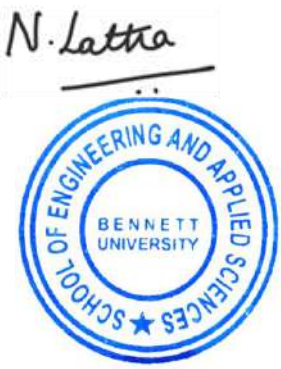
# Program Structure & Syllabus

## Integrated B.Tech.-M.Tech. (Biotechnology)

## Duration: 5 Years

## AY: 2025-2030

## School of Engineering & Applied Sciences
## Department of Biotechnology



## Vision of the University:

To be a global leader in education, research, and innovation, empowering higher learning ecosystem.

## Mission of the University:

1. Empower all the members of the Bennett ecosystem and provide thought leadership, focus on nation building and prepare our graduates to move with the Times.
2. Cultivate international partnerships and collaborations with academic institutions, industry, and government organizations and provide a rigorous and innovative education that equips students with the knowledge, skills, and ethical values required to excel in their careers.
3. Foster a culture of lifelong learning, adaptability, and critical thinking, ensuring graduates are prepared to tackle emerging challenges in all academic fields.
4. Drive interdisciplinary research and innovation, pushing the boundaries of human knowledge, addressing pressing global issues and solving real world problems.
5. Enhance a collaborative environment that encourages faculty and students to engage in research, innovation, and entrepreneurship, creating a lasting impact on society.
6. Promote diversity, equity, and inclusion, ensuring that all individuals, regardless of background, feel welcomed, respected, and empowered.
7. Prepare students to become global citizens, capable of addressing global challenges and contributing to the well-being of communities worldwide.
8. Provide a globally connected career services networking with graduate employers and alumni.
9. Foster a strong sense of ethical responsibility in our graduates, emphasizing the importance of ethical conduct, sustainability, and social impact in professional practice.
10. Commit to ongoing assessment and improvement of our programs and invest in modern infrastructure and advanced technology to support teaching, research, and innovation adapting to the evolving needs of students, industries, and society.

## Vision of the School:

To be a leading centre of excellence in engineering education, research and innovation, fostering the development of skilled engineers who will shape the future of science and technology and contribute to the betterment of society.

## Mission of the School:

1. Provide high-quality science & engineering education: The school is dedicated to delivering rigorous, comprehensive, and contemporary education that equips students with the necessary knowledge, skills, and ethical values to excel in the field of science & engineering.

2. Foster research and innovation: Encourage and support cutting-edge research and innovation in various scientific & engineering disciplines, promoting interdisciplinary collaboration, entrepreneurship skills to address real-world

challenges. The school aims to be at the forefront of technological advancements and contribute to the body of knowledge in science & engineering.

3. Promote experiential learning: Create an environment that generate new knowledge with emphasis on hands-on learning experiences, practical applications of scientific & engineering principles, and collaboration with industry partners. The school strives to develop graduates who are ready to tackle real-world problems , promote entrepreneur and adapt to a rapidly evolving engineering landscape.

4. Cultivate professional ethics and social responsibility: Instill in students a strong sense of professional ethics, integrity, and social responsibility. The school aims to produce engineers who are committed to sustainable development, ethical practices, and actively contribute to society's well-being.

## Vision of the Department:

To be a centre of excellence in education and research in diverse domains of Biotechnology for promotion of scientific advancement and technology.

## Mission of the Department:

1. Nurture a learning ecosystem for developing human resources in Biotechnology with applications to healthcare, food security, agriculture, and environment.
2. Implement dynamic curriculum through effective pedagogy to train globally competent graduates with the skillset and ethical values to thrive in the ever-evolving field of Biotechnology.
3. Empower biotechnology professionals with leadership qualities tailored to drive research, innovation & entrepreneurship in Biotechnology.
4. Strengthen academic and industry collaboration to create opportunities, knowledge and advancing research.

## Program Educational Objectives:

**PEO1:** Our graduates will apply their knowledge and skills to solve complex problems in biotechnology and related fields, and to develop innovative sustainable solutions to address societal challenges in healthcare, food security, and environment.
**PEO2:** Our graduates will possess skills to communicate effectively, work collaboratively, and demonstrate leadership qualities in multidisciplinary teams.
**PEO3:** Our graduates will demonstrate awareness of the social, ethical, and environmental ramifications of biotechnology and will be equipped to make responsible and ethical decisions that benefit society.
**PEO4:** Our graduates will have a strong foundation for continued learning and professional development in biotechnology and related fields.

## PEOs to Mission Statement Mapping:

| **Mission Statements** → / **PEO Statements** ↓ | **M1** | **M2** | **M3** | **M4** |
|---|---|---|---|---|
| **PEO1** | **3** | **2** | **2** | **1** |
| **PEO2** | **2** | **3** | **3** | **3** |

| | | | | |
|---|---|---|---|---|
| **PEO3** | **1** | **2** | **3** | **3** |
| **PEO4** | **3** | **3** | **3** | **3** |

**1: Low** **2: Medium** **3: High**

## Program Outcomes:

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

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

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

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

**PO5: Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and 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 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 teamwork:** 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: Entrepreneurship**: Ability to apply domain knowledge and management skills for effective management of entrepreneurship ventures and become potential contributor to industrial development relevant to the specialization.

**PO13: 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.

## Program Specific Outcomes:

**PSO1:** Gain comprehensive theoretical and practical knowledge for acquiring advanced skills to bring innovations in diverse areas of biotechnology including but not limited to medical, industrial, agriculture, and environmental biotechnology to work towards for solving societal problems through curiosity driven research.

**PSO2:** Understand and adopt bench to bedside approach fostering translational research to develop quality products, processes and services relevant for industries, health research, training and education.

**PSO3:** Demonstrate professional competency, ability to work independently and in an interdisciplinary team, excellent written and verbal communication skill, strong work ethics, analytical and creative skills gained through a range of assignments, open electives, minors, specializations, mini projects, and internship experiences.

## Mapping of POs/PSOs to PEOs:

| S.No | Course Type | |
|---|---|---|
| 1 | MDC | Multidisciplinary Courses |
| 2 | AEC | Ability Enhancement Courses |
| 3 | SEC | Skill Enhancement Courses |
| 4 | VAC | Value Added Courses |

| **PEO Statements**<br><br>**Program Outcomes** | **PEO1** | **PEO2** | **PEO3** | **PEO4** |
|---|---|---|---|---|
| PO1 | 3 | 1 | 1 | 3 |
| PO2 | 2 | 3 | 1 | 2 |
| PO3 | 1 | 3 | 2 | 2 |
| PO4 | 1 | 3 | 1 | 2 |
| PO5 | 1 | 3 | 1 | 2 |
| PO6 | 1 | 1 | 3 | 3 |
| PO7 | 1 | 3 | 3 | 3 |
| PO8 | 1 | 2 | 3 | 3 |
| PO9 | 1 | 1 | 3 | 3 |
| PO10 | 1 | 3 | 3 | 3 |
| PO11 | 1 | 3 | 3 | 3 |
| PO12 | 1 | 1 | 3 | 3 |
| PO13 | 3 | 3 | 3 | 3 |
| PSO1 | 3 | 3 | 3 | 3 |
| PSO2 | 1 | 3 | 3 | 2 |
| PSO3 | 1 | 3 | 3 | 3 |

**1: Low** **2: Medium** **3: High**

**ABBREVIATIONS**

| Semester - I | | | | |
|---|---|---|---|---|
| **S.No** | **Type of Course** | **Subject** | **Credits** | **L-T-P** |
| 1 | MDC | Mathematics Foundations | 3 | 2-1-0 |
| 2 | Major | Chemistry of Biomolecules | 4 | 3-0-2 |
| 3 | Minor/Specialization | Minor/Specialization-I | 4 | 3-0-2 |
| 4 | VAC-1 | Inculcation of Human Values and Professional Ethics | 2 | 2-0-0 |
| 5 | VAC-2 | Social Responsibility and Community Project | 2 | 1-0-2 |
| 6 | SEC-1 | Professional Skills (Will be decided by the University) | 2 | 2-0-0 |
| 7 | AEC-1 | Communication: From Brain to Society | 2 | 1-0-2 |
| | Total | | 19 | |

| Semester-II | | | | |
|---|---|---|---|---|
| **S.No** | **Type of Course** | **Subject** | **Credits** | **L-T-P** |
| 1 | MDC-2 | Physics for Biotechnologists | 3 | 2-0-2 |
| 2 | Major | Cellular Structures and Functions | 4 | 3-0-2 |
| 3 | Major | Bioanalytical Tools and Techniques | 4 | 2-0-4 |
| 5 | Minor/Specialization | Minor/Specialization-II | 4 | 3-0-2 |
| 6 | VAC-3 | Environmental Science | 2 | 2-0-0 |
| 7 | SEC-2 | Leadership and Management Skills | 2 | 2-0-0 |
| 8 | AEC-2 | Foreign Languages (Spanish, French, German etc.) (Will be decided by the University) | 2 | |
| | Total | | 21 | |

| Semester-III | | | | |
|---|---|---|---|---|
| **S.No** | **Type of Course** | **Subject** | **Credits** | **L-T-P** |
| 1 | MDC | Computational Thinking & Programming | 3 | 2-0-2 |
| 2 | Major | Molecular Biology | 4 | 3-0-2 |
| 3 | Major | Enzyme Sciences and Technology | 4 | 3-0- 2 |
| 4 | Minor/Specialization | Minor/Specialization-III | 4 | 2-0-4 |
| 5 | VAC -4 | AI for Everyone | 2 | 1-0-2 |
| 6 | SEC-3 | Innovation & Entrepreneurship / Project Management (SOM) | 1 | 1-0-0 |
| 7 | SEC-4 | Fundamentals of Medical Laboratory Technology | 2 | 0-0-4 |
| 8 | AEC-3 | School/Department Level Course Technical and Creative Writing | 2 | 2-0-0 |
| | Total | | 22 | |

| Semester-IV | | | | |
|---|---|---|---|---|
| S.No | Type of Course | Subject | Credits | L-T-P |
| 1 | Major | Thermodynamics & Chemical Processes | 4 | 3-0-2 |
| 2 | Major | Metabolic Networks | 4 | 3-0-2 |
| 3 | Major | rDNA Technology | 4 | 3-0-2 |
| 4 | Major | Introduction to Biomaterials | 4 | 3-0-2 |
| 5 | Minor/Specialization | Minor/Specialization-IV | 4 | 4-0-0 |
| 6 | AEC-4 | Technical Presentation | 2 | Fixed Credits |
| 7 | VAC-5 | Ayurveda & Nutrition (School specific) | 2 | 2-0-0 |
| | Total | | 24 | |

| Semester-V | | | | |
|---|---|---|---|---|
| S.No | Type of Course | Subject | Credits | L-T-P |
| 1 | Major | Basic and Applied Microbiology | 4 | 2-0-4 |
| 2 | Major | Cell and Tissue Culture Technologies | 4 | 3-0-2 |
| 3 | Major | Immunology | 4 | 2-0- 4 |
| 4 | Minor/Specialization | Minor /Specialization Elective-1 | 4 | |

| Total | 16 | |
|---|---|---|

| Semester-VI | | | | |
|---|---|---|---|---|
| S.No | Type of Course | Subject | Credits | L-T-P |
| 1 | Major | Genetics | 4 | 3-0-2 |
| 2 | Major | Agriculture Biotechnology | 4 | 3-0-2 |
| 3 | Major | Bioprocess Engineering | 4 | 2-0-4 |
| 4 | Major | Fundamentals of Nanobiotechnology | 4 | 3-0-2 |
| 5 | Minor/Specialization | Minor/Specialization Elective-2 | 4 | |
| | | Total | 20 | |

| Semester-VII | | | | |
|---|---|---|---|---|
| S.No | Type of Course | Subject | Credits | L-T-P |
| 1 | Major | Advanced Tools and Techniques in Biotechnology | 5 | 3-0-4 |
| 2 | Major | Major Elective-1 | 3 | 3-0-0 |
| 3 | Major | Major Elective-2 | 3 | 3-0-0 |
| 4 | Major | Major Elective-3 | 3 | 3-0-0 |
| 5 | Minor/Specialization | Minor/Specialization Elective-3 | 4 | |
| 6 | Minor /Specialization | Minor Elective-4 (Minor Project) | 4 | 0-0-8 |
| 7 | SIP | Summer Internship | 2 | 0-0-4 |
| | | Total | 24 | |

| Semester-VIII | | | | |
|---|---|---|---|---|
| **S.No** | **Type of Course** | **Subject** | **Credits** | **L-T-P** |
| 1 | Major | Computational Biology | 5 | 3-0-4 |
| 2 | Major | Medical Microbiology | 5 | 3-0-4 |
| 3 | Elective | M. Tech Elective | 3 | 3-0-0 |
| 4 | Research Project | M. Tech Research Project | 6 | 0-0-12 |
| 5 | Research Project | M. Tech Research Project on Specialization | 10 | 0-0-20 |
| | | Total | 19 | |

| Semester-IX | | | | |
|---|---|---|---|---|
| **S.No** | **Type of Course** | **Subject** | **Credits** | **L-T-P** |
| 1 | Research Project | M. Tech Dissertation I | 20 | 0-0-40 |
| | | Total | 20 | |

| Semester-X | | | | |
|---|---|---|---|---|
| **S.No** | **Type of Course** | **Subject** | **Credits** | **L-T-P** |
| 1 | Research Project | M. Tech Dissertation II | 20 | 0-0-40 |
| | | Total | 20 | |

| | | |
|---|---|---|
| **Total Credits for Integrated B. Tech-M.Tech Degree** | **205** | |

## List of Major Courses

| Sem | Course Name | Course Code | L | T | P | **Credit** |
|---|---|---|---|---|---|---|
| I | Chemistry of Biomolecules | EBTY103L | 3 | 0 | 2 | **4** |
| II | Bioanalytical Tools and Techniques | EBTY1002 | 2 | 0 | 4 | **4** |
| II | Cellular Structures and Functions | EBTY101L | 3 | 0 | 2 | **4** |
| III | Enzyme Sciences and Technology | EBTY2007 | 3 | 0 | 2 | **4** |
| III | Molecular Biology | EBTY2003 | 2 | 0 | 4 | **4** |
| III | Thermodynamics & Chemical Processes | EBTY206L | 3 | 0 | 2 | **4** |
| IV | Metabolic Networks | EBTY2004 | 3 | 0 | 2 | **4** |
| IV | rDNA Technology | EBTY204L | 3 | 0 | 2 | **4** |
| IV | Introduction to Biomaterials | EBTY207L | 3 | 0 | 2 | **4** |
| IV | Cell and Tissue Culture Technologies | EBTY301L | 3 | 0 | 2 | **4** |
| V | Basic and Applied Microbiology | EBTY3003 | 2 | 0 | 4 | **4** |
| V | Immunology | EBTY3001 | 2 | 0 | 4 | **4** |
| VI | Genetics | EBTY3002 | 3 | 0 | 2 | **4** |
| VI | Agriculture Biotechnology | EBTY3004 | 3 | 0 | 2 | **4** |
| VI | Bioprocess Engineering | EBTY3006 | 2 | 0 | 4 | **4** |
| VI | Fundamentals of Nanobiotechnology | EBTY3008 | 3 | 0 | 2 | **4** |
| VII | Multiomics Technologies | EBTY4003 | 3 | 0 | 2 | **4** |
| VII | Major Elective -1 | | 3 | 0 | 0 | **3** |
| VII | Major Elective -2 | | 3 | 0 | 0 | **3** |
| VII | Major Elective-3 | | 3 | 0 | 0 | **3** |
| VIII | Major Course (Online) Approved by the Department | | 3 | 0 | 0 | **3** |
| | **Total Credits** | | | | | **80** |

## List of Major Elective Courses

| Sem | Course Name | Course Code | L | T | P | **Credit** |
|---|---|---|---|---|---|---|
| VII | Introduction to Forensic Sciences | EBTY4043L | 3 | 0 | 0 | **3** |
| VII | Stem Cells & Regenerative Medicine | EBTY4045L | 3 | 0 | 0 | **3** |
| VII | Human Physiology | EBTY4046L | 3 | 0 | 0 | **3** |
| VII | Fundamental of Neuroscience | EBTY350L | 3 | 0 | 0 | 3 |
| VII | Phytopharmaceuticals: Engineering and Production | EBTY345L | 3 | 0 | 0 | 3 |
| VII | Gene Therapy | EBTY342L | 3 | 0 | 0 | 3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| VII | Introduction to Pharmaceutical Sciences | EBTY346L | 3 | 0 | 0 | 3 |

**List of MINOR /SPECIALIZATION ELECTIVES**

| Sem | Course Name | Course Code | L | T | P | **Credit** |
|---|---|---|---|---|---|---|
| VII | Translational Immunology | EBTY4044 | 3 | 0 | 2 | **4** |
| V | Model Organisms in Biology | EBTY3041L | 4 | 0 | 0 | **4** |
| VI | Public Health Management | EBTY3040L | 4 | 0 | 0 | **4** |
| VII | GMOs & Industry | EBTY382M | 4 | 0 | 0 | 4 |

## List of Minor/Specialization Core Courses

| Sem | Course Name | Course Code | L | T | P | **Credit** |
|---|---|---|---|---|---|---|
| I | Introductory Biotechnology | EBTY1001 | 3 | 0 | 2 | **4** |
| II | Food Biotechnology | EBTY1006 | 3 | 0 | 2 | **4** |
| IV | Intellectual Property Rights & Biotechnology Regulations | EBTY2006L | 4 | 0 | 0 | **4** |
| III | Introduction to Bioinformatics | EBTY202L | 2 | 0 | 4 | **4** |

**List of Multidisciplinary Courses (MDC)**

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | **Physics for Biotechnologists** | EPHY106L | 2 | 0 | 2 | 3 |
| 2 | **Mathematics Foundations** | **CBCA104** | 2 | 1 | 0 | 3 |
| 3 | **Computational Thinking and Programming** | CSET101 | 2 | 0 | 2 | 3 |

## List of Major Courses In lieu of the Research Project/ Dissertation

| **S. No** | **Course Name** | **Course Code** | **L** | **T** | **P** | **Credit** |
|---|---|---|---|---|---|---|
| 1 | **Nutraceuticals & Health** | **EBTY447L** | 4 | 0 | 0 | 4 |
| 2 | **Personalised Medicine and Therapeutics** | **EBTY351L** | 3 | 0 | 2 | 4 |
| 3 | **Genetic Engineering** | **EBTY4006L** | 4 | 0 | 0 | 4 |

## List of VAC, SEC, AECs

| **S. No** | **Course Type** | **Course Name** | **Course Code** | **L** | **T** | **P** | **Credits** |
|---|---|---|---|---|---|---|---|
| 1 | VAC-1 | **Inculcation of Human Values and Professional Ethics** | **UVAC1001** | 2 | 0 | 0 | 2 |
| 2 | VAC-2 | **Community Engagement and Social Responsibility** | **UVAC1002** | 1 | 0 | 2 | 2 |
| 3 | VAC-3 | **Environment and Sustainability** | **UVAC1003** | 2 | 0 | 0 | 2 |
| 4 | VAC-4 | **AI For Everyone** | | 1 | 0 | 2 | 2 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 | VAC-5 | **Ayurveda & Nutrition** | **EBTY2001L** | 2 | 0 | 0 | 2 |
| 6 | SEC-1 | **Professional Skills** | **USEC1001** | 1 | 0 | 2 | 2 |
| 7 | SEC-2 | **Leadership and Management Skills** | **USEC1002** | 2 | 0 | 0 | 2 |
| 8 | SEC-3 | **Innovation & Entrepreneurship/ Project Management (SOM)** | **NEW CODE** | 1 | 0 | 0 | 1 |
| 9 | SEC-4 | **Fundamentals of Medical Laboratory Technology** | **EBTY2005P** | 0 | 0 | 4 | 2 |
| 10 | AEC-1 | **Communication Skills** | **UAEC1001** | 1 | 0 | 2 | 2 |
| 11 | AEC-2 | **Soft Skills and Personality Development** | **UAEC1002** | | | | 2 |
| 12 | AEC-3 | **(Will be decided by the Department/School) Technical and Creative Writing** | **NEW CODE** | 2 | 0 | 0 | 2 |
| 13 | AEC-4 | **(Will be decided by the Department/ School) Technical Presentation** | **NEW CODE** | **2** | **0** | **0** | 2 |

## List of Minor/Specialization Elective Courses

| S.No. | Specialization | Semester | Course Name | Course Code | L | T | P | Credit |
|---|---|---|---|---|---|---|---|---|
| 1 | Biomedical Technologies | V | Biomedical Technologies in Diagnostic and Therapy | EBTY361L | 4 | 0 | 0 | 4 |
| 2 | | VI | Bioimaging | EBTY362L | 4 | 0 | 0 | 4 |
| 3 | | VII | Medical Innovations | EBTY461L | 4 | 0 | 0 | 4 |
| 4 | | | Minor Project in Specialization | EBTY499J | 0 | 0 | 8 | 4 |
| 5 | Drug Discovery & Protein Therapeutics | V | Drug Discovery Process and Molecular Basis | EBTY363L | 3 | 0 | 2 | 4 |
| 6 | | VI | Rational Drug Design and Structure Determination | EBTY364L | 3 | 0 | 2 | 4 |
| 7 | | VII | Biotherapeutics | EBTY463L | 3 | 0 | 2 | 4 |
| 8 | | | Minor Project in Specialization | EBTY499J | 0 | 0 | 8 | 4 |
| 9 | Genetic Counselling & Precision Medicine | V | Human Genetics | EBTY365L | 3 | 0 | 2 | 4 |
| 10 | | VI | Genetic Counselling | EBTY368L | 4 | 0 | 0 | 4 |
| 11 | | VII | Genomics and Personalized Medicine | EBTY465L | 3 | 0 | 2 | 4 |
| 12 | | | Minor Project in Specialization | EBTY499J | 0 | 0 | 8 | 4 |
| 13 | Industrial Biotechnology | V | Green Chemicals & Sustainable Products | EBTY370L | 3 | 0 | 2 | 4 |
| 14 | | VI | Biofuels & Biorefinery | EBTY467L | 3 | 0 | 2 | 4 |
| 15 | | VII | Bioprocess Optimization & Scale-up | NEW CODE | 3 | 0 | 2 | 4 |
| 16 | | | Minor Project in Specialization | EBTY499J | 0 | 0 | 8 | 4 |
| 17 | Nanotechnology & Biosensors | V | Nanomedicine | EBTY369L | 3 | 0 | 2 | 4 |
| 18 | | VI | Introduction to Biosensors and Bioelectronics | EBTY376L | 3 | 0 | 2 | 4 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 19 | | **VII** | **Digital healthcare, Theranostics and Lab-on-a-chip** | **EBTY469L** | 3 | 0 | 2 | 4 |
| 20 | | | **Minor Project in Specialization** | **EBTY499J** | 0 | 0 | 8 | 8 |

# Semester I

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | **B. Tech Biotechnology** | | | | |
| **Course Code: CBCA104** | **Mathematics Foundations** | L | T | P | C |
| **Owning School/Department** | **School of Computer Science Engineering and Technology** | 2 | 1 | 0 | 3 |
| **Pre-requisites/Exposure** | **Basic Mathematics** | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1: Apply matrix operations and determinants to solve systems of linear equations using analytical methods.
CO2: Demonstrate understanding of set theory, functions, permutations, and combinations for solving counting and logical problems.
CO3: Analyze data using statistical measures and apply probability concepts including distributions to model uncertainty in real-world situations.

**CO – PO /PSO Mapping**

| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** | **PSO1** | **PSO2** | **PSO3** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | **3** | **3** | **2** | | | | | | **2** | | | | **3** | **2** | |
| **CO2** | | | | | **2** | | | | | | | | **3** | **2** | |
| **CO3** | | | | **2** | | | | **2** | | | | | **3** | | |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I** **10 lecture hours**

Concept of matrix, Notation, Order and Equality, Types of matrices, Transpose of a matrix, Symmetric and skew symmetric matrices, Addition, Multiplication and scalar multiplication of matrices, Properties of matrix addition and multiplications, Determinant of a square matrix, Cramer's rule, Properties of determinants, Adjoint and inverse of a square matrix, Concept of elementary row and column operations, Invertible matrices, Consistency, inconsistency, and number of solutions of system of linear equations by examples, Solving system of linear equations in two or three variables using inverse of a matrix.

**Module II** **10 lecture hours**

Sets, relations, and functions, Sets and their representations, Empty set, Finite & Infinite sets, Equal sets, Subsets, Power set, Universal set, Venn diagrams, Union and Intersection of sets, Difference of sets, Complement of a set, Types of functions – Definitions, Inverse functions, Fundamental Principle of counting, Sum and product rule, The principle of inclusion-exclusion, Permutation definition, Linear and circular permutations, Permutations of 'n' dissimilar things taken 'r' at a time, Permutations when repetitions allowed, Circular permutations, Combinations, Combination with repetition, Combination without repetition.

