M, Advanced grammar in use: A reference and practice book for Advanced learners of English. Cambridge University Press, 2013
5. Ibbotson, M. Cambridge English for Engineering. Cambridge University Press, 2015
6. Kumar, Sanjay, and Pushp Lata. Communication skills. Oxford University Press, 2011.
7. Sudarshana, N., & Savitha, C. *English for Technical Communication*. Cambridge English, 2016

BT1011E CELL BIOLOGY & GENETICS

L	T	P	O	C
3	0	2	7	4

Total Sessions: 39L + 26P

Course outcomes

CO1: Describe the characteristics of the cell and composition, cell organelles structure, and function.
CO2: Illustrate the cell cycle regulation and second messengers involved in cellular signaling.
CO3: Explain the Mendelian genetics, linkage, and crossing over.
CO4: Apply the concepts of genetics to understanding the inheritance of genetic diseases and molecular tools to analyze them.
CO5: Apply the knowledge of cell biology in experiments for the visualization of stained and unstained cells and their organelles.

Introduction to cell structure, composition, and nuclear function

Cell definition and characteristics, cell theory, structure and function of cells, the composition of cells, prokaryotic and eukaryotic cells, membrane structure and organization, transport mechanisms, eukaryotic cell compartmentalization, structural organization of mammalian nuclear envelope and chromosomes, nuclear pore, selective proteins transport to and from the nucleus, internal organization of nucleus and nucleolus

Cell organelles, cell cycle, and signaling

Structure and functions of Mitochondria, Peroxisomes, Endoplasmic reticulum, Ribosomes, Golgi apparatus and Lysosomes-endocytosis and exocytosis-protein sorting and transport-cytoskeleton and cell movement, Mammalian cell cycle, phases of the cell cycle, mitosis- meiosis- regulation of the cell cycle, cyclins, cyclin-dependent kinases, and checkpoint proteins-cell signaling, second messengers, G-protein coupled receptors, tyrosine kinases, PI3- kinase pathway, autocrine, paracrine and endocrine signaling

Mendelian genetics and expression of genes

Mendelian genetics, postulates, monohybrid, and dihybrid cross, Punnett square method, Mendelian principle in human genetics, Pedigrees-genetic counseling-incomplete dominance, and codominance- multiple alleles-Genotype to phenotype-penetrance and expressivity-epistasis and pleiotropy-sex-linked genes and sex determination-inheritance-linkage-crossing over, genes and diseases

Genetic technology and concepts of evolutionary, developmental, and population genetics

Transposable genetic elements-applications of molecular genetics-Gene Therapy-Transgenic plants, animals-Genetic Variation-Hardy Weinberg principle-Population Genetics-Evolutionary genetics-Developmental genetics-Genetic screening, and ethics of genetic technology

Lab experiments

1. Principles and handling of microscopes
2. Light microscope-sample preparation (Wet, Dry) techniques for visualization
3. Demonstration of mitosis in cells
4. Isolation of cell organelles
5. Enumeration of cell count using a hemocytometer
6. Preparation of blood smear, staining, and differential white blood cell count
7. Histology of tissues
8. Histochemical staining and immunohistochemistry
9. Osmotic fragility test
10. Staining and observation of Barr's body
11. Pedigree analysis in human genetics
12. Chromosome preparation and visualization by staining
13. Problems in Genetics and calculations

References

1. Principles of Genetics, 7th edition, Peter Snustad & Michael J. Simmons, 2015 ISBN: 978-1-119-14228-7
2. Concepts of Genetics, 12th Global Edition Michael R. Cummings, William S. Klug, Charlotte A. Spencer, Michael A. Palladino and Darrell Killian 2019 ISBN 9781292265322
3. Lewin's GENES XII, 12th edition Jocelyn E. Krebs, Elliott S Goldstein, Stephen T. Kilpatrick, 2018, ISBN 9781284104493
4. Molecular Cytogenetics Barbara Ann Hamkalo, John Papaconstantinou ISBN 978-1-4615-7481-1 2012
5. Alberts, A. Johnson, J. Lewis, and M. Raff, Molecular Biology of the Cell, 5th Edn., Garland Science, 2008.
6. Harvey Lodish; Arnold Berk; Chris A. Kaiser; Monty Krieger; Anthony Bretscher; Hidde Ploegh; Kelsey C. Martin; Michael Yaffe; Angelika Amon Molecular Cell Biology, 9th Edn., W. H. Freeman, 2021.
7. Karp's Cell and Molecular Biology, 9th Edn., Gerald Karp, Janet Iwasa, Wallace Marshall, ISBN: 978-1-119-59816-9 December 2019
8. G. M. Cooper and R.E. Hausman, The Cell: A Molecular Approach, 4th Edn., Sinauer Associates Inc., 2006.

BT1012E PROCESS CALCULATIONS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course outcomes

CO1: Perform unit conversion involved in bioprocesses and to know the expression of the concentration of dilute solutions
CO2: Solve the material balance problems in unit operations
CO3: Analyze the stoichiometry of cell growth and product formation
CO4: Solve the energy balance problems in fermentation processes

Stoichiometric Principles

Introduction - conversion of units, dimensional consistency, conversion of empirical equations, Dimensionless groups applied in bioprocesses, number of significant figures, precision and accuracy, mole concept and mole fraction, weight fraction and volume fraction, concentration of liquid solutions, stoichiometric principles, graphical differentiation and graphical integration, treatment and interpretation of data.

Material Balance

General material balance equation for steady and unsteady state, simplifications for steady-state processes without chemical reaction, element balance, material balance in processes like crystallization, drying, evaporation, extraction, distillation, absorption, recycle, bypass and purge calculations - Case studies of bioprocess conversion for the production of industrial bioproducts.

Stoichiometry of Bioprocesses

Material balance problems with chemical reactions, stoichiometry of cell growth and product formation, elemental balances, electron balance, degrees of reduction of substrate and biomass, yield coefficients of biomass and product formation, maintenance coefficients, oxygen consumption and heat evolution in aerobic cultures, case studies on heat evolution during fermentation.

Energy Balance in Bioprocesses

Energy balance - heat capacity, estimation of heat capacities, general energy balance, Enthalpy calculation procedures, enthalpy change due to reaction: heat of combustion, heat of reaction for processes with biomass production, energy-balance equation for cell culture and fermentation processes - Case studies with respect to energy balance in typical industrial bioprocesses.

References

1. K.V. Narayanan and B. Lakshmikuttyamma, *Stoichiometry & Process Calculations*, Prentice Hall Publishing, Delhi, 2006.
2. B.I. Bhatt and S. M. Vora, *Stoichiometry*, 4th Edn., Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2001.
3. M. L. Shuler and F. Kargi, *Bioprocess Engineering-Basic Concepts*, 2nd Edn., Prentice Hall, 2004.
4. P. M. Doran, Bioprocess Engineering Principles, 2nd Edition, Academic Press, 2005.

BT1013E ENVIRONMENTAL BIOENGINEERING

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes

CO1: Identify the fundamental concepts and principles of ecology and ecosystems by explaining the interconnections in nature, the value of ecosystems and their services, and the role of biodiversity in ecosystem development.

CO2: Analyze the impact of air and noise pollution on the environment and human health, including the identification of pollution sources, the measurement and analysis of pollutants, and the implementation of control measures to mitigate air and noise pollution.

CO3: Evaluate the sources and classification of water pollutants, assess water quality through analysis, and demonstrate knowledge of sewage and wastewater treatment principles and methods.

CO4: Apply critical thinking and problem-solving skills to assess the effectiveness of biotechnological methods in controlling pollution, such as biodegradation, bioremediation, phytoremediation, and waste management techniques.

Introductory Concepts in Ecology & Ecosystem

Introduction to ecosystems, Ecological balance and consequences of change, Biochemical Diversity in ecosystem development, evolution of an ecosystem-habitat and ecological niche- ecosystem as sustainers of life- value of ecosystems and its services, interconnections in nature examples. Diversity indices, Physical properties, and Tolerance to environmental conditions - Food and energy - First law of thermodynamics and second law of thermodynamics- Producers photosynthesis-consumers and decomposers- role played by decomposers.

Air and Noise pollution

Natural and anthropogenic sources of pollution-Primary and secondary pollutants transport and diffusion of pollutants, Effect of air pollution, Methods of monitoring and control of air pollution, Level of air pollution in India, Ambient air quality in India; The Air (Prevention and Control of Pollution) Act, 1981, Acid rains, control measures for air pollution standards-sampling methods - Noise pollution- Basic properties of sound waves- loudness and intensity levels-decibel-Sources of Noise Pollution–Measurement and analysis of sound- Measures to control noise pollution.

Water pollution

Sources and classification of pollutants, Analysis of water quality, sewage and wastewater treatment, Overview of treatment principles and theory of aeration, Activated Sludge process, Extended Aeration, Nitrification-denitrification, Concepts of waste stabilization ponds.

Biotechnological methods to control pollution

Treatment with micro-organisms-biodegradation and bioremediations, Biochemical aspects of arsenic, cadmium, lead, mercury, carbon-monoxide, ozone & PAN pesticide, Mode of entry of toxic substance, its breakdown and detoxification, biotransformation of xenobiotics, Insecticides, Phytoremediation-Waste water treatment using aquatic plants- Root zone treatment, E-waste management.

References:

1. E.P. Odum, Fundamentals of Ecology, 5th Edn., Brooks/Cole Publishing Co. 2004
2. Zarook Shareefdeen, Ajay Singh, Biotechnology for Odor and Air Pollution Control, Springer 2005
3. Murphy, Enda&King, Eoin, Environmental Noise Pollution: Noise Mapping, Public Health, & Policy, Elsevier, 2014.
4. G. Tchobanoglous, F. Burton, and Stensel, Wastewater Engineering: Treatment, Disposal and Reuse, 4th Edn., Tata McGraw Hill, 2008.
5. C. S. Rao, Environmental Pollution Control Engineering, New Age International, 2021.
6. B.C. Bhattacharyya & Rintu Banerjee, Environmental Biotechnology, Oxford University Press, 2007

MA2006E MATHEMATICS III (B.Tech. BT)

L	T	P	O	C
3	1*	0	5	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Apply the basics of probability theory in solving real life problems.
CO2: Identify the distribution and transformation of random variables.
CO3: Use techniques of statistical inference and its applications.
CO4: Apply regression and correlation for analysing real life problems.

Probability distributions: Random variables, Expectation of a function of a random variable, Mean, Variance and Moment generating function of a probability distribution, Chebyshev's theorem, Binomial distribution, Poisson distribution, Geometric distribution, Hyper- geometric distribution, Normal Distribution, Uniform distribution, Gamma distribution, Beta distribution and Weibull distribution. Transformation of a random variable, Probability distribution of a function of a random variable, Jointly distributed random variables, Marginal and conditional distributions, Bi-variate Normal distribution, Joint probability distribution of functions of random variables.

Statistical Inference: Population and samples, collection and presentation of data, sample size determination, Experimental design. The sampling distribution of the mean (σ known and σ unknown), Sampling distribution of the variance, Point estimation, Maximum likelihood estimation, Method of moments, Interval estimation, Point estimation and interval estimation of mean and variance. Tests of hypothesis, Hypothesis tests concerning one mean and two means. hypothesis tests concerning one variance and two variances, Estimation of proportions, Hypothesis tests concerning one proportion and several proportions, Analysis of rxc contingency tables, Chi-square test for goodness of fit.

Analysis of variance: General principles, Completely randomized designs, Randomized block design.
Regression and Correlation: Curve fitting, Method of least squares, Estimation of simple regression models and hypotheses concerning regression coefficients, Correlation coefficient, Estimation of correlation coefficient, Hypothesis concerning correlation coefficient, Estimation of curvilinear regression models.

References:

1. S. Ross, A First Course in Probability, 9th Edition, Pearson, 2014.
2. R. A. Johnson, Miller and Freund's Probability and Statistics for Engineers, 8th edition, Prentice Hall of Indian, New Delhi, 2011.
3. W. W. Hines, D. C. Montgomery, D. M. Goldsman and C. M. Borror, Probability and Statistics for Engineering, 4th edition, John Wiley & Sons, Inc., New York, 2003.
4. S.M. Ross, Introduction to Probability and statistics for Engineers and Scientists, 5th edition, Academic Press (Elsevier), New Delhi, 2014.

BT2001E PROFESSIONAL ETHICS

L	T	P	O	C
1	0	0	2	1

Total Lecture Sessions: 13

Course Outcomes:
CO1: Develop a clear understanding of human values and use it as the basis for all the activities.
CO2: Understand and follow the ethical aspects of the engineering profession.
CO3: Align with the Code of Ethics prescribed by the Society for Biological Engineering (AIChE), Department of Biotechnology and Indian Council of Medical Research, Govt of India in all professional activities
CO4: Assimilate the elements of academic integrity and Honour Codes, and adopt them in all relevant activities.

Human Values
Morals, values, and ethics – integrity – work ethic – service learning – civic virtue – sharing – honesty – courage – valuing time – cooperation – commitment – empathy – self-confidence – character.

Ethics in Professional Practice
Ethics in professional context – ethical basis of engineering activities – ethical responsibilities to consumers and customers – safety and risk – ethics in management of intellectual property – environmental matters and sustainability.

Code of Ethics and Academic Integrity
Code of ethics of the Society for Biological Engineering (under American Institute of Chemical Engineers), Guidelines by Department of Biotechnology and Indian Council of Medical Research, Govt of India, elements of Academic Integrity: honesty, trust, fairness, respect, responsibility – plagiarism as a violation of academic integrity – Honour Codes: specifying the expected ethical standards from the stakeholders of an organization.

References:
1. R.S. Naagarazan, A Textbook on Professional Ethics and Human Values, 3rd edn., New Age International Pvt. Ltd. 2022
2. A.F. Bainbridge, Ethics for Engineers: A Brief Introduction, CRC Press, 2021
3. E.G. Seebauer and R.L. Barry, Fundamentals of Ethics for Scientists and Engineers, 2000
4. Society for Biological engineering, AIChE Code of Ethics, American Institute of Chemical Engineers, New York
5. Promotion of academic Integrity and prevention of plagiarism in higher educational institutions, UGC 2018
6. Mike Maertin, Qin Zhu and Roland Schinzinger- Ethics in Engineering, 5thedition McGraw Hill 2022
7. Handbook for Institutional Biosafety Committee, Department of Biotechnology, Govt of India (2017 and 2020 versions)
8. National guidelines for stem cell research, Department of Biotechnology and Indian Council of Medical Research, 2017
9. National ethical guidelines for biomedical and health research involving human participants –Indian Council of Medical Research-2017

BT2002E BIOPROCESS ENGINEERING

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course outcomes:
CO1: Design a fermentation process in a bioreactor
CO2: Analyze the cell growth and product formation in different cultivation systems
CO3: Design batch and continuous sterilization
CO4: Perform modeling and simulation of bioprocess

Fermentation and Bioreactor
Introduction to fermentation process, Overview of fermentation industry, Requirements of a fermentation process, Types of fermentation media, Design and optimization of media by response surface methodology, Configuration of bioreactor and ancillaries, Control of pH, temperature, dissolved oxygen and other environmental parameters, containment in bioprocesses.

Cultivation systems and oxygen transfer
Kinetics of cell growth, Unstructured kinetic models for microbial growth, Monod model, Product formation kinetics, Different modes of cultivation systems, Batch, Continuous and fed batch, Oxygen requirements of microbial growth, mass transfer and determination of Kla, Factors affecting Kla.

Design of Sterilization
Sterilization, Thermal death kinetics of microorganisms, Batch and continuous heat, Sterilization of liquid media, Filter sterilization of liquid media, Air sterilization, Design of sterilization equipment, Effluent treatment in bioprocesses, types of treatment methods, containment and effluent disposal.

Modeling and Simulation
Modeling and simulation of bioprocess, Introduction to structured and non- structured models, Compartment model, Dynamic simulation of batch and fed batch systems with case studies, bioreactor system for immobilized enzymes, effectiveness factors, design of immobilized enzyme reactors,

References:
1. J. E. Bailey and D.F. Ollis, Biochemical Engineering Fundamentals, 2nd Edition, McGraw Hill, 2017
2. M. L. Shuler and F. Kargi, Bioprocess Engineering-Basic Concepts, 2nd Edition, Prentice Hall, 2015
3. P. M. Doran, Bioprocess Engineering Principles, 2nd Edition, Academic Press, 2005
4. P. F. Stanbury, S. J. Hall and A. Whitaker, Principles of Fermentation Technology, 3rd Edition, Elsevier, 2016

BT2003E MOLECULAR BIOLOGY & GENETIC ENGINEERING

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Comprehends the concepts of DNA as genetic material, genes and its associated phenotypes
CO2: Analyze central dogma of transmission of genetic information
CO3: Develop the concept of gene regulation and genetic recombination
CO4: Evaluate and analyze cloning of DNA fragments and its modifications.
CO5: Generate synthetic DNA molecules, construct and evaluate synthetic organism.

Griffith's experiment, DNA as a genetic material, Epigenetics, Gene interactions, Lethality, Central dogma of molecular biology, Replication of DNA in prokaryotes and eukaryotes, DNA polymerases and other proteins in replication, Models of replication. Transcription in prokaryotes and eukaryotes, Bacterial RNA polymerase, RNA polymerase I, II and III in eukaryotes, Transcription factors, Post transcriptional processing of RNAs.

Translation in prokaryotes and eukaryotes, Translation machinery, Mechanism of translation, Post translational modifications Regulation of gene expression in prokaryotes, Concept of operon model, *lac*, *gal* and *trp* operons, , DNA damage and repair mechanism, Gene silencing, Genetic recombination, Transposon and transposition, Retroviruses and oncogenes, Homologous recombination in eukaryotes.

Basic concepts of recombinant DNA technology, plasmids, phagemids, cosmids, Restriction Enzymes, Restriction mapping, Construction of plasmids, Modifying enzymes and their applications Ligation of DNA fragments, Screening of recombinant DNA Cloning in M13 vectors, Yeast vectors, Mammalian vector, Expression vectors. Hybridization techniques-Southern hybridization, northern hybridization; Labeling of probes, Nick translation, Construction of genomic DNA and cDNA libraries, Linkers, Adapters.

DNA sequencing methods, Sanger Dideoxy sequencing method, Maxam-Gilbert sequencing method, Polymerase chain reaction, Primer design, Variants of polymerase chain reaction, DNA fingerprinting, DNA footprinting, Site-directed mutagenesis, Restriction fragment length polymorphism, Creation of synthetic bacteria, CRISPR.

References:

1. R. Weaver, Molecular Biology, 5thEdn., McGraw-Hill, 2018.
2. J. D. Watson, T. A. Baker, S. P. Bell, and A. Gann, Molecular Biology of the Gene, 7thEdn.,Pearson, 2013.
3. J. E. Krebs, E. S. Goldstein, S. T. Kilpatrick, Lewin's GENES XII, 12th Edn., Jones and Bartlett Publishers, Inc, 2017
4. G. M. Malacinski,Freifelder's Essential of Molecular Biology, 4thEdn., Jones & Bartlett , 2015.
5. D. S. T. Nicholl, An Introduction to Genetic Engineering, 4th Edn.,Cambridge University Press, 2023.