**Module III** **10**
**lecture hours**

Probability and Statistics, Measure of dispersion, Mean, median, mode, Range, mean deviation variance of ungrouped/grouped data, standard deviation of ungrouped/grouped data. Random experiments: outcomes, sample spaces, events, mutually exclusive events, Multiplication theorem on probability, Conditional probability, independent events, Total probability. Random variables, Independent random variables, Probability distributions, Discrete and continuous probability distributions, Special probability distributions, binomial distribution, Poisson distribution and Normal distribution.

**Studio Work / Laboratory Experiments: NIL**

**TEXTBOOKS/LEARNING RESOURCES:**


a) Sheldon M. Ross, Introduction to probability and statistics for engineers and scientists (6 ed.), Elsevier, 2021.ISBN 978-9351073987.

b) Online resource: MA121: Introduction to Statistics, saylor.org

c) R. K. Jain, S. R. K. Iyengar, Advance Engineering Mathematics 3rd Edition, Narosa Publishing House Pvt. ISBN-10. 8184875606; ISBN-13. 978-8184875607


**Assessment Scheme:**

| **Components** | **Internal Assessment** | **Mid Term Exam** | **End Exam** | **Total** |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 20% | 40% | 100% |

**Course Assessment Plan**

| **Components of Course Evaluation** | **Percentage Distribution** |
|---|---|
| Continuous Evaluation (Tutorial/Assignment/Viva) | 20 |
| Test/Quiz | 20 |
| Midterm Examination | 20 |
| End Term Examination | 40 |
| Total | 100 |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **Course Code: EBTY103L** | Chemistry of Biomolecules | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (Cos)**

On completion of this course, the students will be able to:
CO1: Understand and explain the type of carbohydrates, and their functional role in cells.
CO2: Describe the basic unit of proteins, their different structural confirmations, and their function.
CO3: Discuss the classification and functions of lipids.
CO4: Describe the basic unit of nucleic acids, their different structural forms, and their function.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | - | 2 | 2 | - | - | - | 1 | 1 | 1 | 3 | 3 | 2 | 2 |
| CO2 | 3 | 1 | - | 2 | 2 | - | - | - | 1 | 1 | 1 | 3 | 3 | 2 | 2 |
| CO3 | 3 | 1 | - | 2 | 2 | - | - | - | 1 | 1 | 1 | 3 | 3 | 2 | 2 |
| CO4 | 3 | 1 | - | 2 | 2 | - | - | - | 1 | 1 | 1 | 3 | 3 | 2 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 10 lecture hours**

Concept of chemical bonds and major interactions within macromolecules, chirality
Proteins: Classification and structures of amino acids, peptide bond, introduction to biologically active peptides, Protein structure – primary, secondary, tertiary, and quaternary structures, Protein structure and function, Ramachandran Plot, Folding & Denaturation

**Module II: 10 lecture hours**

Carbohydrates: Carbohydrates: monosaccharides, disaccharides, oligosaccharides, complex carbohydrates: amino sugar, glycoproteins, lectins. Stereoisomerism and optical isomerism of sugars. Ring structure and tautomeric forms, mutarotation Structure and biological functions of homo and hetero-polysaccharides, Structure, occurrence and biological importance of structural polysaccharides e.g. Cellulose, chitin, agar, algenic acids, pectins, glycoproteins, proteoglycans, sialic acids, blood group polysaccharides, bacterial cell wall polysaccharides. Use of carbohydrates as fermentation substrate in biotechnology.

**Module III: 10 lecture hours**

Lipids: Building blocks of Lipids – Fatty acids, Glycerol, Sphingosine, Functions of Lipids Classification of Lipids, structure and properties of Triacylglycerols, phospholipids, glycoplipids, sphingolipids and cholesterol, Eicosanoids – Prostaglandins, thromboxanes and

leukotrienes, Isoprenoids, Sterols (Cholesterol & Plant Sterols), Bile Acids, Steroid Hormones, Lipoproteins – Classification, Composition & their importance, Use of lipid-based formulations to deliver therapeutics.

**Module IV: 12 lecture hours**

Nucleic Acids: Importance of nucleic acids in living system, general composition of nucleic acids, the purine and pyrimidine bases, Tautomeric forms of bases, different types of DNA, DNA properties and function, denaturation and renaturation of DNA, hypochromicity. DNA as a vector in biotechnology, types of RNA (structure and function): mRNA, tRNA and rRNA. Use of RNA in biotechnology.

**List of Experiments:**

1. Safety measures in laboratories
2. Preparation of normal and molar solutions
3. Qualitative tests for carbohydrates
4. Tests for Reducing Sugars
5. Detection and Estimation of starch in leaves
6. Qualitative Tests for nucleic acids
7. Separation of amino acids/ sugars/ bases by thin layer chromatography
8. Estimation of proteins by Biuret Test
9. Estimation of proteins by Lowry's Reagent

**Text Books:**

1. Nelson, David L., and Michael M. Cox. *Lehninger Principles of Biochemistry*. 7th ed. New York, NY: W.H. Freeman, 2017.
2. Kennelly. *IE Harper's Illustrated Biochemistry 32/e*. 32nd ed. Columbus, OH: McGraw-Hill Education, 2022.

**Reference Books:**

1. Stryer, L., Biochemistry, 4th Edition, W.H. Freeman Company, New York, 1995.

**Assessment Scheme:**

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 20% | 40% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **Course Code:** | Introductory Biotechnology | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:
CO1: Describe the structural organization and functional roles of cellular organelles in prokaryotic and eukaryotic cells.
CO2: Explain the structure and function of major biomolecules and their roles in cellular processes.
CO3: Classify major microbial groups and describe their roles in health, environment, and industry.
CO4: Explain beneficial and harmful human-microbe interactions and assess the importance of microbes in biotechnology applications.
CO5: Understand applications of biotechnology across agriculture, medicine, environment, and industry.
CO6: Identify key career opportunities in biotechnology.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | – | – | – | – | – | – | – | – | – | 2 | 2 | – | – |
| CO2 | 3 | 1 | 1 | – | – | – | – | – | – | – | – | 2 | 2 | – | – |
| CO3 | 3 | – | 1 | 1 | – | 1 | – | – | – | – | – | 2 | 2 | 1 | – |
| CO4 | 3 | – | – | – | – | 1 | 1 | – | – | 1 | – | 2 | 2 | 2 | 2 |
| CO5 | 3 | – | 2 | 1 | 2 | 2 | 2 | – | – | – | – | 2 | 3 | 3 | 2 |
| CO6 | – | – | – | – | – | – | – | – | 2 | 2 | 2 | 3 | 2 | 2 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 12 lecture hours**

**Cell as a unit of life**: Cell theory and the concept of the cell as the basic unit of life; prokaryotic and eukaryotic cells; differences between plant and animal cells; structure and function of cellular organelles - plasma membrane, and cell wall, nucleus, mitochondria, endoplasmic reticulum, Golgi apparatus, lysosomes, peroxisomes, cytoskeleton; the cell cycle - mitosis and meiosis; cell death.

**Introduction to key biomolecules** - carbohydrates, lipids, proteins, and nucleic acids; role of proteins as structural and functional molecules in the cell, structure and function of DNA and RNA as genetic material.

**Module II:** **15 lecture hours**

**Microbes and Microbial World -** Diversity, discovery, and evolution of microbes; classification and characteristics of archaea, bacteria, fungi, protozoans, algae, and viruses; environmental roles of extremophiles - bioremediation, biomining, and bioenergy; industrial applications of microbes - protein production; beneficial microbes including gut microflora and probiotics; harmful microbes and their role in bacterial, viral, and fungal infections; bacteriophages; and human-microbe interactions including the microbiome.

**Module III:** **15 lecture hours**

**Biotechnology & its applications**

Applications of biotechnology in agriculture - the Green Revolution, plant tissue culture, genetically modified organisms (GMOs), Bt cotton, and pest-resistant plants; Applications of biotechnology in medicine - vaccine development, molecular diagnostics, drug production, gene therapy, and transgenic animals; Applications of environmental biotechnology - bioplastics, biofuels, and marine biotechnology; Applications of industrial and food biotechnology - aerobic and anaerobic fermentation processes and food production. Careers in Biotechnology.

**List of Experiments**

1. Laboratory Safety and Good Practices and introduction to basic biotechnology lab equipment
2. Preparation of Molar and Normal Solutions
3. Preparation of Buffer Solutions and pH Determination
4. Observation of morphology of microbes on culture plates
5. Mitosis in onion cells
6. Demonstration of fermentation using yeast
7. Agarose Gel Electrophoresis

**Text Books:**


1. Urry, Lisa A., Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, and Rebecca B. Orr. *Campbell Biology.* 12th ed. Pearson. 2021.
2. David L. Nelson; Michael M. Cox. *Lehninger Principles of Biochemistry.* 8th ed. Macmillan. 2021.
3. U. Satyanarayan U, Chakrapani U. *Biotechnology.* Books and Allied (P) Ltd. 2020.


**Reference Books:**


1. Godbey WT. *Biotechnology and its Applications.* Academic Press. 2nd ed. 2021.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 20% | 40% | 100% |

# Semester II

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **Course Code: EPHY106L** | Physics for Biotechnologists | L | T | P | C |
| **Owning School/Department** | SEAS/Physics | 2 | 0 | 2 | 3 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1: Ability to analyse the wave optics phenomena and its practical implications.

CO2: Knowledge to apply LASER and Optical Fiber in biotech research.

CO3: Ability to appreciate the microscopic world and its implication in biotech instrumentation.

CO4: Understanding properties of matter (with special importance on fluids), and how one can cool or liquify the fluids.

**COs-POs/PSOs Mapping**

| | P01 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 1 | - | - | - | 1 | - | 1 | 2 | 1 | - | 2 | 3 | 3 | 1 |
| CO2 | 2 | 1 | - | - | - | 1 | - | 1 | 2 | 1 | - | 2 | 3 | 3 | 1 |
| CO3 | 2 | 2 | 1 | - | 1 | 1 | 1 | - | 2 | 1 | - | 3 | 3 | 3 | 1 |
| CO4 | 2 | 2 | 1 | - | 1 | 1 | 1 | - | 2 | 1 | - | 3 | 3 | 3 | 1 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 12 lecture hours**

Introduction to Wave Optics, Huygen's Principle and Young Double Slit Experiment, Interference from parallel thin films, Wedge shaped film, Newton's Ring, Application of Interference.

Introduction to Diffraction, Types of diffraction, Diffraction by a single slit, Resolving Power of Telescope and Microscope, Diffraction Grating and Application of Diffraction.

Polarized and un-polarized light, Malus's Law, Brewster's Law, Types of Polarization, Nicol Prism, QWP and HWP, Application of Polarization, Polarimetry.

**Module II: 5 lecture hours**

Schematic description of spontaneous and stimulated Emissions, Population Inversion, Working principle of Laser and its application

Principle of propagation of light in optical fiber, Acceptance angle, Types of optical fibers, Optical Fiber in communication, Application in Medical Industry.

**Module III: 7 lecture hours**

Some fundamental problems: Photo-electric effect, X-ray Diffraction, Wave-particle duality, De Broglie's theory, Heisenberg uncertainty principle.

Bohr's theory, Atomic Spectra, Emission and Absorption spectra, Basics of Fluorescence, Brief introduction to Spectroscopy, Electromagnetic force and Basics of Mass spectrometry, Concept of mass spectrometric analysis, Ionization, Elements of a spectrum, Isotopes. Basics of centrifuge.

**Module IV: 3 lecture hours**

Friction, Types of friction, Elastic properties of materials, Hooke's Law, Elastic Moduli.

Streamline flow, Turbulent motion, Critical velocity, Viscosity, Coefficient of viscosity, Poiseulle's equation, Stoke's method, Ostwald viscometer.

Excess pressure inside a liquid drop and soap bubble, Angle of contact, Searl's Torsion balance method, Jaeger's method, Quincke's method, Interfacial surface tension.

**Module V: 3 lecture hours**

Methods of liquefaction of gases (cascade process, Linde's process, and adiabatic demagnetization process) – Measurement of cryogenic temperatures. Origin of Nanotechnology, Nano Scale, Surface to Volume Ratio, Fabrication: Bottom-up and Top-down.

**List of Experiments (any 10)**

1. Estimation of Error in Vernier Callipers & Screw Gauge
2. Determination of wavelength of light using Newton's ring method
3. Determination of refractive index of prism
4. Measurement of wavelength of light source using diffraction grating
5. Find the wavelength of He-Ne laser from double slit experiment
6. Study the variation of angle of rotation of sugar solution with its concentration
7. Measurement of Planck's constant using photoelectric effect
8. e/m of electron by Thomson Method
9. Determination of Young's Modulus of a rod.
10. Determination of Coefficient of Viscosity.
11. Determination of the coefficient of static friction.

**Text Books:**


1. Halliday, David., Resnick, Robert., Walker, Jearl. *Principles of Physics*. Singapore: Wiley, 2014.
2. Ghatak, Ajoy. *Optics*. United Kingdom: McGraw-Hill Education, 2010.
3. Beiser, Arthur. *Concepts of modern physics*. Boston: McGraw-Hill, 2003.


**Reference Books:**


1. Jenkins, Francis Arthur., White, Harvey Elliott. *Fundamentals of Optics.* Colombia: McGraw-Hill, 1976.
2. Krane, Kenneth S.*Modern Physics*. United Kingdom: Wiley, 2019.

3. Young, Hugh D., Freedman, Roger A.. *University Physics with Modern Physics*. N.p.: Pearson Education, 2015.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 20% | 40% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **Course Code: EBTY101L** | Cellular Structures and Functions | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1: Understand the concept of origin and evolution of cells, structural and functional differences between prokaryotic and eukaryotic cells and describe the structure and roles of cellular organelles.

CO2: Understand the role of cytoskeleton components in cell movement, mechanism of muscle contraction and junctions involved in cell-to-cell interaction.

CO3: Describe the processes of involved in the movement of small molecules and macromolecules across the cell membrane and development of action potential.

CO4: Explain the molecular mechanisms involved in intracellular vesicular trafficking and protein sorting between the ER and Golgi complex, transport of molecules in and out of the nucleus, and the targeting of proteins to mitochondria, chloroplasts, and peroxisomes.

CO5: Understand the processes of the cell cycle, mitosis, meiosis, and programmed cell death.

CO6: Understand the principles of cell signalling, concept of oncogenes, tumour suppressor genes, and role of signalling in cancer development.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 1 | - | 2 | - | - | 1 | 2 | 2 | 3 | 3 | 2 | 1 |
| CO2 | 3 | 2 | 2 | 1 | - | 2 | - | - | 1 | 2 | 2 | 3 | 3 | 2 | 1 |
| CO3 | 3 | 2 | 2 | 1 | - | 2 | - | - | 1 | 2 | 2 | 3 | 3 | 2 | 1 |
| CO4 | 3 | 2 | 2 | 1 | - | 2 | - | - | 1 | 2 | 2 | 3 | 3 | 2 | 1 |
| CO5 | 3 | 2 | 2 | 1 | - | 2 | - | - | 1 | 2 | 2 | 3 | 3 | 2 | 1 |
| CO6 | 3 | 2 | 2 | 1 | - | 2 | - | - | 1 | 2 | 2 | 3 | 3 | 2 | 1 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 18 lecture hours**

**An overview of cells:** Origin and evolution of cells, prokaryotic & eukaryotic cells,

Composition of cells: Plasma membrane & Cell wall ; The Nucleus - Nuclear Envelope-structure of nuclear pore complex, nuclear lamina, Chromatin: molecular organization, Nucleolus; Mitochondria, Chloroplast & Peroxisomes - Structural organization, Function, Marker enzymes, Semiautonomous nature of mitochondria and chloroplast, chloroplast DNA, Peroxisomes'assembly, Glyoxisomes

Endoplasmic reticulum, Golgi apparatus and Lysosomes,Vacuoles, Centrioles.

**Cytoskeleton and cell movement:** Structure and organization of microfilaments, microtubules, and intermediate filaments; motor proteins and cellular movement; mechanics of muscle contraction; cell to cell interactions: Adhesion Junctions, Tight Junctions, Gap Junctions, Plasmodesmata.

**Tools & Techniques in Cell Biology** for visualization and separation of cells and organelles – Microscopy, Flow cytometry & Differential centrifugation.

**Module II: 15 lecture hours**

**Transport of small molecules across the plasma membrane:** simple diffusion, active and passive transport of molecules across membrane, ion channels, generation of action potential.

**Transport of macromolecules**: Endocytosis, Exocytosis, Phagocytosis, Pinocytosis.

**Protein sorting:** Role of Endoplasmic reticulum and Golgi complex in intracellular vesicular trafficking and protein sorting, transport of molecules in and out of the nucleus, transport of proteins into Mitochondria, Chloroplasts and Peroxisomes.

**Module III: 9 lecture hours**

**Cell Division, Death, and Renewal:** Mitosis and Meiosis, programmed cell death and cell renewal.

**Introduction to Cell Signalling and Cancer:** General Principles of Cell Signalling, Autocrine, Paracrine and Endocrine modes of signalling, Ligand and receptors, Signalling via G-Protein-linked cell receptors, enzyme-linked cell receptors and kinase receptors, Ion-Channel–Linked Receptor, Hormone Receptor-Interaction, Role of signalling in cancer, oncogenes, tumour suppressor genes & apoptosis.

**List of Experiments:**

1. Preparation of buffers
2. Introduction to Microscopy
3. Bacterial culture media preparation and streaking
4. Cell counting using hemocytometer and calculation of cell viability
5. Yeast culture media preparation and streaking
6. Yeast/fungal cell staining using lactophenol cotton blue stain
7. Staining of human cheek cells using methylene blue
8. Staining of plant cells using safranin
9. Analysis of plasma membrane permeability (osmosis)
10. Mitosis in Onion root tip

**Text Books:**


1. Cooper, Geoffrey M., and Kenneth E. Adams. *The Cell: A Molecular Approach*. 9th ed. New York: Oxford University Press. 2022.
2. Lodish, Harvey. *Molecular cell biology*. 9th ed. Macmillan, 2021.
3. Karp, Gerald., Iwasa, Janet., Marshall, Wallace. Karp's *Cell and Molecular Biology:*

*Concepts and Experiments*. 8th ed. United Kingdom: Wiley, 2016.

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **Course Code:** | Bioanalytical Tools and Techniques | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 2 | 0 | 4 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Reference Books:**


1. Alberts, Bruce. *Molecular biology of the cell*. Garland science, 2017.
2. Yu, Hanry. *The Cell as a Machine*. Cambridge University Press, 2018.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 20% | 40% | 100% |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1: Explain and demonstrate adherence to laboratory safety protocols and the operation of basic lab instruments.

CO2: Apply principles of centrifugation, electrophoresis, and chromatography to separate and analyse biological molecules.

CO3: Evaluate data from UV-Vis spectroscopy, chromatography, Microscopy and electrophoresis experiments to determine unknown sample characteristics.

CO4: Design and interpret experiments using microscopy, spectrometry, and buffer systems, integrating basic statistics and graphical analysis.

**CO-PO/PSO Mapping:**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 1 | 3 | 1 | 1 | 1 | 2 | 3 | - | 2 | 3 | 3 | 3 |
| CO2 | 3 | 3 | 3 | 2 | 3 | 1 | 1 | 1 | 2 | 3 | - | 2 | 3 | 3 | 2 |
| CO3 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 3 | - | 3 | 3 | 3 | 3 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 3 | 3 | - | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 8 lecture hours**

**Lab Safety and Good Laboratory Practices:**

Introduction to laboratory safety guidelines and regulations, Proper handling and disposal of biological materials and hazardous chemicals.

**Basic laboratory equipment and their uses**

Water baths, pH meter, Vortex, Centrifuges, Autoclave, Deep freezers, Ice flaking machine, Laminar flow, Water purification systems, Autoclave, Incubators, Shaker-Incubator, Weighing balance, Electrophoretic systems, Principle, types and applications of Polymerase Chain Reaction (PCR), Micropipettes, Multichannel Pipette, Biosafety Cabinets.

**Buffers and Buffering Capacity**

Concept of Acids and Bases, Buffers, Buffering Capacity, Types of Buffers – Acidic, Basic and Physiological buffers, Henderson-Hasselbalch equation, buffer preparation, pH and pKa

**Centrifugation:**

Basics of Centrifugation, g and RPM, Ultracentrifugation, Differential and Density Gradient Centrifugation and Subcellular Fractionation.

**Module II: 12 lecture hours**

**Basic Principles and applications of chromatography**: Principles of separation, Factors affecting separation, Partition Coefficient, Types of Chromatographic Techniques – Introduction to Thin Layer Chromatography, Paper Chromatography, Size Exclusion Chromatography, Ion Exchange Chromatography, Affinity Chromatography, Gas Chromatography (GC) and HPLC. Introduction to AKTA Purification System and its application in various chromatography.

**Filtration and Membrane-Based Techniques:** Ultrafiltration, Microfiltration, Dialysis.

**Electrophoresis:** Principles of gel electrophoresis, Paper Electrophoresis, Gel Electrophoresis, DNA and protein electrophoresis techniques-Agarose gel, PAGE, Native and SDS PAGE.

**Molecular Spectroscopy:**

Introduction to spectroscopy, Principles of absorption- Lambert Beer's law, UV-Visible Absorption, Fluorescence and Mass Spectroscopy.

**Module III: 8 lecture hours**

**Basic Principle and applications of Microscopy:**

Microscopy-Principles of Light microscopy; Phase contrast microscopy; Electron (Scanning Electron Microscopy & Transmission Electron Microscopy), Fluorescence, and Confocal, Applications in cellular imaging and analysis.

**List of Experiments**

1. Basic lab safety rules and Basic laboratory instrumentation – Principles and Handling of pH meter, water bath, Vortex, Centrifugation, Autoclaving, Multichannel, Pipette Aid, Micropipettes
2. Concept of Molarity, Molality and Normality, unit conversions.
3. Preparation of Buffers – Acetate, Phosphate & Tris Buffers
4. Verification of Lambert Beers Law- Determination of Absorption Maxima and Preparation of Standard curve
5. Sucrose density gradient centrifugation for separation of dyes of different molecular weights.
6. Separation of plant pigments by Paper Chromatography.
7. Separation of amino acids by Thin Layer Chromatography & Calculation of Rf value
8. Separate Blue dextran and Methyl Orange by Gel filtration chromatography.
9. Agarose Gel Electrophoresis to determine molecular weight of DNA.
10. SDS PAGE analysis to determine molecular weight of BSA and unknown protein.

**Text Books:**

1. S. K. Sawhney, R. Singh. Introductory Practical Biochemistry. Editor(s): ISBN: 978-81-7319-302-6. E-ISBN: Publication Year: Reprint 2014.

| **Name of Program** | B.Tech. Biotechnology | | | | |
|---|---|---|---|---|---|
| **Course Code** | Food Biotechnology | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | | | | | |

2. Plummer, David T. An Introduction to Practical Biochemistry. India, McGraw-Hill, 1987.

3. Hofmann, A., & Clokie, S. (Eds.). *Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology* (8th ed.). Cambridge: Cambridge University Press. 2018.

**Reference Books:**

1. A. K. Srivastava and Sabari Ghoshal, *Fundamentals of Bioanalytical Techniques and Instrumentation*, Prentice Hall India Learning Private Limited, 2009.

**Assessment Scheme**:

| **Components** | **Internal Assessment** | **Mid Term Exam** | **End Exam** | **Total** |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 20% | 40% | 100% |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

**CO1:** Explain the role of biotechnology in enzyme production and apply knowledge of food preservation and processing techniques in industrial settings.

**CO2:** Demonstrate an understanding of traditional and modern fermentation processes, including the development of starter cultures, probiotics, and single-cell proteins.

**CO3:** Identify and analyze various food additives, preservatives, and their biological effects, including applications of bio-preservatives and microbial antimicrobials in food safety.

**CO4:** Apply biosafety and quality assurance protocols such as GMP, HACCP, and biosensor-based techniques to assess and ensure food quality and regulatory compliance.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 1 | - | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 1 | 3 | 2 | 3 | 3 | 3 | 3 |
| CO3 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 14 lecture hours**

**Introduction to Food Biotechnology:** Historical development and scope, role of Biotechnology in Food Science, Types and classification of foods

**Biotechnology in Food Processing and Preservation**:

**Industrial enzyme production for food industry**: α-amylase in corn syrup industry, Chymosin (rennin) in dairy industry
**Principles of food preservation**: Bactericidal preservation methods: Cooking, canning, pasteurization, sterilization, irradiation
Bacteriostatic preservation methods: Drying, salting, curing, smoking, refrigeration, freezing
**Food preservation techniques:**
Physical methods (freezing, drying, irradiation, canning)
Chemical methods (preservatives and bio-preservatives)
Biological methods (Bio-preservatives): Bacteriocins, antibiotics, antioxidants, bacteriophages
**Food processing methods:**
Dehydration, blanching, canning, extrusion, frying
Pasteurization, chilling, freezing, fermentation, packaging
**Single Cell Proteins (SCPs)**: Microbial production, nutritional value, and uses

**Module 2** **14 lecture hours**

**Fermentation Technology and Indigenous Foods**
Introduction to fermentation as an economic method of food processing; Types of fermentation: Lactic acid, alkaline, alcoholic, leavened bread
**Indigenous fermented foods:** From India, Southeast Asia, and other global regions, Production techniques and cultural significance; Ayurvedic applications of fermented foods & health benefits; Fermented dairy and plant-based beverages
**Probiotics, prebiotics, postbiotics:** Definition, applications, health impacts
**Starter cultures:** Role in controlled fermentation, Strain improvement via biotechnology

**Module 3** **14 Lecture hours**

**Food Safety, Quality Assurance, and Regulatory Frameworks**
**Food additives and preservatives:** Classification (intentional vs. non-intentional), Organic acids, vitamins, pigments, and flavours
**Foodborne illnesses:** Bacterial agents (e.g., *Salmonella*, *Listeria*); Nonbacterial agents (protozoa, fungi, viruses); Food contamination sources and detection methods
**Food Contamination and detection:** Sources, microbial tests, biosensor technologies
**Quality assurance in foods:** Allergen testing; Food contact material analysis; Food ingredient verification; Biosensors in food safety
Good Manufacturing Practices (GMP); Hazard Analysis and Critical Control Points (HACCP); Quality control systems in the food industry; Global food safety regulations and case studies

**List of Epxeriments:**

1. Preparation of Yogurt or Curd using microbial culture and monitoring fermentation kinetics (pH, acidity)
2. Isolation of amylase-producing bacteria from soil and testing enzyme activity using starch-iodine assay

3. Demonstration of pasteurization: Comparative microbial analysis before and after heat treatment
4. Food spoilage study: Observation of microbial growth on different food samples under varied conditions (light, temp)
5. To ferment grapes- wine preparation
6. To produce beer from barley grain by alcoholic fermentation process by using *S. cerevisiae*
7. Extraction and estimation of natural food preservatives and their antimicrobial effects
8. Detection of adulterants in food (e.g., metanil yellow in turmeric, starch in milk, etc.)

**Text Books :**


1. Fellows, P. J. *Food Processing Technology: Principles and Practice*. Elsevier Science, 2009.
2. Adam, Joy. 'Biotechnology: Food and Agriculture'. *Biotechnology: Food and Agriculture*, 2016.
3. Mukhopadhyay, S. N. *Food Engineering: Process and Technology, Viva Books*, 2017.
4. Joshi, V.K., and Ramesh C. Ray. *Advances in Food Biotechnology*. Hoboken, NJ: Wiley Blackwell, 2015.
5. Hui, Y.H., ed. *Handbook of Food Science, Technology, and Engineering*. 4 vols. Boca Raton, FL: CRC Press, 2006.
6. Lee, Byong H. *Fundamentals of Food Biotechnology*. 2nd ed. Hoboken, NJ: Wiley-Blackwell, 2015.


**Assessment Scheme :**

| Components | Internal Assessment | Mid Term Exam | End Term Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 20% | 40% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **Course Code** | Environmental Science-BU | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 2 | 0 | 0 | 2 |
| **Pre-requisites/Exposure** | Nil | | | | |

## Course Outcomes (COs)

On completion of this course, the students will be able to:

CO1: Understand the concepts of environment, sustainability, population growth, and the use of natural resources, including their impact on sustainable development.

CO2: Explain the causes and effects of climate change and evaluate strategies for mitigation and adaptation at local, regional, and global levels.

CO3: Identify different types of pollution and emerging contaminants, and apply appropriate waste management and pollution control methods.

CO4: Understand major environmental laws, policies, and international agreements, and explain their importance in environmental protection and sustainability.

### CO-PO/PSO Mapping

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 2 | 1 | 1 | 3 | 2 | 1 | 2 | 1 | 3 | 3 | 2 | 1 |
| CO2 | 3 | 3 | 2 | 1 | 1 | 2 | 3 | 2 | 3 | 3 | 1 | 2 | 3 | 2 | 2 |
| CO3 | 1 | 2 | 3 | 3 | 2 | 1 | 3 | 1 | 1 | 3 | 2 | 3 | 2 | 3 | 2 |
| CO4 | 3 | 2 | 3 | 1 | 1 | 1 | 2 | 3 | 1 | 2 | 3 | 2 | 2 | 3 | 3 |

1= weakly related 2 = moderately related 3 = strongly related

## Course Contents:

**Module I: Population growth, Resource Consumption and Sustainable Development (6 hours)**

Introduction to environment and sustainability, Population explosion and growth curve, Fundamentals of ecology, Natural resources-renewable and non-renewable resources and energy, Problem associated with natural resources, Biodiversity, Sustainable development goals (SDGs).

**Module II: Environmental Issues and Climate Change: (8 hours)**

Local/Regional/Global environmental issues: Urban pollution, waste management, Deforestation, desertification, transboundary pollution, Global warming, ozone depletion, loss of biodiversity and ocean acidification.

Causes and effects of climate change, Carbon footprint and reduction strategies, Climate change mitigation and adaptation: Climate-resilient agriculture, water conservation, disaster management.

**Module III: Environmental Pollution and Management (10 hours)**

Types of pollution: air, water, soil, noise pollution, thermal, and nuclear pollution, sources and effects of pollution on human health, Emerging Contaminants, Pollution control and prevention Strategies, Environmental impact assessments (EIA), Life cycle analysis (LCA), Waste management concepts and methods, Waste-to-Energy, Concept of circular economy and practices (zero waste cities).

**Module IV: Environmental Policies and Legislation (6 hours)**

International Environmental Treaties and Conventions: Paris Agreement, Kyoto Protocol, Montreal Protocol, National Environmental Laws and Regulations: Environmental Protection Act, Water Act, Air Act, Forest Conservation Act, Wildlife Protection Act.

## Textbooks:


1. Miller, G. Tyler, and Scott E. Spoolman. Environmental Science. 16th ed. Boston: Cengage Learning, 2019. ISBN 9781337569613.
2. Masters, Gilbert M., and Wendell P. Ela. *Introduction to Environmental Engineering and Science*. 3rd ed. Boston: Pearson, 2023. ISBN 9780137848584.
3. E. Barucha, Textbook of Environmental Studies for undergraduate Courses, 2nd Edition, Universities Press,2013, ISBN: 9788173718625.
4. R. Rajagopalan, Environmental Studies: From Crisis to Cure, 3rd Edition, Oxford University Press, 2016, ISBN: 9780199459759.
5. C.S. Rao, Environmental Pollution Control Engineering, 4th Edition, New Age International Pvt. Ltd, 2023, 978-8122472288.


## Reference Books:


1. Davis, Mackenzie L., and Susan J. Masten. Principles of Environmental Engineering and Science. 3rd ed. New York: McGraw-Hill Education, 2013. ISBN 9781259060472.
2. B. Jospeh Environmental Studies simplified, 3rd Edition, McGraw Hill Education ISBN: 9789352605170.
3. A Kaushik, C.P. Kaushik, Environmental Science, 7th Edition, New Age International Pvt. Ltd, 2023, 978-8122484861.
4. D.K. Asthana & M. Asthana, A textbook of Environmental Studies for undergraduate students, 2nd Edition, S. Chand & Company LTD, 2012, ISBN:81-219-2764-1.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Term Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 20% | 40% | 100% |

# Semester III

**Course Outcomes (COs)**

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **Course Code: CSET101** | Computational Thinking and Programming | L | T | P | C |
| **Owning School/Department** | SEAS/ Computer Science & Engineering | 2 | 0 | 2 | 3 |
| **Pre-requisites/Exposure** | - | | | | |

By the end of this program, students will be able to -

CO1: Understand the fundamentals of computer hardware, software, algorithms and programming

CO2: Understand basics of Python programming and write recursive algorithms to handle all recursive data structures.

CO3: Apply appropriate searching and sorting techniques and understand graph algorithms for various practical problems.

CO4: Understand and formulate new/improved solutions for programming problems using learned data structure

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 1 | 1 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 3 | 1 | 3 | 3 |
| CO2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | - | 2 | 2 | 2 | 3 | 1 | 3 | 2 |
| CO3 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | - | 2 | 2 | 2 | 3 | 1 | 3 | 2 |
| CO4 | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 1 | 3 | 2 | 2 | 3 | 1 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 8**
**lecture hours**

Overview of course, Introduction: Introduction to Computer Science; Computer Algorithms; Computer Hardware; Computer Software; The process of Computational Problem Solving; Introduction to Python programming language Data and Expressions: Literals; Variables and Identifiers; Operators; Expressions and Data Types, Logical operator; Boolean operator; Boolean Expressions; Control Structures; Selection Control, Iterative Control Lists: List Structures; Lists in Python, Iterating Over Lists in Python, Biopython: tools for biological computation.

**Module II: 7**
**lecture hours**

Functions: Program routes; Calling Value Returning Functions; Calling Non- value Returning Functions Parameter Passing; Keyword and Default Arguments in Python; Variable Scope; Modular design Modules; Top-Down Design Python Modules; File Handling Operation in file, Reading and Writing Text Files, Sequences, Strings.

**Module III: 7**
**lecture hours**

Files. Exceptions Data Collections Applying Lists, List Operations, Dictionary Type in Python Set Data Type in Python; Non-Sequential Collections, Dictionary Operations Introduction to Object Oriented Programming, Class, Object.

**Module IV:** **6 lecture hours**

Encapsulation, Data abstraction, Inheritance, Polymorphism, Graphics Programming: Graphics Programming, Using Graphical Objects, Interactive Graphics, Displaying Images, Generating Colors, Graphics Objects, Entry Objects, Test Case: Numpy, scipy; Test Case: panda, Matplotlib and Seaborn.

**List of Experiments :**

The lab component of this course is designed to introduce online-coding tools such as Microsoft Azure, Colab to the students and provide hands-on experience with the concepts taught in the lectures.

**Text Books :**


1. Dierbach, C. 'Introduction to Computer Science Using PYTHON: A Computational Problem-Solving Focus'*), Wiley*, 2015, 978–0470555156.
2. Kanetkar, Yashavant. *Let Us Python*. New Delhi, India: BPB Publications, 2019.


**Reference Books :**


1. Downey, Allen, Chris Meyer, and Jeffrey Elkner. *How to Think like a Computer Scientist : Learning with Python*. Wellsley, Ma: Green Tea Press, 2016.
2. Martin, C. *Python: The Complete Reference*. McGraw-Hill, 2018.
3. "Data Structures Tutorial." 2014. GeeksforGeeks. GeeksforGeeks. February 2014.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 20% | 40% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **Course Code** | Molecular Biology | L | T | P | C |
| **Owning School/Department** | SEAS/ Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1: Demonstrate a comprehensive understanding of DNA as the genetic material.
CO2: Describe the structural organization of genetic material in prokaryotic and eukaryotic gene structures, as well as explain genome organization
CO3: Comprehend the mechanisms of DNA replication, repair, RNA synthesis, and protein synthesis.
CO4: Explain the regulation of gene expression at both transcriptional and post-transcriptional levels
CO5: Demonstrate familiarity with model systems and their applications in genetic studies.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 2 | 3 | 1 | 3 | 1 | 2 | 3 | - | - | 2 | 3 | 3 | 1 |
| CO2 | 3 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 3 | - | - | 2 | 3 | 3 | 1 |
| CO3 | 3 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 3 | - | - | 2 | 3 | 3 | 1 |
| CO4 | 3 | 2 | 1 | 3 | 2 | 1 | 1 | 1 | 2 | 3 | - | - | 2 | 3 | 3 | 1 |
| CO5 | 3 | 2 | 1 | 3 | 3 | 1 | 1 | 3 | 2 | 3 | - | - | 2 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 12 lecture hours**

**Nucleic acids as Genetic Material:** MacLeod and MacCarty's experiment, Hershey and Chase's experiment, Griffith's experiment, DNA and RNA as a genetic material, The flow of genetic information: the central dogma.

**Structural Organization of Genetic Material:** Watson-Crick's discovery of structure of DNA. Structure of DNA: A, B and Z Structure, Concept of gene, structure of eukaryotic and prokaryotic gene. Non-coding DNA, repetitive sequences, Satellite DNA, Transposon and transposition, Concept of Introns & Exons, DNA Topology, Types of RNA: Coding and non-coding RNAs, Secondary structures in RNA, Chromatin Structure- Heterochromatin, Euchromatin, Organization of Chromosomes

**DNA Replication:** Models of DNA replication, DNA replication in prokaryotes and eukaryotes, Enzymes of DNA replication, Eukaryotic telomeres and replication Inhibitors. Mitochondrial (D-loop) DNA replication, Viral DNA Replication, Rolling circle mechanism.

**Transcription and Gene Regulation** : Mechanism of transcription in prokaryotes and eukaryotes, Transcription factors, Post transcriptional processing of mRNA – 5'capping, splicing, polyadenylation. In prokaryotes: Induction and repression, Concept of operon model, lac, gal and trp operons, regulation of gene expression in eukaryotes, Transcription factors and their role in gene regulation, Inhibitors of transcription

**Module II: Translation 12 lecture hours**

Translation in Prokaryotes and Eukaryotes, differences between prokaryotic and eukaryotic protein synthesis, Assembly line of polypeptide synthesis - ribosome structure and assembly, various steps in protein synthesis. Charged tRNA, aminoacyl tRNA synthetases. Proteins involved in initiation, elongation and termination of polypeptides. Fidelity of translation. Inhibitors of protein synthesis. Regulation of translation **Genetic Code,** Amino acids, Selenocysteine and Pyrrolysine as amino acids, Wobble Hypothesis, Codon usage.

**Module III: Post-transcriptional Modifications & Mutations 9 lecture hours**

Post-translation modifications, RNAi regulatory mechanisms, Epigenetic modifications and Genetic Disorders: Mutations and their classification, spontaneous, induced, lethal, Mutagens: their types and actions, DNA damage, Mutagenicity testing using microbial systems: Ames Test, Promoter Methylation and Histone acetylation.

**Module IV: DNA Repair & Recombination 9 lecture hours**

Repair and Recombination Mechanisms: Photo-reactivation, Excision Repair, Mismatch Repair, Double-Strand Breakage Repair, SOS Repair, Genetic recombination: Site-specific recombination and Homologous recombination.

**List of Experiments**

1. Calculations and Buffer/Solution Preparations
2. Genomic DNA isolation from bacterial cell.
3. Plasmid DNA isolation from prokaryotic cell.
4. Plant DNA isolation and quantification.
5. Visualization, quantification, quality check of DNA by agarose gel electrophoresis and spectrophotometric analysis.
6. DNA damage assay using pUC19 DNA.
7. Genomic DNA isolation from human cheek cells
8. Gene expression: Lac Operon Induction-Media preparation-1
9. Lac Operon Induction and analysis of data

**Text Books :**

1. Alberts Bruce, Heald Rebecca, Johnson Alexander, Lewis Julian, Raff Martin, Roberts Keith, and Walter Peter, *Molecular Biology of the Cell* (7th ed.), W. W. Norton & Company, 2022.
2. Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick. *Lewin's GENES XII* (12th ed.), Jones & Bartlett Learning, 2017.

**Reference Books :**

1. Lodish Harvey, Berk Arnold, Zipursky Lawrence, Matsudaira Paul, Baltimore David and Darnell James, *Molecular Cell Biology* (8th ed.), W. H. Freeman, 2016.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 40% | 20% | 40% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **Course Code:** | Enzyme Sciences and Technology | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the basic concept of enzymes, coenzymes, cofactors, prosthetic groups, ribozymes, classification, types, and nomenclature of enzymes.

CO2 : Understand the mechanism of enzyme catalysis, specificity of enzymes, and factors affecting catalysis.

CO3 : Apply the principles of enzyme kinetics and the Michaelis-Menten equation to determine values of Km and Vmax and study factors affecting enzyme velocity, and understand the kinetics of multi-substrate reactions.

CO4 : Understand the mechanisms for different types of enzyme inhibition and examples of inhibitors.

CO5 : Apply isolation and purification strategies to obtain enzymes from various sources and methods of immobilization of enzymes.

CO6 : Understand the role of enzymes in various industries, medical and research applications, and the latest technologies.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 2 | - | 2 | 1 | - | 1 | 1 | 1 | 3 | 3 | 3 | 2 |
| CO2 | 3 | 3 | 3 | 3 | - | 2 | 1 | - | 1 | 1 | 1 | 3 | 3 | 3 | 2 |
| CO3 | 3 | 3 | 3 | 3 | - | 2 | 1 | - | 1 | 1 | 1 | 3 | 3 | 3 | 2 |
| CO4 | 3 | 3 | 2 | 2 | - | 2 | 1 | - | 1 | 1 | 1 | 3 | 3 | 3 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | - | 2 | 1 | 3 | 3 | 3 | 3 | 3 |
| CO6 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | - | 2 | 2 | 3 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 14 lectures hours**

Introduction of protein and their functions.

**Introduction to Enzymes:** History and significance of enzymes, Nomenclature and classification of enzymes, Coenzymes and cofactors, Zymogens, Ribozymes, Abzymes, Allosteric enzymes. Metal-activated enzymes and metalloenzymes. Types of Enzyme assays – Continuous & discontinuous, coupled Assays; Enzyme activity, specific activity, units to express enzyme activity. Activity Units – IU and katal, Features of enzyme catalysis, Concept of Active Site, factors affecting the rate of enzymatic reactions, activation energy and transition state theory. Catalytic power and specificity of enzymes, Fischer's lock and key hypothesis, Koshland's induced fit hypothesis.

**Module II: 16 lecture hours**

**Enzyme Kinetics:** Michaelis-Menten kinetics, Single-substrate and multi-substrate reactions. Derivation of Michaelis-Menten equation; other enzyme plots like Lineweaver-Burk plot, Eadie-Hofstee and Hanes plot. Determination of Km Vmax and Kcat, specificity constant. Types of bisubstrate reactions (sequential-ordered and random, ping pong reactions), examples.

**Enzyme inhibition mechanisms:** Reversible inhibition and irreversible inhibition and their subtypes (competitive, uncompetitive, non-competitive and mixed). Mechanism based inhibitors (β-lactam antibiotics). Structural analogs (allopurinol, methotrexate).

**Regulation of Enzyme Activity:** Allosteric enzymes, ATCase as an example, reversible covalent modification- glycogen phosphorylase and glutamine synthase. Zymogen activation

**Module III: 12 lecture hours**

**Enzyme Engineering and Applications:** Methods of production of enzyme, Extraction of enzyme of soluble and membrane bound enzymes, Nature of extraction medium, purification of enzyme, criteria of purity, determination of molecular weight of enzyme. Immobilized enzymes. Application of enzyme in industries; medical applications. Enzymatic biocatalysis in sustainable processes. Emerging trends in enzyme technology.

**List of Experiments**

1. Enzyme Assay: Calculation of Enzyme Activity and Specific activity
2. Effect of substrate concentration on Enzyme activity and determination of its Km and Vmax.
3. Effect of pH on enzyme activity
4. Effect of Temperature on Enzyme Activity
5. Immobilization of Enzyme using calcium alginate beads
6. Partial purification of an Enzyme using Ammonium sulfate fractionation
7. Assay of Salivary amylase
8. Application of enzymes case study

**Text Books :**

1. Nicholas C. Price, *Fundamentals of Enzymology* (3rd ed.), Oxford University Press, 2009.

2. David L. Nelson, Michael M. Cox, *Lehninger Principles of Biochemistry* (7th ed.) W H Freeman & Co, 2017.

**Reference Books :**

1 Julio Polaina, Andrew P. MacCabe, *Industrial Enzymes Structure Function and Applications*, Springer 2007.
2. Helmut uhling, *Enzyme technology*, John Wiley 1998.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 20% | 40% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **Course Code: EBTY202L** | Introduction to Bioinformatics | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 2 | 0 | 4 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

By the end of this program, students will be able to:
CO1: Understand various biological databases and interpret the pairwise sequence alignment of biological sequences.
CO2: Understand various approaches of structure prediction of proteins and RNA and analyze the proteomics data from mass spectrometry.
CO3: Understand multiple sequence alignment, construct the phylogenetic tree, and genome browsers.

**CO-PO/PSO Mapping**

| | P01 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 1 | 1 | 2 | 2 | - | - | 2 | 2 | 1 | 3 | 3 | 3 | 2 |
| CO2 | 3 | 3 | 2 | 2 | 2 | 2 | - | - | 2 | 2 | 2 | 3 | 3 | 3 | 2 |
| CO3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | - | 2 | 2 | 2 | 3 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: Overview of Bioinformatics & Biological Databases 8 lecture hours**

**Introduction to Bioinformatics:** Historical background. Scope of bioinformatics. Genomics, Proteomics, Computer aided drug design (CADD) and Systems Biology. **Biological Databases**: Primary, secondary, and composite databases with examples; Protein & Nucleic

Acid Databases, Small Molecule Databases, Information submission and retrieval systems; Biomedical databases.

**Module II: Sequence Alignment & Phylogeny 8 lecture hours**

Sequence Alignment - Pairwise sequence alignment methods: Dynamic programming (global and local alignment algorithms); Scoring Matrices (PAM and BLOSUM); Overview of BLAST; MegaBLAST; PSI-BLAST; BLAT; FASTA. Multiple sequence Alignment methods: Clustal Omega; ClustalW2; DIALIGN; kalign; MAFFT; MUSCLE; PASTA; PRANK; T-Coffee; Visualization: Jalview. **Molecular Evolution and Phylogenetics:** MSA; Tree building and visualization; Phylogenetic analysis and data integration.

**Module III : Genome annotation 6 lecture hours**

Introduction to genomics, gene structure in prokaryotes and eukaryotes, Genome Browsers: UCSC Genome Browser; ENSEMBL Genome Browser; JBrowse Genome Annotation: Gene Prediction Methods for Prokaryotes and Eukaryotes; Genome annotation methods and pipelines; Genome-wide association analysis, SNP and CNV analysis from genome data (plants/animal).

**Module IV: Structure Prediction 6 lecture hours**

**RNA structure prediction:** RNA Secondary Structure Prediction Methods and assessment**;** M-fold and RNA structure web comparative assessment**;** RNA 3D structure prediction. **Protein Structure and function Prediction,** Homology Modeling, Threading Ab-initio methods, AlphaFold**;** Protein structure validation; Prediction of transmembrane Alpha helices and Beta strands**;** Prediction of disordered regions**;** Predicting protein function**;** Motifs and domains**;** Tandem Mass spectrometry and peptide identification

**List of Experiments**

1. Retrieval and download the nucleotide/ protein sequence from GenBank/ UniProt.
2. Overview of BLAST and its variants.
3. Assessment of pairwise sequence similarity using local and global alignment methods and their interpretations.
4. Multiple Sequence alignment and Phylogenetic tree construction.
5. Genome and gene feature analysis.
6. Protein structure prediction and assessment using different computational methods.
7. RNA structure prediction and assessment using different computational methods.
8. Peptide identification using mass spectrometry data.

**Text Books :**

1. Baxevanis, Andreas D. *et. Al., Bioinformatics*, (4th ed.), John Wiley & Sons, 2020.

**Reference Books :**

1. Mount, David W. "*Bioinformatics: sequence and genome analysis*." (2004).

2. Lesk, Arthur. *Introduction to Bioinformatics*. United Kingdom: OUP Oxford, 2014.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 20% | 40% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **Course code:** | Fundamentals of Medical Laboratory Technology | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 0 | 0 | 4 | 2 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1: Apply Good Laboratory Practices (GLP), biosafety, sterilization techniques, and aseptic methods in laboratory settings.

CO2: Analyse the significance of blood and body fluids in diagnostic applications, and interpret results of LFT, KFT, and CBC.

CO3: Demonstrate staining, fixation, and sectioning techniques in histopathology and histochemistry to study tissue organization.

CO4: Evaluate ethical principles, confidentiality, and informed consent practices in medical lab settings.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 3 | 3 | 2 | 1 | - | 2 | 2 | 1 | 2 | 3 | 3 | 3 |
| CO2 | 3 | 3 | 2 | 3 | 3 | 1 | 1 | - | 2 | 2 | - | 2 | 3 | 3 | 3 |
| CO3 | 3 | 2 | 3 | 2 | 3 | - | - | - | 2 | 1 | 1 | 2 | 3 | 3 | 2 |
| CO4 | 2 | 2 | 1 | 1 | - | 3 | 2 | 3 | 2 | 2 | 1 | 2 | 2 | 2 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: Introduction to Medical Lab Technology**

Laboratory organization, roles & responsibilities, good laboratory practices, biosafety, Sterilization and Disinfection Procedures, Aseptic techniques, sample collection, transport & preservation, microbiology: culturing, staining, common pathogens, molecular testing – RT-PCR. Classification and Importance of clinical samples (Body fluids including Urine, Blood, CSF, Plasma, BALF, Sputum etc.) in medical diagnostics. Liver Function Tests (LFT), Kidney Function Tests (KFT), Blood Glucose tests (Fasting Blood Sugar and HbA1c), and Hemograms (Complete Blood Count or CBC).

**Module II: Haematology and Phlebotomy**

Haematopoiesis, Blood composition and functions, Mechanism of blood coagulation, Disorders of blood. Importance of blood as a sample for diagnosis of communicable and non-communicable diseases. Materials required for blood collection. Blood collection techniques, venous and capillary, preservations and sampling errors. Home collection of blood, its preservations and safe transportation of blood sample, Uses of anticoagulants, Process of analysing the blood specimens, layout of laboratory report. Ethics, accreditation, and regulatory guidelines.