BT2091E BIOPROCESS LABORATORY

L	T	P	O	C
0	0	4	2	2

Course Outcomes:

CO1: Perform the kinetics of fermentation processes
CO2: Design and optimization of medium components for biomass production
CO3: Analyze the oxygen transfer rate in fermentation processes
CO4: Execute small scale and pilot scale study for fermentation of biological products

Syllabus/List of experiments:

1. Construction of growth curve of bacteria – estimation of biomass, calculation of specific growth rate, yield coefficient, utilization and product formation kinetics in shake flask culture.
2. Control of pH and temperature in a bioprocess.
3. Control of flow rates and pressure in a bioprocess.
4. Enzyme kinetics – Determination of Michaelis Menten parameters.
5. Enzyme immobilization and whole cell immobilization.
6. Kinetics of immobilized enzyme reactions.
7. Determination of volumetric oxygen transfer co-efficient (Kla) in a fermentor by static gassing out and sulphite oxidation methods.
8. Determination of Residence Time Distribution (RTD) of CSTR.
9. Determination of mixing time in stirred tank reactor with Newtonian and Non-Newtonian fluids.
10. Determination of thermal death kinetics.
11. Fermentation process of some biomolecules.
12. Measurement of ethanol production in a fermentor.

References:

1. J. E. Bailey and D.F. Ollis, Biochemical Engineering Fundamentals, 2nd Edition, McGraw Hill, 2017.
2. M. L. Shuler, F. Kargi, Bioprocess Engineering Basic Concepts, 2nd Edition, Prentice Hall, 2015

BT2092E MOLECULAR BIOLOGY LABORATORY

L	T	P	O	C
0	0	4	2	2

Course Outcomes:

CO1: Prepare DNA and RNA from any biological sources
CO2: Generate and analyze the restriction pattern of DNA molecules.
CO3: Transform yeast, bacteria with plasmid DNA for phenotypic analysis.
CO4: Amplify DNA fragment and evaluate.
CO5: Design, comprehend and assess any DNA molecules.

Syllabus/List of experiments:

1. Isolation of plasmid from Escherichia coli (*E.coli*).
2. Transformation of *E.coli.*
3. Transformation of yeast.
4. Selection of recombinants (blue-white screening).
5. Restriction mapping of plasmids/vectors
6. Isolation of genomic DNA from eukaryotes
7. PCR out of a gene/ DNA fragment from genomic DNA
8. Cloning PCR product into a vector
9. Restriction mapping of a DNA fragment cloned in a vector.
10. Isolation of DNA fragments by restriction digestion and gel elution
11. Cloning of isolated DNA fragment into a plasmid
12. Isolation of mRNA from eukaryotes and cDNA synthesis
13. Gene expression analysis using Real-Time PCR
14. Site directed mutagenesis of a cloned gene.
15. Southern hybridization of a cloned fragment
16. Separation of chromosomes using Contour clamped homogenous electric field.

References:

1. J. Sambrook and D. W. Russell, Molecular Cloning: A Laboratory Manual, 3 volume set, 3rd Edn., Cold Spring Harbor Laboratory Press, 2001.
2. D. C. Amberg, D. J. Burke, and J. N. Strathern, Methods in Yeast Genetics, Cold Spring Harbor Laboratory Press, 2005.
3. J. D. Watson, T. A. Baker, S. P. Bell, and A. Gann, Molecular Biology of the Gene, 6th Edn., Benjamin Cummings, 2007.
4. C. Guthrie and G. R. Fink, Methods in Enzymology: Guide to Yeast Genetics and Molecular Cell Biology, Volume 350 (Part B), 1st Edn., Academic Press, 2002.
5. I. H. Segel, Biochemical Calculations, 2nd Edn., Wiley, 1976.

MA2016E MATHEMATICS IV (B.Tech. BT)

L	T	P	O	C
3	1*	0	5	4

Total Lecture Sessions: 39

Course Outcomes:
CO1: Model managerial problems in industries to linear programming problems and solve it using various techniques and algorithms.
CO2: Model and solve PDEs using analytic methods.
CO3: Solve linear and nonlinear equations using numerical methods.
CO4: Evaluate definite integrals and solve ODEs using numerical methods.

Linear Programming: Introduction, Optimization model, Formulation and applications, Classical optimization techniques: single and multi-variable problems, Types of constraints, Linear optimization algorithms: Graphical method, Simplex method, Basic solution and extreme point, Degeneracy, Primal simplex method, Dual linear programs, Duality theory, Dual simplex method, Primal-dual algorithm.

Partial Differential Equations: Basic Concepts, Cauchy's problem for first order equations, Quasilinear and nonlinear PDEs of first order, Charpit's Method, Classification of second order partial differential equations, Modelling: Vibrating String, Wave equation, Separation of variables, Use of Fourier Series, D'Alembert's Solution of the wave equation, Heat equation: solution by Fourier series, Heat equation: solution by Fourier Integrals and transforms, Laplace equation, solution of PDEs by Laplace transforms.

Numerical Methods: Solution of algebraic and transcendental equations: Fixed point iteration method, Regula-Falsi method, Newton Raphson method. Iterative methods to solve linear system of equations: Gauss Jacobi, Gauss Seidel, Successive over relaxation method. Numerical integration: Composite Trapezoidal and Simpson's methods. Numerical solution of ordinary differential equations: Euler's method, modified Euler's method, Taylor's method, Runge-Kutta methods, Multistep methods - Milne's and Adams' methods.

References:

1. G Mohan and Kusum Deep, Optimization Techniques, New age International Publishers, 2009
2. Wayne Winston, Operations Research - Applications and Algorithms, Cengage Learning Fourth edition, 2011.
3. D. Greenspan, Introduction to Partial Differential Equations, Dover Publications; 1st edition, 2000.
4. E. Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 9th Edition, 2012.
5. Jain M.K., Iyengar S.R.K., Jain R.K., Numerical methods for Scientific and Engineering Computation, 8th edition, New Age International (P) Ltd, 2022.

BT2011E BIOINFORMATICS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Utilize the available online biological databases to retrieve and analyze sequences.
CO2: Analyze the basic algorithms for sequence analysis of proteins and nucleic acids.
CO3: Develop an idea about the predictive methods for the structure and function of any given nucleic acid and protein sequences based on sequence homology.
CO4: Apply bioinformatics approaches to solve biological problems, such as gene annotation, molecular evolution, and drug designing.
CO5: Critically evaluate the results of bioinformatics analyses and their biological significance.

Introduction to Bioinformatics and Biological Databases
Introduction to Bioinformatics: definitions, historical overview, applications and scope, Biology to understand the Bioinformatics – Important Biological Databases: Retrieving and analyzing data from biological databases, Genbank, NCBI, DDBJ, Pubmed, UniProt, PROSITE, SCOP, RCSB-PDB, EMBL-EBI, STRING, TCGA.

Sequence Alignment and Phylogenetics Analysis
Sequence alignment tools and algorithms: Substitution matrices, PAM, BLOSUM, Gap penalties, pairwise sequence alignment using Dynamic Needleman-Wunsch, Smith-Waterman, and Heuristic programming algorithms, FASTA and BLAST-Multiple sequence alignments: Common multiple alignment methods, CLUSTALX, identification of motifs and patterns, Hidden Markov model-Phylogenetic Analysis: Elements of phylogenetic models, Determining the substitution model tree, Evaluating phylogenetic trees.

Structure Prediction and Analysis
Predictive methods, Codon bias detection, Modular nature of proteins - Protein identity based on the primary, secondary, and tertiary structure of proteins, protein homology modeling, Bioinformatics approaches for Molecular modeling in drug discovery, Protein-Protein interactions

Data Analysis and Interpretation
High throughput sequencing and data analysis: Human Genome Project, Next generation sequencing, Detection of SNPs and their relevance, Detection of functional sites in the DNA sequences, Gene predictions, Microarray data analysis, Gene expression analysis

References:
1. Arthur K. Lesk , Introduction to Bioinformatics, 5th Edn., Oxford University Press, 2019.
2. J. Pevsner, Bioinformatics and Functional Genomics, 3rd Edn., Wiley-Blackwell, 2015.
3. M. Axelson-Fisk, Comparative Gene Finding: Models, Algorithms and Implementation. 2ndEdn, Germany: Springer London, 2015.
4. D.W.Mount, Bioinformatics: Sequence and Genome analysis, 2nd Edn., Cold Spring Harbor Laboratory Press, 2004.
5. S. Datta, D. Nettleton, Statistical Analysis of Next Generation Sequencing Data. Springer International Publishing, 1st Edn, 2014.

BT2012E DOWNSTREAM PROCESS ENGINEERING

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Recognize the basis for various steps in downstream processing and their economics, to design a strategy for the purification of a product.
CO2: Apply the basic laws governing downstream processing unit operations to solve practical problems in industry and research.
CO3: Assess techniques such as precipitation, membrane separation and chromatographic technique for the purification of a targeted protein(s) or any other biological material.
CO4: Propose a technique to give final polishing to the isolated product.

Introduction to downstream processing
Introduction to the various downstream processing steps and their significance in biotechnology, Economics of downstream processing, cost-cutting strategies, Process design criteria for various classes of bioproducts (high volume, low-value products, and low volume, high-value products) with suitable problems. Physico-chemical basis of different bioseparation processes

Primary Separation and Recovery Processes
Cell disruption by chemical, mechanical, and enzymatic methods; Centrifugation and Filtration: basic principles, design characteristics Ultracentrifuges, problems based on the laws governing filtration and centrifugation; Flocculation, and sedimentation.

Enrichment Operations
Extraction: Basic equations of extraction, Aqueous two-phase extraction, batch extraction, staged extraction and differential extraction, Supercritical fluid extraction, problems related to the extraction; Adsorption and Leaching, Precipitation methods; Membrane-based purification: Ultrafiltration and Microfiltration, Reverse osmosis, Dialysis.

Product Resolution / Fractionation and Polishing
General chromatography theory and the different chromatographic techniques like adsorption, partition, ion exchange, affinity, gel filtration and HPLC, Dialysis, Crystallization, and Drying. Any Emerging Technologies in downstream processing in biotechnology industries.

References:
1. N. K. Prasad, Downstream Process Technology - A New Horizon in Biotechnology", Prentice Hall of India, New Delhi, 2012.
2. M. R. Ladisch, Bioseparations Engineering: Principles, Practice and Economics, 1st Edn., Wiley Interscience, 2001.
3. J. D. Seader and E.J. Henley, Separation Process Principles, 3rd Edn., Wiley, 2010.
4. Sivasankar B, Bioseparations: Principles and Techniques, Prentice-Hall of India Pvt. Ltd., 2008.
5. P. A. Belter, E. L. Cussler, and W.S. Hu, Bioseparation: Downstream Processing for Biotechnology, 2nd Edn., Wiley-Interscience, 1994.

BT2013E BIOPHARMACEUTICAL TECHNOLOGY

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Examine the growth of biopharmaceutical industries with time and the recent scenario of different pharmaceutical molecules.
CO2: Analyze the evolution of biopharmaceutical product development and identify the key sources of different biopharmaceuticals.
CO3: Apply the principles of drug formulation, pharmacokinetics and pharmacodynamics properties for designing and developing new or modified drugs.
CO4: Evaluate and design novel steps involved in the industrial production & purification of clinically relevant biopharmaceuticals and related therapies.

Introduction to Biopharmaceutical Industries
History of Pharmaceutical Industry; Introduction to Small Molecules, Biopharmaceuticals, Biologics, Biogenerics and Biosimilars; Industries dealing with biopharmaceuticals and its market value: World scenario, Indian scenario.

Drug Discovery and Development
Overall Drug Development Process: Drug Discovery, Dosage forms, Mode of Administration and Drug Formulations, Pharmacokinetics (ADME), Pharmacodynamics (Toxicity studies), Clinical Trials, Regulatory Agencies and Approval such as USFDA, Central Drugs Standard Control Organization, Certifications such as ISO9001, ISO13485 etc; Pharmaceutical Manufacturing: Sources: Bacteria, Fungi, Transgenic Plant, Transgenic Animal, Insect-based, Large-Scale Bioreactors specific for each source; current Good Manufacturing Practices.

Pharmacokinetics and Pharmacodynamics
Pharmacokinetics: Drug Absorption by GI tract; Therapeutic concentration profile, pharmacokinetic models - compartment models (one, two, multi, open models); Assessment of biopharmaceutical properties: Drug half-life, Volume of Distribution, Bioavailability and Bioequivalence; Pharmacodynamics: agonist/antagonist, drug-receptor/target interactions, factors affecting drug-target interactions; Dosage regimens: dose-response relationships - graded dose and quantal dose-responses; Pharmaceutical pre-formulation: Solubility, Dissociation, Dissolution, Physical Properties; Excipients.

Case studies on industrially relevant biopharmaceuticals
Production and distribution of industrially relevant biopharmaceuticals: Therapeutic Proteins - Cytokines, Hormones; Monoclonal Antibodies; Cell Therapy – Stem cell, CAR-T cell therapy; Gene Therapy; Vaccines.

References:
1. Aulton, M. E., & Taylor, K. (Eds.). Aulton's pharmaceutics: the design and manufacture of medicines. Elsevier Health Sciences, 2013
2. N Tozer, T., & Rowland, M. Essentials Of Pharmacokinetics & Pharmacodynamics. Wolters Kluwer, 2016
3. Fahr, A. Voigt's pharmaceutical technology. John Wiley & Sons. 2018
4. Ramzan, I. (Ed.). Biologics, Biosimilars, and Biobetters: An Introduction for Pharmacists, Physicians and Other Health Practitioners. John Wiley & Sons. 2020
5. Sheets, R. Fundamentals of Biologicals Regulation: Vaccines and Biotechnology Medicines. Academic Press. 2017
6. Feng, X., Xie, H. G., Malhotra, A., & Yang, C. F. (Eds.). Biologics and Biosimilars: Drug Discovery and Clinical Applications. CRC Press. 2022

BT2093E BIOINFORMATICS LABORATORY

L	T	P	O	C
0	0	4	2	2

Course Outcomes:

CO1: Utilize the online available database and basic algorithms for nucleic acid and protein sequence analysis.
CO2: Demonstrate the predictive methods for protein structure, function, and phylogenetic relatedness.
CO3: Analyze & compare the nucleic acid and protein sequences.
CO4: Apply protein-protein interactions and microarray data analysis for experimental design.
CO5: Develop hypotheses based on bioinformatics data and design experiments to test them.

Syllabus/List of Experiments:

1. Basics of sequence analysis, Retrieving a sequence-nucleic acid/Protein
2. Pairwise comparison of sequences using dynamic programming
3. Pairwise comparison of sequences using BLAST
4. Alignment of multiple sequences
5. Phylogenetic analysis-Parameters affecting evolutionary trees.
6. Secondary and tertiary structure prediction of proteins.
7. Identification of functional sites in Genes and Genomes
8. Restriction mapping of DNA sequences
9. Protein-ligand interactions
10. Comparison of two genomes
11. Primer design.
12. Protein-Protein interaction analysis
13. Microarray data analysis

References:

1. J. Pevsner, Bioinformatics and Functional Genomics, 3rd Edn., Wiley-Blackwell, 2015.
2. M. Axelson-Fisk, Comparative Gene Finding: Models, Algorithms and Implementation. 2nd Edn, Germany: Springer London, 2015.
3. D. W. Mount, Bioinformatics: Sequence and Genome analysis, 2ndEdn., Cold Spring Harbor Laboratory Press, 2004.
4. Curry, E. Introduction to Bioinformatics with R: A Practical Guide for Biologists. United States, 1stEdn, CRC Press, 2020.
5. E. Korpelainen, J. Tuimala, P. Somervuo, M. Huss, G. Wong, RNA-seq Data Analysis: A Practical Approach. 1st Edn, Chapman & Hall/CRC Computational Biology Series, 2014.

BT2094E DOWNSTREAM PROCESS LABORATORY

L	T	P	O	C
0	0	4	2	2

Course Outcomes:

CO1: Apply the principles of cell disruption, filtration, concentration, extraction and drying using different techniques and analyze the efficiency of the method.

CO2: Plan and evaluate the downstream processing steps for the expression and purification of a recombinant protein in a systematic manner using various techniques.

CO3: Design experimental setup to isolate proteins/enzymes and other small molecules of commercial significance using various precipitation and chromatographic techniques.

Syllabus / List of Experiments:

1. Solid-liquid separation by filtration, sedimentation and flocculation
2. Separation of small molecules from macromolecules by ultra filtration and dialysis
3. Estimation and separation of proteins using different techniques.
4. Bacterial cell disruption using different methods like physical, chemical and enzymatic methods
5. Aqueous two-phase extraction and batch extraction
6. Separation of carbohydrates/amino acids by TLC.
7. Downstream processing of a recombinant protein over expressed in bacterial system.
8. Separation of a recombinant protein in bacterial cell lysate using Ammonium sulphate precipitation
9. High resolution purification of the recombinant protein by affinity chromatography.
10. Downstream processing of lysozyme from egg white using ion exchange chromatography.
11. Gel filtration chromatography to remove the salts and other ions present in the final product.
12. Downstream processing of citric acid produced using *Aspergillus spp.*
13. Downstream processing of caffeine from tea dust.
14. Experiments involving crystallization of the downstream processed material
15. Product polishing by lyophilisation and drying

References:

1. Scopes, R. K. Protein Purification: Principles and Practice, 3rd Edn., Springer, 2013.
2. Andreas, H., Walker, J. M., Wilson, K., Clokie, S. (Eds.). Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology, United Kingdom: Cambridge University Press 2018.
3. Belter, P. A., Cussler, E. L., and Hu, W.S. Bioseparation: Downstream Processing for Biotechnology, 2nd Edn., Wiley-Interscience, 1994.
4. Abelson, J. N. Simon, M. I. and Deutscher, M. P. Methods in Enzymology: Guide to Protein Purification, Volume 182, Academic Press, 1990.
5. Published research articles related to the experiments.

BT3001E ANALYTICAL TECHNIQUES AND INSTRUMENTATION

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1:Analyse and identify suitable analytical techniques for quantification of biological macromolecules
CO2: Apply the working principles of electrophoretic, spectroscopic, chromatographic and microscopic techniques for molecular characterisation
CO3: Intrepret the data procured from the molecular characterization and provide appropriate structural and functional details.
CO4: Design series of experiments involving various techniques for purification and analysis of proteins, lipids, DNA and carbohydrates.

Electrophoretic Techniques
Principles and instrumentation of Gel electrophoresis (for DNA and Proteins); Isoelectric focusing; Two-dimensional gel electrophoresis; Pulse field gel electrophoresis; Western blot, Southern blot.

Spectroscopic Techniques
Introduction to absorption and emission spectroscopy: Theory (Beer-Lambert's law) and instrumentation of single beam and double beam UV-visible spectrophotometers, calibration and standardization; Theory and instrumentation of fluorescence and phosphorescence spectrometry; Flame emission and atomic absorption spectroscopy; Infrared spectrometry: FTIR; Raman spectroscopy.

Chromatography and Structure analysis
Gas chromatography and HPLC; Flow Cytometry; Mass spectrometry: Ionization and fragmentation, Basics of LC/MS & GC/MS, Tandem mass spectrometry; X-ray diffraction crystallography; Nuclear magnetic resonance spectrometry; Circular Dichroism; Thermal analysis techniques.

Microscopic Techniques
Basic principles of microscopic methods, Types of microscopy: Phase contrast, fluorescence, Electron; Principles of SEM, TEM & Cryo-EM, Fluorescence microscopy: widefield, confocal microscopy, Super-resolution; Scanning probe microscopy: STM, AFM;

References:

1. Wilson, K., Hofmann, A., Walker, J. M., & Clokie, S. (Eds.). Wilson and Walker's principles and techniques of biochemistry and molecular biology. Cambridge university press. 2018
2. Parson, W. W., & Burda, C. Modern Optical Spectroscopy: From Fundamentals to Applications in Chemistry, Biochemistry and Biophysics. Springer. 2022
3. Ramesh, V. (Ed.). Biomolecular and bioanalytical techniques: theory, methodology and applications. John Wiley & Sons. 2019
4. Van Emon, J. M. (Ed.). Immunoassay and other bioanalytical techniques. CRC Press. 2016
5. Sahoo, H. Optical spectroscopic and microscopic techniques. Springer Singapore. 2022
6. Hofmann, A., Simon, A., Grkovic, T., & Jones, M. Methods of molecular analysis in the life sciences. Cambridge University Press. 2014

BT3002E IMMUNOTECHNOLOGY

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Explain different molecules, cells and tissues of the vertebrate immune system and the cooperation between innate and adaptive immunity.
CO2: Discuss and compare the innate and adaptive immune response mechanisms in physiological and pathological states.
CO3: Apply the knowledge of antigen-antibody interactions for the development of novel immunodiagnostic techniques and kits for industrial use.
CO4: Develop novel therapy for human diseases by applying biotechnological principles in basic and translational immunology.

Cellular and Molecular Components of Vertebrate Immune System
Overview of the immune system- Cells and organs of innate and acquired immunity- Innate immunity, Inflammatory response- Structure and classes of antibodies- Antibody-antigen interactions, Agglutination and precipitation reactions- Mechanism of antigen processing and presentation, Major Histocompatibility Complex genes and their role- Complement system.

Immune Response Mechanisms and Enhancement Techniques
Maturation, activation and differentiation of B and T lymphocytes, gene rearrangements and antibody/ T cell receptor diversity generation- Mechanism and kinetics of humoral (B) and T cell-mediated immune responses, Antibody class switching, Cytokines, ADCC- Methods of enhancing immunogenicity, Hapten carrier conjugate- Immune responses against microbial pathogens and evasion mechanisms.

Dysfunctions and diseases of immune system and immunodiagnostic methods
Immune system dysfunction, hypersensitivity reactions, graft rejection mechanisms, HLA typing methods, autoimmune diseases, systemic inflammatory response syndrome, primary and secondary immunodeficiencies- Experimental models of common human immune system diseases- Immunological techniques; RIA, ELISA, ELISPOT assay, immunofluorescence microscopy, immunoblotting, immune cell sorting and immunoelectron microscopy.

Immunotherapeutic approaches
Immuno-therapeutics, hybridoma technology, bispecific monoclonal antibodies, antibody engineering- immunization and immunomodulation techniques with vaccines; different types, mRNA, vector and subunit vaccines, antibodies- General and specific immunosuppressive therapies.

References:

1. Jenni Punt, Sharon Stranford, Patricia Jones and Judy Owen. Kuby Immunology, 8th Edn., W.H.Freeman, 2018.
2. Kenneth M. Murphy, Casey Weaver, Leslie J. Berg. Janeway's Immunobiology, 10th Edn., W. W. Norton & Company, 2022.
3. A. K. Abbas, A.H.Lichtman and S. Pillai. Cellular and Molecular Immunology, 10th Edn., Elsevier, 2021.
4. Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt and Peter J. Delves. Roitt's Essential Immunology, 13th Edn., Wiley Blackwell, 2017.

BT3003E BIOSAFETY AND BIOETHICS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Define ethical values in scientific research and ethical violations
CO2: Analyze the biological, chemical, physical, and radioactive laboratory hazards and their prevention and safety measures
CO3: Apply the concepts and ethical guidelines to carry out research in genetic engineering, animal, human, and stem cell research
CO4: Summarize the national and international guidelines and policies for good laboratory practices and biosafety.

Responsible Conduct of Science
Values in science, responsible conduct of science, scientific publications, misconduct in science, negligence, and error, conflict of interest, academic honesty, research fabrication and falsification, plagiarism, plagiarism policies, consequences, detection tools, Image manipulation, ethical violations, reference management, research with humans, animals and stem cells-Intellectual property rights, patenting, patent laws, authorship, and author disputes

Laboratory Safety
Biohazards, risks and safety equipment, biosafety cabinets, biosafety levels 1 and 2, 3 and 4, containment laboratory, good microbiological techniques, Recombinant DNA technology, and biosafety, handling hazardous chemicals, electrical and fire accidents, laboratory decontamination, chemical disinfection, gaseous disinfection, heat sterilization, biological indicators, chemical transport, storage and usage, radiation safety, electrical safety, fire safety, biohazard spills, and bio-waste segregation

Guidelines for research in stem cells, hazardous microorganisms, and genetic modifications Recombinant DNA technology work, genetically engineered organisms, and non-GE hazardous microorganisms, biosafety and biosecurity at the institute, National guidelines for stem cell research, Institutional biosafety committee compliance adherence, containment and storage of hazardous microorganisms and genetically modified organisms-Decontamination and disposal

Ethics in animal and human research
Ethical guidelines for the use of animals in research, Committee for Control and Supervision of Experiments on Animals (CCSEA), guidelines, the role of the institutional animal ethics committee, guidelines for the use of rodents, fishes, birds, and large animals, Ethical guidelines for biomedical research in human participants, Indian Council of Medical Research (ICMR) guidelines, Institutional human ethics committee roles, and responsibilities, International guidelines for recombinant DNA technology work.

References

1. Handbook for Institutional Biosafety Committee, Department of Biotechnology, Govt of India. (2017 & 2020)
2. Laboratory Biosafety Manual 4th edition and associated monographs- Decontamination and Waste Management (World Health Organization) 2020.
3. Laboratory Biosafety Manual 4th edition and associated monographs- Personal Protective equipment (World Health Organization) 2020.
4. Laboratory Biosafety Manual 4th edition and associated monographs Biological Safety Cabinet and containment devices (World Health Organization) 2020.
5. National guidelines for stem cell research, Department of Biotechnology and Indian Council of Medical Research, 2017
6. National ethical guidelines for biomedical and health research involving human participants –Indian Council of Medical Research-2017
7. Ethics in research- Editors Lorella Congiunti, Francesco Lo Piccolo, Antonio Russo, Mario Serio https://doi.org/10.1007/978-3-031-24060-7 Springer 2023
8. An Introduction to Ethical, Safety, and Intellectual Property Rights Issues in Biotechnology Padma Nambisan eBook ISBN: 9780128092514 Elsevier 2017
9. On Being a Scientist, 3rdEdn., National Academy Press, USA, 2009.

BT3091E IMMUNOLOGY LABORATORY

L	T	P	O	C
0	0	4	2	2

Course Outcomes:

CO1: Investigate antigen-antibody interactions and apply the knowledge to diagnostic immunology
CO2: Explain the methods of studying immune reactions
CO3: Apply the principle of western blotting and demonstrate the presence of specific protein molecules

Syllabus/List of experiments

1. Lymphocytes isolation and staining
2. Purification of immunoglobulins.
3. Dot Enzyme-linked immunosorbent assay (ELISA)
4. Antibody Capture ELISA
5. Sandwich ELISA
6. Western blotting
7. Identification of blood group
8. Ouchterlony double diffusion.
9. Countercurrent immunoelectrophoresis
10. Latex agglutination
11. Immunoprecipitation
12. Quantitative precipitin assay
13. Phagocytosis assay
14. Complement fixation assay
15. qRT-PCR based immune cell gene expression assay (differentiation/infection)
16. Enumeration of bacterial infection load

References

1. Immunology and serology in laboratory medicine- Mary Louise Turgeon, 2020
2. Manual of Molecular and clinical lab immunology Barbara Detrick, Robert G. Hamilton, James D. Folds, American Society for Microbiology Press, 2016
3. Kuby Immunology by Jenni Punt, Sharon Stranford, Patricia Jones, Judith A Owen, WH Freeman; 8th ed. 2018.
4. Wilson, Keith, Andreas Hofmann, John M. Walker, and Samuel Clokie, eds. Wilson and Walker's principles and techniques of biochemistry and molecular biology. Cambridge University Press, 2018.

BT3011E PLANT BIOTECHNOLOGY

L	T	P	O	C
3	0	0	6	3

Total Lectures Session: 39

Course Outcomes:
CO1: Describe the basic concepts and principles of plant tissue culture and its application.
CO2: Evaluate different methods of plant transformation.
CO3: Assess the state-of-the-art techniques used in plant biotechnology.
CO4: Identify the biotechnological applications and metabolic pathways in plants.

Plant cell and tissue culture techniques:
Media composition, Sterilization and agents of sterilization used in tissue culture lab, Concept of plasticity and totipotency, Single cell clones and organogenesis, Artificial seeds, Micropropagation and its applications, Somatic embryogenesis, Protoplast culture and fusion, Embryo culture and embryo rescue, Shoot tip, Anther, pollen, and ovary culture for production of haploid plants, Cybrid production and its application in crop improvement, Cryobiology of plant cell culture and establishment of gene bank.

Tissue culture Applications
Tissue culture application: Production of haploids, germplasm conservation, production of secondary metabolites from plant cell culture, industrial production of useful biochemicals by higher-plant cell cultures, bioreactor systems.

Plant Transformation Technology
Agrobacterium mediated gene transfer and its application, features of Ti plasmid, hairy root, Structure and functions of Ti and Ri plasmids and their application, binary vectors, uses of 35S promoter, reporter genes, matrix attachment region, biolistic gene transfer, transgene stability and gene silencing;

Secondary Metabolite Pathways and Biotechnological applications
Shikimate pathway, Phenylpropanoid pathway, terpenoid synthesis pathways, Biotechnological applications: Mass multiplication of economically important plants, biopesticides, biofertilizers, phytoremediation, nutraceuticals, cosmeceuticals, biofuels, single-cell protein. Commercial status and public acceptance of genetically modified crops.

References:
1. C. N. Stewart Jr, Plant biotechnology and genetics: principles, techniques, and applications. John Wiley & Sons. 2016.
2. S. Umesha, Plant Biotechnology, 2nd Edn., CRC Press, 2019
3. A. Altman, P.M. Hasegawa, Plant Biotechnology and Agriculture: Prospects for the 21st century, 1st Edn., Academic Press, 2012.
4. A. Slater, N. Scott, and M. R. Fowler, Plant Biotechnnology: The Genetic Manipulation of Plants, 2nd Edn., Oxford University Press, 2008.
5. K. Oksman-Caldentey and W.H. Barz, Plant Biotechnology and Transgenic Plants, 1st Edn., CRC press, 2002.
6. H. Daniell and C. Chase, Molecular Biology and Biotechnology of Plant Organelles: Chloroplasts and Mitochondria, 1st Edn., Springer, 2007.
7. R. Verpoorte and A. W. Alfermann, Metabolic Engineering of Plant Secondary Metabolism, 1 st Edn., Springer, 2002.

BT3092E PLANT BIOTECHNOLOGY LABORATORY

L	T	P	O	C
0	0	4	2	2

Course Outcomes:

CO1: Acquire hands-on experience in various plant tissue culture techniques.
CO2: Demonstrate the plant regeneration processes, including regeneration from seeds, vegetative multiplication from axillary buds, and callus induction.
CO3: Demonstrate essential molecular biology techniques applicable to plant biotechnology

Syllabus / List of Experiments:

1. Requirements for Plant Tissue Culture Laboratory.
2. Techniques in plant tissue culture.
3. Media components and preparations.
4. Sterilization technique and inoculation of various explant.
5. Aseptic culture establishment of various explant.
6. Regeneration from seed.
7. Callus induction and plant regeneration
8. Vegetative multiplication from axillary buds.
9. Micropropagation of Banana.
10. Micropropagation of Rose.
11. Embryo and endosperm culture.
12. Protoplast isolation.
13. Genomic DNA isolation from plant sample.
14. Plasmid DNA isolation from *Agrobacterium*

References:

1. Trigiano, R. N. Plant Tissue Culture Concepts and Laboratory Exercises. CRC Press. 2018
2. Coleman, J., Evans, D., & Kearns, A. Plant Cell Culture. CRC Press. 2020
3. Mauseth, J. D., & Snook, A. Botany: A Lab Manual. Jones & Bartlett Learning, LLC. 2016
4. Plant Cell, Tissue and Organ Culture: Fundamental Methods. Springer Berlin Heidelberg. 2013

BT3093E PROJECT PART-I

L	T	P	O	C
0	0	6	3	3

Course Outcomes:

CO1: Apply the principles of natural science, mathematics and engineering for designing experiments to solve various complex problems in society, environment, health and industry.
CO2: Develop skills to use modern tools and equipment as an individual or team with professional and ethical commitments.
CO3: Disseminate the information gained during the hands-on experience through written reports and presentations.
CO4: Plan and execute the project objectives in a timely manner with appropriate financial management.
CO5: Demonstrate the ability to adapt and self-learn new techniques in the context of technological changes.

Objective:

The students will be given the flexibility to come up with project proposals in consultation with the faculty members. Students will form groups having a maximum of four members. At the end of the semester, students will submit a detailed project report and should give an effective presentation summarizing the methodology, structure, results and conclusions of the project work to an evaluation committee duly constituted for the purpose.

BT4091E INTERNSHIP

L	T	P	O	C
0	0	4	2	2

Course Outcomes:

CO1: Identify the layout, machinery, organizational structure and production processes in industry/research laboratory.

CO2: Implement the industrial practices and work culture as an individual, team member or leader in multidisciplinary settings.

CO3: Evaluate the impact of engineering solutions in a global, economic, environmental and societal context.

CO4: Communicate effectively on complex engineering activities with the engineering community and with society at large by Technical report and presentation.

Objectives:

The students should connect with industry/ laboratory/research institute and get practical knowledge on research/production processes. During the internship, they develop skills to carry out research in the research institutes/laboratories. They should undergo training individually in reputed firms/ research institutes / laboratories for the specified duration of 2 months. After the completion of training, a detailed report should be submitted within ten days from the commencement of next semester. The students will be evaluated as per the Regulations.

BT4092E PROJECT PART-II

L	T	P	O	C
0	0	6	3	3

Course Outcomes:

CO1: Apply the principles of natural science, mathematics and engineering for designing experiments to solve various complex problems in society, environment, health and industry.
CO2: Develop skills to use modern tools and equipment as an individual or team with professional and ethical commitments.
CO3: Disseminate the information gained during the hands-on experience through written reports and presentations.
CO4: Plan and execute the project objectives in a timely manner with appropriate financial management.
CO5: Demonstrate the ability to adapt and self-learn new techniques in the context of technological changes.

Objective:

The students will be given the flexibility to come up with project proposals in consultation with the faculty members. Students will form groups having a maximum of four members. At the end of the semester, students will submit a detailed project report and should give an effective presentation summarizing the methodology, structure, results and conclusions of the project work to an evaluation committee duly constituted for the purpose.

BT2021E ENZYME KINETICS AND TECHNOLOGY

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Apply the rules of enzyme classification and principles of enzyme catalysis in metabolic reactions.
CO2: Analyze and investigate the enzyme kinetics and give appropriate interpretations on kinetic parameters of free and immobilized enzymes.
CO3: Investigate the enzyme inhibition kinetics and apply modern computational tools for interpretation of kinetic data.
CO4: Propose strategies for quantifying enzyme activity and improve catalytic efficiency in the context of industrial applications.

Introduction to Enzymes
Classification and nomenclature of enzymes: Hydrolases, Oxidoreductases, Peptidases, Esterases, Lyases, Kinases, ATPases, Ligases; Conformation and stereochemistry: Nomenclature: d/l, D/L, R/S; Importance of shapes in biological reactions, Chirality- diastereomers and prochiral molecules.

Catalytic reaction kinetics
Basic catalytic principles, Factors contributing to enzymatic catalytic rates, Single and multi-substrate systems, Quantification of enzyme activity; Michaelis-Menten theory and kinetics, Initial velocity, Steady state kinetics, Multi-substrate Kinetics (ping-pong, bi-bi);

Enzyme inhibition and binding kinetics
Enzyme inhibition, Enzyme inhibition kinetics; Enzyme-Substrate binding kinetics (Hill equation), Allosteric enzyme; Effect of pH and temperature on enzyme activity, Role of metal ions in enzyme activity; Roles and mechanisms of co-factors and co-enzymes in enzyme catalytic activity;

Enzyme Engineering
Enzyme immobilization, Effect of immobilization on enzyme activity, Immobilized enzyme kinetics; Structural enzymology, Enzyme Engineering: Improvement for thermal stability, catalytic activity, Chemical modifications & site-directed mutagenesis, role of enzyme engineering in industry;

References:
1. Palmer, T., & Bonner, P. L. Enzymes: biochemistry, biotechnology, clinical chemistry. Elsevier. 2007
2. Svendsen, A. (Ed.). Understanding Enzymes: Function, Design, Engineering, and Analysis. CRC Press. 2016
3. Punekar, N. S. Enzymes: catalysis, kinetics and mechanisms. Springer. 2018
4. Suzuki, H. How enzymes work: from structure to function. CRC Press. 2019

BT2022E BIOPHYSICS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Apply the basic principles of physical interaction on biological systems
CO2: Analyse the theories that formulate the biomolecular interfaces
CO3: Apply the fundamentals of bioenergetics and diffusion dynamics to interpret the properties of biological materials
CO4: Illustrate the physical functioning principles of membrane organelles and molecules in living systems.

Molecular Structure & Interactions of Biological Systems
Molecular and Ionic intermolecular interactions as the basis for biological structure formation: Hydration radii, Debye-Huckel Radii, Intermolecular interactions;

Biomolecular interfaces
Interfacial phenomena and Membranes: Surface tension, Phase boundaries, Adsorption Isotherms, Self-assembly, van der Waals theory, Electrical Double layers, DLVO theory;

Energetics and Dynamics of Biological Systems
Fundamentals of Thermodynamics & Equilibrium: Free Energy, Entropy, Van't Hoff Equation; Diffusion dynamics and kinetics: Flux, Brownian Diffusion, Stokes-Einstein Equation; Mechanical Properties of Biological materials: viscosity, Visco-elastic properties; Crowded and Disordered dynamics;

Physical principles in Living Systems
Dynamics of Molecular Motors; Mitochondrial Fission & Fusion dynamics; Membrane Lipid Diffusion Dynamics; Protein Folding Kinetics;

References:
1. Glaser, R. Biophysics: an introduction. Springer Science & Business Media. 2012
2. Phillips, R., Kondev, J., Theriot, J., & Garcia, H. Physical biology of the cell. Garland Science. 2012
3. Cotterill, R. Biophysics: An Introduction. John Wiley & Sons. 2003
4. Dillon, P. F. Biophysics: a physiological approach. Cambridge University Press. 2012
5. Rubin, A. B. Fundamentals of Biophysics. John Wiley & Sons. 2014
6. Haynie, D. T. Biological Thermodynamics. Cambridge University Press. 2008

BT2023E BIOENERGY AND BIOFUELS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Identify and describe the properties of properties and different types of bioenergy and biofuels
CO2: Design processes of biomass conversion which is useful especially for biofuel production
CO3: Explain the concepts of bioenergy from biomass as source of alternative energy
CO4: Apply basic knowledge to select appropriate biofuel feedstocks for microbial fuel cells and production of biofuel of interest

Introduction and Perspective of Bioenergy and Biofuels
Overview of biofuel, bioenergy and biorefinery concepts, current energy consumption, Fundamental concepts in understanding biofuel/bioenergy production, Fossil versus renewable energy resources, economic impact of biofuels, Comparison of Bio-energy Sources, Biorefinery, Biofuel production and applications.