**Module III:**

Theory and practical principles, techniques in histology, Histochemistry, Histopathology and their applications to study Ultrastructure and organization of cell organelles, Stains and principles: Common stains, staining, fixation embedding sectioning, histochemical and frozen sections. Mixing solutions and fixatives. Processing and embedding, blocking sectioning, sharpening, histochemical and frozen sections.

**Module IV: Medical Records & Medical Ethics**

Definition, Medical Record Forms and their Content, Incomplete Record Control, Utility & functions of Medical Records in Laboratories, Medical ethics- Definition, Goal, Scope. Basic principles of medical ethics – Confidentiality, Malpractice and negligence. Rational and irrational drug therapy, Autonomy and informed consent - Right of patients**,** Informed consent.

**List of Experiments**

1. Demonstration of Good Laboratory Practices (GLP), Biosafety Cabinets, PPE, and Biohazard Disposal
2. Sterilization and Disinfection Techniques using autoclave, hot air oven, and chemical disinfectants.
3. Aseptic Technique and Microbial Culture Streaking (including blood agar and nutrient agar).
4. Gram Staining and Identification of Common Clinical Pathogens (E. coli, Staphylococcus, etc.).
5. Urinalysis: Physical, Chemical, and Microscopic Examination – Protein, glucose, pH and WBCs/Microbes.
6. Preparation of Peripheral Blood Smear and Differential WBC Staining (Leishman or Wright-Giemsa stain).
7. Analysis of Liver and Kidney Function Tests Using Simulated Patient Data.
8. Observation and Analysis of Pre-Stained Histological Slides (H&E and Special Stains).

**Text Books :**


1. Praful B. Godkar, Darshan P. Godkar. *Textbook Of Medical Clinical Laboratory Science And Molecular Diagnosis.* 3rd ed. 2018.
2. John W Baynes, PhD and Marek H. Dominiczak, Dr, Hab, Med, FRCPath. Medical Biochemistry E-Book. ElsevierHealth Sciences 6th Edition 2022. ISBN :9780323834506.
3. Textbook of Medical Lab Technology, Sood, Jaypee Brothers Publications.


**Reference Books :**


1. Fundamentals of urine and body fluid analysis (3rd ed.) - Brunzel, N. A.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 60% | 0% | 40% | 100% |

# Semester IV

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **Course Code: EBTY206L** | Thermodynamics and Chemical Processes | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | -- | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1: Understand and apply the fundamental laws of thermodynamics to analyse biochemical and energy systems.
CO2: Interpret thermodynamic property data and analyse phase behaviour of pure substances and gas mixtures.
CO3: Perform material and energy balance calculations in bioprocessing s ms including those with reactions.
CO4: Explain bioreactor configurations, reaction kinetics, and their role in process design and scale-up.
CO5: Analyse fluid flow and mixing phenomena in bioreactors, including effects of rheology and non-Newtonian behaviour.
CO6: Apply principles of heat and mass transfer to bioprocessing equipment.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 2 | 2 | 3 | 3 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 2 | 3 | 3 | 3 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 2 | 2 | 3 | 3 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 3 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 2 | 2 | 3 | 3 |
| CO6 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 2 | 2 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I:**
**6 lecture hours**

**Fundamentals of Thermodynamics**: Introduction to thermodynamics, Laws of thermodynamics, Heat and work interactions in biochemical systems, Free energy, entropy, and equilibrium, Energy coupling in metabolic reactions, Thermodynamics vs. kinetics.

**Module II:** **6 lecture hours**

**Thermodynamic Properties and Phase Behaviour:** Phase diagrams, P-v-T behaviour, Thermodynamic property estimation, Ideal and real gas equations, Humid air properties and psychrometrics.

**Module III:** **8 lecture hours**

**Material and Energy Balances:** Mass and energy conservation principles**,** Material balance with recycle, purge, and bypass**,** Energy balances with and without chemical reactions, Biomass yield, oxygen demand, steam table use.

**Module IV:** **7 lecture hours**

**Bioreactor Engineering and Reaction Kinetics:** Bioreactor types, configurations, and control, Reaction types: zero, first order, enzymatic (Michaelis-Menten), Kinetic modelling and rate expressions, Impact of temperature and yield optimization.

**Module V:** **7 lecture hours**

**Fluid flow and Mixing:** Newtonian and non-Newtonian fluids, Broth rheology, Mixing equipment, Power requirements, Flow patterns, Impellers, Retrofitting strategies.

**Module VI:** **8 lecture hours**

**Heat and Mass Transfer in Fermentation Systems:** Heat exchangers, conduction and convection mechanisms**,** Mass transfer theories (film theory, convective transfer)**,** Oxygen transfer, kLa, and $qO_2$**,** Practical methods for aeration and oxygenation.

**List of Experiments**

1. Demonstration of the first law of thermodynamics.
2. Demonstration of the second law of thermodynamics.
3. Determination of stored energy content or calorific value.
4. Transesterification of soybean oil for biodiesel production and purification and determination of mass balance.
5. Acid hydrolysis of sucrose and study of reaction kinetics: determination of reaction yield and reaction rate.
6. To determine the relative viscosity of given liquid using Ostwald's viscometer.
7. Solvent based extraction of the natural pigments.
8. Collection of natural pigment through rotary evaporation and purification of pigments.
9. Standard operating procedure of the BioFlo120 bioreactor system for bacterial culture fermentation.
10. Determination of the kLa (volumetric mass transfer co-efficient) in the bioreactor by chemical method.

**Text Books:**

1. J.M. Smith, H.C. Van Ness, and M.M. Abbott, Introduction to Chemical Engineering Thermodynamics, 7th Edition, McGraw-Hill Education, 2005. ISBN: 978-0072530139.
2. P.M. Doran, Bioprocess Engineering Principles, 2nd Edition, Academic Press, 2013. ISBN: 978-0122208515.
3.C.J. Geankoplis, Transport Processes and Separation Process Principles: Chemical and Biochemical Operations, 4th Edition, Prentice Hall, 2003. ISBN: 978-0131012674.

**Reference Books:**

1. J.E. Bailey & D.F. Ollis, Biochemical Engineering Fundamentals, 4th Edition, McGraw-Hill Education, 2019. ISBN: 978-0071837268.
2. P. Atkins & J. de Paula, Physical Chemistry, 10th Edition, Oxford University Press, 2014. ISBN: 978-0199697393.
3. Perry's Chemical Engineers' Handbook, 8th Edition, McGraw-Hill Education, 2007. ISBN: 978-0071422949.
4. Peter F. Stanbury, Allan Whitaker, and Stephen J. Hall, Principles of Fermentation Technology, Pergamon, 2013. ISBN: 978-0122211415.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Term Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 20% | 40% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **Course Code:** EBTY204L | rDNA Technology | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

**CO1:** Understand the basic concepts of recombinant DNA technology and different types of cloning methods that are used for making recombinant DNA.

**CO2:** Apply different enzymes for designing recombinant DNA for making transgenic organisms.

**CO3:** Explain different type of PCR techniques that can be used to develop rDNA technology.

**CO4:** Apply the knowledge to select different vectors and host systems to generate genetically modified organisms.

**CO5:** Explain technologies available to make different DNA libraries for genome sequencing.

**CO6:** Create genetically modified organisms, transgenic bacteria and yeast.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | 1 | - | 2 | - | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 1 | 1 | 2 | 3 | 3 | 3 | 3 | 2 |
| CO3 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 1 | 1 | 2 | 3 | 3 | 3 | 3 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |
| CO5 | 3 | 2 | 1 | 1 | - | 2 | - | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO6 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 1 | 2 | 1 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 15 lecture hours**

**Introduction to Gene cloning and DNA Manipulation.** Basic concepts of recombinant DNA technology & Gene cloning, Subcloning, TA cloning, gateway cloning, Enzymes used in genetic engineering: Restriction enzymes, Isoschizomers, methylation sensitivity and star activity, Restriction mapping, Other Enzymes used in Cloning (DNA polymerases, RNA polymerases, DNA methyl transferases, Reverse transcriptase, terminal transferase, T4 DNA ligase, Nucleases, RNases, DNAse-Exonuclease I, Exonuclease III, Alkaline phosphatase, Polynucleotide kinase) Blunt end and cohesive end ligation, Klenow fragment, Linkers and adaptors, Homopolymer tailing.

**Module II: 10 lecture hours**

**Cloning Vectors:** Plasmids, Ti and Ri plasmids, Bacteriophage vectors, Cosmids, Yeast vectors, Phagemids, BAC, phage artificial chromosomes (PAC), YAC, Shuttle vectors, Gateway Vectors.

**Techniques used in Genetic Engineering:** Isolation and quantification of nucleic acids and plasmids, Electrophoresis, Polymerase chain reaction and different types of PCR. *In-silico* tools to design the cloning experiments, Site-directed mutagenesis, Primer designing for PCR, Transformation methods.

**Gene Manipulation:** Making loss or gain of function of a gene- CRISPR, RNAi, knockout and overexpression system.

**Host Cells and Expression vectors for different cellular systems:** Host cells: Prokaryotic hosts, Eukaryotic hosts. Bacteria and Yeast as expression system. Constitutive and Inducible promoters, protein expression/purification strategy: Fluorescent tags, protein purification tags.

**Module III: 17 lecture hours**

**Making and Screening DNA Libraries:** Genomic Library, cDNA Library, Screening DNA Libraries: Colony and Plaque Hybridization, Probes, Immunological screening

**Labelling and detection of nucleic acid sequences:** Radioactive and nonradioactive labels, Methods: End labelling, primer extension and Nick translation.

**Blotting/Hybridization Techniques**-Southern, Northern, Western Blotting.

**Sequencing methods:** Sequencing methods: Maxam-Gilbert method, Sanger Dideoxy method, Automated DNA Sequencing. Analysis of sequence data/Electrophoreograms.

**Application of Genetic Engineering.** Production of enzymes, and therapeutic products, Gene therapy: Types, Vectors used in gene therapy, Case study and ethical issues, DNA profiling. Somatic cell nuclear transfer (SCNT), Cloning of sheep (Dolly), Generation and Applications of Transgenic organisms. Biodiversity, Biosafety, Bioethical issues related to rDNA Technology.

**List of Experiments:**

1. Designing of Primers for any selected gene GoI sequence retrieval, primer designing, vector information retrieval.
2. Preparation of Competent Cells & Transformation Competent cells preparations of DH5α, Media preparation with and without antibiotics, to check quality of the comp cells
3. Amplification of vector

4. Amplification of GoI
5. Purification of GoI using Gel elution method
6. RE digestion of Vector and GoI, gel elution
7. Concentration determination, Ligation, transformation of ligated DNA into *E. coli*
8. Screening of transformants using colony PCR
9. Isolation of Plasmid DNA & Restriction Digestion to rDNA integrity
10. Transformation of yeast

**Text Books :**


1. Brown, T. A. *Gene Cloning and DNA Analysis: An Introduction*. Wiley Blackwell, 2016.
2. Primrose, Sandy B., and Richard Twyman. *Principles of Gene Manipulation and Genomics*. 7th ed. Hoboken, NJ: Wiley-Blackwell, 2013.
3. Glick, Berhard, and Chery L. Patten. *Molecular Biotechnology, Principles and Applications of Recombinant DNA*. Taylor & Francis, 2017.


**Reference Books :**


1. Michael, R., and Joseph Green. *Molecular Cloning: A Laboratory Manual*, 2013.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Term Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 40% | 20% | 40% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **Course Code:** | Metabolic Networks | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1: Understand metabolic networks, anabolism, catabolism, pathways for carbohydrates and metabolism, and enzymes involved in regulation.

CO2: Understand diseases caused by defects in carbohydrate metabolism with emphasis on metabolic control and cure.

CO3: Apply the knowledge of various catabolic and anabolic pathways in lipid metabolism, their regulation, and diseases associated with errors in lipid metabolism.

CO4: Understand the degradation and biosynthetic pathways of nucleic acids and their clinical significance.

CO5: Understand the nitrogen cycle and other catabolic pathways of amino acids.

CO6: Understand the degradation mechanism of amino acids and their association with different diseases.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 2 | - | 1 | - | - | 1 | 1 | 1 | 3 | 3 | 3 | 2 |
| CO2 | 3 | 3 | 3 | 2 | 1 | 1 | 1 | - | 2 | 1 | 1 | 3 | 3 | 3 | 3 |
| CO3 | 3 | 3 | 2 | 2 | - | 1 | - | - | 1 | 1 | 1 | 3 | 3 | 3 | 2 |
| CO4 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | - | 2 | 1 | 1 | 3 | 3 | 3 | 3 |
| CO5 | 3 | 3 | 2 | 2 | - | 1 | - | - | 1 | 1 | 1 | 3 | 3 | 3 | 2 |
| CO6 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | - | 2 | 1 | 1 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 12 lecture hours**

**Overview of metabolism**: Anabolism and Catabolism, Thermodynamics of metabolic reactions, Gibbs free energy, equilibrium constants.

**Carbohydrate Metabolism:** Photosynthesis, Glycolysis, reactions of glycolysis. Regulation of glycolytic pathway, Fermentation: anaerobic fate of pyruvate, Cori and Cori cycle, Citric acid cycle, TCA Cycle Inhibitors, Overview of Starve feed cycle. Oxidative phosphorylation: complexes I to V and their role, Pentose phosphate pathway, gluconeogenesis, Synthesis and breakdown of Glycogen, glycogen storage diseases; Von Gierke, Pompe, and McArdle, caused by errors in carbohydrate metabolism.

**Module II: 16 lecture hours**

**Lipid metabolism:** Oxidation of fatty acids (saturated and unsaturated fatty acids), odd-chain fatty acids metabolism, Ketone Bodies, Fatty acid biosysnthesis, biosynthesis of cholesterol and its regulation. Fates of cholesterol, cholesterol transport. Familial Hypercholesterolemia, Dyslipidemia, and atherosclerosis., Phospholipid and Glycolipid metabolism, Inborn Errors in lipid metabolism.

**Nucleic Acid Metabolism:** Nucleotide biosynthesis and salvage: Purine Nucleotide Biosynthesis; Regulation of Purine Synthesis; Catabolism and Salvage of Purine Nucleotides; Clinical Significances of Purine Metabolism; Synthesis of Pyrimidine Nucleotides; Synthesis of Thymine Nucleotides; Clinical Relevance of Tetrahydrofolate; Regulation of Pyrimidine Synthesis; Catabolism and Salvage of Pyrimidine Nucleotides; Clinical Significances of Pyrimidine Metabolism; Formation of Deoxyribonucleotides; Regulation of dNTP Formation.

**Module III: 14 lecture hours**

**Metabolism of Amino Acids:** Nitrogen Cycle**,** Urea Cycle, Metabolic Disorders of Urea Cycle, Relationship between Urea cycle and TCA cycle, Catabolic pathways of individual amino acids, Glucogenic and ketogenic amino acids. Metabolism of one carbon unit, Overview of amino acid synthesis: Biosynthesis of nonessential amino acids and its regulation; precursor functions of amino acids. Disorders of amino acid metabolism: Phenylketonuria, Alkaptonuria, Maple syrup urine disease, Methylmalonic aciduria, Homocystinuria, and Hartnup's disease.

Integration of Metabolic pathways, Metabolic changes during starve-feed cycle, exercise, diabetes and alcohol abuse, xenobiotic metabolism.

**List of Experiments**

1. Estimation of blood glucose in serum using GOD-POD method (Glucose oxidase Peroxidase)
2. Sugar fermentation by microorganisms.
3. Assay of serum transaminase – SGOT
4. Assay of serum transaminase SGPT
5. Estimation of Urea
6. Total Cholesterol estimation
7. Continuous assay of Lactate Dehydrogenase
8. Case studies: Obesity, Dyslipidaemia, Metabolic syndrome, Fasting, Ketosis.

**Text Books :**

1. David L. Nelson, Michael M. Cox, *Lehninger Principles of Biochemistry* (7th ed.) W H Freeman & Co, 2017.
2. Victor Rodwell, David Bender, et al. Thirty First Edition, ISE Harper's Illustrated Biochemistry McGraw Hill (A and L Lange series), 2018.
3. Thomas M Devlin. Textbook of Biochemistry with Clinical Correlations, 7th Edition, Wiley-Liss, 2022.

**Reference Books :**

1. Berg, J.M., Tymoczko, J.L. and Stryer L., W.H. Biochemistry (7th ed.), Freeman and Company (New York), 2012.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 40% | 20% | 40% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY207L** | Introduction to Biomaterials | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

**CO1 :** Understand the basics concepts of polymers science and hydrogel technology. Students will be able to define and remember choice of different biomaterials for various biological applications.

**CO2 :** Learn various theories and principles of biodegradability, biocompatibility, drug release kinetics and thermodynamics of hydrogels formation.

**CO3 :** Apply concepts to experimentally investigate biologically relevant materials and their interaction with cells such as bio-adhesive conducting polymer, environmental stimuli responsive hydrogels, metal corrosions etc for various biomedical applications. Apply knowledge for production, purification, applications, and global market of: Thermoplastic.

**CO4 :** Analyse and evaluate the techno-economic feasibility of biomaterials to devise products for various biomedical applications like drug delivery, molecular diagnostics, biosensors, bioelectronics, soft robotics, surgical implants etc.

## CO-PO/PSO Mapping

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | 1 | - | 2 | 3 | 1 | 1 | 1 | 2 | 3 | 3 | 3 | 2 |
| CO2 | 3 | 3 | 2 | 2 | 2 | 1 | 3 | 1 | 1 | 1 | 2 | 3 | 3 | 3 | 2 |
| CO3 | 3 | 2 | 3 | 2 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 2 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

## Course Contents:

**Module I: 6 lecture hours**

INTRODUCTION TO BIO-MATERIALS

Definition and classification of bio-materials, mechanical properties, visco elasticity, biomaterial performance, body response to implants, wound healing, blood compatibility, Nano scale phenomena.

Polymers: definition, classification based on composition, source, structure; Calculation of number average MW and weight average MW; Polymer crystallinity, melting temperature, tacticity, glass transition.

Hydrogels: structure and synthesis; thermodynamics of hydrogel formation; polyelectrolyte hydrogels; application of layered bielectrolyte hydrogel in implant coating; Application of unpaired hydrogel; swelling behaviour as a function of pH, electrical stimuli, and biological stimuli.

**Module II: 8 lecture hours**

Application of polymers *in vivo*; degradation lifetime and mechanism; factors affecting biodegradation; Gopferich theory and factors affecting surface vs bulk erosion; drug release kinetics and strategy; triggered drug release.

Polymer and nanoparticle conjugates and their applications in drug delivery, and molecular diagnostics. Biologically assembled nanoparticles – DNA and protein nanostructures and self-assembly. Artificial muscles, application in soft robotics.

**Module III: 14 lecture hours**

Biomaterial types, organic vs. inorganic biomaterials, metallic biomaterials, synthetic biomaterials. Production, purification, applications, and global market of: Thermoplastic starch blends, Polylactic acid (PLA), Poly-3-hydroxybutyrate (PHB), Polyamide 11, Bio-polyethylene, bio-polyethylene terephthalate. Biocompatible plastics used in medical devices: Cyclic olefin copolymer (COC), polycarbonate (PC), medical grade polyvinylchloride (PVC), polyethersulfone (PES), polyethylene (PE), and polypropylene (PP). Techno-economic feasibility of biomaterial production processes.

Cellulose, microcrystalline cellulose, nano-crystalline cellulose, bacterial nano-cellulose, silk as a biomaterial. Tissue engineering. Biomedical applications of biocompatible biomaterials: Joint replacements, Bone plates, Intraocular lenses (IOLs) for eye surgery, Bone cement, Artificial ligaments and tendons, Dental implants for tooth fixation, Blood vessel prostheses, Heart valves, Skin repair devices (artificial tissue), Cochlear replacements, Contact lenses, Breast implants, Drug delivery mechanisms, Vascular grafts, Nerve conduits, Surgical sutures, clips, and staples for wound closure, Pins and screws for fracture stabilisation, Surgical mesh.

## List of Experiments:

1 Extraction of Starch from potato

| Name of Program | B.Tech. Biotechnology | | | | |
|---|---|---|---|---|---|
| **VAC-5**<br>**Course Code: EBTY2001L** | Ayurveda & Nutrition | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 2 | 0 | 0 | 2 |
| **Pre-requisites/Exposure** | - | | | | |

2 Preparation of Bioplastic from Potato Starch

3 Preparation of gel beads using Sodium Alginate and Calcium Chloride

4 Drug/ dye release study of pH-responsive sodium alginate polyacrylamide methylene blue loaded double network hybrid hydrogel

5 To check the permeability & release rate of natural semi-permeable membrane eggshell.

6 To Prepare Urea-Formaldehyde resin

7 Bleaching of jute fibers using sodium hypochlorite and acetic acid

8 Preparation of adhesive hemostatic hydrogel for repair of bleeding blood vessels

9 To prepare magnetic field responsive hydrogels

**Text Books :**


1. Young, Robert J, and P A Lovell. *Introduction to Polymers*. Cheltenham, England: Stanley Thorne (Publishers) Ltd. 2000.
2. Ratner, Buddy D., Allan S. Hoffman, Frederick J. Schoen, and Jack E. Lemons. "Biomaterials Science, An Introduction to Materials in Medicine 2nd Edittion, 2004.
3. Fan, Liang-tseng, and Satish K. Singh. *Controlled release: A quantitative treatment*. Vol. 13. Springer Science & Business Media, 2012.


**Reference Books :**


1. Park, Joon, and Young Kon Kim. 'Metallic Biomaterials'. In *Biomaterials*, 1–20. CRC Press, 2002.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Term Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 20% | 40% | 100% |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1: Understand the fundamental principles of Ayurveda, including Doshas, Dhatus, Malas, and Agni, and their relevance to health and nutrition.

CO2: Apply Ayurvedic concepts of food as medicine, including food classification (Satvic, Rajasic, Tamasic) and personalized dietary guidelines based on Prakriti.

CO3: Recognize the nutritional benefits of Ayurvedic superfoods like turmeric, amla, ghee, and ashwagandha in supporting health and well-being.

CO4: Integrate Ayurvedic dietary practices to manage health, prevent diseases, and promote holistic well-being.

**COs-POs/PSOs Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 1 | - | 2 | - | - | 1 | 2 | 2 | 3 | 3 | 2 | 1 |
| CO2 | 3 | 2 | 2 | 1 | - | 2 | - | - | 1 | 2 | 2 | 3 | 3 | 2 | 1 |
| CO3 | 3 | 2 | 2 | 1 | - | 2 | - | - | 1 | 2 | 2 | 3 | 3 | 2 | 1 |
| CO4 | 3 | 2 | 2 | 1 | - | 2 | - | - | 1 | 2 | 2 | 3 | 3 | 2 | 1 |
| CO5 | 3 | 2 | 2 | 1 | - | 2 | - | - | 1 | 2 | 2 | 3 | 3 | 2 | 1 |
| CO6 | 3 | 2 | 2 | 1 | - | 2 | - | - | 1 | 2 | 2 | 3 | 3 | 2 | 1 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 10 lecture hours**

**Fundamentals of Ayurveda and Nutrition:** History and Philosophy of Ayurveda; Key Concepts in Ayurveda: Doshas (Vata, Pitta, Kapha), Dhatus, Malas, and Agni

**Introduction to Nutrition:** Macronutrients and Micronutrients and their role in health; Concept of balanced diet: ayurvedic and modern perspectives

**Module II: 10 lecture hours**

**Ayurvedic foundations of nutrition and digestion**: Introduction to the concept of food as medicine in Ayurveda; exploration of how food impacts physical and mental health in Ayurvedic philosophy; classification of food into three categories: Satvic (Promotes purity and balance), Rajasic (Stimulates energy and activity), Tamasic (Leads to lethargy and dullness); Understanding the role of ahara rasa (Taste) in digestion and overall well-being.
**Overview of Ayurvedic dietary guidelines:** Seasonal dietary adaptations; Personalized diet based on individual constitution (Prakriti) and prakriti analysis.

**Module III: 8 lecture hours**

**Ayurvedic Supplements:** Nutritional benefits of supplements like turmeric, amla, and ghee, moringa, ashwagandha, cumin, fenugreek, basil, etc., formulation of Ayurvedic supplements, Quality control.
**Case Studies:** Applying Ayurvedic diets for health management and disease prevention.

**Text Books :**

1. *Ayurveda: The Science of Self-Healing* by Dr. Vasant Lad
2. *Essentials of Human Nutrition* by Jim Mann and A. Stewart Truswell
3. *The Complete Book of Ayurvedic Home Remedies* by Dr. Vasant Lad
4. *The Everyday Ayurveda Guide to Self-Care* by Kate O'Donnell
5. *Ayurveda and the Mind* by Dr. David Frawley
6. *Prakriti: Your Ayurvedic Constitution* by Dr. Robert E. Svoboda
7. Ayurvedic dietary guidelines and digestion in journals like *Journal of Ayurveda and Integrative Medicine (JAIM)* or *Alternative and Complementary Medicine*.
8. *Ayurvedic Superfoods* by Vaidya Atreya Smith
9. *Healing Spices* by Bharat B. Aggarwal
10. *Integrative Nutrition* by Joshua Rosenthal

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 20% | 40% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **Course Code:** | Intellectual Property Rights & Biotechnology Regulations | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 4 | 0 | 0 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1: Understand the key concepts of IPR types, with special reference to Biotechnology.