Processes for biomass conversion
Introduction to thermochemical, biochemical, and mechanical processes, Types of reactors, chemical equilibrium and reaction kinetics, Thermochemical conversion (pyrolysis, gasification, reforming, combustion), Biochemical conversion (various metabolic process, chemical oxygen demand and biological oxygen demand, anaerobic digestion, fermentation); Oil extraction and esterification; Pretreatment of biomass (pelleting; chipping; biodrying, etc.); Management of solids / liquids / gaseous biomass process waste.

Bioenergy from biomass as source of alternative energy
Biomass and its properties and types: proximate and ultimate analysis, calorific value, density, moisture content, Type 1: ligno-cellulosic, starchy, sugar, oilseeds; Type 2: municipal residual waste, organic waste, sewage sludge, manure; Type 3: biofuels from biomass conversion processes (solid: biochar; liquids: bioethanol and biodiesel; gaseous: biogas and syngas).Wet milling of grain for alcohol production, grain dry milling cooking for alcohol production, use of cellulosic feed stocks for alcohol production chemistry of biodiesel production; Biodiesel production by using various microorganisms, algae and Transesterification process: Chemistry of biodiesel production, oil Sources and production by plants and other sources, methods of biodiesel production

Biofuel feedstocks and production of biofuel
Various types of feedstocks, starch feedstocks, sugar feedstocks, lignocellulosic feedstocks, plant oils and animal fats, miscellaneous feedstocks; Ethanol production from sugar, starch feedstock and lignocellulosic feedstocks; Different enzymes, enzyme hydrolysis, and their applications in ethanol production; fermentation process and types of fermenters, bioreactor operation and design. Microbial fuel cells, Microbiology of methane production, biomass sources for methane production, biogas composition and use, biochemical basis of fuel cell design

References:

1. Erick J. Vandamme, Wim Soetaert, Biofuels, Wiley, 2011
2. Caye M. Drapcho,Terry H. Walker, Biofuels Engineering Process Technology M.G.Hills.2nd Edn 2020
3. Butterworth-Heinemann, Biotol series, VCH Ellis Horwood,Product Recovery in Bioprocess Technology, Elsevier,1992
4. Vaughn C. Nelson, Kenneth L. Starcher, Introduction to Bioenergy,CRC Press, 2016
5. G. N. Tiwari and M. K. Ghosal,, Fundamentals of Renewable Energy Sources, Narosa Publishing House, , 2007

BT2024E FOOD PROCESS TECHNOLOGY

L	T	P	O	C
3	0	0	6	3

Total Lectures Session: 39

Course Outcomes:
CO1: Understand the role of biotechnology in food processing and fermented food production.
CO2: Know principal types of microorganisms used in the food industry.
CO3: Delineate food safety issues and new biotechnologies bacterial, plant and animal products.
CO4: Comprehend food preservation by physical, chemical and biological agents.

Introduction to Food Process Technology
Food processing, Nutritional values of food, Use of enzymes in food industry, Factors affecting growth and survival of microorganisms in food, Single cell protein, genetically modified food, Fermented food products, Dairy products- Fermented milk, Cheese, Butter, Fermented Meat, Fermented fish.

Food Microbiology
Microbiology of milk & milk products like cheese, butter, ice-cream, milk powder; Microbiology of meat, fish, poultry & egg and their products. Food spoilage, Bacterial agents of food borne illness- *Clostridium, Salmonella, Vibrio*, Non-bacterial agents of food borne illness - Helminthes, protozoa, Algae, Fungi, Viruses

Food Preservation
Role of chemicals and enzymes in food preservation, Biochemical engineering for flavor and food production, Microbiology of food preservation-physical, chemical and biological based preservation system, Canning: Preservation principle of canning of food items.

Food Safety Issues and new biotechnologies
Food standards, safety evaluation of novel food products, genetically modified microorganisms and their products, genetically modified plants and their products, genetically modified animals and their products, detection methods of GM crops.
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References:
1. Fellows, P. J. Food Processing Technology: Principles and Practices. 5th Edn., Woodhead Publishing, 2022.
2. Lee, B. H. Fundamentals of Food Biotechnology. 2nd Edn., United Kingdom: Wiley, 2015.
3. Johnson-Green, P. Introduction to Food Biotechnology, CRC Press, 1st Edn., 2018.
4. Jay, J. M., Loessner, M. J., D. A. Golden, D. A. Modern Food Microbiology, 7th Edn., Springer, 2006.

BT2025E INTEGRATED PHYSIOLOGY AND PHARMACOLOGY

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: To provide students with a comprehensive understanding of the principles of both physiology and pharmacology and their interplay in maintaining human health and treating diseases

CO2: To develop critical thinking skills in evaluating the therapeutic uses, efficacy, and safety of drugs based on their physiological effects

CO3: To facilitate the application of physiological concepts and the pharmacological basis of drug action to real-world scenarios and health-related issues

CO4: To prepare students for careers in healthcare, pharmaceutical research, or related fields by providing a strong foundation in both physiology and pharmacology

Foundations of Integrated Physiology and Pharmacology: Nervous and Musculoskeletal Systems

Overview of the discipline of physiology, Levels of organization in the human body, Homeostasis and control systems - Definition and scope of pharmacology, Integration of physiological and pharmacological concepts, Importance of understanding drug effects in the context of human physiology - Nervous System, Structure and function of neurons, Nerve impulse transmission, Organization of the nervous system, Major drug classes for treating CNS disorders (e.g., sedatives, analgesics, antidepressants, antipsychotics), Mechanisms of action and therapeutic uses of CNS drugs - Musculoskeletal System, Structure and function of skeletal muscle, Sliding filament theory of muscle contraction, Skeletal system and its physiological roles

Cardiovascular and Respiratory Physiology and Pharmacology

Cardiovascular System, Heart structure and function, Cardiac cycle and regulation of heart rate, Blood vessels and circulation, Regulation of blood pressure, Pathophysiology of cardiovascular diseases, hypertension, coronary artery disease, and heart failure, Pharmacology of drugs used to treat cardiovascular diseases, Antihypertensives, antiarrhythmics, and vasodilators, Drugs for managing heart failure and thromboembolic disorders, Pharmacological approaches to dyslipidemia and atherosclerosis - Respiratory System, Structure and function of the respiratory system, Gas exchange and transport, Respiratory adaptations to exercise and altitude, Pathophysiology of respiratory disorders, asthma, chronic obstructive pulmonary disease (COPD), and respiratory infections, Drugs for managing asthma, chronic obstructive pulmonary disease (COPD), and allergic rhinitis, Bronchodilators, corticosteroids, and antihistamines

Physiology, Pharmacology, and Pathophysiology of the Digestive and Renal Systems

Digestive System, Structure and function of the gastrointestinal tract, Digestion and absorption of nutrients, Pathophysiology of common gastrointestinal disorders, irritable bowel syndrome (IBS), gastroesophageal reflux disease (GERD), and inflammatory bowel disease (IBD), Pharmacology of drugs used in gastrointestinal disorders (e.g., acid-related disorders, inflammatory bowel disease, nausea and vomiting), Proton pump inhibitors, H2-receptor antagonists, and antidiarrheal agents, Pharmacotherapy for constipation and peptic ulcer disease - Renal and Urinary System, Structure and function of the kidney, Urine formation and composition, Regulation of water and electrolyte balance, Acid-base balance and excretion of waste products, Pathophysiology of renal disorders, acute kidney injury (AKI), chronic kidney disease (CKD), and urinary tract infections, Diuretics and their mechanisms of action, Pharmacology of drugs used in renal disorders (e.g., hypertension, renal failure, urinary tract infections)

Endocrine, Reproductive, and Immune System Physiology and Pharmacology

Endocrine System, Major endocrine glands, hormones and their actions, Common endocrine disorders, diabetes, thyroid dysfunction, and adrenal gland disorders, their pathophysiology, and the impact on physiological function, Antidiabetic agents, thyroid and anti-thyroid drugs, and corticosteroids - Reproductive System, Male and female reproductive organs, Menstruation, Gametogenesis, fertilization, and early development, Contraceptives, In vitro Fertilization, Common reproductive disorders, polycystic ovary syndrome (PCOS), endometriosis, and erectile dysfunction, Pharmacotherapy for reproductive and hormonal disorders - Immune System, Components of the immune system, Innate and adaptive immunity, Immune responses and disorders, Vaccination and immunotherapy, Pharmacotherapy for autoimmune diseases, inflammation, and immunodeficiency

References:

1. Eric P. Widmaier; Hershel Raff; Arthur J. Vander. Vanders Human Physiology. McGraw-Hill US Higher Ed ISE, 16th Edition, 2023. ISBN: 1264125739, 9781264125739.

2. J. Gordon Betts, Peter DeSaix, Eddie Johnson, Oksana Korol, Dean H. Kruse, Brandon Poe, Kelly A. Young, James A. Wise. Anatomy and Physiology. Openstax, 2022. ISBN: 1938168135, 9781938168130, 1947172042, 9781947172043, 1938168305, 9781938168307.
3. Elaine N Marieb, Katja N. Hoehn. Human Anatomy & Physiology, Global Edition. Pearson, 12th Edition, 2022. ISBN: 1292421800, 9781292421803.
4. Craig Stevens. Brenner and Stevens' Pharmacology. Elsevier, 6th Edition, 2022. ISBN: 0323758983, 9780323758987.
5. Shane Bullock, Elizabeth Manias. Fundamentals of Pharmacology. Pearson, 9th Edition, 2022. ISBN: 9780655702474.
6. Derek G. Waller, Andrew W. Hitchings, Anthony P. Sampson. Medical Pharmacology and Therapeutics. Elsevier, 6th Edition, 2022. ISBN: 0702081590, 9780702081590.
7. Henry Hitner, Barbara Nagle, Michele B. Kaufman, Hannah Ariel, Yael Peimani-Lalehzarzadeh. Pharmacology: An Introduction. McGraw Hill, 8th Edition, 2021. ISBN: 1260021823, 9781260021820.
8. C. P. Page. Dale's pharmacology condensed. 3d Edition, 2021. ISBN: 9780702078187, 0702078182.

BT2026E ADVANCED CYTOGENETICS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Explain genomic architecture, chromosome functions, and the relationship of nuclear structure to function
CO2: Apply the knowledge of chromosome organization and decipher the relation between chromosome copy number and diseases
CO3: Illustrate the techniques used in the study of chromosome and DNA
CO4: Describe the principles of clinical cytogenetics and diagnostics

Introduction to genetics, chromosome structure, function, and abnormalities
Introduction to cytogenetics-DNA-chromosomes and cell division, chromatin, chromosome replication and its segregation, structure of chromatins, Nucleosomes, centrosome, Karyotype analysis, Sex determination, and sex chromosomes, Sex chromosome X and Y, Structural chromosome abnormalities, Chromosome inactivation, Variations in chromosome number and structure

Mendelism, inheritance and genetic diseases
Mendelism, the basic principles of inheritance, the chromosomal basis of Mendelism, chromosomal rearrangement associated with Mendelian disorders-Eukaryotic chromosome-Telomeres-Extrachromosomal replicons-linkage-crossing over-chromosome mapping in eukaryotes-Genetic diseases X-linked, autosomal inheritance-chromosome rearrangements, inversions, translocations

Developmental, population, and evolutionary genetics
Inheritance of complex traits, Genetic control of development-sex determination of Drosophila, C. Elegans, Zygotic gene activity in development-population genetics-evolutionary genetics, variation in phenotypes, chromosome structure, nucleotide sequences, molecular evolution, genetics of speciation

Molecular cytogenetics and techniques
Cytogenetic approaches for studying human diseases-cancer cytogenetics-molecular cytogenetics, and Techniques-Fluorescence in situ hybridization-comparative genomic hybridization, Array comparative genomic hybridization, multi-color fluorescence in situ hybridization, fluorescence in situ hybridization detection of HER2 amplification

References:
1. Principles of Genetics, 7th edition, Peter Snustad & Michael J. Simmons, 2015 ISBN: 978-1-119-14228-7
2. Concepts of Genetics, 12th Global Edition Michael R. Cummings, William S. Klug, Charlotte A. Spencer, Michael A. Palladino and Darrell Killian 2019 ISBN 9781292265322
3. Lewin,s GENES XII, 12th edition Jocelyn E. Krebs, Elliott S Goldstein, Stephen T. Kilpatrick, 2018, ISBN 9781284104493
4. Molecular Cytogenetics Barbara Ann Hamkalo, John Papaconstantinou ISBN 978-1-4615-7481-1 2012

BT2061E INNOVATION ENTREPRENEURSHIP & IPR

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Build knowledge about Sources of Information and Support for Entrepreneurship
CO2: Demonstrate the concept of Innovation, Intellectual Property Rights (IPR) and Technology Business incubation
CO3: To develop and strengthen entrepreneurial quality and motivation in students and to impart basic entrepreneurial skills and understanding to run a business efficiently and effectively.
CO4: Identify and evaluate new business opportunities in biotechnology

Syllabus:

Introduction to innovation and idea development: Introduction to Innovation, managing innovation, types of innovation, creativity, concept of design thinking, measuring innovation, Novelty -definition, identification- Protection of innovation - Introduction to Intellectual Property Rights – IPR, Patents, Trademarks, Copy Rights, grassroots innovation, Issues and Challenges in Commercialization of Technology Innovations. Concept of novelty and inventive steps in biotechnology. Patent laws related to microbial, pharmaceutical, environmental and agricultural inventions, case studies in public health,

Entrepreneurship basics – scope of entrepreneurship, characteristics of an entrepreneur, building a business, business plan, concept of lean canvas model, Entrepreneurship and Innovations, Converting Innovation to Economic Value - Growth Strategies, value proposition, Market Segments, Revenue Model, Social Entrepreneurship, Intrapreneurship, biotechnology entrepreneurship case studies.

Technology product development, Technology Life Cycle, how to implement and manage a technological innovation, new product development, managing the resources, technology business incubation, Sources of Information and schemes to support technology entrepreneurship, overview of the steps involved in the technology development in biotechnology.

Functional areas of entrepreneurship - marketing management, operations management, personnel management, financial management, procedure and formalities in setting up an Industrial unit, Problems for Small Scale Enterprises and Industrial Sickness.

Site visits to understand the Entrepreneurship activities of startups.

References:

1. K.D. Sibley, The Law & Strategy of Biotechnology Patents, Butterworth-Heinemann, 1994.
2. Hisrich R D, Peters M P, “Entrepreneurship” 8th Edition, Tata McGraw-Hill, 2013
3. Holt David H., Entrepreneurship: New Venture Creation, Pearson Education, 2016
4. Debasish Biswas, Chanchal Dey, Entrepreneurship Development in India, 2021, Taylor & Francis
5. Tarek Khalil, Management of Technology, Tata McGraw-Hill
6. Barringer, B. R. (2015). Entrepreneurship: Successfully launching new ventures, Pearson Education India
7. Desai, Vasant, Small-Scale Industries and Entrepreneurship. Himalaya Publishing House, Delhi. 2008
8. Donald F. Kuratko, Entrepreneurship: Theory, Process, Practice. Cengage Learning India, Delhi, 2017
9. Cynthia, L. Greene . Entrepreneurship Ideas in Action. Thomson Asia Pvt. Ltd., Singapore. 2004

BT2071E PYTHON FOR BIOLOGISTS

L	T	P	O	C
2	0	2	5	3

Total Sessions: 26L + 26P

Course Outcomes:
CO1: Explain the basic principles of Python programming language
CO2: Demonstrate the ability to perform common UNIX command-line tasks
CO3: Use Python to write scripts and programs for data manipulation and analysis in biology
CO4: Develop and apply algorithms for solving biological problems using Python
CO5: Analyze and interpret biological data using Python

Introduction to Python and Data structure type
Introduction to Python Programming and Environment: Basic UNIX Command, Python Syntax and Basic Data type, Flow control, and function definitions- Data structure in Python: Lists, tuples and dictionaries, string manipulation, regular expression**.**

Reading and Writing files in Python
Reading and Writing Files in Python-Introduction to data formats (e.g., CSV, FASTA, GenBank) Parsing and processing biological data files using Python,

Data Analysis and Visualization
NumPy and Pandas for data manipulation in Python, Matplotlib and Seaborn for data visualization such as heatmaps, scatter plots, or box plots, Data analysis and statistical tests in Python- visualizing biological networks, such as gene regulatory networks or protein-protein interaction networks using Python.

Biological Applications and Algorithms in Python
Algorithms and Data Structures in Python: Sorting and searching algorithms, Trees and graphs data structures, Algorithm design and optimization for biological problems-Retrieving the protein and DNA sequence data, Sequence analysis and alignment, Phylogenetic analysis.

List of Experiments:
1. Practice Common UNIX commands (Module 1)
2. Variable Creation and assignments with Basic arithmetic operations (Module 1)
3. Basic String manipulation operations (Module 1)
4. Working with Loops and Lists (Module 1)
5. Reading a common file type (Module 2)
6. Converting the file formats (Module 2)
7. Running Bioinformatic programs from within Python (Module 2)
8. Extract relevant information from the BLAST results, such as E-values, and sequence similarities (Module3)
9. Write script to generate interactive visualizations of biological data, such as heatmaps & box plots (Module3)
10. Biological Network Analysis using Python libraries (Module 3)
11. Sequence Retrieval and download from biological databases using python (Module 4)
12. Regulation Expression Search (Module 4)
13. Python libraries like Biopython or PyMOL to parse protein structure files like PDB format (Module 4)

References:

1. Martin Jones, Python for Biologists, 1st Edn, Createspace Independent Publishing Platform, 2013
2. Jake VanderPlas, Python Data Science Handbook: Essential Tools for Working with Data, 1st Edn, Shroff/O'Reilly, 2016.
3. Michael T. Goodrich, Data Structures and Algorithms in Python, 1st Edn, Wiley, 2013.
4. Tiago Anta, Bioinformatics with Python Cookbook, 2nd Edn, CBC Publisher, 2018.
5. Mitchell L. Model, Bioinformatics Programming using Python,1st Edn Shroff/O'Reilly, 2019.
6. Mitchell L. Model, Bioinformatics Programming Using Python: Practical Programming for Biological Data, 1st Edn, 2017.
7. Yasha Hasija, Hands-on Data Science for Biologists using Python, CRC Press, 1st Edn, 2021

BT3021E BIOREACTOR DESIGN AND ANALYSIS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Make use of basic fundamentals involved in biochemical reactions and its applications
CO2: Analysis of mass and energy balances to design the bioreactors
CO3: Correlation between biological and engineering design for effective bioreactor configuration
CO4: Fabrication of precise bioreactors for bioprocess of cells and metabolites

Biochemical Reactions and Bioreactor Configuration

Principles and kinetics of chemical and biochemical reactions - Fundamentals of homogeneous reactions for batch, plug flow, semi-batch, stirred tank/ mixed reactors, Energy and mass balances inbiological reaction modeling, Types of bioreactors and their configurations, Classification based schuegerl, kafarov components of bioreactors and their operation.

Ideal Reactors

Reactors based on flow characteristics, ideal and non-ideal bioreactors, Design of ideal reactors, Material and energy balance, Batch bioreactor design, Performance equations for ideal reactors and non-isothermal reactors, Batch reactor analysis for kinetics (synchronous growth and its application in product production), Design and analysis of fed batch systems.