CO2: Understand legal frameworks, specialized IPR mechanisms and industrial aspects of IPR with case studies of Biotech companies.

CO3: Demonstrate a comprehensive understanding of research methodologies and the different types of research (applied or basic) in the context of biotechnology.

CO4: Apply effective techniques for literature review, data collection, and scientific documentation.

CO5: Analyze and navigate ethical aspects of research, including considerations for bioethics, animal ethics, GMO ethics, and clinical trials.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 1 | - | 1 | 1 | - | 2 | - | 3 | 1 | 1 | - | 3 | 2 | 1 | 2 |
| CO2 | 1 | - | 1 | 1 | - | 3 | - | 3 | 1 | 3 | - | 3 | 1 | 1 | 2 |
| CO3 | 1 | 1 | 2 | 1 | - | 3 | 1 | 3 | 2 | 2 | 1 | 3 | 2 | 1 | 3 |
| CO4 | 1 | 2 | 2 | 1 | 3 | 2 | - | 3 | 1 | 1 | 1 | 3 | 2 | 2 | 3 |
| CO5 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 3 | 1 | 1 | 1 | 3 | 1 | 2 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 12 lecture hours**

**Introduction to Intellectual Property Rights (IPR)**

Definition and scope of IPR in Agriculture, Healthcare & Pharma, Types: Patents, trademarks, copyrights, trade secrets, geographical indications. WTO-TRIPS and its impact on biotech industries in developing nations. Ethical considerations: Patenting life forms, gene editing, and traditional knowledge with special reference to case studies of Biotechnology.

**Module II: 16 lecture hours**

**Legal Framework:**

Procedure of obtaining patents, how to search patents, how to look for key words, Infringement of patents, Infringement case studies. Indian Patent Act, 1970: Key provisions, Section 3(j) (non-patentable subjects). TRIPS Agreement: Compliance and implications for Biotech inventions. Specialized IPR Mechanisms: Plant Variety Protection and Farmers' Rights Act, 2001. Role of Biotechnology Patent Facilitation Cell (BPFC), National Research Development Council (NRDC), Biodiversity Act 2002. Bioprospecting and Bio-piracy; Patenting Biotech Inventions: Applications, Generics and Biosimilars, Evergreening, Compulsory Licensing.

U.S.: Coordinated Framework (USDA, FDA, EPA) and product-driven regulation. EU: Process-driven regulation for GMOs and the Cartagena Protocol. Biotechnology Regulatory Authority of India (BRAI) Bill, 2013: Objectives and challenges.

**Module III:** **14 lecture hours**

**Biosafety:** Introduction to biosafety and health hazards concerning biotechnology, Transport, storage and precautions in use and disposal of clinical samples and biological samples. The Cartagena protocol on biosafety. GEAC, RCGM, Institutional Biosafety Committees (IBSCs). Introduction to the concept of containment level and Good Laboratory Practices (GLP) and Good Manufacturing Practices (GMP). Biosafety Levelsm-BSL-1, BSL-2 and BSL-3.

**Module IV:** **14 lecture hours**

**Bioethics**: Necessity for Bioethics, Moral and Legal aspects, Nuremberg Trials, Nuremberg Code and its impact on clinical research, Animal ethics, ethics in GMO, Clinical trials, Informed consent, Plagiarism, Declaration of Helsinki, Ethics Committees, Professional ethics. Guidelines from ICMR, Patient's privacy, different paradigms of Bioethics – National & International. Ethical issues against the molecular technologies. Talk by Industry Expert.

**Textbooks:**


1. Nambisan, Padma. *An introduction to ethical, safety and intellectual property rights issues in biotechnology*. Academic Press, 2017.
2. Ramakrishna, B., and Anil Kumar HS. *Fundamentals of intellectual property rights: for students, industrialist and patent lawyers*. Notion Press, 2017.
3. Sateesh, M. K. (2010). Bioethics and Biosafety. New Delhi: I. K. International Pvt Ltd.
4. Arras, John D. *Methods in Bioethics*. New York, NY: Oxford University Press,2017.


**Reference Books :**


1. Ahuja, Virendra Kumar. "Law Relating to Intellectual Property Rights." Lexis Nexis, 2019.
2. Booth, Wayne C., Gregory G. Colomb, Joseph M. Williams, Joseph Bizup, and William T. Fitzgerald. The Craft of Research. 4th ed. Chicago Guides to Writing, Editing and Publishing. Chicago, IL: University of Chicago Press, 2016.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 20% | 40% | 100% |

# Semester V

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **Course Code:** | Agriculture Biotechnology | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

**CO1:** Demonstrate an in-depth understanding of plant tissue culture techniques and their applications in micropropagation, protoplast fusion, somatic embryogenesis, and crop improvement in agriculture, horticulture, and forestry.

**CO2:** Differentiate between conventional and molecular methods of crop improvement and evaluate the role of marker-assisted selection and genetic engineering in enhancing agriculturally important traits.

**CO3:** Design and analyse gene constructs for plant transformation, apply transformation techniques, and interpret data related to the selection, confirmation, and evaluation of transgenic plants.

**CO4:** Assess the current and future applications of plant biotechnology, including bioreactors, gene editing, while critically evaluating biosafety, ethical, and regulatory frameworks.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 1 | - | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 1 | 3 | 2 | 3 | 3 | 3 | 3 |
| CO3 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 16 lecture hours**

**Introduction to Plant Biotechnology –** Overview, Scope & Applications**,**

**Plant Cell Culture:** Introduction to Plant Tissue Culture. history & milestones, Laboratory organization, aseptic techniques, sterilization methods.

**Tissue culture media**: Types, composition, preparation; Selection of media based on explant and objective.

**Plant Growth Regulators** & their role in organogenesis and embryogenesis.

**Micro propagation techniques**, Callus & Cell Suspension Culture, Protoplast Isolation, Culture and Fusion, Organogenesis and Somatic embryogenesis. Synthetic seeds, Agrobacterium based hairy root culture & applications in plant biotechnology.

**Conventional versus non-conventional methods of plant improvement-** Traditional breeding, mutation breeding, hybrid seed production, limitations of traditional breeding methods, molecular (non-conventional) breeding and marker assisted selection (MAS), genetic engineering

**Module 2** **14 lecture hours**

**Steps in Plant Genetic Engineering:** Gene isolation, cloning, Promoters, Selectable markers, vectors

**Tissue Culture in Genetic Engineering:** Micropropagation, soma-clonal variation, Embryo rescue, pollen/anther/ovary/apical bud culture.

**Methods of Transformation:** Vector mediated and direct methods, Selection and Regeneration of Transgenic Plants, Molecular Confirmation of Transgenic Plants, Evaluation of Transgenic Traits.

**Improvement of Plant Traits:** Case studies of Herbicide resistance, Stress tolerance (biotic/abiotic), Nutritional enhancement (Biofortification), Delayed ripening, Bt crops, Metabolic pathway engineering

**Module 3** **12 lecture hours**

**Plants as Bioreactors:** Molecular farming, Production of therapeutic proteins, vaccines
**Gene Editing Technologies:** Applications and limitations
**Regulatory Aspects:** Biosafety, bioethics
**Public Perception and Global Perspectives**
**Emerging Trends in Plant Biotechnology**

**List of Experiments**

1. To prepare different media required for in-vitro plant tissue culture
2. To Sterilize and sow seeds of *Nicotiana tabacum* (tobacco) and *Arabidopsis thaliana*
3. To prepare electrocompetent cells of *Agrobacterium tumefaciens* (GV3101 strain)
4. To transform *Agrobacterium tumefaciens* with sGFP-pEff and sGFP-pZP211 vector to prepare agrobacterium for plant transformation
5. To perform colony PCR to confirm the transformed Agrobacterium colonies containing sGFP-pPZP211 and sGFP-pEff vector
6. To prepare explant of *Tobacco* in-vitro plant tissue culture.
7. To transform Tobacco with *Agrobacterium* using Co-culture method using sGFP pZP211 vector.
8. To transform Tobacco with *Agrobacterium tumefaciens* infiltration for transient expression of sGFP-pEff vector
9. To transform *Arabidopsis thaliana via* Agrobacterium-mediated floral dip method using sGFP-pZP211 vector.
10. To observe green fluorescence from tobacco leaves transformed with sGFP-pEff via the agroinfiltration method

**Text Books :**

7. Adam, Joy. 'Applied Biotechnology in Genetic Engineering, Pharmaceuticals and Agriculture'. *Applied Biotechnology in Genetic Engineering*, 2016, 978–1682862766.
8. Chawla, H. S. *Introduction to Plant Biotechnology (3/e)*. 3rd ed. Boca Raton, FL: CRC Press, 2018.
9. Chawla, H.S. *Plant Biotechnology*. New Delhi: Oxford & IBH Publishing Co., 2002.
10. Bhojwani, S.S., and M.K. Razdan. *Plant Tissue Culture: Theory and Practice*. Amsterdam: Elsevier, 1996.
11. Primrose, Sandy B., and Richard M. Twyman. *Principles of Gene Manipulation and Genomics*. 7th ed. Oxford: Wiley-Blackwell, 2006.
12. Singh, B.D. *Biotechnology: Expanding Horizons*. 3rd ed. New Delhi: Kalyani Publishers, 2012.
13. Stewart Jr., C. Neal. *Plant Biotechnology and Genetics: Principles, Techniques, and Applications*. Hoboken, NJ: John Wiley & Sons, 2008.

**Reference Books :**

1. Taiz, Lincoln, Ian Max Moller, Angus Murphy, and Emeritus Eduardo Zeiger. *Plant Physiology and Development*. 7th ed. New York, NY: Oxford University Press, 2023.

**Assessment Scheme :**

| Components | Internal Assessment | Mid Term Exam | End Term Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 20% | 40% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech Biotechnology | | | | |
| **Course Code:** | Basic and Applied Microbiology | L | T | P | C |
| **Owning School/Department** | SEAS/ Biotechnology | 2 | 0 | 4 | 4 |
| **Pre-requisites/Exposure** | | | | | |

**Course Outcomes (COs)**

On completion of this course, students should be able to:
CO1: Describe the historical development and classification systems in microbiology and explain the role of pioneer scientists.
CO2: knowledge of microbial structure, growth, and control methods to culture, identify, and analyse microorganisms.
CO3: Demonstrate techniques of microbial staining, isolation, enumeration, and antimicrobial sensitivity testing through laboratory experiments.
CO4: Analyse microbial pathogenesis and interpret the role of human microbiome in health and disease.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | - | 2 | 2 | 3 | 2 | 2 |
| CO2 | 3 | 3 | 2 | 3 | 3 | 2 | 1 | 1 | 2 | 3 | - | 3 | 2 | 3 | 3 | 3 |
| CO3 | 3 | 2 | 3 | 3 | 3 | 2 | 1 | 1 | 3 | 3 | - | 3 | 2 | 3 | 3 | 3 |
| CO4 | 3 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 2 | 3 | - | 3 | 2 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 3 lecture hours**

**History of development of Microbiology**

Historical Developments, Contributions of Scientists in development of medical microbiology Spontaneous generation vs. biogenesis, development of various microbiological techniques, concept of fermentation, Robert Koch's Postulates and Anomalies, Whittaker's five kingdom and Carl Woese's three kingdom classification systems and their utility.

**Module II: 12 lecture hours**

**Microbes –** Introduction**,** Classification of various microbes based on size, shape, cellular structure, composition and function**:** Acellular microorganisms (Viruses, Viroids, Prions) and Cellular microorganisms (Bacteria, Algae, Fungi and Protozoa) with emphasis on distribution and occurrence, morphology, and economic importance.

**Microbial growth and control:** Bacterial cell division, microbial nutrition, microbial growth, effect of environmental factors on microbial growth, temperature, pH, osmolarity, oxygen content, Controlling microbial growth: heat, radiation, filtration, chemical control**.**

Antimicrobial drugs: synthetic, natural: antibiotics. Antimicrobial resistance: Cause, spread, mechanism, new developments, Biosafety and Biowaste management.

**Module III: 8 lecture hours**

**Microbial Pathogenesis and Host-pathogen Interactions**

The structure, classification, growth and identification of intracellular and extracellular pathogens, opportunistic pathogens, nosocomial infections. Development and spread of infectious diseases: invasion, pathogen, parasite, pathogenicity, virulence factors, carriers and their types. Routes, mechanisms of invasion and establishment of infection caused by Bacterial, Viral, Fungal and protozoan pathogens.

**Human microbiome and its role in Health and Disease**. **5 lecture hours**

Introduction to the microbial interactions (Antagonism or Amenalism, Commensalism, Prototropism or Proto-cooperation and Mutualism or Symbiosis). Composition of Human microbiome at various sites of human body (Gut-Brain Axis, Gut-Lung Axis and Liver), Role of microbiome in human health: Influence of microbiome on the host immunity, effects of antibiotics. Probiotics, prebiotics and synbiotics.

**List of Experiments**

1. Understanding and implementation of biosafety guidelines and biowaste management in a Microbiology Laboratory.
2. Understanding sterilization and disinfection techniques via validation of autoclave efficacy using *Bacillus stearothermophilus* spore strip assay.
3. To prepare and distinguish between various types of culture media (minimal, enriched, differential; solid and broth) for bacterial and fungal cultivation.
4. Isolation of single microbial (pure bacterial and fungal) colonies by streak plate method
5. Gram staining to differentiate between Gram-positive and Gram-negative bacteria.
6. Acid Fast Staining and Smear Microscopy.
7. Plotting bacterial growth curve using optical density measurement.
8. Detection of microbial contamination in biological samples using methylene blue reduction assay.
9. To perform antibiotic sensitivity testing of bacterial strains using Kirby-Bauer disc diffusion assay
10. Quantification of virus (bacteriophage) by plaque formation assay.

**Text Books :**


**1.** Greenwood D., Slack, R, Barer, M.R. & Irving, W.L. (2012). Medical Microbiology E-Book: A Guide to Microbial Infections: Pathogenesis, Immunity, Laboratory Diagnosis and control.

**2.** Michael Pelczar Jr. *Microbiology* (5th ed.). McGraw Hill Education, 2001. ISBN-10: 0074623206, ISBN-13: 978-0074623206.

**3.** Prescott, Harley, And Klein's Microbiology, Seventh Edition Published by McGraw-Hill, ISBN 978–0–07–299291–5.

**4.** Michael T. Madigan, John M. Martinko, David A. Stahl. *Brock Biology of Microorganisms* (14th ed.). Pearson Education, 2017. ISBN-10: 9332586861, ISBN13: 978-9332586864.

**5.** Ananthanarayan and Paniker's Textbook of Microbiology, Universities Press (India) Pvt. Ltd.; 13th edition (28 August 2024). ISBN-10: 9393330654 ISBN-13: 978-9393330659.

**Reference Books :**


1. IT Kudva, NA. Cornick, PJ Plummer, Q Zhang, TL Nicholson, JP Bannantine and BH Bellaire. *Virulence Mechanisms of Bacterial Pathogens*, (2016) 5th edition, ASM Press.
2. Levinson, W. & Jawetz E. (1996). Medical Microbiology and immunology: examination and board review. Appleton & Lange.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 40% | 20% | 40% | 100% |
| | | | | |

| Name of Program | B.Tech. Biotechnology | | | | |
|---|---|---|---|---|---|
| Course Code: EBTY301L | Cell and Tissue Culture Technologies | L | T | P | C |
| Owning School/Department | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| Pre-requisites/Exposure | Cellular Structures and Functions | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1: Understand the requirements of different types of cells, media, cellular interactions and culture Environment

CO2: Apply the sterile techniques towards maintenance, subculture, characterization of cell culture.

CO3: Understand the mammalian and insect cell characterization and differentiation and apply the cryopreservation for cell banking.

CO4: Understand the principles and applications of the insect cell expression system, including the characteristics of various insect cell lines used.

CO5: Explain the cell Immortalization and scale up towards applications of cell culture as source of valuable products.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | - | 1 | - | 1 | - | 3 | - | 3 | 3 | 1 | 1 | 3 | 3 | 3 | 3 | 1 |
| CO2 | 3 | 3 | - | 3 | - | 1 | - | 3 | - | 1 | 3 | 3 | 3 | 3 | 3 | 1 |
| CO3 | 1 | 3 | - | 3 | 3 | 3 | - | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 1 |
| CO4 | 3 | 3 | - | 3 | 3 | 3 | - | 1 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 1 |
| CO5 | 3 | 3 | - | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 1 | 3 | 3 | 3 | 3 | 1 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I:** **16**
**lecture hours**

**Introduction:** Animal cell culture: Historic background, Advantages and limitations. Biology of animal cells: Cellular interactions; Culture Environment, Cell adhesion, Cell adhesion molecules, Intracellular junctions, Cytoskeleton, Extracellular Matrix, Cell Motility.

**Design and layout of the Cell Culture Laboratory:** Planning furnishing and services-Requirements, Services, Ventilation, Sterile environment, Incubation and culture, Incubation and culture, Storage.

**Aseptic Techniques, Culture vessels and Safety:** Introduction, Elements, Sterile handling, Safety elements, Ionizing radiation, Biohazards, Bioethics and Quality assurance.

**Media, Cell Lines and Subculture.** Culture vessel types, Choice of culture vessels, Specialized systems. Defined Media and Supplements, Physicochemical Properties of Media, Serum, Serum Free Media; Preparation and sterilization of reagents and apparatus. Subculture and propagation, Different types of mammalian cells, Cell line selection, Subculture; Kinetics of cells in culture, Growth parameters

**Primary Culture:** Principles, Initiation of a primary cell culture, Isolation of the tissue, Types of primary culture

**Authentication and Validation:** Misidentification and cross contamination, Causes and avoidance of misidentification, Techniques for cell line authentications, Validation, Quality assurance

**Microbial Contamination:** Sources of contamination, Types of contamination, Monitoring and Eradication of contamination**.**

**Cytotoxicity:** Introduction, In vitro limitations, Nature of assay, Viability assay, Survival assay, Microtitration assay, Transformation assay.

**Module II:** **16**
**lecture hours**

**Cryopreservation and banking:** Rationale for freezing, Considerations before cryopreservation, Principles of Cryopreservation, Design and control of freezer stocks, Cell banks, Cell transportation.

**Cloning and Cell sorting:** Cell cloning, Isolation of clones, Density gradient, Gravity sedimentation.

**Cell Line Characterization and Differentiation:** Genotypic, Phenotypic, Cell morphology, Antigenic markers, Cell cycles. Differentiation: Different stages, Proliferation and differentiation, Induction of differentiation.

**Scale-up and automation:** Scale-up in suspension and monolayer, Large scale processes, Automation, Industry applications

**Cell Immortalization and Quantitation:** Immortalization with viral genes, Immortalization of human fibroblasts and Telomerase-induced immortalization. Cell counting, Cytometry, Cell proliferation, Cell Cycle Time.

**Application:** Cell culture as source of valuable products, Hybridoma Technology, Scale up of animal cell culture. Three-Dimensional culture. Organ Culture, Histotypic Culture.

**Module III:** **10**
**lecture hours**

**Insect Cell Culture:** Baculovirus expression system, Different types of vector systems, Promoters, pFastBAC, Bacmid, Different types of insect cells: SF9, SF21, Tni and S2 cells. Different types of transfection methods. Scale up of insect cell cultivation processes: Cost effectiveness, Process design. BacMam Vectors. Optimizing protein expression at the cellular level, Recombinant protein expression.

**List of Experiments**

1. Introduction to general safety guidelines, sterile techniques and introduction of cell culture laboratory instruments
2. Introduction to various types of media, introduction of various components in media and DMEM media preparation.
3. Subculture of adherent cell lines from T75 to 6 well plate.
4. Calculations for cell seeding.
5. Cell visualisation under microscope, basics of hemocytometer.
6. Calculation of cell counting by hemocytometer . Principle of trypan blue exclusion assay, live cells vs dead cells analysis, Viable cell counts.
7. Live cells vs dead cells analysis. basic calculation of cells seeding in 96 well plate and viable cell counts.
8. Live cells analysis on the basis of mitochondrial enzyme oxidoreductase.
9. Subculture of suspension cells and calculations for cell seeding .
10. Introduction of cryopreservation and cryopreservation of cells.
11. Thawing of cells and subculture.
12. Transfection of mammalian cell lines by lipofectamine method.

**Text Books :**


1. Freshney, R. Ian. *Culture of animal cells: a manual of basic technique and specialized applications*. John Wiley & Sons, 2015.
2. Chawla, H. S. *Introduction to Plant Biotechnology (3/e)*. 3rd ed. London, England: CRC Press, 2017.


**Reference Books :**


1. Wagner, Roland, and Hansjörg Hauser. "*1.1 Industrial Use and Perspectives of Animal Cell Culture*." *De Gruyter EBooks*, 2014.
2. Taiz, Lincoln, and Eduardo Zeiger. 'Sinauer (an Imprint Of)'. In *Plant Physiology and Development*. Oxford University Press, 2015.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 40% | 20% | 40% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **Course code:** | Immunology | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 2 | 0 | 4 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1: Explain the components and functions of innate and adaptive immunity, and roles of immune cells and lymphoid organs.

CO2: Understand key molecular and cellular mechanisms involved in innate immunity, inflammation, complement system and adaptive immunity.

CO3: Understand the structure, development, and genetic mechanisms of B-cell and T-cell receptors and their roles in adaptive immunity.

CO4: Analyze the processes of antigen processing and presentation via MHC molecules and the mechanisms of central and peripheral tolerance.

CO5: Distinguish between types of hypersensitivity, autoimmunity, and immunodeficiency, and discuss their underlying causes and treatments.

CO6: Demonstrate foundational knowledge of transplantation immunology and the application of basic immunological techniques in research and diagnostics.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | 1 | - | 2 | - | - | 2 | 2 | 2 | 1 | 3 | 3 | 2 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 2 | - | - | 2 | 2 | 3 | 1 | 3 | 3 | 2 |
| CO3 | 3 | 3 | 2 | 2 | - | 2 | 3 | - | 2 | 2 | 2 | 1 | 3 | 3 | 2 |
| CO4 | 3 | 3 | 2 | 2 | - | 2 | - | - | 2 | 2 | 2 | 1 | 3 | 3 | 2 |
| CO5 | 3 | 3 | 1 | 1 | - | 2 | - | - | 2 | 2 | 2 | 1 | 3 | 3 | 2 |
| CO6 | 3 | 3 | 3 | 3 | 2 | 2 | - | - | 2 | 2 | 3 | 1 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 10 lecture hours**

**Introduction to Immunology:** Historical Perspective, Humoral and Cellular Immunity Innate and Acquired Immunity

**Cells and organs of the immune system:** cells of the immune system, hematopoiesis, key characteristics, distribution, and function of lymphoid and myeloid cells; CD nomenclature; primary and secondary lymphoid tissues and organs.

**Innate Immunity:** Non-immunological barriers (physical, chemical, and anatomical), cells and soluble mediators of innate immunity; pattern recognition receptors (PRRs), pathogen-associated molecular patterns (PAMPS); inflammation; cytokines and chemokines; Complement system.

**Adaptive immunity:** Mediators of adaptive immunity, structure of antigen, concept of antigenicity and immunogenicity, interaction between adaptive and innate immunity, clonal selection theory.

**Module II: 10 lecture hours**

**B-Cell Biology:** Structure of antibodies and B-cell receptor, isotypes, allotypes, idiotypes, types of B cell epitopes, stages of B-cell development, organization of heavy and light chain genes; mechanism of antibody DNA rearrangement, somatic hypermutation, class switching.
**T-Cell Biology:** Development of T cells and functions, positive and negative selection of T cells in the thymus, structure of T-cell receptor and coreceptors.
**Major Histocompatibility Complex (MHC) and Antigen presentation:** Structure of MHC glycoproteins and their properties; professional antigen presenting cells, pathways of antigen processing and presentation.
**Tolerance:** Central and Peripheral.

**Module III: 8 lecture hours**

**Hypersensitivity:** Gell and Coombs classification; representative examples of type I, II, III and IV hypersensitive reactions, autoantigens.
**Autoimmunity:** Organ-specific and systemic autoimmune diseases; mechanisms for the induction of autoimmunity, treatment strategies.
**Immunodeficiency:** primary and secondary immunodeficiency, treatment strategies.
**Transplantation immunology:** graft rejection; major and minor histocompatibility antigens, immunosuppressive therapy; Graft vs host disease (GVHD) and privileged sites in human body.

**Introduction to immunotechniques**: Immunoassays, immunofluorescence, immunoblots.

**List of Experiments**

1. WBC and Differential cell count
2. IgG Purification using affinity chromatography
3. Indirect ELISA
4. Dot ELISA
5. Lateral flow-based rapid antigen test
6. Antigen-antibody reactions: Precipitation (Ouchterlony double diffusion)
7. Dot blot
8. SDS-PAGE and Western Blot
9. Immunoprecipitation
10. Immunohistochemistry
11. Agglutination – Blood Grouping
12. Latex Agglutination Assay

**Text Books:**


1. Punt, Jenni, Sharon Stranford, Patricia Jones, and Judith A. Owen. *Kuby Immunology*. 8th ed. New York, NY: W.H. Freeman, 2022.
2. Kenneth M. Murphy, Casey Weaver, Leslie Berg. *Janeway's Immunobiology*. 9th ed. Wiley 2024.