Reactor Design for Different Systems

Definition of chemostat and turbidostat, Single flow single stage chemostat, Single flow multistage chemostat, Chemostat with recycle, Concepts of dilution rate and productivity analysis in CSTR, Plugflow analysis, Design of plug flow reactor, comparison of productivity in plug flow and chemostat.

Non-ideal Reactor Systems

Non-ideal flow in bioreactors, Reasons for non-ideality, Mixing time and Residence time distributions, Models for non-ideal reactors, plug flow with axial dispersion, tanks-n-series model, Multiphase bio reactors, Packed bed reactors, Air-lift reactors, Bubble column reactors, Fluidized bed reactors, Tricklebed reactors, Stability analysis of bioreactors.

References

1. A. Moser, Bioprocess Technology - Kinetics and Reactors, 2nd Edition, Springer Verlag. 2012
2. O. Levenspiel., Chemical Reaction Engineering, 3rd Edition, John Wiley Eastern Ltd. 2006
3. J.E. Bailey, D.F. Ollis, Biochemical Engineering Fundamentals, 3rd Edition, McGraw-Hill. 2017
4. B. Atkinson, Biological Reactors, 2nd Edition, Pion Ltd. 2011
5. H. W. Blanch and D. S. Clark, Biochemical Engineering, 1st Edition, CRC Press. 1997

BT3022E STRUCTURAL BIOLOGY

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Conceptualize the three dimensional structures of different biomolecules.
CO2: Correlate the structural integrity of proteins, nucleic acids and lipids with their corresponding functions
CO3: Apply the principles of molecular structure determination techniques to identify the interactions
CO4: Determine the possibility of molecular interactions using mathematical analysis.

Hierarchy of Protein Structures
Brief discussions: Amino acids, Nucleotides, Carbohydrates, Lipid, Chirality of biological molecules;
Structure of proteins, Composition and primary structures of proteins, Secondary structure of proteins-alpha helix, beta sheet, coiled-coiled. Three dimensional conformations, Motifs, Fold, Properties of structures, Ramachandran plot, Membrane proteins, Globular and Fibrous proteins, Quaternary structures-dimers, homodimers and heterodimers, tetramers; Protein folding

Nucleic Acid structures and Protein-Nucleic Acid interactions
Principles of nucleic acid structures, Base pairing, Base stacking, Stabilized forms of DNA-A, B and Z forms, Melting of DNA double helix, RNA folding and catalysis; Protein-DNA interactions, Transcription factors.

Protein-Ligand/Lipid interactions
Protein-protein interactions: Antigens and antibodies, Protein-lipid interactions, Ribosomes, Protein-carbohydrate interactions. Protein-ligand interactions, Scatchard plot, Co-operative interactions, Allosteric effect, Hill constants.

Analytical Methods
Computational Structural Analysis; Surface Plasmon Resonance; Quartz Crystal Microbalance with Dissipation; Isothermal Titration Calorimetry; X-ray spectroscopy; Optical spectroscopy: Fluorescence Spectroscopy; Circular Dichroism; Mass spectrometry; Structure analysis using NMR and cryo-electron microscopy.

References:
1. Branden, C. I., & Tooze, J. Introduction to protein structure. Garland Science. 2012
2. Lesk, A. Introduction to protein science: architecture, function, and genomics. Oxford university press. 2010
3. Pal, S. Fundamentals of Molecular Structural Biology. Academic Press. 2019
4. Buxbaum, E. Fundamentals of protein structure and function (Vol. 31). New York: Springer. 2007
5. Meyerkord, C. L., & Fu, H. Protein-protein interactions. Springer, New York. 2015
6. Tripathi, T., & Dubey, V. K. (Eds.). Advances in protein molecular and structural biology methods. Academic Press. 2022

BT3023E BIOMECHANICS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Apply the mechanical principles to perceive human contact and motion
CO2: Analyse the biomechanics of movement through bone-muscle relationship.
CO3: Discover the physical basis of bone and muscle movement
CO4: Calculate the biological properties using standard mathematical models and measurements.

Mechanical Analysis of Human Contact & Motion
Mechanical behavior of bodies in contact, relationship between work, power and energy – Angular kinematics of human movement-measuring angles, angular kinematic relationships –relationships between linear and angular motion – Angular kinetics of human movement-resistance to angular acceleration, angular momentum – Equilibrium and human movement-equilibrium, center of gravity, stability and balance – Kinematic concepts for human motion-forms of motion and joint movement terminology – Kinetic concepts for human motion-basic concepts related to kinetics .- mechanical loads on the human body .

Biomechanics of Bone
Bone structure & composition, blood circulation in bone – mechanical properties of bone, viscoelastic properties of bone – Maxwell & Voight models – viscoelastic properties of articular cartilage – Anisotropy and composite models for bone – Bone growth and development – Bone response to stress – Osteoporosis – causes, diagnosis, treatment – Elasticity and strength of bone. Biofluid Mechanics, Newtonian viscous fluid, non viscous fluid – Rheological properties of blood – Structure and composition of blood vessel – Remodeling of blood vessels – Nature of fluids, Propulsion in fluid medium – Mechanical properties of arterioles, capillary vessels and veins – Bio-viscoelastic solids.

Biomechanics of Muscles
Structure of skeletal muscle –muscle fibers, motor units – Structure of skeletal muscle-fiber types, fiber architecture – Sliding element theory of skeletal muscle.- Skeletal muscle function – Contraction of skeletal muscle and Hill"s three element model – Factors affecting muscular force generation – Muscular strength, power and endurance – Muscle injuries. Structure of the shoulder – Movements of shoulder complex – Loads on the shoulder – Structure of the spine – Movements of the spine – Muscles and loads on the spine – Structure and movements of the hip – Loads on the hip.

Mathematical overview of Biomechanics:
Units of measurements - Vector analysis - Coordinate systems. Forces and moments - Muscle forces Statics - Newton's laws - Solving problems - Simple musculoskeletal problems - Advance musculoskeletal problems Kinematics - Rotational and Translational motion - Displacement, Velocity and acceleration Kinetics - Inertial forces - Work Energy and power - Friction

References:
1. Susan J Hall, "basic biomechanics", Tata Mcgraw hill, 4th edition, 2004.
2. Schneck D J, and Bronzino J D, "Biomechanics- Principles and Applications", CRC Press, 2nd Edition, 2000.
3. Duane Knudson, "Fundamentals of Biomechanics", Springer, 2nd edition, 2007.
4. Fung Y C, Biomechanics: "Mechanical Properties of Living Tissues", Springer, 2nd edition, 1993.

BT3024E DRUG DISCOVERY & DEVELOPMENT

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Explain the fundamentals of drug discovery to develop innovative therapeutics with different modalities.
CO2: Apply bioinformatics tools for target identification and to understand the drug and target interactions.
CO3: Design drug repurposing and prediction of new lead molecules using computational analysis.
CO4: Analyze and interpret the quantitative and qualitative relationship of drug molecules with their biological activity.

Introduction and historical perspective on drug discovery and development
Introduction and history: The drug discovery process: From ancient times to the present day, Explain the basic principles of drug design and discovery, including disease selection, Concept of target, different approaches to identify drug targets, Target validation, Single target versus multi-targets approaches, Off target and adverse effects, Drug repurposing, lead optimization, and clinical development, Examples of few drug discovery in old days and recent times, Small molecules vs Biopharmaceuticals, LD50, ED50, LC50, EC50, MIC and MEC.

In-silico drug designing
Internet as a source of-BIG DATA–Introduction to Open Source and Commercial in silico tools and software, Datasets- Drug Bank, Dr. Duke's Phytochemicals, Binding Database, TTD, Kegg, Pub Chem, ChEMBL, Structure drawing software–ChemDraw, Marvin Sketch, CD/Chemsketch, Homology Modeling- Modeller, Prime, SWISS Model Docking–Argus Lab, Autodock, FLOG, Cdocker, Glide QSAR–PaDEL, Excel, QSARINS, PHAKISO ADMET–PreADME, ADMETox, AlphaFOLD- Target understanding at the molecular level, lead optimization and in-silico validation, Structure and ligand-based drug design, Molecular docking and docking algorithms, drug-receptor interactions, Docking Software's–ArgusLab and Autodock-de-novo ligand design, Evaluate ADME-Tox properties to enhance drug candidate quality, Pharmacodynamics and Pharmacokinetics, Designing and development of disease model-Quantitative Structure-Activity Relationship: Lipophilicity, electronic and steric factors, Hansch analysis, Free Wilson analysis, QSAR, 3D–QSAR with comparative molecular field analysis (CoMFA) and comparative similarity indices analysis (CoMSIA), Validation of QSAR model

Molecular Modeling and simulations
Data representation and formats: Data formats for 2D, SMILES/InChI notations, matrix representation, connection tables, 3D data formats, PDB, CIF, RES, Mol2, SDF formats, Z-matrix, topology and parameter files, the chirality of drugs and its consequences, diastereomers, meso compounds, stereogenic unit and stereogenic center- Molecular and quantum mechanics: Energy minimization methods for ligand and protein using force fields and programs, MM, AMBER, CHARMM, OPLS, GROMOS, GROMACS, CVFF, Deriding and Universal force field- Lead optimization, Conformational Analysis: local and global energy minima, identification of bioactive conformation. Bioactive vs. global minimum conformations- Molecular dynamics: Dynamics of drugs, biomolecules, drug-receptor complexes, Determination of B-max and Kd by transforming data with hill plot and Scatchard plot Idea about classical method, Langevin method, QM method. Molecular Dynamics using simple models. Monte Carlo simulations and Molecular dynamics in performing a conformational search- De Novo drug Design–General principles, Automated de-Novo drug design–LUDI, SPROUT, LEGEND

Case Studies and Recent Trends in Drug Discovery
Translational Medicine and Biomarkers, Organizational Considerations and Trends in the Pharmaceutical Industry, Approaches and methodologies of drug repurposing, Examples of Repositioned drugs in different diseases, Opportunities and challenges, Regulatory and intellectual property issues, Case Studies in Drug Discovery, recent trends, and project with hands-on sessions.

References:
1. Nag A, Dey B. Computer-aided Drug Design and Delivery Systems: McGraw-Hill, 2011.
2. Hill RG, Richards D. Drug Discovery and Development: Drug Discovery and Development E-Book: Elsevier Health Sciences; 2021.
3. Roche VF, Zito SW, Lemke TL, Williams DA. Foye's Principles of Medicinal Chemistry: Wolters Kluwer; 2020.
4. Höltje HD, Sippl W, Rognan D, Folkers G. Molecular Modeling: Basic Principles and Applications: Wiley; 2008.

5. Piantadosi, Steven. Clinical Trials: A Methodologic Perspective. Germany, Wiley, 2017
6. Schlick T. Molecular Modeling and Simulation: An Interdisciplinary Guide: Springer New York; 2013.
7. Molecular Modelling: Principles And Applications, 2/E: Pearson Education; 2009.

BT3025E MARINE BIOTECHNOLOGY

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Demonstrate a comprehensive understanding of the theories and processes involved in the production of marine pharmaceuticals
CO2: Identify and analyze the various causes of marine pollution, ranging from industrial runoff to plastic waste, and develop strategies to prevent and mitigate these pollution sources.
CO3: Assess the economic, ecological, and cultural importance of marine ecosystems and their role in maintaining biodiversity and ecosystem services.
CO4: Analyze the theory and rationale behind the production of genetically modified fish, including the ethical considerations and environmental impacts associated with this technology.

Syllabus:
Types of marine environment - Physical, Chemical and Biological aspects, Marine organisms, Types of marine microbes and their biology; Introduction to marine pharmacology, Microbial metabolites, Microbial interaction Microbes of Biotechnological importance, Primary and secondary metabolite. Bioaugmentation, Biofouling, Corrosion Process and control of marine structures, Bioremediation, Nutrient cycling, Bio-fertilization,

Probiotics, Regulation of bacterial growth, Marine pollution-major pollutants (heavy metal, pesticide, oil, thermal, radioactive, plastics, litter and microbial), Biological indicators and accumulators. Marine resources assessment, Methods of surveying the living resources (Acoustic, Aerial and Remote sensing), Population study and Marine environment protection Population dynamics, Abundance and density, Growth and mortality (fishing & natural),

Algal biotechnology single cell protein, hydrocolloids, agarose, carrageen alginates and other byproducts. Marine Enzymes sources and their applications Marine Lipids sources and their applications.

Conservation and management- in situ and ex situ, IUCN categorization, Marine biosphere reserves, Marine parks - heritage sites. Chromosome manipulation in aquaculture – hybridization, Ploidy induction, Gynogenesis, Androgenesis and sex reversal in commercially important fishes, Transgenic fish, Tools for disease diagnosis in cultivable organisms,

References:

1. M. Fingerman, R. Nagabhushanam and M.-F. Thompson. Recent Advances in Marine Biotechnology, Science Publishers I999.
2. P. Proksch, Frontiers in Marine Biotechnology, 1st Edn., Taylor & Francis, 2006.
3. G. Sanchez and E. Hernandez, Environmental Biotechnology and Cleaner Bioprocesses, 1st Edn., CRC press, I999.
4. P. Proksch, Frontiers in Marine Biotechnology, 1st Edn., Taylor & Francis, 2006.
5. M. Fingerman and R. Nagabhushanam, Molecular Genetics of Marine Organisms, Illustrated Edn., Science Pub., 2004.

BT3026E BIOCONJUGATE TECHNOLOGY & APPLICATIONS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Apply the knowledge of chemical reactivity to modify the biomolecules for practical use.
CO2: Illustrate the chemical properties of the cross-linkers and design conjugated molecules for target specificity.
CO3: Outline the methods used to modify the small molecules and biological macromolecules
CO4: Apply the knowledge of bioconjugation techniques for use in industry, clinical care, and diagnosis.

Functional Targets and Chemistry of Active Groups
Modification of Amino Acids, Peptides and Proteins – Modification of sugars, polysaccharides and glycoconjugates, modification of nucleic acids and oligonucleotides. Amine reactive chemical reactions, Thiol reactive chemical reactions, carboxylate reactive chemical reactions, hydroxyl reactive chemical reactions, aldehyde and ketone reactive chemical reactions, Photoreactive chemical reactions.

Bioconjugate Reagents
Bioconjugate Reagents-Zero length cross linkers, Homobifunctional cross linkers, Heterobifunctional cross linkers, Trifunctional cross linkers, Dendrimers and Dendrons, Cleavable reagent systems, tags and probes. Chemical properties of the bioconjugate reagents and the scheme used for cross linking. Application of the bioconjugate reagents in industry, clinical care, and diagnosis.

Modification of Biological Macromolecules by Conjugation
Modification of Enzyme and Nucleic Acids-Properties of common enzymes, Activated enzymes for conjugation, biotinylated enzymes, chemical modification of nucleic acids, biotin labeling of DNA- enzyme conjugation to DNA, Fluorescent of DNA. Significance of the modified biological macromolecules.

Aplications of Bioconjugate Technology
Bioconjugate Aplications- Preparation of Hapten-carrier Immunogen conjugates, antibody modification and conjugation, immunotoxin conjugation techniques, liposome conjugated and derivatives, Colloidal–gold-labeled proteins , modification with synthetic polymers.

References:

1. Hermanson, G.T. Bioconjugate Techniques, 3rd Edn., Academic Press, 2013.
2. Narain, R., Chemistry of Bioconjugates: Synthesis, Characterization, and Biomedical Applications, John Wiley UK 2014.
3. Massa S., and Devoogdt N. (Eds.), Bioconjugation: Methods and Protocols: Volume 2033 of Methods in Molecular Biology 2033, Springer New York, 2019.
4. Mark S. S. (Ed.), Bioconjugation Protocols: Strategies and Methods, Volume 751 of Methods in Molecular Biology, 2nd Edn., Humana, 2016.

BT3027E METABOLIC ENGINEERING

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Explain the fundamental concepts of metabolic engineering and its importance in manipulating cellular metabolism.
CO2: Assess the metabolic pathways using metabolic flux analysis.
CO3: Analyze the metabolic control using metabolic control analysis (MCA) and apply the MCA theorems.
CO4: Evaluate the applications of metabolic engineering and omics technologies in biotechnology.

Introduction to Metabolic Engineering
Introduction to metabolic engineering: Essence of Metabolic engineering, Basic concepts of metabolic engineering; Overview of Cellular metabolism, Cellular metabolism, Transport processes, Fueling reactions, Biosynthetic reactions, Polymerization, and Growth energetics.

Metabolic Flux Analysis
Metabolic flux analysis, Methods for metabolic flux analysis, Application of metabolic flux analysis, Amino acid production by bacteria, Metabolic flux analysis for glutamic acid and lysine biosynthetic networks, Fluxes in mammalian cell cultures, Flux analysis and design of culture media.

Metabolic Control Analysis
Metabolic control analysis (MCA), Control coefficient and elasticity, Summation and Connectivity theorems, Determination of Flux control coefficients, MCA of Linear Pathways and Branched Pathways,

Applications of Metabolic Engineering
Introduction to Omics: Functional genomics, proteomics, metabolomics, systems biology; Application of metabolic engineering: Enhancement of product yield, Alteration of nitrogen metabolism, Production of antibiotics, vitamins, polyketides, etc., Bioconversions, Case studies from Research Articles.

References:
1. G. N. Stephanopoulos, A. A. Aristidou, and J. Nielson, Metabolic Engineering: Principles and Methodologies, Academic Press, 1998.
2. N. V. Torres and E. O. Voit, Pathway Analysis and Optimization in Metabolic Engineering, Reprint., Cambridge University Press, 2011.
3. B. Kholodenko, Metabolic Engineering in the Post Genomic Era, New edition Edn., Taylor & Francis, 2004.
4. Cortassa, S. An Introduction to Metabolic and Cellular Engineering. Singapore: World Scientific. 2012
5. Jens Nielsen, Metabolic Engineering. Germany: Springer. 2010

BT3028E ANIMAL BIOTECHNOLOGY

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Identify and design the techniques for culturing animal cells and discuss their application in research and industry.
CO2: Explain the methods for animal cloning and production of transgenic animals for agricultural and therapeutic applications.
CO3: Describe the cell manipulation methods used in assisted reproduction techniques for therapy and conservation of endangered animals.
CO4: Evaluate and compare the potential benefits or dangers of animal biotechnology approaches to the environment.

Principle, components and method of animal cell culture
Animal biotechnology, Scope- Animal cell culture, types and sources of tissues, equipment, cell culture media and reagents, nutritional requirements, principles of sterile techniques, establishment of primary culture, secondary culture, definite and continuous cell lines- Methods of immortalization- Suspension cultures- Common contaminants- 3D and organ cultures.

Techniques for large scale production of animal cells for industrial and therapeutic purpose
Cell synchronization methods- Growth characteristics and kinetics of cultured cells- Scale up of monolayer and suspension cultures and automation, Microcarrier attached growth and stacked culture techniques- Preservation of cells- 3D bioprinting in human therapeutics- Artificial meat.

Stem cells and adult cell reprogramming
Stem cells, Types and sources, Molecular determinants of pluripotency, Induced differentiation of stem cell cultures, Directed differentiation of germ layers. Somatic cell reprogramming.

Applications of genetic engineering methods for animal improvement and ethical issues
Conventional methods for animal improvement, Artificial insemination, Embryo biotechniques- Micro manipulation of gametes, assisted reproductive techniques, in vitro fertilization- Creation of Dolly and animal cloning by somatic cell nuclear transfer- Animal transgenesis technology, Application of transgenic animals in agriculture and human therapeutics- Ethical issues in animal biotechnology.