**Reference Books:**


1. Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt. *Roitt's Essential Immunology.* 3rd ed. Wiley, 2016.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 40% | 20% | 40% | 100% |

# Semester VI

| Name of Program | B.Tech. Biotechnology | | | | |
|---|---|---|---|---|---|
| **Course Code:** | Genetics | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

## Course Outcomes (COs)

On completion of this course, the students will be able to:

CO1: Explain Mendel's principles of inheritance and apply them to human genetics.

CO2: Describe chromosomal inheritance mechanisms and explain the basis of genetic disorders.

CO3: Discuss the role of genetic variation in evolution and its impact on population genetics.

CO4: Identify types of genetic mutations and their effects on organisms.

CO5: Examine the inheritance patterns of complex traits and their relevance to genetic counselling.

## CO-PO/PSO Mapping

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 1 | 1 | 1 | 1 | 1 | - | - | - | - | - | 3 | 3 | 1 | - |
| CO2 | 2 | 1 | 1 | 1 | 3 | 1 | - | - | - | - | - | 3 | 3 | 1 | - |
| CO3 | 3 | 3 | 2 | 2 | 3 | 3 | - | - | - | - | - | 3 | 3 | 2 | 2 |
| CO4 | 3 | 2 | 2 | 2 | 1 | 3 | - | - | - | 2 | - | 3 | 3 | 2 | - |
| CO5 | 3 | 2 | 2 | 2 | 1 | 2 | - | - | - | 2 | - | 3 | 3 | 2 | - |

1=weakly related 2= moderately related 3=strongly related

## Course Contents:

### Module 1: Foundations of Classical Genetics 10 lecture hours

Mendelism: The birth of genetics, Mendel's experiments with peas, Monohybrid and Dihybrid crosses, Principles of dominance, segregation, and independent assortment, Applications of Mendel's Principles: Punnett square, Probability methods, Testing Genetic Hypotheses: the chi-square test, Mendelian principles in human genetics: pedigrees, Mendelian segregation in human families, genetic counselling, Extensions of Mendelism

### Module 2: The Chromosomal Basis of Inheritance 10 lecture hours

Chromosomal basis of Mendelism: Chromosomes, The Chromosome Theory of Heredity, Sex-Linked Genes, Sex chromosomes and determination, Dosage Compensation of X-Linked Genes, Extra Chromosomal Inheritance, Cytogenetics: Human karyotype, Polyploidy, Aneuploidy, Rearrangements of Chromosome Structure, Linkage and Recombination

**Module 3: Genetic Variations & Mutations 10 lecture hours**

Concept of genetic variations and its significance; Sources of genetic variations –mutations, sexual reproduction, gene flow, transposable elements, genetic drift, horizontal gene transfer (in microorganisms); Classification of mutations- origin, effect on function, location, molecular change, Phenotypic effect, Polymorphism vs. Mutation; Common polymorphisms (SNPs, microsatellites) and their relevance in population genetics and genome-wide association study.

**Module 3: Quantitative, Population & Evolutionary Genetics 6 lecture hours**

Quantitative traits, Polygenic inheritance, Phenotypic variance, Heritability, QTL mapping Population Genetics: Gene pool, Allele frequencies, Hardy-Weinberg equilibrium Evolutionary forces: Mutation, Selection, Genetic drift, Migration, Selection types: Positive, negative, balancing

**Module 5: Microbial Genetics 6 lecture hours**

The genetics of bacteria: mutant genes in bacteria, unidirectional gene transfer in bacteria, Mechanisms of genetic exchange in bacteria: transformation, conjugation, plasmids and episomes, The genetics of viruses: Bacteriophage T4, Bacteriophage lambda, The evolutionary significance of genetic exchange in bacteria.

**Text Books :**

1. Hartl DL, Ruvolo M. Genetics: Analysis of Genes and Genomes. 9th ed. Jones & Bartlett Learning; 2021.

2. Griffiths AJF, Wessler SR, Lewontin RC, Carroll SB. Introduction to Genetic Analysis. 11th ed. W.H. Freeman & Co.; 2020.

3. Pierce BA. Genetics: A Conceptual Approach. 6th ed. W.H. Freeman & Co.; 2017.

**Reference Books :**

1. Snustad DP, Simmons MJ. Principles of Genetics. 7th ed. Wiley; 2020.

2. Strachan T, Read AP, Preece MA. Human Molecular Genetics. 5th ed. Garland Science; 2018.

**Lab Experiments:**

1. Family tree construction using standard pedigree symbols
2. Pedigree drawing and interpretation from case studies to identify inheritance patterns
3. Karyotype preparation and analysis from metaphase spread images to identify chromosomal abnormalities
4. Genetic polymorphism analysis using PCR and gel electrophoresis
5. *In silico* QTL analysis for identifying quantitative trait loci associated with phenotypic traits
6. Testing Hardy-Weinberg equilibrium using population genotype data

7. Isolation of bacteriophages from soil samples and enumeration of plaque-forming units (PFU)
8. Preparation of bacteriophage lysate of *Escherichia coli* bacteriophage P1
9. Transfer of an antibiotic resistance cassette using *E. coli* bacteriophage as a vector

## Assessment Scheme:

| **Components** | **Internal Assessment** | **Mid Term Exam** | **End Exam** | **Total** |
|---|---|---|---|---|
| **Weightage (%)** | **40%** | **20%** | **40%** | **100** |

| **Name of Program** | B.Tech. Biotechnology | | | | |
|---|---|---|---|---|---|
| **Course Code:** | **Bioprocess Engineering** | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 2 | 0 | 4 | 4 |
| **Pre-requisites/Exposure** | Thermodynamics & Chemical Processes | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:
CO1: Students will learn about bioprocess equipment and plant design.
CO2: Students will learn about cell growth kinetics involved in batch, fed-batch, and continuous fermentation processes.
CO3: Student will be able to analyse the microbial product.
CO4: Student will be able to purify the microbial product.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 2 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 2 | 1 | 3 | 3 | 2 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 2 | 2 | 2 | 3 | 2 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 2 | 2 | 1 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 6 lecture hours**

**Bioprocess Equipment and Plant Design**- Bioreactor design. Heat exchangers, condensers, evaporators. Storage vessel for volatile and non-volatile fluids, pressure vessel structure. Extractor, distillation, and absorption tower. Pumps, mechanical seals, valves, and switches. piping, plant layout and design.

**Module II 8 lecture hours**

**Bioprocess Engineering Principles**: Introduction to Bioprocess Technology, Advantage of bioprocess over chemical process. Batch fermentation and batch growth kinetics, unstructured non-segregated models to predict specific growth rate, substrate limited growth and Monod equation. Product formation kinetics. Kinetics of substrate uptake. Effect of maintenance on yields, observed yield, biomass yield from substrate, product yield from biomass, product yield from substrate. Kinetics of cell death. Fed-batch and continuous fermentation, chemostat, growth kinetics in fed-batch and continuous fermentation. Various types of fermentation: submerged fermentation, solid-state fermentation, aerobic and anaerobic fermentation.

**Module III: 8 lecture hours**

**Bioproduct Separation and Purification:** Filtration and ultrafiltration. Centrifugation. Cell disruption techniques. Solvent extraction. Aqueous two-phase liquid extraction. Precipitation methods. Chromatography. Crystallization. Drying. Distillation. Pervaporation.

**Module IV: 6 lecture hours**

**Industrial fermentation**: Production of Industrial chemicals, biochemicals and chemotherapeutic products, Anaerobic processes-ethanol production, lactic acid production, acetone-butanol-ethanol production. Aerobic processes- citric acid production, production of bakers' yeast, production of penicillin. Industrial enzyme production and purification-cellulases, amylases. Production of Microbial insecticides; microbial flavours and fragrances, newer antibiotics, anti-cancer agents, amino acids.

**List of Experiments**

1. Determination of the specific growth rate, maximum specific growth rate and saturation constant of microorganism during a batch fermentation.
2. Fed-batch fermentation.
3. Continuous fermentation.
4. Cellulase/amylase production and purification.
5. Citric acid production and purification.
6. Lactic acid production and purification.
7. Anaerobic fermentation for ethanol/butanol/1,3 propanediol production and purification.
8. Determination of organic acid/alcohol concentration using HPLC/GC.
9. Lab Exam.

**Text Books :**


1. Doran, Pauline M. *Bioprocess Engineering Principles*. 2nd ed. Academic Press, 2012.
2. Shuler, M. L., and F. Kargi. *Bioprocess Engineering-Basic Concepts*. Prentice Hall, 2004.


**Reference Books :**

1. Stanbury, Peter F., Allan Whitaker, and Stephen J. Hall. *Principles of Fermentation Technology*. Pergamon, 2013.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Term Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 20% | 40% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **Course code -----** | Fundamentals of Nanobiotechnology | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | | | | | |

Course Outcomes (COs)

On completion of this course, the students will be able to:

CO1: Understand the principles and Fundamentals of nanomaterial and nanotechnology

CO2: Describe the process for synthesis of nanomaterial and their applications.

CO3: Understand the fundamentals of analytical techniques used for interactions and their operation on nanomaterial and biotechnology.

CO4: Understand the current state-of-the-art of nanobiotechnology and its industrial applications.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | - | 2 | - | - | 3 | 3 | - | - |
| CO2 | 3 | 2 | 3 | 3 | 3 | 3 | - | - | - | 1 | - | 3 | 3 | 3 | 1 |
| CO3 | 2 | 2 | 3 | 2 | 3 | 3 | 2 | - | - | - | - | 3 | 3 | - | - |
| CO4 | 3 | 2 | 3 | 2 | 3 | 2 | - | - | - | 1 | - | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I:** **10 lecture hours**

Introduction to nanotechnology, Special properties of nanomaterials, advancement in nanotechnology, Nanomaterial fabrication methods, Various types of nanomaterials (metal and semiconductor nanoparticles, polymeric nanoparticles, etc.), intermolecular interaction at nanoscale and surface properties of nanomaterial. Types of nanoparticles/ liposomes/ lipid nanoparticles/ micelles/ dendrimers/ nanocapsules, Biomaterials Materials used for biosensors: Metals; Polymers; natural and synthetic material.

**Module II:** **10 lecture hours**

An overview of nano-biosensing: Bio-sensors and their various components, applications (molecular analysis, food safety, biomedical and environmental monitoring, etc.) lab-on-a-chip sensing and detection systems, BioMEMS/Biosensors: Concepts and toxicology of nanomaterials, environment safety. Functional materials Used in biosensors Fabrication; Composites, thin films, core-shell nanomaterial and application in fluorescence biosensors porous materials.

**Module III:** **8 lecture hours**

Nanomaterial analytical techniques (SEM, TEM, XRD, Particle size, Raman spectroscopy, etc.) Nanostructured biocompatible material and Interactions with Biomolecules, Bio-functional nanomaterial for sensing application. (Biomarkers for diagnostics, Agriculture pesticides, environmental sensing etc.) Bioimaging and signal enhancement suing nanoparticles based optical sensing, Point-of-Care systems.

**List of Experiments:**

1. Introduction of nanotechnology laboratory and safety practices
2. Synthesis of Gold Nanoparticles (Turkevich Method)
3. Green Synthesis of Silver Nanoparticles Using Lemon Juice
4. Characterization of Nanoparticles using Dynamic Light Scattering (DLS)
5. Surface Functionalization of Nanoparticles for Targeted Drug Delivery
6. DNA-Nanoparticle Conjugation and Gel Electrophoresis Analysis
7. UV-Vis Spectroscopy of Nanoparticles (Demonstration)
8. Surface functionalization and FTIR characterization.

**Text & Reference Books:**


1. Nanotechnology: An Introduction, by Jeremy Ramsden, 2011, *Elsevier Publishers*.
2. Nanobiotechnology: Concepts, Applications and Perspectives, edited by C.M. Niemeyer and C. A. Mirkin, 2012, Wiley-VCH Verlag GmbH & Co.
3. Nanomedicine, edited by Huw Summers, 2013, *Elsevier Publishers.*
4. Nano-Bio-Sensing, edited by Sandro Carrara, 2011, Springer Publishers
5. Murty, Budaraju S., P. Shankar, Baldev Raj, B. B. Rath, and James Murday. *Textbook of Nanoscience and Nanotechnology*. Springer Science & Business Media, 2013.


**Reference Books :**


1. Sengupta A, Sarkar CK, editors. Introduction to nano: basics to nanoscience and

nanotechnology. Springer; 2015 Jul 1.

2. Alshamrani, M. (2022). Broad-spectrum theranostics and biomedical application of functionalized nanomaterials. *Polymers*, *14*(6), 1221.
3. Bhushan B. Introduction to nanotechnology. In Springer handbook of nanotechnology 2017 (pp. 1-19). Berlin, Heidelberg: Springer Berlin Heidelberg.
4. Balaji S. Nanobiotechnology. MJP Publisher; 2019 Jun 7.
5. Klefenz H. Nanobiotechnology: from molecules to systems. Engineering in life sciences. 2004 Jun;4(3):211-8.

**Assessment Scheme :**

| Components | Internal Assessment | Mid Term Exam | End Term Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 20% | 40% | 100% |

# Semester VII

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY491J** | Mini Project-II | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 0 | 0 | 6 | 3 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Apply core subjects knowledge to identify a research area and research topic.
CO2 : Design and conduct experiments according to the selected problem.
CO3 : Analyse data obtained from the experiment and communicate it through the presentation.
CO4 : Evaluate the shortcomings of the project and future research in the field.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | - | 3 | 1 | - | 1 | - | - | 3 | - | 3 | 3 | 3 | 2 | 3 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 1 | - | 3 | 3 | - | 2 | 3 | 3 | 3 | 3 |
| CO3 | 3 | 3 | 2 | 3 | 3 | - | - | 3 | 3 | 3 | 2 | 3 | 1 | 3 | 3 |
| CO4 | 3 | 3 | 1 | 1 | - | - | - | - | 2 | 3 | 3 | 3 | 1 | 2 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents :**
This is a lab-based course.

**List of Experiments :**
The experiments will vary from individual project to project.

**Text Books :**
Research papers as assigned by the project supervising faculty.

**Reference Books :**
Research papers as assigned by the project supervising faculty.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 60% | - | 40% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | Integrated B.Tech. – M. Tech. Biotechnology | | | | |
| **Course code -----** | Advanced Tools and Techniques in Biotechnology | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Bioanalytical Techniques EBTY104P | | | | |

Course Outcomes (COs)

On completion of this course, the students will be able to:
CO1: Understanding the concepts of the NMR, CryoEM and X-ray crystallography
CO2: Understand basics of surface characterization and related analytical techniques
CO3: Understand the techniques and its implementation towards the sample analysis and applicability
CO4: To understand and apply various analytical techniques for industrial applications

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | - | 2 | - | - | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 2 |
| CO2 | 3 | 2 | 2 | 2 | - | 2 | - | - | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 2 |
| CO3 | 3 | 2 | 2 | 2 | - | 2 | - | - | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 2 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO4 | 3 | 3 | 3 | 3 | - | 2 | - | - | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

Course Contents:

**Module I: (15 hrs.)**

Nuclear Magnetic Resonance. Overview of NMR principles. Chemical shifts. Theory of Nuclear Magnetic Resonance, Applications of Proton NMR, Carbon-13 NMR.

Cryo Electron Microscopy: Overview of electron microscopy and its evolution. Applications and significance of CryoEM in biology and medicine. Sample handling and grid preparation. Cryoprotection. Image Acquisition and Data Collection. CryoEM in Drug Discovery and Disease Mechanisms.

X-ray Diffraction (XRD): Introduction to X-ray Crystallography, Basic principles of X-ray interaction with matter. Crystallization conditions. Different Methods of Crystallization. X-ray Diffraction and Data Collection.

**Module II: (12 Hrs.)**

Fluorescence microscopy: Confocal imaging, High-throughput imaging, Live-cell imaging, Image processing and quantitative analysis.

Surface Characterization Techniques: Scanning Tunnelling Microscopy (STM), Atomic Force Microscopy (AFM), Cantilever design and application, Various Modes of Imaging, Force Spectroscopy, High-Speed Imaging, Piezo Force Microscopy (PFM), Nanomechanical analysis of soft surfaces, biological imaging and related applications.

**Module III: (15 Hrs.)**

Electrochemical spectroscopy: Introduction to electrochemistry – basic concepts and requirements, Cyclic voltametric, Amperometry, Potentiometry, Impedance spectroscopy, Electrochemical circuit elements, 3-electrode measurements, challenges and artefacts.

Infrared Spectroscopy: Theory, Infrared Sources and Transducers, Instruments, Adsorption and Reflection Spectrometry, Photoacoustic Infrared Spectrometry, Near and Far Infrared Spectrometry, Emission Spectroscopy, Microspectrometry.

Mass Spectroscopy: Fundamentals of mass spectrometry, principles and components of the mass spectrometer and sample analysis, mass spectrometry: Ionization sources, Mass analysers, MALDI, sample preparation and analysis.

**Experimental section:**

1. Protein crystallization: Crystal tray set up
2. Differential analysis of crystalline and amorphous sample on XRD
3. FTIR measurements of powders and thin films
4. Electrochemical: Cyclic voltametric (CV) sample analysis and CV cure preparation
5. Fluorescence microscopy: Sample imaging with multiple parameter and filter channel

6. Post processing of Multi-channel Fluorescence Image using Imagej Software
7. Mass Spectroscopy: MALDI-TOF analysis of proteins

Text Books:


1. Skoog, Holler, Nieman, (2017), Principles of Instrumentation Analysis, Harcourt
2. Roop B, (2009) Biomolecular Crystallography: Principles, Practice, and Application to Structural Biology, Garland Science; 1st edition
3. Rhodes, G. (2010). Crystallography made crystal clear: a guide for users of macromolecular models. Elsevier.
4. Robert M Glaeser, Eva Nogales, Wah Chiu, (2021) Single-particle Cryo-EM of Biological Macromolecules, Biophysical Society, IOP publishing
5. Bhushan B, editor. Springer handbook of nanotechnology. Springer; 2017 Nov 5.
6. Oldham K, Myland J. Fundamentals of electrochemical science. Elsevier; 2012 Dec 2.


Reference Books:


1. X-ray Crystallography. (2021, May 1). https://chem.libretexts.org/@go/page/316
2. Raja, P. M. V., & Barron, A. R. (2021, March 21). NMR Spectroscopy. Rice University. https://chem.libretexts.org/@go/page/55887
3. Proteins. (2020, August 13). College of Saint Benedict/Saint John's University. https://chem.libretexts.org/@go/page/189779
4. Wilson and Walker, (2000), Practical Biochemistry: Principles and Techniques, Cambridge Low Price Editions
5. Bagotsky VS, editor. Fundamentals of electrochemistry. John Wiley & Sons; 2005 Dec 2.
6. Dietzek B, Cialla D, Schmitt M, Popp J. Introduction to the fundamentals of Raman spectroscopy. InConfocal Raman Microscopy 2010 Aug 31 (pp. 21-42). Berlin, Heidelberg: Springer Berlin Heidelberg.


Assessment Scheme:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 20% | 40% | 100% |

# Semester VIII

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| EBTY4096J | M. Tech Research Project on Specialization | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 0 | 0 | 20 | 10 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the scientific concepts of their project.

CO2 : Critically evaluate a research area to identify a research topic.

CO3 : Design and conduct experiments.

CO4 : Analyse data and conclude.

CO5 : Present experimental data.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

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

1=weakly related 2= moderately related 3=strongly related

**Course Contents :**

This is a research-based course.

**List of Experiments :**

The experiments will vary from individual project to project.

**Text Books :**

Material will be assigned by the project supervisor.

**Reference Books :**

Study material as assigned by the project supervisor.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 50% | - | 50% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | Integrated B.Tech.-M.Tech. Biotechnology | | | | |
| **EBTY4095J** | M. Tech. Research Project | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 0 | 0 | 12 | 6 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1: Critically evaluate a research area to identify research gaps.

CO2: Define a research problem and create hypothetical solutions.

CO3: Design and conduct experiments to find evidence.

CO4: Analyse data, prepare a scientific report, and present the findings.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 3 | 3 | 2 | 3 | 1 | 3 | 2 | 2 | 2 | 3 | 3 | 2 | 3 | 3 | 2 |
| CO2 | 3 | 2 | 3 | 2 | 3 | 2 | 3 | 2 | 1 | 2 | 2 | 3 | 2 | 1 | 3 | 2 |
| CO3 | 2 | 2 | 3 | 3 | 3 | 1 | 3 | 2 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| CO4 | 3 | 2 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

This is a research-based course.

**List of Experiments**

The experiments will vary from individual project to project.

**Text Books :**

Material will be assigned by the project supervisor.

**Reference Books :**

Study material as assigned by the project supervisor.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 50% | - | 50% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | M.Tech. Biotechnology | | | | |
| **Course Code:** | Medical Microbiology | L | T | P | C |
| **Owning School/Department** | SEAS/ Biotechnology | 4 | 0 | 4 | 6 |
| **Pre-requisites/Exposure** | Microbes and Immune System | | | | |

**Course Outcomes (COs)**

On completion of this course, students should be able to:

CO1: Understand the structure, classification, growth and identification of various microorganisms including bacteria, fungi, parasite and virus.
CO2: Describe different types of pathogens, infectious diseases and their mechanisms of pathogenesis.
CO3: Understand the role of host in infectious disease, including natural barriers to infection, innate and acquired immune responses to infection, and inflammation.
CO4: Apply various diagnostic and therapeutic interventions against various infectious diseases and Antimicrobial resistant (AMR) pathogens.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 2 | 3 | 1 | 3 | 1 | 2 | 3 | - | - | 2 | 3 | 3 | 1 |
| CO2 | 3 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 3 | - | - | 2 | 3 | 3 | 1 |
| CO3 | 3 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 3 | - | - | 2 | 3 | 3 | 1 |
| CO4 | 3 | 2 | 1 | 3 | 2 | 1 | 1 | 1 | 2 | 3 | - | - | 2 | 3 | 3 | 1 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 22 lecture hours**

**Microbial Pathogenesis**

The structure, classification, growth and identification of pathogens. Intracellular and extracellular bacterial pathogens, Superficial, Cutaneous, Sub-cutaneous; Types of Mycoses (with specific example of causative fungi) - Endemic and Opportunistic. Viral pathogens. Infectious diseases, Mechanism of pathogenesis and major virulence factors for various pathogens including Bacteria, Fungi, Viruses and Protozoa. Adaptation strategies of pathogen- impact of host- and pathogen- metabolism on immunity and pathogen survival. Immune evasion mechanisms of pathogens; Mechanisms of Chronic/Latent infections – host-pathogen interactions. Human microbiome and its role in Health Disease.

**Module II:** **11 lecture hours**

**Advanced Diagnostics Methods for Infectious Diseases**

Diagnostics methods and their advancements to detect Bacterial, Fungal Viral and Protozoan pathogens. Modern approaches for diagnosis of infectious diseases: Basic concepts of gene probes, dot hybridization and PCR based assays, Lateral Flow Assays, Interferon Gamma Release Assay (IGRA), Tuberculin Skin Test (TST) and X-ray based diagnosis of infections. Various methods of phenotypic drug susceptibility testing, Modern methods of detection of AMR, passive and active prophylactic measures. Principles of biosafety and biomedical waste management.

**Module III:** **10 lecture hours**

**Therapeutic Interventions against Infectious Diseases**

Classes and mechanism of action of currently available drugs and new inhibitors in the pipeline to targeting bacterial, fungal, Viral and Protozoan infections. Antiviral chemotherapy, Killed and attenuated vaccines, Neutralizing Antibodies, Reverse transcriptase inhibitor, protease inhibitor, Interferons, fusion inhibitor *etc.*

**List of Experiments**

1. Bacterial agglutination test to differentiate between various serotypes of bacterial pathogens.
2. Alamar Blue assay to test the screen antimicrobial compounds.
3. Vital staining for determining bacterial viability using fluorescence Microscopy.
4. Acid Fast Staining and Smear Microscopy.
5. To screen auxotrophic mutants to determine the mutagenicity of a compound using AMES test.
6. To Perform bacterial conjugation to understand the naturally occurring transfer of antibiotic resistance from one bacterium to another.
7. Widal Test to detect the presence of Salmonella genus which causes enteric or Typhoid Fever.
8. Endotoxin LPS detection by ELISA.
9. Triple Sugar Iron Agar protocol to differentiate bacteria based on their fermentation of lactose, glucose and sucrose and on the production of hydrogen sulfide.
10. Viral Plaque Assay.
11. Visit to Clinical Diagnostics labs at GIMS Hospital, Greater Noida.