References:
1. Amanda Capes-Davis, R. Ian Freshney, Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, 8th Edition, Wiley-Blackwell, 2021.
2. Ralf Pörtner, Animal Cell Biotechnology, Methods and Protocols, 4th Edition, Humana Press, Springer US, 2019.
3. Ian Gordon, Reproductive technologies in farm animals, 2nd Edition, Oxford:CAB International, 2017.
4. Louis-Marie Houdebine, Transgenic Animals: Generation and Use, Ebook, CRC Press, 2021.

BT3029E NANO BIOENGINEERING

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Explain the challenges and opportunities associated with biology on the nanoscale, as well as the characteristics and applications of biologically relevant molecular nanostructures.
CO2: Apply the knowledge of biomolecules for designing nanostructures by understanding the principles of self-assembly and self-organization and apply them to biology.
CO3: Evaluate different nanomedicines used for various disease conditions, assess the drug targeting strategies, and understand the nanotoxicity mechanisms.
CO4: Critically analyze the role of Bio-MEMS in various applications and assess their impact on healthcare and biomedical research.

Introduction to Nanobiotechnology
Challenges and opportunities associated with biology on the Nanoscale, biologically relevant molecular nanostructures-Carbon nanotubes, quantum dots, metal-based nanostructures, nanowires, polymer-based nanostructures. Introduction to 'Top-down' vs. 'Bottom-up' synthesis approach with suitable examples. Molecular nanomachines.

Bionanomaterials
Biomolecules for designing nanostructures; Function and application of DNA-based nanostructures, DNA templated electronics, DNA-gold bioconjugates, nano printing of DNA, RNA, and Proteins; use of these nanostructures in biological and medical applications, Engineered nanopores, Principles of self-assembly, self-organization and its application to biology.

Nanotechnology in medicine
Nanomedicines for various disease conditions: infectious diseases, neurological diseases, pulmonary disorders, cardiovascular diseases, cancer: nano-chemotherapy, -radiation therapy, -immunotherapy, -nuclear medicine therapy, -photodynamic therapy, -photothermal and RF hyperthermia therapy, gene therapy. Drug targeting strategies for site-specific drug delivery-passive and active targeting, time and rate-controlled drug delivery, Nanotoxicity- Experimental Models in Nanotoxicology- In vitro Models, In Vivo Models, Predicting Penetration and Fate of Nanoparticles in the Body, Toxicity Mechanisms.

Introduction to BioMEMS
Bio- microelectromechanical systems (Bio-MEMS), cell manipulations, Microfluidics: Introduction, properties of biological fluids in microchannels, devices, Lab-on-a-Chip: Microanalytical systems in chemistry and biology, MEMS Implants and Bioelectric Interfaces: Implantable microelectrodes, shunts, etc.

References:

1. S. B. Sinnott, Introduction to Nanoscience and Nanotechnology, 2nd Edition, CRC Press, 2019.
2. T. Vo-Dinh, Nanotechnology in Biology and Medicine: Methods, Devices and Applications, 2nd Edn., CRC, 2017.
3. Albert Folch, Introduction to BioMEMS, 2nd Edn, CRC Press, 2016.
4. Oliver Brand, Martyn G. Boutelle, Philip G. D. Brooks, Handbook of BioMEMS and Biomedical Technology, 2nd Edn, Springer, 2019
5. Vladimir Torchilin Handbook of Materials for Nanomedicine: Polymeric Nanomaterials (Jenny Stanford Series on Biomedical Nanotechnology 7) 1st Edn. Jenny Stanford Publishing,2020
6. Kumar, V., Dasgupta, N., & Ranjan, S. (Eds.).. Nanotoxicology: Toxicity Evaluation, Risk Assessment and Management (1st ed.). CRC Press.2018

BT3030E SYSTEMS BIOLOGY

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Comprehend the principles and concepts of systems biology.
CO2: Apply mathematical and computational methods to model biological systems.
CO3: Develop an idea about the interdisciplinary nature of systems biology and its importance in biological research
CO4: Analyze and interpret biological data using Omics and network Biology approaches
CO5: Critically evaluate the strengths and limitations of different modeling methods in systems biology through application and case studies.

Fundamental of Systems Biology
Introduction to systems biology: Definition and evolution of systems Biology, Scope, Types of data used in modeling-types of models: gene regulatory, metabolic, Signal pathway, disease, population-types of modeling frameworks: Deterministic vs Stochastic; Static vs. Dynamics; Robustness and Stability of systems- Methods used in systems biology: Ordinary differential equations (ODE), Linear ODEs, Non-linear ODEs, steady states, Stability analysis - Linear systems, Non-linear systems, Phase plane analysis, Stable and unstable limit cycles, Oscillations, Bi-stability, Positive and negative feedback, Parameter estimation and validation – Data sources: Regression techniques, maximum likelihood, least squares methods- optimization algorithms, Michaelis-Menten and Hill functions.

Mathematical modeling in systems biology
Introduction to mathematical modeling in biology: Stochastic models and Simulation Chemical master equation, Gillespie algorithm; Stochastic ODEs Spatial models in biology, Agent-based models in biology, Dynamical systems in biology, Multiscale modeling approaches, Logical modeling, Logic gates; Graph construction; Boolean networks-Metabolic control analysis (MCA), connectivity relations theorems, Flux Balance Analysis (FBA)-Neural Modeling: Hodgkin-Huxley model, Markov models, Action potentials, Voltage-activated Ion channels, Nernst Equation, Electrical Properties of Neurons Tools and databases: SBML; Modeling tools- Gepasi, Virtual cell, Cell Designer, GENESIS, Population growth and dynamics, Epidemiological models, Pharmacokinetics and pharmacodynamics Modeling, modeling cellular processes and signaling pathways

Data Integration and Network Analysis
Omics data integration: Genomics, Proteomics, Metabolomics, epigenomics data integration techniques- Network Analysis: Type of network, directed and undirected networks with examples, Cliques, Network motifs; bipartite networks-Models of networks: Random, real-world, Barabasi-Albert model, scale-free network, modularity, heterogeneity and randomness of networks-Centrality measures- degree centrality, betweenness, closeness, eigenvalue, page-rank etc; hubs, bottlenecks, modules-Biological Networks analysis: Protein-protein interaction, Gene regulatory, Pathway, Metabolic- Metabolic pathways and flux balance analysis data, lethality-centrality rule, Host-pathogen protein-protein interaction networks both bipartite and bridge networks, Disease-disease networks

Application and Case Studies
Systems Biology Application: Drug Design and Discovery, Biomarker Identification for Personalized Medicine-Case studies to understand the disease model: Cancer, Neurodegenerative disorder- Emerging technologies and future directions in Systems Biology such as Single-Cell Systems Biology, Systems Pharmacology, Synthetic Biology.

References:

1. Alon, Uri. An Introduction to Systems Biology: Design Principles of Biological Circuits. United States, CRC Press, 2019.
2. Klipp, E., W. Liebermeister, C. Wierling, A. Kowald, H. Lehrach and R. Herwig. Systems Biology: A Textbook, 2nd Edn, Wiley, 2011.
3. Junker, Björn H., and Schreiber, Falk. Analysis of Biological Networks. Germany, Wiley, ebook, 2011.
4. J. Pevsner, Bioinformatics and Functional Genomics, 3rd Edn., Wiley-Blackwell, 2015.
5. M. Axelson-Fisk, Comparative Gene Finding: Models, Algorithms and Implementation. 2ndEdn, Germany: Springer London, 2015.
6. Eberhard O. Voit - A First Course in Systems Biology. 2nd Edn Taylor & Francis, 2018

BT3031E PHARMACOLOGY & TOXICOLOGY

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Explain the mechanism of drug action at organ system or sub cellular levels.
CO2: Explain the mechanism of drug action and its relevance in the treatment of different communicable and non-communicable diseases
CO3: Apply the basic pharmacological knowledge in the prevention and treatment of various diseases.
CO4: Demonstrate the principles of toxicology and treatment of various poisonings.
CO5: Combine the principles of pharmacology with other bio-medical sciences

General Pharmacology & Toxicology
Introduction to Pharmacology- Definition, scope of pharmacology, essential drugs concept and routes of drug administration, agonists, antagonists, spare receptors, addiction, tolerance, dependence, tachyphylaxis, idiosyncrasy, allergy. Pharmacokinetics - Membrane transport, absorption, distribution, metabolism and excretion of drugs. Enzyme induction, enzyme inhibition, kinetics of elimination. Pharmacodynamics - Principles and mechanisms of drug action. Receptor theories and classification of receptors, regulation of receptors. drug receptors interactions, signal transduction mechanisms, therapeutic index, combined effects of drugs and factors modifying drug action. Principles of toxicology - Definition and basic knowledge of acute, sub-acute and chronic toxicity. General principles of treatment of poisoning.

Pharmacology of drugs acting on Nervous system
Pharmacology of drugs acting on peripheral nervous system - Organization and function of ANS. Neurohumoral transmission, co-transmission and classification of neurotransmitters. Parasympathomimetics, Parasympatholytics, Sympathomimetics, sympatholytics. Neuromuscular blocking agents and skeletal muscle relaxants (peripheral). Local anesthetic agents. Pharmacology of drugs acting on central nervous system - Neurohumoral transmission in the C.N.S. importance of various neurotransmitters like GABA, Glutamate, Glycine, serotonin, dopamine. Sedatives, hypnotics and centrally acting muscle relaxants. Anti-epileptics

Pharmacology of drugs acting on Cardiovascular and Respiratory system
Cardio vascular system - Drugs used in congestive heart failure, Anti-hypertensive drugs, Anti-anginal drugs, Anti-arrhythmic drugs, and Anti-hyperlipidemic drugs. Respiratory - Anti-asthmatic drugs, Drugs used in the management of COPD, Expectorants and antitussives, Nasal decongestants, and Respiratory stimulants.

Chemotherapy
General principles of chemotherapy. Antibiotics - Penicillins, cephalosporins, chloramphenicol, macrolides, quinolones and fluoroquinolones, tetracycline and aminoglycosides, Antitubercular agents, Antifungal agents, Antiviral drugs, Anti-helmintics, Anti-amoebic agents, Anti-cancer drugs. Clinical symptoms and management of poisoning due to barbiturates, morphine, organophosphorus compounds, lead, mercury and arsenic.

References:

1. Ritter, J. M., Flower, R. J., Henderson, G., Loke, Y. K, MacEwan, D., Rang and Dale's Pharmacology, 10th Edn., Elsevier. 2023
2. Katzung B. G., Masters S. B., Trevor A. J., Basic and clinical pharmacology, 15th Edn., Tata McGraw-Hill. 2021
3. Goodman and Gilman's, The Pharmacological Basis of Therapeutics, 13th Edn., Tata McGraw-Hill. 2017
4. Satoskar, R. S., Bhandarkar, S. D., Pharmacology and Pharmacotherapeutics 26th Edn., Elsevier Health Sciences. 2020
5. Tripathi, K. D., Essentials of Medical Pharmacology, 8th Edn., JAYPEE Brothers Medical Publishers (P) Ltd, New Delhi. 2023

BT3032E GENOMICS AND PROTEOMICS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Understanding the fundamental techniques of genomics and proteomics
CO2: Describe the current genomics and proteomics technologies and how to use them in the expanding omics sector
CO3: Evaluate experimental planning for gene identification and its expression study
CO4: Comprehend the applications of genomics and proteomics

Genomics Introduction
Structure and organization of prokaryotic and eukaryotic genomes - nuclear, mitochondrial and chloroplast genomes, computational analysis of sequences, gene annotation, alignment statistics, genetic variation polymorphism, phylogenetics, tools for genome analysis– PCR, RFLP, DNA fingerprinting, RAPD, automated DNA sequencing, linkage and pedigree analysis, construction of genetic maps, FISH to identify chromosome landmarks.

Gene Identification and Expression
Genome annotation, identifying the function of a new gene, gene ontology, comparative genomics, protein structural genomics, determining gene function by sequence comparison and through conserved protein, global expression profiling, analysis of RNA expression, microarray techniques.

Proteomics Introduction
Identification and analysis of proteins by 2D analysis, tryptic digestion of protein and peptide fingerprinting, mass spectrometry, clinical proteomics and disease biomarkers, protein-protein interactions.

Applications of Genomics and Proteomics
Analysis of human genome, application of proteome analysis- drug development and toxicology, pharmaceutical applications, proteomics in drug discovery in humans, phage antibodies as tools, capstone project on genomics and proteomics

References:
1. T. A. Brown, Gene Cloning and DNA Analysis: An Introduction, Garland Science, 8th Edn., John Wiley & Sons, 2020.
2. Wilson and Walker, Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press, 8th edition, 2018.
3. A. J. F. Griffiths, S. R. Wessler, R. C. Lewontin, W. M. Gelbart, D. T. Suzuki, J. H. Miller, An Introduction to Genetic Analysis, 11th Edn. W.H.Freeman & Co Ltd, 2012.
4. S.B. Primrose, R.M. Twyman, R.W. Old. Principles of Gene Manipulation and Genomics. 7th Edn., Blackwell Publishers, 2006.

BT3033E BIOSENSORS & DIAGNOSTICS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Explain basic knowledge of different types of biosensors
CO2: Predict the appropriate techniques for the development of biosensors of various applications
CO3: describe different applications of biosensors
CO4: Asses suitability of the different biosensor technologies available in diagnostic field

Introduction to biosensors
Introduction to biosensors, Concept and applications, Different types of biosensors- Electrochemical, optical and thermometric; Static biosensor probes vs flow systems, Enzyme membranes vs enzyme reactors, Commercial development of biosensors

Molecular biology techniques useful for biosensor development
Molecular beacons, Oligoriboprobes, Ribozymes, Role of bioinformatics in molecular diagnostics. DNA diagnostic systems, Hybridization probes, Non-isotopic hybridization procedures, In situ hybridization, Diagnostic of genetic diseases, detection of mutation in DNA, DNA amplification and quantification, molecular markers and DNA polymorphism, Use of PCR, DNA finger printing.

Immunology techniques useful for biosensor development
Immunodiagnostic procedures, Monoclonal antibodies and their applications in diagnostics, Human leukocyte antigen (HLA), HLA typing. Advances in electrochemical immune sensors

Application of biosensors
Biosensors for personal diabetes management, Non-invasive blood-gas monitoring, Blood-glucose sensors, Application of biosensors to environmental samples, Biocore-an optical biosensors, Biochips and their application to genomics.

References:

1. D. L. Wise, Bioinstrumentation and Biosensors, 1st Edn., CRC Press, 1991.
2. Rene Lalauze, Chemical Sensors and Biosensors, 1st Edn, Wiley-ISTE, 2013.
3. J. Cooper and T. Cass, Biosensors, 2nd Edn., Oxford University Press, 2004.
4. Ursula E. Spichiger–Keller, Chemical Sensors and Biosensors for Medical and Biological Applications, 1st Edn., Wiley VCH 1998.
5. B. R. Eggins, Chemical Sensors and Biosensors, Ist Edn, Wiley, 2008.
6. J. R. Birch and E. S. Lennox, Monoclonal Antibodies: Principles and Applications, 1st Edn., Wiley-Liss, 1995.
7. Mustafa Kemal Sezgintürk , Commercial Biosensors and Their Applications: Clinical, Food, and Beyond,1st Edn, Elsevier,2020

BT3034E BIOMATERIALS & ARTIFICIAL ORGANS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Identify and describe the properties of different classes of materials used in medicine, including metals, polymers, hydrogels, ceramics, composites, and natural materials.
CO2: Evaluate the potential risks and challenges associated with implant-associated infection tumorigenesis, and degradation of materials in the biological environment.
CO3: Analyze the structure and functions of various artificial organs, different types of substitutes, and their clinical use
CO4: Explain the process of 3D bioprinting, including problem identification, design, material selection, and object fabrication.

Materials for biomedical application
Properties of materials - Classes of materials used in medicine – Metals – Polymers - Hydrogels -bioresorbable and biodegradable materials – Ceramics - Natural materials - Composites thin films – Grafts - Coating medical fabrics and biologically functional materials - Smart materials - Pyrolytic carbon for long term medical implants - Textured and porous materials non-fouling surfaces.

Understanding the Host Response and Interactions with Biomaterials
Host reactions to biomaterials – Inflammation - Wound healing and foreign body response - Systemic toxicity and hypersensitivity - Blood coagulation and blood-material interactions – Tumorigenesis - Implant associated infection - Testing of biomaterials – in-vitro & in-vivo assessment of tissue compatibility - Testing of blood material interactions - Degradation of materials in the biological environment - Effects of the biological environment on metals - Polymers and ceramics.

Artificial Organs
Artificial blood: Blood components & characteristics; Oxygen-carrying plasma expanders; Blood substitutes; Crystalloid & colloidal solutions as volume expanders; Artificial oxygen carriers; Fluorocarbons; Hemoglobin-based artificial blood. Artificial skin: Structure & functions of skin; Characteristics & clinical use of skin substitutes conceptual stages in treating massive skin loss- Skin substitutes: characteristics & uses, types of skin substitutes. Artificial Pancreas & Artificial Lungs: Parenteral Structure & function of Pancreas-Endocrine pancreas & insulin secretion-Artificial Lungs: Gas exchange systems; Cardiopulmonary Bypass; Oxygen & CO2 transport; Coupling of oxygen & CO2 exchange- Shear-Induced Transport Augmentation and Devices for Improved Gas Transport.

3-D bioprinting
Opportunities and Challenges of 3D bioprinting: bio fabrication in medical applications- Additive manufacturing and rapid prototyping-3D Manufacturing: Materials and Methods-Core Principles and Physical Foundations underlying 3D Bioprinting-Development of bioinks-the Basic process of 3D bioprinting (problem, design, material selection, and object fabrication)

References:

1. Bhatt, S. V. Biomaterials (3rd Ed.). Alpha Science International, Limited. 2017
2. Ratner, B. D., & Hoffman, A. S. Biomaterials Science: An Introduction to Materials in Medicine (3rd Ed.). Academic Press. 2012
3. Wagner, W. R., Sakiyama-Elbert, S. E., Zhang, G., & Yaszemski, M. J. Biomaterials Science: An Introduction to Materials in Medicine. Elsevier. 2020
4. Annesini, M. C., Marrelli, L., Piemonte, V., & Turchetti, L. Artificial Organ Engineering. 2017
5. Ong, J. L., Appleford, M. R., & Mani, G. Introduction to Biomaterials: Basic Theory with Engineering Applications. Cambridge University Press. 2014
6. Wu, Y., Fuh, J., & Ozbolat, I. T. 3D Bioprinting in Tissue and Organ Regeneration. Academic Press. 2022

BT3071E ARTIFICIAL INTELLIGENCE & MACHINE LEARNING IN LIFE SCIENCES

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Explain the basic principles of AI and ML and their applications in life science
CO2: Identify and use common AI and ML tools and algorithms for data analysis in life science
CO3: Apply AI and ML approaches to solve biological problems, such as drug discovery, and disease diagnosis from omics data.
CO4: Analyze and interpret AI and ML data, including genomic, transcriptomic, and proteomic data

Introduction to Artificial Intelligence and Machine Learning
Fundamentals of Artificial Intelligence and Machine Learning: Definitions, Historical overview and Scope in Life Science, Supervised, Unsupervised, Reinforcement learning, and Transfer Learning, Model training, validation, and evaluation, Classification vs Prediction Problems, Regression models, Mean Square Error, R^2 Score, Rule-based machine learning- Handling Biological data: genomics, Transcriptomics, Proteomics, Data preprocessing, and quality control, Feature Selection and Dimensionality Reduction.