**Text Books :**


1. Greenwood D., Slack, R, Barer, M.R. & Irving, W.L. (2012). Medical Microbiology E- Book: A Guide to Microbial Infections: Pathogenesis, Immunity, Laboratory Diagnosis and control.
2. Michael Pelczar Jr. *Microbiology* (5th ed.). McGraw Hill Education, 2001. ISBN-10: 0074623206, ISBN-13: 978-0074623206.
3. Prescott, Harley, And Klein's Microbiology, Seventh Edition Published by McGraw-Hill, ISBN 978–0–07–299291–5.
4. Michael T. Madigan , John M. Martinko, David A. Stahl. *Brock Biology of Microorganisms* (14th ed.). Pearson Education, 2017. ISBN-10: 9332586861, ISBN13: 978-9332586864.
5. Ananthanarayan and Paniker's Textbook of Microbiology, Universities Press (India) Pvt. Ltd.; 13th edition (28 August 2024). ISBN-10: 9393330654 ISBN-13: 978-9393330659.


**Reference Books :**

1. IT Kudva, NA. Cornick, PJ Plummer, Q Zhang, TL Nicholson, JP Bannantine and BH Bellaire. *Virulence Mechanisms of Bacterial Pathogens*, (2016) 5th edition, ASM Press.
2. Levinson, W. & Jawetz E. (1996). Medical Microbiology and immunology: examination and board review. Appleton & Lange.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 40% | 20% | 40% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | Integrated B.Tech.-M.Tech. Biotechnology | | | | |
| **EBTY** | Computational Biology | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 4 | 5 |
| **Pre-requisites/Exposure** | Computational Thinking and Programming (ECSE105L)<br>Introduction to Bioinformatics (EBTY202L) | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1: Apply computational techniques to analyze biological data, including genomic sequences, protein structures, and molecular interactions.

CO2: Understand the basic principles of computational biology, focusing on the modeling and simulation of biological systems.

CO3: Integrate computational methods for predicting protein structures and dynamics to gain insights into structure, function, and disease mechanisms.

CO4: Analyze and interpret the concept of network and system biology. Understand the QSAR-based drug discovery.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | 1 | - | 2 | - | 1 | 1 | 2 | 1 | - | 3 | 3 | 3 | 1 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 1 | 1 | 2 | 3 | 2 | 3 | 3 | 3 | 2 |
| CO3 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 1 | 1 | 2 | 3 | - | 3 | 3 | 3 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | - | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

Medium /

**Module I: 8 lecture hours**

**Introduction to Computational Biology:** Biological database, sequence alignment and phylogenetics, genomic data analysis, structural bioinformatics: protein and nucleic acid structure prediction

**Module II: 17 lecture hours**

**Molecular Dynamics and Simulations:** Introduction to Molecular Dynamics (MD): principles of MD simulations, force fields (AMBER, CHARMM, GROMOS), and applications in studying biomolecular dynamics. Simulating Protein-Ligand Interactions: Setting up and running MD simulations for protein-ligand complexes, analyzing trajectories, and extracting insights from the results. Advanced Simulation Techniques: steered MD, umbrella sampling, and free energy perturbation. Introduction to Quantum Mechanics/Molecular Mechanics (QM/MM): combining quantum mechanics with molecular mechanics to study complex biological systems. Applications of MD simulations: investigating protein folding, conformational changes, and the impact of mutations on protein function.

**Module III: 17 lecture hours**

**Network and Systems Biology:** Applications in drug discovery and development. Multi-omics-based biomarker identification. Introduction to cheminformatics and QSAR-based screening of natural compounds for drug discovery. AI-driven drug repurposing strategies. Translational approaches for integrating computational models into real-world therapeutic development.

**List of Experiments:**

1. Linux commands and shell scripting
2. Rigid and flexible docking
3. Protein structure prediction
4. Nucleic acid structure prediction
5. Generating MD simulations input using web utilities
6. Case study: MD simulations on a protein-drug complex (part-1)
7. Case study: MD simulations on a protein-drug complex (part-2)
8. Case study: MD simulations on a protein-drug complex (part-3)
9. Cytoscape to visualize and analyze protein-protein interaction (PPI) networks
10. Predict drug targets using STITCH interaction networks
11. QSAR for drug discovery

**Text Books :**

1. Wünschiers, Röbbe. *Computational Biology*. Berlin, Heidelberg: Springer Berlin Heidelberg, 2013.

**Reference Books :**

1. Fenyö, David, ed. *Computational Biology*. Humana Press, 2010.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 40% | 20% | 40% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | Integrated B.Tech. – M. Tech. Biotechnology | | | | |
| **Course code -----** | Nano-Biotechnology | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Biomaterials - EBTY207L | | | | |

Course Outcomes (COs)

On completion of this course, the students will be able to:

CO1: Understand the principles and Fundamentals of nanomaterial and nanotechnology

CO2: Describe the process for synthesis of nanomaterial and their applications.

CO3: Understand the fundamentals of analytical techniques used for interactions and their operation on nanomaterial and biotechnology.

CO4: Understand the current state-of-the-art of nanobiotechnology and its industrial applications.

## CO-PO/PSO Mapping

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | - | 2 | - | - | 3 | 3 | - | - |
| CO2 | 3 | 2 | 3 | 3 | 3 | 3 | - | - | - | 1 | - | 3 | 3 | 3 | 1 |
| CO3 | 2 | 2 | 3 | 2 | 3 | 3 | 2 | - | - | - | - | 3 | 3 | - | - |
| CO4 | 3 | 2 | 3 | 2 | 3 | 2 | - | - | - | 1 | - | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

## Course Contents:

Module I: 14 lecture hours

Introduction to nanotechnology, Special properties of nanomaterials, past and present of advancement in nanotechnology, Nanomaterial fabrication methods, Various types of nanomaterials (metal and semiconductor nanoparticles, polymeric nanoparticles, etc.), intermolecular interaction at nanoscale and surface properties of nanomaterial.

Module II: 14 lecture hours

An overview of nano-biosensing: Bio-sensors and their various components, applications (molecular analysis, food safety, biomedical and environmental monitoring, etc.) lab-on-a-chip sensing and detection systems, BioMEMS/Biosensors for diagnostics. Nanomedicine: Concepts and toxicology of nanomaterials, nanoparticle dynamics and interaction in biological environment.

Module III: 14 lecture hours

Nanostructured biocompatible material and Interactions with Biomolecules, Bio-functional nanomaterial for diagnostic application. (Targeted drug delivery, aptamer-based therapy, Implants; wound healing etc.) Bioimaging and signal enhancement with nanoparticles, Point-of-Care systems.

Text & Reference Books:


1. Nanotechnology: An Introduction, by Jeremy Ramsden, 2011, *Elsevier Publishers*.
2. Nanobiotechnology: Concepts, Applications and Perspectives, edited by C.M. Niemeyer and C. A. Mirkin, 2012, Wiley-VCH Verlag GmbH & Co.
3. Nanomedicine, edited by Huw Summers, 2013, *Elsevier Publishers*.
4. Nano-Bio-Sensing, edited by Sandro Carrara, 2011, Springer Publishers

5. Additionally, other latest research articles related to the topic will be discussed.

Reference Books :


1. Sengupta A, Sarkar CK, editors. Introduction to nano: basics to nanoscience and nanotechnology. Springer; 2015 Jul 1.
2. Alshamrani, M. (2022). Broad-spectrum theranostics and biomedical application of functionalized nanomaterials. *Polymers*, *14*(6), 1221.
3. Bhushan B. Introduction to nanotechnology. In Springer handbook of nanotechnology 2017 (pp. 1-19). Berlin, Heidelberg: Springer Berlin Heidelberg.
4. Balaji S. Nanobiotechnology. MJP Publisher; 2019 Jun 7.
5. Klefenz H. Nanobiotechnology: from molecules to systems. Engineering in life sciences. 2004 Jun;4(3):211-8.


Assessment Scheme :

| **Components** | **Internal Assessment** | **Mid Term Exam** | **End Term Exam** | **Total** |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 20% | 40% | 100% |

| **Name of Program** | Integrated B.Tech. – M. Tech. Biotechnology | | | | |
|---|---|---|---|---|---|
| **Course code -----** | Immunotechnology | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Microbes & Immune System | | | | |

Course Outcomes (COs)

On completion of this course, the students will be able to:

CO1: Understand the applications of immune system mediators for diagnostics.

CO2: Describe the process of vaccine development, their types, and processes for vaccine production, efficacy and safety assessment.

CO3: Describe immunotherapeutic strategies cancer vaccines, adoptive cell therapies, monoclonal antibodies, and immune checkpoint inhibitors, along with their mechanisms.

CO4: Design immunotherapeutic strategies to address various diseases.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | - | 2 | - | - | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 2 |
| CO2 | 3 | 2 | 2 | 2 | - | 2 | - | - | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 2 |
| CO3 | 3 | 2 | 2 | 2 | - | 2 | - | - | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 2 |
| CO4 | 3 | 3 | 3 | 3 | - | 2 | - | - | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

Course Contents:

**Module I: (15 hours)**

**Introduction to the immune system and its components-**general overview of mediators of immune system

**Introduction to Immunodiagnostics**

Antibody-based immunodiagnostic tests (with case studies) - Enzyme-linked immunosorbent assays (ELISA), Western blot, radioimmunoassays, lateral flow assays; immunohistochemistry and immunofluorescence in tissue-based diagnostics; flow cytometry for quantitative analysis of cell populations; immunophenotyping and minimal residual disease detection, multiplex bead array, and proximity ligation assays.

T cell-based diagnostic assays (with case studies): ELISPOT assay, intracellular cytokine staining, T Cell proliferation assay, mixed lymphocyte reaction, T Cell receptor sequencing, T cell cytotoxicity assay, T Cell memory assessment using activation-induced marker assay, tetramer staining, T Cell subset analysis, and cytokine release assay.

**Module II: (12 hours)**

**Vaccine development**

Overview of vaccines and historical perspective, basic principle of the vaccine development process, types of vaccines (live attenuated vaccines, inactivated vaccines, subunit, recombinant, polysaccharide, and conjugate vaccines, toxoid vaccines, mRNA vaccines, and viral vector vaccines), criteria for the selection of target antigen, vaccine adjuvants, vaccine delivery systems and administration routes, concept of reverse vaccinology, vaccine production pipeline (case studies), vaccine safety and efficacy assessment (case study), vaccine hesitancy.

**Module III: (15 hours)**

Introduction to immunotherapy, types of immunotherapeutic strategies - cancer vaccines (therapeutic versus preventive cancer vaccines), tumor antigen identification, adoptive cell therapies (CAR-T cell therapy, NK cell therapy, macrophage-based cell therapy, tumor-infiltrating lymphocyte therapy), monoclonal antibodies (mechanisms of action, antibody-drug conjugates, bispecific antibodies, nanobodies), cytokine-based therapies, oncolytic viruses (mechanisms of action, examples of oncolytic viruses in trials), inhibitors targeting immune checkpoints (PD-1 and PD-L1 inhibitors, CTLA-4 inhibitors, new checkpoint targets in development), Toll-like Receptor agonists.

Clinical applications of immunotherapy (case studies) - immunotherapy for cancer, autoimmune diseases, infectious diseases, transplantation.

Limitations and challenges in immunotherapy, regulatory processes, emerging areas in immunotherapy.

Text Books:


1. Suman, P., Chandra. *Immunodiagnostic Technologies from Laboratory to Point-Of-Care Testing, Springer Nature Singapore. 2021. ISBN:* 978-981-15-5822-1.
2. Ashfield, R., Oli, A. N., Esimone, C., and Anagu, L. *Vaccinology and Methods in Vaccine Research*. Academic Press, 2022. ISBN: 978-0-323-91146-7.
3. Naing, A., Hajjar, J., *Immunotherapy*. Cham: Springer International Publishing, 2021.


Reference Books:


1. Stranford, S., Owen, J., Jones, P., & Punt, J. Kuby's Immunology, Media Update (8th ed.). W.H. Freeman, 2023. ISBN: 9781319498658.


Assessment Scheme:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 20% | 40% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | Integrated B.Tech. – M. Tech. Biotechnology | | | | |
| **Course code** | Environmental Biotechnology | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Environment and Sustainability (ESEA301L)<br>Bioprocess Design and Upscaling (EBTY304L) | | | | |

Course Outcomes (COs)

On completion of this course, the students will be able to:

CO1: Understand the fundamental principles of ecosystem dynamics and environmental microbiology

CO2: Evaluate and analyse environmental pollution and its impact

CO3: Apply bioremediation techniques to address environmental contaminants

CO4: Utilize microbial and biotechnological innovations for environmental protection and sustainability

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 1 | 1 | 1 | 3 | 1 | 1 | 1 | 2 | 3 | 3 | 3 | 3 | 3 |
| CO2 | 3 | 2 | 3 | 1 | 1 | 2 | 3 | 1 | 1 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| CO3 | 3 | 3 | 3 | 2 | 1 | 3 | 3 | 1 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| CO4 | 3 | 3 | 3 | 2 | 1 | 3 | 3 | 1 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |

1 = weakly related 2 = moderately related 3 = strongly related

Course Contents:

**Module I: (15 hours)**

**Introduction to Environment, ecosystem and sustainability**: Overview of environment and sustainability, Sustainable Development goals (SDGs), Basics of ecosystem structure and function, Concepts of energy transfer and nutrient cycling in an ecosystem.

**Sources and types of pollution**: Soil, air and water pollution, Measurement of pollution (techniques and instrumentation), Environmental health and ecotoxicology, Indices of toxicity. Microbial biosensors in environmental monitoring, Carbon footprint, Risk assessment, Environmental impact assessment, Life cycle analysis.

**Basics of environmental microbiology**: Microbial ecology, growth and metabolism, Respiration and energy generation, Microbial transformation, degradation reactions and kinetics, Culture dependent and independent analyses of microbial communities (Environmental metagenomics).

**Module II: (15 hours)**

**Bioremediation technology**: Scope and characteristics of contaminates, Types of bioremediations (Phyto, microbial, and genetically modified microbes), Engineered strategies for bioremediation (insitu and exsitu bioremediation), Biomining, Landfarming, Microbial cleaning of gases (biofiltration and bioscrubbing), Bioreactors for waste management.

**Microbial detoxification of hazardous chemicals**: Synthetic detergents, Pesticides, Hydrocarbons, Chlorinated hydrocarbons, Explosives, Microbial interaction with plastics, Antibiotics and others emerging pollutants.

**Module III: (12 hours)**

**Biological energy and nutrient recovery from waste:** Biological phosphorus and nitrogen removal and recovery from wastewater, Biofuels (Case studies), Biofertilizers, Biocompost, vermicompost and Bio-pesticides production.

**Microbial role in carbon storage and capture:** Carbon sequestration (Case studies), Conversion to valuable products (fuels, chemicals, and material).

**Role of biotechnology in environmental protection:** Application of biotechnological innovations in environmental conservation and sustainability, Waste valorization (Case studies of various startups), Green chemistry, BioE3 policy.

**Textbooks:**


1. B. Rittmann and P. L. McCarty, *Environmental Biotechnology: Principle & Applications*, 2nd Edition, McGraw Hill Companies Incorporated, 2012. ISBN 0-470-84373-X.
2. G. M. Evans and J. C. Furlong, *Environmental Biotechnology: Theory and Applications*, 2nd Edition, Wiley Publishers, 2010. ISBN 0-470-84372-1.
4. P.K. Mohapatra, *Textbook of Environmental Biotechnology*, 1st Edition, IK International Publishing House Pvt. Ltd, 2013. 978-8188237548.
3. B. C. Bhattacharya and R. Banerjee, *Environmental Biotechnology*, Oxford University Press, USA, 2007. 978-0195687828.


**Reference Books:**


1. Scragg, A, *Environmental Biotechnology*, 2nd Edition, Oxford University Press, USA, 2007. ISBN 9780013032984.
2. Metcalf and Eddy Inc, *Wastewater Engineering: Treatment and Resource recovery*, McGraw-Hill publication, 5th Edition, 2013. ISBN10: 0073401188.


**Assessment Scheme:**

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 40% | 20% | 40% | 100% |

# Electives

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY341L** | AMR Theory and Methods | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Microbes & Immune System | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the historical development of antibiotics and their impact on human health. Analyse the global emergence of antimicrobial resistance (AMR) and its consequences for public health. Understand the mechanisms of AMR, including target modification, drug modification, and efflux pumps. Investigate the occurrence of AMR in bacteria, fungi, viruses, and parasites.

CO2 : Understand the One Health approach and its significance in combating AMR in humans, animals, and the environment (One Health). Explore the concept of antimicrobial stewardship and its role in preserving the effectiveness of antibiotics. Differentiate between multidrug resistance (MDR), extensively drug-resistant (XDR), and totally drug-resistant (TDR) pathogens. Analyse the cycle of AMR and its perpetuation in ESKAPE pathogens and their significance in healthcare-associated infections.

CO3 : Understand the principles of antimicrobial susceptibility testing (AST) and its role in detecting AMR. Understand the role of resistome in understanding the genetic basis of AMR at a global scale. Familiarize with AMR databanks and their role in surveillance and research. Discuss quality assurance procedures in AST, including the use of QC strains. Explore various approaches and technologies for developing novel therapeutics including phage therapy, immunotherapy etc. and their potential in overcoming AMR challenges. Understand the mechanisms of action of novel therapeutics against AMR. Discuss the challenges and prospects of implementing novel therapeutics in clinical practice.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 3 | 3 | 2 | 3 | 1 | 3 | 2 | 1 | 2 | - | 2 | 3 | 3 | 2 |
| CO2 | 2 | 2 | 3 | 3 | 3 | 1 | 3 | 2 | 1 | 2 | - | 2 | 3 | 3 | 2 |
| CO3 | 2 | 2 | 3 | 3 | 3 | 1 | 3 | 2 | 1 | 2 | - | 2 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 14 lecture hours**

History of antibiotic use since 1945. Discovery of antibiotics and antibiotic resistance. Global burden of AMR. Modes of bacterial resistance. Antibiotic Classes and Mechanisms. Mechanisms of resistance: target modification, drug modification, efflux pumps. AMR in fungi, viruses and parasites.

**Module II: 14 lecture hours**

Reservoirs of antimicrobial resistance: soil, water, agricultural practices. One health approach. Antimicrobial stewardship and monitoring. National Action Plan. Multidrug resistance: MDR, XDR and TDR. ESKAPE pathogens. AMR in community and hospital. Cycle of AMR.

**Module III: 14 lecture hours**

Detection of AMR: antimicrobial susceptibility testing. Resistome. AMR databank, Quality assurance of AMR using QC strains to assure the quality of AST. Novel therapeutics to target AMR.

**Text Books :**

1. Weber, Todd, Ed. *Antimicrobial Resistance: Beyond The Breakpoint: 06 (Issues In Infectious Diseases)*, N.D.
2. 2.Drlica, Karl, Ed. *Antimicrobial Resistance In The 21st Century (Emerging Infectious Diseases Of The 21st Century)*, N.D.

**Reference Books :**

1. Dr. Himanshu Baweja, *Anti-Microbial Resistance Crisis In Current Medical Era A Pandemic*, ASIN B081RKMQHL.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY342L** | Gene Therapy | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 2 | 0 | 2 | 3 |
| **Pre-requisites/Exposure** | rDNA Technology | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Describe different methods of gene transfer techniques and gene therapy types.

CO2 : Apply and define advanced genome editing methods and molecular medicine.

CO3 : Evaluate ethical concerns associated with novel methods of gene therapy.

CO4 : Compare methods, ethical concerns, and safety issues of gene therapy available for different diseases.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | - | - | - | 1 | - | - | 3 | 2 | 1 | - |
| CO2 | 3 | 3 | 3 | 3 | 3 | - | - | - | 1 | - | - | 3 | 2 | 1 | - |
| CO3 | 3 | - | - | - | - | 3 | - | 3 | - | - | - | 3 | - | - | 2 |
| CO4 | 3 | 3 | - | 3 | 3 | 3 | - | 3 | - | - | - | 3 | - | 1 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 10 lecture hours**

Introduction of gene therapy: Basic mechanisms and approaches in gene therapy, Gene therapy in germline vs. somatic cells; In vivo and ex vivo gene therapy; Vectors used for gene therapy, Retroviral vector, Adenovirus vector, Adeno-associated virus, Lentiviral vectors, and non-viral gene transfer techniques.

**Module II: 10 lecture hours**

Advanced methods of gene therapy, how to target vector to the particular cell; Genome Editing, Gene therapy using CRISPR/Cas9 Technology, use of RNAi and other non-coding RNAs, ethical considerations in all these novel methods of therapy; Recent advancement in Molecular Medicine and Gene Therapy; Genetically altered mice as models for gene therapy.

**Module III: 8 lecture hours**

Applications of gene therapy, Gene therapy for cardiovascular/ Neurological disorders, cystic fibrosis, Duchenne Muscular Dystrophy (DMD), Bleeding disorders, HIV infection, cancer, Severe combined immunodeficiency syndrome (SCID), Gene therapy of nonheritable disorders. Clinical trials for diseases, Ethical and safety issues in gene therapy.

**List of Experiments :**

1. Video demonstration of non-viral gene transfer techniques (physical methods).
2. Electroporation system demonstration using Gene Pulsar BioRad X cell.
3. Video demonstration of different chemical methods of gene transfer.
4. PEI mediated gene transfection in mammalian cells.
5. RNA interference technology video demonstration.
6. CRISPR-CAS9, gene-editing technique video demonstration
7. Designing of guide-RNA for CRISPR-CAS9.
8. Viral vector-mediated gene therapy video demonstration.
9. Genetically altered mice models for gene therapy.
10. Cancer gene therapy discussion.

**Text Books :**


1. Friedman, T. *The Development of Human Gene Therapy*. Cold Spring Harbor, NY: Cold Spring Harbor Lab.Press, 1999.
2. Lemoine, Nick. *Understanding Gene Therapy*. London, England: Taylor & Francis, 2023.
3. Giacca, Mauro. *Gene therapy*. Springer Science & Business Media, 2010.


**Reference Books :**


1. Verma, Inder M., and Matthew D. Weitzman. 'Gene Therapy: Twenty-First Century Medicine'. *Annual Review of Biochemistry* 74, no. 1 (2005): 711–38. https://doi.org/10.1146/annurev.biochem.74.050304.091637.

2. Hunt, Kelly K., and Stephan A. Vorburger. *Gene Therapy for Cancer*. PDF. Edited by Kelly K. Hunt, Stephan A. Vorburger, and Stephen G. Swisher. 2007th ed. Cancer Drug Discovery and Development. New York, NY: Humana Press, 2006.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the basics of the immune system and the types of immunity, types of antigens, antigen processing and presentation with MHC, and functions of antibodies in generating the immune responses and activating the complement system.

CO2 : Understand technologies for producing monoclonal and polyclonal antibodies with specific properties, and methods for antibody expression, downstream purification, formulation, and assessing stability.

CO3 : Describe types of antibodies and their functions and strategies for antibody engineering for humanization, and affinity maturation.

CO4 : Explain basic and advanced techniques used for the characterization of antibodies and applications of monoclonal antibodies in clinical diagnosis and treatment.

**CO-PO/PSO Mapping**

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Name of Program** | | | | | B.Tech. Biotechnology | | | | | | | | | | |
| **EBTY441L** | | | | | Antibody Engineering Technologies | | | | | | | | L | T | P | C |
| **Owning School/Department** | | | | | SEAS/Biotechnology | | | | | | | | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | | | | | Microbes & Immune System | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO-9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 | |
| CO1 | 3 | 2 | 2 | 2 | - | 2 | - | - | 2 | 2 | 2 | 2 | 3 | 3 | 2 | |
| CO2 | 3 | 2 | 2 | 2 | - | 2 | - | - | 2 | 2 | 2 | 2 | 3 | 3 | 2 | |
| CO3 | 3 | 2 | 2 | 2 | - | 2 | - | - | 2 | 2 | 2 | 2 | 3 | 3 | 2 | |
| CO4 | 3 | 2 | 2 | 2 | - | 2 | - | - | 2 | 2 | 2 | 2 | 3 | 3 | 2 | |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 15 lecture hours**

**Introduction:** Immunity, Types of immunity, Antigens – Molecular structure, Types of antigens, haptens; Antigenic determinants, Antigen processing pathways. Major

Histocompatibility Complex - MHC genes, MHC Types, MHC and immune responsiveness and disease susceptibility, HLA typing.

**Antibody functions:** Role of complement system in immunity; Classical Complement Pathway, Alternative Complement Pathway, Issues with Complement System. Immunological memories: Passive memory, Active Memory.

**Module II: 15 lecture hours**

**Antibody engineering.** Humanization, Affinity maturation, Effector function, Expression vector and Host systems, Cell culture optimization, Downstream processing: Purification, formulation and stability.

**Antibody Discovery Methodologies**: Hybridoma techniques, Phage Display, and Direct B-cell cloning technology. Hybridoma techniques and monoclonal Ab production. Myeloma cell lines, fusion of myeloma cell lines with Ab producing B cells, fusion methods, selection and screening for positive hybrids, production and purification and characterization of MAb. Production of human MAb and their applications. Production of polyclonal Ab with different type of Ag: Ag preparation and modification, adjuvants, dose and route of Ag administration, collection of sera. Antibody genes and antibody engineering- chimeric and hybrid monoclonal antibodies; Catalytic antibodies and generation of immunoglobulin gene libraries.