Classification and Clustering Algorithms
CART (Classification and Regression Tree): Linear and Logistic Regression, Decision trees, Random-Forest, Support Vector Machine, k-Nearest Neighbors, evaluating regression model's performance (Confusion matrix, accuracy score)-Clustering: K-means clustering, Hierarchical clustering.

Deep Learning Algorithms and Visualization
Deep Learning: Introduction, Types of Deep Learning, Artificial Neural Networks, Deep Neural Networks, Feed Forward Networks, Recurrent Neural Networks, Long Short-Term Memory, Convolutional Neural Networks, Transfer Learning in Natural Language Processing- Reinforcement Learning: applications- Biological Data Visualization techniques and Interpretation, Addressing bias and fairness in algorithm design.

Applications and Case Studies
Application of Artificial Intelligence and Machine Learning: Disease identification and diagnosis -Hands-on projects and case studies, Data Preprocessing and Exploration, Working with real-life biological datasets

References:
1. Badar M. S., A Guide to Applied Machine Learning for Biologists, 1st Edn, Springer International Publishing, 2023.
2. Çetinkaya-Rundel, M., Wickham, H., Grolemund, G. R for Data Science: Import, Tidy, Transform, Visualize, and Model Data. (n.p.): O'Reilly Media, 3rd Edn, 2023.
3. Yuxi, L.. Python Machine Learning By Example: Build Intelligent Systems Using Python, TensorFlow 2, PyTorch, and Scikit-learn, 3rd Edn. United Kingdom, Packt Publishing, 2020.
4. J. Pevsner, Bioinformatics and Functional Genomics, 3rdEdn., Wiley-Blackwell, 2015
5. Stevens, Tim J., and Boucher, Wayne. Python Programming for Biology: Bioinformatics and Beyond. United Kingdom, Cambridge University Press, 2015.
6. Mohanty S., N., Sarkar, A., Jena, O., P., Nalinipriya, G. Machine Learning for Healthcare Applications. United Kingdom, Wiley, 2021.

BT3081E MASTERING SCIENTIFIC COMMUNICATION: EFFECTIVE WRITING AND PRESENTATION SKILLS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Demonstrate an understanding of the principles, structure, and conventions of scientific writing
CO2: Conduct comprehensive literature reviews and synthesize existing research
CO3: Design and deliver effective scientific presentations, utilizing appropriate visual aids
CO4: Prepare comprehensive scientific reports with appropriate structure, content, and formatting

Introduction to Scientific Writing and Research Planning
Overview of the course and its objectives - Principles and characteristics of effective scientific writing - Understanding the target audience and purpose of scientific communication - Research Planning and Organization, Techniques for planning and organizing a scientific research project, Developing a research question and objectives, Creating a research timeline and workflow - Literature Review and Synthesis, Strategies for conducting a comprehensive literature review, Synthesizing existing research and identifying research gaps, Proper citation and referencing practices - Data Analysis and Interpretation, Introduction to statistical analysis techniques for scientific data, Interpreting and presenting data effectively, Visualizing data using graphs, charts, and diagrams.

Clear and Effective Scientific Communication
Clear and Concise Writing, Writing with clarity, conciseness, and precision in scientific communication, Crafting effective scientific sentences and paragraphs, Avoiding common pitfalls and improving readability - Scientific Ethics and Integrity, Understanding ethical considerations in scientific research and writing, Plagiarism, authorship, and conflicts of interest, Responsible conduct of research and publication ethics - Introduction to Scientific Presentations, Designing effective scientific presentations and engaging the audience, Structure and organization of scientific talks, Handling questions and fostering discussion - Effective use of visuals and multimedia in presentations - Visualizing Data, Techniques for creating clear and impactful data visualizations, Selecting appropriate graphs and charts for different types of data, Enhancing data visualizations with labels and annotations.

Effective Scientific Communication in Different Formats
Effective Scientific Poster Design, Principles of effective scientific poster design, Layout, color, and font choices for poster presentations, Balancing visuals and text to convey key research findings - Writing for Different Publication Formats, Writing research articles, review papers, and conference papers, Understanding the structure and requirements of different publication formats, Tailoring writing style and content for specific publication types - Writing Scientific Manuscripts, Writing concise and informative abstracts and main text, Summarizing key findings and implications of research, Crafting abstracts for different types of scientific documents - Effective Use of References, Proper citation practices and referencing styles (APA, MLA, etc.), Tools and techniques for managing references and bibliographies, Avoiding plagiarism and maintaining academic integrity.

Scientific Publishing and Research Proposal Writing
Publication Process, Overview of the publication process in scientific journals, Manuscript preparation, formatting, and submission, Responding to reviewers' comments and revising manuscripts - Peer Review Process, Understanding the peer review process in scientific publishing, Providing and receiving constructive feedback, Addressing reviewers' comments and improving manuscripts - Writing Research Proposals, Techniques for writing persuasive research proposals, Identifying funding opportunities and writing effective grant proposals, Budgeting and justifying research expenses.

References:

1. Claus Ascheron. Scientific publishing and presentation: A practical guide with advice on doctoral studies and career planning. Springer, 2023. ISBN: 3662664038, 9783662664032.
2. Jean-luc Lebrun, Justin Lebrun. Scientific Writing 3.0: A Reader And Writer's Guide, World Scientific Publishing Company 2022. ISBN: 9789811228834, 9789811229534, 9789811228841, 9789811228858.
3. C. George Thomas. Research Methodology and Scientific Writing. Springer, 2021. ISBN: 3030648648, 9783030648640, 9783030648657.
4. Gábor L Lövei. Writing and Publishing Scientific Papers: A Primer for the Non-English Speaker, Open Book Publishers, 2021. ISBN: 1800640897, 9781800640894.

5. Denys N. Wheatley. Scientific Writing and Publishing: A Comprehensive Manual for Authors, Cambridge University Press, 2021. ISBN: 9781108835206, 9781108891899, 9781108799805.
6. Mangey Ram, Om Prakash Nautiyal, Durgesh Pant. Scientific Methods Used in Research and Writing, CRC Press, 2020. ISBN: 0367627140, 9780367627140.
7. Cathryn Roos, Gregory Roos. Real Science in Clear English: A Guide to Scientific Writing for the Global Market. Springer Singapore, 2019. ISBN: 978-981-13-7819-5, 978-981-13-7820-1.
8. Nicholas Rowe. Academic & Scientific Poster Presentation : A Modern Comprehensive Guide. Springer, 2017. ISBN: 978-3-319-61280-5, 3319612808, 978-3-319-61278-2.

BT3082E ECONOMICS FOR STEM (SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS)

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Evaluate the economics of the management, operation, growth, and profitability of engineering firms and analyze operations of markets under varying competitive conditions
CO2:Demonstrate the assessment of benefit/cost, life cycle, and break-even analysis for various economic alternatives.
CO3: Analyze cost/revenue data and carry out economic analyses in the decision-making process to justify or reject alternatives/projects on an economic basis.
CO4: Generate a constructive evaluation of a social problem by emphasizing the significance of environmental responsibility and exhibiting comprehension of global factors that impact business and ethical considerations.

Introduction to Economics in STEM
Overview of Economics: Understanding the basic principles of economics, including supply and demand, market equilibrium, and the role of prices in resource allocation; Introduction to STEM Fields: Exploring the different disciplines within STEM (Science, Technology, Engineering, and Mathematics) and understanding their significance in modern society).

Production Functions and Cost Analysis
Production functions in the short and long run, Cost concepts, Short run, and long-run costs, economies and diseconomies of scale, economies and diseconomies of scope-Break even analysis-Vertical & horizontal integration-Product markets.

Production Functions, Cost Analysis, and Market Structure
Pricing in different markets, Price discrimination, Deadweight loss-consumer's surplus, Game Theory, Prisoner's Dilemma, Maximin, Minimax, Saddle point, Nash Equilibrium, Market structure-Competitive market-Imperfect competition (Monopoly, Monopolistic competition, and Oligopoly), and barriers to entry.

Macroeconomics and Financial Markets: Indicators and Policies

Macroeconomic Aggregates, Gross Domestic Product, Gross national product, net domestic product, Transfer payments, Depreciation, Economic Indicators; Models of measuring national income, Fiscal deficit, primary deficit, Inflation and deflation, Fiscal and Monetary Policies, Monetary system, Indian stock market, Development Banks, NBFIs, the role of the Reserve Bank of India, Money Market, Capital Market, NIFTY, SENSEX, Financial ratios.

Essential Reading:
1. R. S. Pindyck, D. L. Rubinfield and P. L. Mehta, Microeconomics, Pearson Education, 9th Edition, 2018.
2. P. A. Samuelson and W. D. Nordhaus, Economics, Tata McGraw Hill, 19th ed., 2015.
3. N. G. Mankiw, Principles of Microeconomics, Cengage Publications, 7th ed., 2014.
4. S. B. Gupta, Monetary Economics: Institutions, Theory & Policy, New Delhi: S. Chand & Company Ltd., 2013.
5. K. E. Case, R. C. Fair and S. Oster, Principles of Economics, Prentice Hall, 10th ed., 2011.

BT4021E SYNTHETIC BIOLOGY

L	T	P	O	C
3	0	0	6	3

Total Lectures Session: 39

Course Outcomes:
CO1: Understanding the new tools for cost-effective DNA synthesis
CO2: Recall the usage of proteins in the field of synthetic biology
CO3: Evaluate experimental planning from biological parts to circuit design
CO4: Comprehend and address design and application of synthetic biology

New tools for cost-effective DNA synthesis
Oligonucleotide synthesis: Column oligonucleotide synthesis, Microarray Oligonucleotide Pool Synthesis, Microfluidic and Fluidic Systems, Photolithography, Electrochemical Arrays, Inkjet Printing. Gene assembly, Applications of DNA synthesis: Gene circuits, codon optimization and Genome synthesis.

Proteins as a tool for synthetic biology
Protein engineering methods: Directed evolution, Generating sequence diversity: Random mutagenesis, Recombination, Site-directed Diversification. Screening and selection of protein: High-throughput screening in microtiter plates, Flow cytometry, Phage display, Cell-Free ribosome and mRNA display, Auxotrophic complementation. Application of protein engineering in synthetic biology.

From Biological Parts to Circuit Design
The parts: Transcription, Translation, Degradation. Assembling parts, Circuit design: Semirational Directed evolution, Design of experiment approaches

Design and application of synthetic biology
Target organisms and cell types for therapeutic applications of synthetic biology: Synthetic Gene Circuits encoded by recombinant DNA, Types of synthetic gene circuits: Genetic Switches, Oscillators, filters, communication modules, Functional proteins and RNA components of synthetic gene circuits, Induction of synthetic gene circuits, Alternatives to Recombinant DNA: Synthetic/Modified RNA, Proteins, and Other Analogue Molecules, Therapeutic applications of synthetic biology.

References:
1. G. George, E. Regis, Regenesis: how synthetic biology will Reinvent nature and ourselves. 1st Edn.,Perseus Book Press, 2014.
2. G Baldwin, T Bayer, R Dickinson, T Ellis, P. S Freemont, R.I. Kitney, K. M. Polizzi, G.B. Stan, Synthetic biology: A primer.1st Edn., Imperial College Press. 2016.
3. H. Zhao, Synthetic Biology: Tools and Applications, 1st Edn.. Academic Press, 2013
4. C. Smolke, Synthetic Biology: Parts, Devices and Applications, Vol 8, Wiley, 2018

BT4022E BIOCHEMICAL THERMODYNAMICS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Demonstrate the understanding of thermodynamics laws and properties.
CO2: Examine the behaviour of gases and analyze the concept of phase equilibria
CO3: Apply the concepts of solution thermodynamics and various reaction equilibria
CO4: Utilize thermodynamics to assess and resolve challenges in biological systems

Fundamentals of Thermodynamics
Systems, Open system and closed system, State and path function, Zeroth law of thermodynamics, Reversible and irreversible processes, First law of thermodynamics, Internal Energy, Enthalpy, Flow processes, Concept of Entropy and second law of thermodynamics, Third law of thermodynamics.

Thermodynamic Properties of Pure fluids and Phase Equilibria
Thermodynamic properties and their relationships, Maxwell's equations, Gibbs-Helmholtz equation, Behavior of ideal gases, Properties of gases showing non-ideal behaviour, Phase rule, Vapour-liquid equilibrium, Liquid-liquid equilibrium.

Properties of Solutions and Chemical Reaction equilibria
Fugacity of pure gases, liquids and solids, Partial Molar properties, Chemical Potential, Solution thermodynamics, Homogeneous chemical reactions, Effect of pressure and temperature on equilibrium constant, Activity coefficient, Ionic equilibria, Dissociation equilibria of acids and bases, Henry's law, Properties of fluids, Gibbs free energy, Entropy and heat capacity relation, Colligative properties

Thermodynamics in Biochemical Processes
Thermodynamics and energetics of metabolic pathways, Free energy of transfer of amino acids, Protein stability and protein dynamics, Membrane transport, Protein folding and pathological misfolding, Interaction free energy, Thermodynamics of oxidation-reduction reactions, Energetics of DNA-protein Interactions.

References:
1. Narayanan, K. V. A Textbook of Chemical Engineering Thermodynamics. India, PHI Learning, 2013.
2. Atkins, Peter William, et al. Atkins' Physical Chemistry: Thermodynamics and Kinetics. United Kingdom, Oxford University Press, 2018.
3. B.R. Puri, L.R. Sharma and M.S. Pathania, Principles of Physical Chemistry, Vishal Publishing Co, 2017.
4. Haynie, Donald Templeton. Biological Thermodynamics. United Kingdom, Cambridge University Press, 2014.

BT4023E TISSUE ENGINEERING

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Describe the fundamental principles and concepts of tissue engineering, including cell adhesion, migration, and cell-matrix interactions.

CO2: Evaluate different fabrication techniques for films, hydrogels, and scaffolds and assess the challenges and techniques in the development of cell-seeded tissue engineering constructs

CO3: Identify and differentiate between various types and sources of stem cells and their application in tissue engineering

CO4: Critically analyze and evaluate the specific challenges, strategies, and advancements in various tissue engineering applications

Fundamentals of Tissue Engineering

Introduction to tissue engineering: Basic definition; current scope of development; use in therapeutics, cells as therapeutic agents, cell numbers and growth rates; mechanical Forces on Cells-Cell Adhesion-Cell Migration. Cell-Matrix& Cell-Cell Interactions, Control of cell migration in tissue engineering. Measure tissue characteristics, appearance, cellular component, Extracellular Matrix: Structure, Function and Tissue Engineering, mechanical measurements, and physical properties.

Biomaterial-tissue interactions

Role of biomaterials, growth factors, bioactive molecules, Protein-Surface Interactions, Cell-surface Interaction, Polymer/Organic Coatings; Fabrication techniques of films and hydrogels; fabrication of scaffolds; different solid support systems, animal cell culture (2D and 3D); strategies for the development of cell-seeded tissue engineering construct; implantation and integration of tissue-engineered products.

Stem cell technology

Stem Cells: Introduction, hematopoietic differentiation pathway Potency and plasticity of stem cells, sources, embryonic stem cells, hematopoietic and mesenchymal stem cells, Stem Cell markers, FACS analysis, Differentiation, Stem cell systems- Liver, neuronal stem cells, Types & sources of stem cell with characteristics: embryonic, adult, hematopoietic, fetal, cord blood, placenta, bone marrow, primordial germ cells, cancer stem cells induced pluripotent stem cells.

Application of tissue engineering

Bioengineering Of Human Skin Substitute; Nerve Tissue Engineering; Musculoskeletal Tissue Engineering; Bone Tissue Engineering; Cartilage Tissue Engineering; Temporomandibular Tissue Engineering; Smooth Muscle Tissue Engineering; Esophagus Tissue Engineering. Vascular Graft Tissue Engineering, Cardiac Tissue Engineering, Heart Valve Tissue Engineering, Urologic Organ Tissue Engineering, Hepatic Tissue Engineering, Renal Tissue Engineering, and tracheal Tissue Engineering. Tissue-engineered product characterization, safety, efficacy. Cryobiology, Vitrification technology, Preservation -freezing and drying.

References:

1. Palsson, B., & Bhatia, S. Tissue Engineering (1st ed.). Pearson Prentice Hall. 2016
2. Fisher, J. P., Antonios, G., Mikos, G., Bronzino, J. D., & Peterson, D. R. Tissue Engineering: Principles and Practices (1st ed.). CRC Press. 2017
3. Lanza, R., Langer, R., & Vacanti, J. P. Principles of Tissue Engineering (5th ed.). 2020
4. Temenoff, J. S., & Mikos, A. G. Biomaterials: The Intersection of Biology and Materials Science. 2009
5. Vishwakarma, A., Sharpe, P., Shi, S., & Ramalingam, M. Stem Cell Biology and Tissue Engineering in Dental Sciences (1st ed.). 2014

BT4024E CANCER BIOLOGY

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Describe the hallmark of cancer and cancer cells characteristics
CO2: Summarize mechanisms of protooncogene-oncogene conversion and its role in cancer development
CO3: Apply the concepts of cell cycle regulation and illustrate how cell cycle dysfunction can lead to cancer
CO4: Explain chemical, radiation-induced carcinogenesis, and hormone-dependent cancers

Cancer cell characteristics, genes, and signaling involved
Hallmarks of cancer cells, initiation, and progression, steps involved in tumor progression, the role of genes in cancer-introduction to proto-oncogenes, oncogenes, and tumor suppressor genes, benign and malignant-the genetic basis of cancer-Mutations and cancer-Signal switches and aberrations in cancer, -types of cancers-nature of cancer and classification-epigenetics of cancer-cancer stem cells-cell signaling in cancer-apoptosis

Cell cycle dysregulation and cancer, lymphatic system, and genomic instability
Cell cycle clock, and dysregulation of the cell cycle-retinoblastoma, and consequences of loss of checkpoint controls-DNA damage response-cyclin and cyclin-dependent kinases fluctuation in cancer, pRB phosphorylation and dephosphorylation, control of pRB function in cancer, oncogene-induced replication stress, mitotic checkpoints in cancer, Cell cycle control and therapeutic opportunities, Angiogenesis and metastasis, invasion, lymphatic system in cancer, genomic instability

Carcinogenesis by physical, chemical, and biological agents
Chemical carcinogenesis, Metabolism of chemical carcinogens, Targets of chemical carcinogens- Principles of physical carcinogenesis-Radiation carcinogenesis-Free radical aspects of carcinogenesis, Infectious causes of cancer, virally induced carcinogenesis, tumor viruses, bacteria, and parasites causing cancer, molecular mechanisms linking infections and cancer-hormones and cancer-immunity, and cancer

Cancer diagnosis, therapeutics, and experimental research
Detection of different types of cancers, advances in cancer detection, Prediction of aggressiveness of cancer, advantages, and limitations for the different forms of cancer therapy like Chemotherapy-radiation therapy-immunotherapy-radio-immunotherapy-Chemoprevention of cancer-Cancer drug discovery, experiments for cancer cell research-animal models in cancer research

References:

1. Misra, Gauri, and Jyotika Rajawat, eds. Protocol Handbook for Cancer Biology. Academic Press, 2021.
2. Anisman, Hymie, and Alexander W. Kusnecov. Cancer: How Lifestyles May Impact Disease Development, Progression, and Treatment. Academic Press, 2022.
3. Weinberg, Robert A. The Biology of Cancer: Second International Student Edition. WW Norton & Company, 2013.
4. Kleinsmith, Lewis J. "Principles of cancer biology." Pearson, 2006.
5. Amiji, Mansoor M., and Lara Scheherazade Milane, eds. Cancer Immunology and Immunotherapy: Volume 1 of Delivery Strategies and Engineering Technologies in Cancer Immunotherapy. Academic Press, 2021.

B4025E INFECTION BIOLOGY

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:

CO1: Recognize and evaluate the public health issues caused by microbial infection
CO2: Describe and revise Host-pathogen interaction together with antimicrobial resistance
CO3: Integrate and apply WHO's objectives toward infectious diseases and public health problems
CO4: Learn contemporary experimental tools and legislations related to infectious disease

Introduction to Infectious Disease and Public Health Science

Pathogens and infection: bacterial, viral, fungal, and protozoan pathogens causing disease in humans and live stocks; WHO's communicable and non-communicable diseases; Endemic, Epidemic, and Pandemic; infectious diseases of India; Indian priority pathogens; Public health science: data science and identification of public health problems.

Cell and Molecular Mechanisms of Infection

Molecular cell biology of infections: Extra and intracellular pathogens, microbial attachment and entry into host cells; phagocytosis, Host cell interaction with microbial pathogens: cell death and autophagy, the role of innate and adaptive immune cells in infection; antimicrobial effector mechanisms, vaccine, host immune evasion and molecular strategies for intracellular survival.

Antimicrobial Resistance (AMR) and WHO Programs on AMR

Antimicrobial resistance (AMR): molecular mechanisms of AMR, antimicrobial drugs administration, misuse, and WHO's Antimicrobial Stewardship Programs (ASP)- Global Leaders Group on Antimicrobial Resistance-Strategic and Technical Advisory Group for Antimicrobial Resistance (STAG-AMR). WHO's infection prevention and control strategy

Infectious Disease Research, Diagnosis and Biosafety

Application of cell culture, hybridoma technology; culturing infectious microorganisms, and genetic engineering of infectious microorganisms-model systems for studying infection. Detecting and diagnosis of infectious agents. Ethics and biowarfare-legislations on biosafety.

References:

1. Foundations of Infectious Disease: A Public Health Perspective. David Adams, Jones & Bartlett Learning, 16 March 2020, ISBN: 9781284179644,
2. Human Infectious Disease and Public Health, William Fullick, 2019, Oxford University Press, ISBN: 9780198814382
3. Antibiotic Drug Resistance, José-Luis Capelo-Martínez, Gilberto Igrejas. 2020 John Wiley & Sons, Inc. First published:23 August 2019 Print ISBN:9781119282525 |Online ISBN:9781119282549 |DOI:10.1002/9781119282549
4. Mims' Pathogenesis of Infectious Disease, Anthony Nash, Robert Dalziel, J. Fitzgerald, 6th Edition - January 21, 2015, Paperback ISBN: 9780123971883.
5. Mims' Medical Microbiology and Immunology, 6th ed. (2018) by Goering, Dockrell, Zuckerman & Chiodini (Eds.)
6. Antimicrobial Stewardship Programs, Kimberly D. Leuthnera and Gary V. Doern, J Clin Microbiol. 2013 Dec; 51(12): 3916–3920. PMID: 23926165
7. Data Science for Infectious Disease Data Analytics: An Introduction with R, Lily Wang, CRC Press, ISBN: 9781000643084.
8. Charting the Next Pandemic Modeling Infectious Disease Spreading in the Data Science Age, Ana Pastore y Piontti, Nicola Perra, Luca Rossi, Nicole Samay, Alessandro Vespignani, Corrado Gioannini, Marcelo F. C. Gomes, Bruno Gonçalves · 2018, Springer International Publishing, ISBN: 9783319932903
9. Hunter's Tropical Medicine and Emerging Infectious Diseases, Edward T Ryan, David R Hill, Tom Solomon, Naomi Aronson, Timothy P Endy · 2019, Elsevier Health Sciences, ISBN: 9780323625500.

BT4026E AGRICULTURE BIOTECHNOLOGY

L	T	P	O	C
3	0	0	6	3

Total Lectures Sessions: 39

Course Outcomes:
CO1: Understand the basic concepts of crop domestication and evolution of agriculture.
CO2: Recall different techniques used in molecular marker-aided breeding
CO3: Comprehend the new modern biotechnology techniques used in agriculture for crop improvement
CO4: Analyze the advantages and disadvantages of genetically modified crops

Evolution of Agriculture
Domesticated crops, weeds, invasive species, understanding domestication process, Genes of Domestication, hybrid species and new polyploids in domestication, Post Domestication Selection, New domestication, Features of Domesticated Genomes, Superdomestication. Genomics-Based Application Agriculture, Applications of Plant Metabolomics in Agricultural Biotechnology

Molecular Marker-aided Breeding
Types of Markers, Morphological Markers, Biochemical Markers, Molecular Markers, Restriction Fragment Length Polymorphism, Linkage Analysis, RAPD Markers, Microsatellites, Sequence-characterized Amplified Region, Single Nucleotide Polymorphism, Amplified Fragment Length Polymorphism, Quantitative Trait Loci.

CRISPR Technologies for Plant Biotechnology Innovation:
Genome Editing Technologies: Historical Perspective and the Rise of Genome Editing Tools, CRISPR/Cas-Based Genome Engineering, Better Crops with CRISPR/Cas Techniques, Genome Edited Versus Transgenic Crops.

Genetically modified crops and Intellectual Property of Plant Innovation
Intellectual Property Protection of Plant Innovation, Environmental Impacts of Genetically Modified (GM) Crop Use: Impacts on Pesticide Use and Carbon Emissions, GMO controversy.

References:
1. C. O. Adetunji, D. G. Panpatte, Y.K. Jhala. Agricultural Biotechnology: Food Security Hot Spots, 1st Edn., CRC Press, 2022
2. A. Altman, P.M. Hasegawa, Plant Biotechnology and Agriculture: Prospects for the 21st century, 1st Edn., Academic Press, 2012.
3. S. J. Smyth, P. W. Phillips, D. Castle. Handbook on agriculture, biotechnology and development, 1st Edn., Edward Elgar Publishing, 2014.
4. C. N. Stewart Jr, Plant biotechnology and genetics: principles, techniques, and applications. John Wiley & Sons. 2016.
5. S. Umesha, Plant Biotechnology, 2nd Edn., CRC Press, 2019

BT4027E HERBS & NUTRACEUTICALS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Identify herbs as the source of raw material for traditional and modern medicine.
CO2: Demonstrate the production of herbal drugs from cultivation to product.
CO3: Apply the knowledge of the herbal cosmetics, natural sweeteners and nutraceuticals for human health care.
CO4: Outline the WHO and ICH guidelines for evaluation of herbal drugs.
CO5: Analyze crude drugs, their chemical nature and appraise their uses.

Herbs and Herbal Drug Industry
Herbs as raw materials - Definition of herb, herbal medicine, herbal medicinal product, herbal drug preparation. Source of Herbs - Selection, identification and authentication of herbal materials. Good agricultural practices in cultivation of medicinal plants including Organic farming. Pest and Pest management in medicinal plants: Biopesticides/Bioinsecticides. Processing of herbal raw material.
Herbal drugs industry: Present scope and future prospects. A brief account of plant based industries and institutions involved in work on medicinal and aromatic plants in India and abroad.

Herbal Drugs
Herbs used in allopathy and traditional systems of medicine namely, Ayurveda, Siddha, Homeopathy and Chinese systems of medicine. Definition, classification, properties of secondary metabolites and their medicinal value - Alkaloids, Glycosides, Flavonoids, Tannins, Volatile oil and Resins. General introduction on primary metabolites and their use in medicine – Acacia, Agar, Tragacanth, Honey. Proteins and Enzymes: Gelatin, casein, proteolytic enzymes (Papain, bromelain, serratiopeptidase, urokinase, streptokinase, pepsin). Lipids (Waxes, fats, fixed oils): Castor oil, Chaulmoogra oil, Wool Fat, Bees Wax.

Herbal Cosmetics and Excipients
Sources and description of raw materials of herbal origin used via, fixed oils, waxes, gums, colours, perfumes, protective agents, bleaching agents, antioxidants in products such as skin care, hair care and oral hygiene products. Herbal excipients – Significance of substances of natural origin as excipients – colorants, sweeteners, binders, diluents, viscosity builders, disintegrants, flavors & perfumes.

Nutraceuticals
General aspects, Market, growth, scope and types of products available in the market. Health benefits and role of Nutraceuticals in ailments like Diabetes, cardiovascular diseases, Cancer, Irritable bowel syndrome and various Gastro intestinal diseases. Study of the following herbs as health food: Alfaalfa, Ginger, Fenugreek, Garlic, Honey, Amla, Ginseng, Ashwagandha, Spirulina. Phytoestrogens in plants; isoflavones; flavonols, polyphenols, tannins, saponins, lignans, lycopene, chitin, caratenoids. phytosterols.

References:

1. Evans W. C., Trease and Evans Pharmacognosy, 16th Edn., W. B. Sounders & AMP; Co., London, 2009.
2. Gokhale, S. B., and Kokate, C. K., Text book of Pharmacognosy, 37th Edn., Nirali Prakashan, New Delhi , 2007.
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4. Tripathi, K. D., Essentials of Medical Pharmacology, 8th Edn., 2023, JAYPEE Brothers Medical Publishers (P) Ltd, New Delhi.
5. Choudhary, R. D., Herbal Drug industry: A Practical Approach to Industrial Pharmacognosy, 1st Edn., Eastern Publisher, New Delhi, 1996.
6. Pharmacopoeal standards for Ayurvedic Formulation (Council of Research in Indian Medicine & Homeopathy)
7. Mukherjee, P.W., Quality Control of Herbal Drugs: An Approach to Evaluation of Botanicals. Business Horizons Publishers, New Delhi, India, 2002.
8. WHO. Quality Control Methods for Medicinal Plant Materials. World Health Organization, Geneva, 1999.

BT4028E BLOOD SUBSTITUTES

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Identify the cellular and molecular composition of human blood and discuss the role of hematopoietic system in blood production.
CO2: Analyze the need for the production of artificial blood and its substitutes in human diseases.
CO3: Explain the cell culture- and genetic engineering- based methods used for the production of blood components.
CO4: Evaluate and compare the potential benefits or risks and the ethical considerations associated with the production and use of blood substitutes in human therapeutic setting.

Composition and functions of blood
Composition of human blood- different types of cells, soluble factors- Physiological functions of the blood- Regulation of oxygen affinity for haemoglobin, dissociation of haemoglobin tetramer- Hematopoietic microenvironment.

Mechanism of blood production in physiological and pathological states
Mechanisms and regulation of blood cell production from HSC, erythropoietin and molecular regulation of erythropoiesis, hematopoietic colony stimulating factors; GM-CSF, G-CSF and M-CSF- Molecular basis of ABO blood group antigens- Anaemia and other diseases for blood transfusion and component therapy.

Cell culture and genetic engineering-based methods for blood component production
Production of recombinant erythropoietin and colony stimulating factors for therapeutic use- Bone marrow culture- Blood pharming; Isolation, enumeration and induced differentiation of HSC- Enzymatic methods for the conversion of Group A and Group B RBC to Group O RBC- Experimental approaches for Rh modification- Preparation of plasma fractions of albumin, immunoglobulins and coagulation factors- Production of anti-haemophilic factors and tPA by recombinant DNA technology.

Manufacturing practices and ethical considerations for haemoglobin substitutes and carriers
Haemoglobin blood substitute production- chemically modified haemoglobin, haemoglobin-based oxygen carriers (HBOCs), recombinant production of haemoglobin, liposome encapsulated haemoglobin- fabrication and in vivo trials. Use of perfluorochemicals in oxygen transport- current status, potential clinical applications. Ethical and regulatory perspectives on clinical trials for blood substitutes and artificial blood.

References:
1. Alan D. Kaye, Henry Liu, Jonathan S. Jahr, Blood Substitutes and Oxygen Biotherapeutics, ebook, Springer International Publishing, 2022.
2. Sarah Leavitt, Seth Perelman, Corey S. Scher, Alan David Kaye, Henry H. Liu, Essentials of Blood Product Management in Anesthesia Practice, ebook, Springer International Publishing, 2021.
3. Jack Goldstein, Biotechnology of Blood, ebook, Elsevier Science, 2014.
4. Weifeng Xu, Xiaohui (Sophia) Xu, Bioanalytical Aspects in Biological Therapeutics, ebook , Wiley, 2022.
5. Jonathan Hoggatt, Louis M. Pelus, Hematopoietic Stem Cells- Methods and Protocols, ebook, Springer US, 2022.

BT4029E PROGRAMMING FOR BIOLOGISTS

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Explain the basics of programming languages and their relevance to biology.
CO2: Use the Linux command-line interface and perform essential file operations.
CO3: Write and execute Python by integrating R scripts for data manipulation, analysis, and visualization of biological data.
CO4: Develop proficiency in utilizing relevant bioinformatics libraries, packages, and tools.
CO5: Apply programming skills to solve biological problems and complete practical projects & case studies

Fundamentals of Programming
Overview of programming languages in bioinformatics: Linux, R, Python- Linux Fundamentals: Introduction to the Linux operating system, Basic and advanced commands, file manipulations.

R and Python syntax and packages
R Fundamentals: Introduction to R syntax and data structures, Data manipulation and transformation, Statistical analysis and visualization, Bioconductor packages for genomics analysis- Python Fundamentals: Introduction to Python syntax and data structures, File handling and data input/output, Control structures and loops, Functions and modules-packages: Biopython, Bioconda, Scipy, NumPy, Pandas, Matplotlib, Seaborn, BioPandas, PySCeS, Scikit-bio and etc

Integrating Python and R for Bioinformatics applications
Interfacing Python and R, Integrating Python libraries with R Advanced Topics and Applications: Introduction to machine learning in bioinformatics using Python.

Hands-on Training and Project
Applying programming skills to solve biological problems: -Hands-on projects and case studies

References:

1. Shotts, W. The Linux Command Line, 2nd Edition: A Complete Introduction. United States: No Starch Press. 2nd Edn, 2019.
2. Çetinkaya-Rundel, M., Wickham, H., Grolemund, G. R for Data Science: Import, Tidy, Transform, Visualize, and Model Data. (n.p.): O'Reilly Media, 3rd Edn, 2023.
3. Bassi, S. Python for Bioinformatics. United Kingdom: CRC Press, Taylor & Francis Group, 2nd Edn, 2018.
4. Jones, M. Effective Python Development for Biologists: Tools and Techniques for Building Biological Programs. United Kingdom: CreateSpace Independent Publishing Platform, 2nd Edn, 2016
5. Antao, T. Bioinformatics with Python Cookbook: Learn how to Use Modern Python Bioinformatics Libraries and Applications to Do Cutting-edge Research in Computational Biology. 3rd Edn, United Kingdom: Packt Publishing, 2022.
6. Alexander Z., Ion M., Bioinformatics Algorithms: Techniques and Applications. United Kingdom: Wiley, 1st Edn, 2008.
7. Buffalo, V. Bioinformatics Data Skills: Reproducible and Robust Research with Open Source Tools. 1st Edn, United States: O'Reilly Media, 2015.
8. Model, M. L. Bioinformatics Programming Using Python. India: Shroff Publishers, 2nd Edn, 2010.

BT4030E ARTIFICIAL INTELLIGENCE IN COMPUTATIONAL BIOLOGY

L	T	P	O	C
3	0	0	6	3

Total Lecture Sessions: 39

Course Outcomes:
CO1: Explain the fundamental concepts of artificial intelligence and its application in computational biology.
CO2: Apply Artificial intelligence to analyze biological datasets and predict biological phenomena.
CO3: Implement deep learning techniques for genomic sequence analysis and protein structure prediction.
CO4: Utilize network-based methods to model biological systems and analyze biological networks.
CO5: Critically assess and apply recent research papers and developments in the field of AI-driven computational biology.

Introduction to Computational Biology and AI
Overview of artificial intelligence and machine learning, Introduction to biological data types and sources- Data preprocessing techniques for biological data: normalization, dimensionality reduction, Feature selection methods in genomics and proteomics, Handling imbalanced biological datasets.

Machine Learning for Biological Data
Supervised learning algorithms for classification and regression tasks, Feature selection and dimensionality reduction techniques machine learning algorithms (decision trees, support vector machines), Neural networks and deep learning architectures for biological data-Unsupervised Learning and Clustering:
Clustering algorithms (k-means, hierarchical clustering) for biological data, Dimensionality reduction techniques (PCA, t-SNE) and their applications in Analyzing gene expression patterns and cellular heterogeneity- Deep Learning for Biological data: Neural networks and deep learning architectures for sequence analysis.

Applications of AI in Systems and Network Analysis
AI-driven modeling of biological systems (ODE-based models, agent-based modeling), Network-based approaches using AI techniques (graph neural networks, network alignment), Drug discovery and personalized medicine using AI in systems biology, Deep Learning for Genomics and Protein Structure Prediction, Convolutional neural networks (CNNs) for DNA sequence analysis, Recurrent neural networks (RNNs) for biological sequence modeling, Protein structure prediction using deep learning methods. Graph theory fundamentals and its applications in biology, Network-based representation of biological systems, Network alignment and community detection in biological networks.

Current Topics in AI-Driven Biology Research and Hands-on Sessions
Transfer learning and domain adaptation in genomics, Explainable AI techniques in computational biology, AI-driven drug discovery and personalized medicine, Case studies: Disease prediction and biomarker discovery, Team-based projects applying AI methods to solve specific current biological problems using Hands-on exercises using popular AI frameworks and bioinformatics tools. Problem can be solved such as disease prediction, protein-protein interaction prediction or drug-target interaction prediction, Presentation of project findings and discussions.

References:

1. Badar M. S., A Guide to Applied Machine Learning for Biologists, 1st Edn, Springer International Publishing, 2023.
2. Compeau P, Pevzner P. Bioinformatics Algorithms: An Active Learning Approach: Active Learning Publishers; 2015.
3. Durbin R. Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids: Cambridge University Press; 2007.
4. Goodfellow I, Bengio Y, Courville A. Deep Learning: Alanna Maldonado; 2023.
5. J. Pevsner, Bioinformatics and Functional Genomics, 3rdEdn., Wiley-Blackwell, 2015
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BT4093E PROJECT PART-III

L	T	P	O	C
0	0	12	6	6

CO1: Apply the principles of natural science, mathematics and engineering for designing experiments to solve various complex problems in society, environment, health and industry.
CO2: Develop skills to use modern tools and equipment as an individual or team with professional and ethical commitments.
CO3: Disseminate the information gained during the hands-on experience through written reports and presentations.
CO4: Plan and execute the project objectives in a timely manner with appropriate financial management.
CO5: Demonstrate the ability to adapt and self-learn new techniques in the context of technological changes.

Objective:
The students will be given the flexibility to come up with project proposals in consultation with the faculty members. Students will form groups having a maximum of four members. At the end of the semester, students will submit a detailed project report and should give an effective presentation summarizing the methodology, structure, results and conclusions of the project work to an evaluation committee duly constituted for the purpose.