**Module III: 12 lecture hours**

**Analytical Characterization.** Antigen-Antibody interactions: Immunoprecipitation- mancini method, ouchterloney method, immune electrophoresis, rocket immunoelectrophoresis, crossed immunoelectrophoresis, agglutination and complement mediated immune reactions;

**Advanced techniques**. RIA, ELISA, Western blotting, ELISPOT and ELAST assay, peptide based immuno binding assay, immunohistochemistry, immunofluorescence, flow cytometry and immunoelectron microscopy; detection of molecules in living cells, in situ localization by techniques such as FISH and GISH. Surface plasmon resonance (SPR), Biosenor assays for assessing ligand–receptor interaction, CMI techniques- lymphoproliferation assay, Mixed lymphocyte reaction, Cell Cytotoxicity assays. Antibody Engineering Applications: Application of MAb in biomedical research, in clinical diagnosis and treatment.

**Text Books :**


1. Strohl, William R., and Lila M. Strohl. Therapeutic Antibody Engineering. Woodhead Publishing, 2012.
2. McCafferty, J. Antibody Engineering: A Practical Approach. IRL Press, 1996.


**Reference Books :**


1. Kindt, T. J., Goldsby, R. A., and Osborne, B. A. Kuby Immunology. New York: W.H. Freeman and Co., 2007
2. Murphy, K., Travers, P., and Walport, M. Janeway's Immunobiology. Garland Science, Taylor and Francis Group, LLC, 2008.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 30% | 30% | 40% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY442L** | Biomedical Genomics | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Genetics & Molecular Biology, rDNA Technology | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand Mendelian genetics, inheritance patterns in humans, pedigrees analysis, Hardy-Weinberg Equilibrium, epigenetics, risk and odds ratios, and chi-square tests for analysis of genetic data.

CO2 : Explain cytogenetic and molecular technologies and biochemical screening for genetic testing and understand the use of genetic resources like OMIM and the Genetic Testing Registry.

CO3 : Understand the basics of embryology, dysmorphology, techniques for prenatal defect diagnosis, risks associated with invasive procedures, approaches for diagnosing metabolic diseases, and use of genomics for cancer diagnosis and treatment.

CO4 : Understand ethical issues in biomedical genomics, the future of biomedical genomics, and its potential impact on healthcare through pre-symptomatic detection and prevention and personalized medicine.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | - | - | - | - | - | - | - | 1 | 1 | 3 | 3 | 3 | 1 |
| CO2 | 3 | 2 | - | - | 2 | - | - | - | - | 1 | 1 | 3 | 3 | 3 | 1 |
| CO3 | 3 | 2 | - | - | - | - | - | - | - | 1 | 1 | 3 | 3 | 3 | 1 |
| CO4 | 3 | 2 | - | - | - | - | - | 2 | - | 1 | 1 | 3 | 3 | 3 | 1 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 7 lecture hours**

Review of Mendelian genetics, Inheritance patterns in humans (mendelian and non-mendelian), pedigree analysis, Hardy-Weinberg Equilibrium, risk and odd ratios, Chi-square test and its use in analysis of genetic data. Epigenetics and applications.

**Module II: 15 lecture hours**

Genetic Testing Technologies: Cytogenetic testing technologies (karyotyping, FISH), Molecular testing technologies (microarray; genomic tiling arrays, Next generation sequencing- whole genome, exome; SNP Chips, Gene Panels). Biochemical screening. Genetic Resources: OMIM, Genetic Testing Registry.

**Module III: 20 lecture hours**

Basics of embryology, dysmorphology, Prenatal defect diagnosis techniques, Foetal genome sampling procedures; risks associated with invasive procedures, approaches for diagnosis of metabolic diseases, genomics for cancer diagnosis and treatment.

Ethical Issues in Biomedical Genomics (Genetic discrimination, Gene editing)**.**

Future of Biomedical genomics: rise of clinical DNA sequencing; Pre-symptomatic detection and prevention. Personalized medicine.

**Text Books :**

1. Kumar, Dhavendra. *Hardcover ISBN 9780124201965, eBook ISBN 9780127999227,* 2016.

2. Ginsburg, Geoffrey, and Huntington Willard. *Genomic and Precision Medicine, Foundations, Translation, and Implementation*, 2016.

**Reference Books :**

1. Brown, Stuart M., John G. Hay, and Ostre, H. *Essentials of Medical Genomics*. PDF. 2nd ed. Hoboken, NJ: Wiley-Blackwell, 2008.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY443L** | Stem Cells and Tissue Engineering | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Cell and Tissue Culture Technologies | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Define the stem cell sources, isolation, typical characteristics, and different types.

CO2 : Explain cancer stem cells and their role as biomarkers and treatment resistance.

CO3 : Understand the concept of tissue engineering and reprogramming.

CO4 : Demonstrate the knowledge of stem cells in regenerative medicine and tissue engineering with different applications and case studies.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 1 | 2 | - | 3 | - | - | 1 | 1 | - | - | 3 | 2 | 3 | - |
| CO2 | 2 | 1 | 2 | 1 | 3 | - | - | 1 | - | - | - | 3 | 2 | 3 | - |
| CO3 | 2 | 1 | - | 1 | 3 | 1 | - | 3 | - | 1 | - | 3 | 2 | 3 | 1 |
| CO4 | 2 | 2 | 1 | 3 | - | 2 | - | 3 | 2 | - | - | 3 | 2 | 3 | 1 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 15 lecture hours**

**Introduction:** History: Development in the field over the years, Dolly the sheap introduction , Pollices affecting the stem cell research.

**Types of stem cells:** Embryonic stem cells, Induced pluripotent stem cells, Perinatal stem cells and adult stem cells. Adult stem cells: Hematopoietic stem cells, Mesenchymal stem cells- Bone marrow derived mesenchymal stem cells and adipose derived stem cells. Advantages and disadvantages of embryonic versus adult Stem Cells.

**Stem cell sources:** including human umbillical cord, bone marrow, adipose tissue and amniotic fluid. Typical characteristics of stem cells and types. Stem cell properties: Self-renewal and potency. Functional potency. Different routes of cell administration**.**

**Cancer stem cells:** The Role of Epithelial – Mesenchymal Transition in Cancer Metastasis, and cancer stem cell biomarkers.

**Module II:** **16 lecture hours**

**Tissue engineering:** Tissue Architecture, Stable Connections between cells and the Maintenance of Tissue Structure, Morphogenesis and the dynamics of cell adhesion, Basis of growth and differentiation. Micro- and Nanotechnologies and tissue and organ fabrication. Tissue development and dynamics.

Stem cell culture methods: Basic pluripotent stem cell culture protocols, Mechanisms in Stem Cell Biology, Quality control of cell cultures. Stem cells Niches.

Reprogramming: Reprogramming of stem cells, Reprogramming of iPS Cells. Cell proliferation and Epigenetics, Epigenetic and microRNA mediated Regulation in Stem Cells. Molecular mediators of reprogramming and pluripotency. Concept of pioneer transcription factors in stem cell's differentiation/pluripotency, Scaffolds used in Tissue Engineering.

Ethical aspects of stem cell research. Ethical issues surrounding embryonic stem cells.

**Module III:** **11 lecture hours**

**Applications of Stem cells in regenerative medicine/Tissue engineering**. Regenerative medicine, Therapeutic Cloning (somatic cell nuclear transfer) and its benefit, Cells as Therapeutic Agents, Gene Therapy. Biomaterials in Tissue Engineering: Improving synthetic materials, Naturally derived materials. Host response to biomaterials. Applications of biomaterials in pediatric tissue engineering. Tissue Engineering Applications of 3-dimensional bioprinting. Types of 3D Bioprinting Technologies.

**Case Studies of Tissue Engineering.** Therapeutic applications to treat diabetes, towards cardiovascular research and neurodegenerative disease. Potential problems with using embryonic stem cells in humans.

**Regulatory controls towards Stem cell Culture.**

**Text Books :**


1. Burgess, Rob. *Stem Cells: A Short Course*. Wiley-Blackwell, 2015.
2. Jonathan, M. W. 'The Science of Stem Cells'. *The Science of Stem Cells*, 2018.


**Reference Books :**


1. Marek, J., Andrzej Łos, and Emilia Hudecki. 'Stem Cells and Biomaterials for Regenerative Medicine'. *Stem Cells and Biomaterials for Regenerative Medicine*, 2020.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 45% | 25% | 30% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY444L** | Forensic Sciences | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Develop a foundational understanding of forensic science and its scope, including the use of molecular techniques and analytical methods in forensic sciences.

CO2 : Acquire knowledge of data management in forensics, encompassing the collection, organization, and analysis of forensic data.
CO3 : Analyze case studies to comprehend the practical applications of forensic science techniques in solving criminal cases.
CO4 : Familiarize themselves with the areas where biotechnology can be applied in forensic sciences.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 3 | 3 | 2 | - | 1 | 2 | 3 | - | 3 | 3 | 2 | 1 |
| CO2 | 3 | 2 | 2 | 3 | 3 | 2 | - | 1 | 2 | 3 | - | 3 | 3 | 2 | 1 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 2 | - | 1 | 2 | 3 | - | 3 | 3 | 2 | 1 |
| CO4 | 3 | 3 | 2 | 2 | 3 | 2 | - | 2 | 3 | 3 | - | 3 | 3 | 2 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 6 lecture hours**

Introduction to forensic science and its scope. Branches of forensic science. Application and limitations of forensic science. Sample collection and preservation. Locard's Exchange Principle.

**Module II: 18 lecture hours**

Use of molecular techniques in forensic sciences: DNA fingerprinting, Restriction fragment length polymorphism (RFLP); Random amplified polymorphic DNA (RAPD); Amplified fragment length polymorphism (AFLP); Microsatellites; PCR amplifications; Single nucleotide polymorphism (SNPs); Genetic linkage mapping. Short Tandem Repeat (STR) Analysis, Mitochondrial DNA (mtDNA) Analysis. Microbiome in forensics.

**Module III: 18 lecture hours**

Analytical techniques in forensic sciences: GC and HPLC, Spectrometry and chromatography, Blood analysis: Tests for Blood, Precipitin test, blood spatter analysis. Toxicology: Toxins & Biological Poisons, Alcohol, Thallium, Barium, Nerve Agents. Case studies. Data management in forensics.

**Text Books :**


1. Dr, Rukmani. *An Introduction to Forensic Science in Criminal Investigation*, n.d.
2. Wolstenholme, Rosalind. 'The Electromagnetic Spectrum'. *Analytical Techniques in Forensic Science*. Wiley, 5 January 2021.


**Reference Books :**


1. Rudin, Norah, and Keith Inman. *An Introduction to Forensic DNA Analysis, Second Edition*. 2nd ed. Boca Raton, FL: CRC Press, 2001.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY343L** | Protein Engineering and Applications | L | T | P | C |

| | | | | | |
|---|---|---|---|---|---|
| **Owning School/Department** | SEAS/Biotechnology | 2 | 0 | 2 | 3 |
| **Pre-requisites/Exposure** | Genetics & Molecular Biology | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the concepts and strategies used in protein engineering

CO2 : Understand and the constructs

CO3 : Describe the different expression systems

CO4 : Explain the industrial applications of protein engineering

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 1 | 3 | 2 | 1 | - | - | 2 | - | 1 | 3 | 3 | 3 | 3 |
| CO2 | 3 | 3 | - | 3 | - | 1 | - | - | - | - | 3 | 3 | 3 | 3 | 3 |
| CO3 | 3 | 3 | 1 | 3 | 1 | 1 | 2 | 1 | 1 | 2 | 3 | 3 | 3 | 3 | 3 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 10 lecture hours**

**Recombinant DNA and Gene Cloning:** Cloning vectors for recombinant DNA: Plasmids as vectors; Bacteriophage. Expression vectors: Elements for expression; Fusion tags; Tag cleavage; examples of expression vectors in different expression systems; pET vectors.

**Introduction to proteins:** Introduction. Soluble proteins. Membrane proteins: Integral membrane proteins and Peripheral membrane proteins. Integral membrane proteins: Type I, Type II, and Type III. Transmembrane region: alpha helices and beta barrels. Lipid composition of membrane proteins. Transmembrane proteins as drug targets; examples and diffculties. Protein sequencing. Post translational modifications: PTMs involving addition of functional groups such as enzymatic and non enzymatic addition; Other proteins or peptides; Chemical modifications; examples of post translational modifications.

**Protein homology:** Homology; kind of homology; Sequence conservation; Pairwise alignment and sequence identity.

**Mutagenesis:** Introduction. Types: Random mutagenesis; Site-directed mutagenesis; Combinatorial mutagenesis, Insertional mutagenesis. CRISPR-Cas9: Introduction; Gene expression regulation; Advantages and limitations.

**Module II: 8 lecture hours**

**Protein design:** Rational protein design; Directed evolution; Examples. Methods for selection: Bacterial, phage or ribosome display.

**Heterologous overexpression systems:** DNA transformation into expression host; Strong promoters; Prokaryotic and eukaryotic systems for protein production; Choice of host organisms; Examples; Bioreactors; Uses of cleavable fusion proteins.

**Protein purification:** Protein Extraction by Cell Disruption: Physical disruption of cells; Enzymatic disruption of cells; Chemical cell lysis. Initial purification. Membrane protein purification: Surfactants; Detergent solubilization. Protein separation techniques; General concepts of chromatography: Affinity chromatography; Size exclusion chromatography; Ion exchange chromatography. Polyacrylamide gel electrophoresis.

**Module III: 10 lecture hours**

**Protein characterization:** Homogeneity and purity. Stability: TM. Denaturation: Urea. Aggregation. Protein Fluorescence. Western Blotting. DLS. CD. ITC and SPR.

**Protein structure and function:** Protein structure; Protein folding; Protein and peptide design and engineering; Relationship of structure and function.

**Methods of structure determination:** X-ray crystallography; NMR and CryoEM. Computational approach. Homology modeling.
**Applications across diverse industry**: Medical applications. Antibody engineering. Food and detergent industry applications, Environmental applications, Nanobiotechnology applications, Biosensors, Other applications.

**List of Experiments :**

1. Introduction to the rational designing of the protein, in-silico designing and online computation tools and online practice of protein information resources.
2. Introduction to buffer characteristics and selection criteria. Introduction to buffer pH ranges and additives for the stability of proteins.
3. Introduction to role of detergents in protein solubilization, types of detergents and their role in protein and lipid interactions and to prepare buffer containing detergent.
4. To learn about the role and need of signal sequence in natural conditions, the different tags and spacer, and the options & advantages of Fusion tags (MBP, GST, GFP).
5. Rational construct designing.
6. Introduction to different methods of crystallization and setup hanging drop crystal tray.
7. Introduction to protein concentrators.
8. Introduction to buffer exchange and dialysis.
9. Protein expression characterization: Affinity Chromatography.
10. Data analysis based on SDS PAGE: Fusion tag comparison.
11. Study pure versus impure sample and study protein sample stability.
12. Introduction to site-directed mutagenesis (SDM) strategy and Site-directed mutagenesis (SDM).
13. Case Study: Identify the catalytic residue (Based on structure analysis).
14. Case Study: Based on structure analysis: Mutational role study in disease biology.

**Text Books :**

1. Sheehan, Mallorie N. *Protein Engineering: Design, Selection, and Applications: Protein Biochemistry, Synthesis, Structure and Cellular Functions*. Nova Science Publishers, Inc, 2013.
2. Torres, Anton. *Protein Engineering and Design*. Syrawood Publishing House, 2017.

**Reference Books :**

1. Mus-Veteau, Isabelle, ed. *Heterologous Expression of Membrane Proteins*. 2nd ed. Methods in Molecular Biology (Clifton, N.J.) 1432. New York, NY: Humana Press, 2016.

## Assessment Scheme:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 45% | 25% | 30% | 100% |

| Name of Program | B.Tech. Biotechnology | | | | |
|---|---|---|---|---|---|
| EBTY445L | Bioenergy and Biofuels | L | T | P | C |

| | | | | | |
|---|---|---|---|---|---|
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand various renewable feedstocks, their availability, and attributes for biofuels production.

CO2 : Understand the broad concept of second and third generation biofuel production from biomass and various low-cost agri-residues and biowastes.

CO3 : Understand the increasing role of renewable energy engineers to address growing energy needs.

CO4 : Develop engineering skills to produce and purify different biofuels.

CO5 : Design novel processes for biofuel production.

CO6 : Design new industrial facility for biofuel production.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 2 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 3 | | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 3 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 1 | 3 | 3 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| CO6 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 14 lecture hours**

Introduction to bioenergy. Oil economy of the world. Road map of bioenergy. Basics of Biomass Technologies. Relation between photosynthesis and bioenergy. Electron Transport Process in Light Reaction. Hill Reaction. Carbon Dioxide Conversion to Carbohydrate. Photorespiration and Calvin Cycle. C3 and C4 Plant Structure and Photosynthesis Process. Biomass Production System and their Categorization. Important Parameters to Select Biomass.

**Module II: 14 lecture hours**

Different conversion technologies of Biomass to biofuel: thermochemical conversion, syngas fermentation. Classification of Pyrolysis. Bio-oil. Biomass conversion to heat and power. Introduction to Gasification. Thermochemical Process of Gasification. Feedstock Treatment of Gasification. Anaerobic Digestion. Fischer Tropsch Synthesis for Liquid Fuels. Biomass Torrefaction. Hydrothermal Technology for Biofuel. Biodiesel production from oil seeds, waste oils and algae. Environmental impacts of biofuel production.

**Module III: 14 lecture hours**

Concept of bioenergy in greenhouse gas emission reduction and commercial production. Production methods, global market, current research, and development activities in the field of various biofuels: bioethanol, biodiesel, biobutanol, biogas and biooil. Feedstock pre-treatment and hydrolysis. Algae as a feedstock for biofuel production and its market potential.

**Text Books :**

1.Brown, Robert C., and Tristan R. Brown. *Biorenewable Resources: Engineering New Products from Agriculture*. Wiley-Blackwell, 2013.

**Reference Books :**

1. Klass, Donald L. *Biomass for Renewable Energy, Fuels, and Chemicals*. San Diego, CA: Academic Press, 1998.
2. Klass, Donald L. *Biomass for Renewable Energy, Fuels, and Chemicals*. San Diego, CA: Academic Press, 1998.
3. Drapcho, Caye M., Nghiem Phu Nhuan, and Terry H. Walker. *Biofuels Engineering Process Technology, Second Edition*. 2nd ed. McGraw-Hill Education, 2020.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 45% | 20% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY446L** | Waste Management & By-Products | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Bioprocess Design & Upscaling | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand basic concepts of different waste management technologies.

CO2 : Understand the applications of biotechnology in solid & hazardous waste management and wastewater treatment.

CO3 : Apply the most recent bioprocesses engineering technologies in solid waste management.

CO4 : Apply the most recent bioprocesses engineering technologies in wastewater management.

CO5 : Apply the most recent bioprocesses engineering technologies in hazardous waste management.

CO6 : Design and create new technologies for simultaneous waste management and by-product recovery.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 2 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 1 | 3 | 3 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| CO6 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I:** **14 lecture hours**

**Solid waste management:** Types of solid waste. Agricultural solid waste. Forest residues. Industrial solid waste. Municipal solid waste. Biological treatment of solid waste. Biochemical treatment of solid waste. Composting methods. Anaerobic treatment of solid waste. Solid-state fermentation. Slurry phase bioreactor. Current challenges of solid waste management. Solid waste management and bio-based product development technologies. Case studies on biotechnology for solid waste management and by-product recovery. Landfill design for solid wastes.

**Module II:** **18 lecture hours**

**Wastewater management:** Water pollution and human health. Municipal wastewater treatment methods. Industrial wastewater treatment methods. Characterization of wastewater. Significance of BOD, COD, suspended solids and volatile solids. Reactors for wastewater treatment and reactors analysis. Primary and secondary treatment of wastewater. Activated sludge process. Modifications of activated sludge process. Trickling filter. Bio-towers. Rotating biological contactors. Stabilization ponds. Sludge disposal. Sludge thickeners. Sludge volume reduction. Sludge conditioning and digestion. Advanced wastewater treatment methods. Nitrification and Denitrification processes. Biological phosphorous removal. ANAMOX process. Effluent disinfection. Wastewater treatment and by product recovery.

**Module III:** **10 lecture hours**

**Hazardous waste management:** Sources of hazardous waste. Electronic waste. Biomedical waste. Management of Covid-19 related wastes. Radioactive Waste. Industrial hazardous waste. Fate and environmental effects of hazardous chemicals. Physico-chemical treatment of hazardous waste. Biological treatment of hazardous waste. In-situ treatment of hazardous waste. Bioremediation. Case studies on biotechnology for hazardous waste management. Landfill design for hazardous wastes.

**Text Books :**


1. Tchobanoglous, George, and Frank Kreith. *Handbook of Solid Waste Management*. 2nd ed. McGraw-Hill Education, 2002.
2. Inamuddin, Anish. *Sustainable Bioconversion of Waste to Value Added Products*. Springer, n.d.
3. Whittaker, Dave. 'Integrated Waste Management: A Sustainable Approach', 2018, 978–1632399571.


**Reference Books :**


1. Loehr, Raymond. *Agricultural Waste Management: Problems, Processes, and Approaches*. Elsevier, 2007.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

| **Name of Program** | B.Tech. Biotechnology | | | | |
|---|---|---|---|---|---|
| **EBTY344L** | Plant-microbe Interactions | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |

| **Pre-requisites/Exposure** | Agriculture Biotechnology |
|---|---|

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the symbiotic interaction of microbes and plants.

CO2 : Explain the immune responses of the plants.

CO3 : Undwerstand the molecules that play important roles during plant defense.

CO4 : Apply knowledge to genetically modify plants with enhanced immune response.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 1 | - | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 1 | 3 | 2 | 3 | 3 | 3 | 3 |
| CO3 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |
| CO5 | 3 | 2 | 1 | 1 | - | 2 | - | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 3 |
| CO6 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 1 | 2 | 1 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 14 lecture hours**

Introduction to plant Microbe Interactions: Introduction on the impact of microbial diseases on the global agricultural productivity; Interactions between plants and microbes- pathogenic interaction and their effect on productivity and symbiotic interactions and contribution to plant health. Concept of plant immunity- Pattern Triggered Immunity (PTI), mechanism of PTI and signalling molecules of PTI; Effector Triggered Immunity (ETI), mechanism and signalling molecules involved in immune response.

**Module II: 18 lecture hours**

Plant pathogens: Pathogenic organisms- bacterial, viral, fungal and nematodes, necrotrophs, biotroph; hypersensitive response (HR) and role of reactive oxygen species during HR; systemic infection; Infection mechanisms- process of infection from surface attachment and structural modifications during infection, enzymes involved, the role of toxins and other compounds, invasion of plant tissue, virulence factors, plant hormones and their role during microbial interaction; plant defense and stress responses against pathogens; host and non-host resistance.

Symbiosis: Establishment of symbiotic relations (mycorrhiza, rhizobium). Endophytes.

Impact of pathogens: major concerns in agriculture and horticulture regarding pathogenic interaction, genetic modifications of crop for improved disease resistance.

**Module III: 10 lecture hours** Defense molecules: Role of secondary metabolites during plant-microbe interaction and metabolic engineering to enhance the production of secondary metabolites for prevention of disease; plantibodies and disease resistance; defense proteins, phytoanticipins and phytoalexins.

**Text Books :**

1. Schirawski, Jan, and Michael H. Perlin. 'Plant Microbe Interaction 2017, MDPI St'. *MDPI St.Alban-Anlage* 66 (2017).

**Reference Books :**

1. Lugtenberg, Ben. *Principles of Plant-Microbe Interactions*. Springer International Publishing Switzerland, 2015.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 45% | 20% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY447L** | Nutraceuticals & Health | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Demonstrate understanding of nutraceuticals, including their sources, classifications, and functions in promoting human health, as well as knowledge of nutraceutical production through metabolic engineering and biosynthetic pathway transfer

CO2 : Comprehend the therapeutic benefits of nutraceuticals and grasp the concept of designer foods.

CO3 : Understand the regulatory and safety considerations, including quality control, standardization, and compliance with guidelines, for both nutraceuticals and designer foods.

CO4 : Apply critical thinking skills to evaluate scientific literature, clinical studies, safety assessments, and effectively communicate the principles, advancements, and potential health benefits of nutraceuticals and designer foods.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 1 | 3 | 1 | 1 | - | 2 | 3 | 1 | 3 | 3 | 3 | 1 |
| CO2 | 3 | 2 | 2 | 1 | 3 | 1 | 1 | - | 2 | 3 | 1 | 3 | 3 | 3 | 1 |
| CO3 | 3 | 2 | 2 | 1 | 3 | 1 | 2 | - | 2 | 3 | 1 | 3 | 3 | 3 | 2 |
| CO4 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | - | 2 | 3 | 2 | 3 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 10 lecture hours**

**Nutraceuticals:** Introduction to nutraceuticals, Properties, structure, classification: Traditional and non-traditional; Dietary, herbal, and supplementary; functions of nutraceuticals in human health: disease prevention, Health promotion.

**Module II: 14 lecture hours**

Functional foods as source of nutraceuticals; Anti-nutritional factors present in foods and methods to overcome; traditional foods as nutraceuticals; Nutritive and non-nutritive food components with potential health effects; Nutraceuticals in fruits, vegetables, nuts, grains, herbs and their impact on health, nutraceuticals of animal, algae and microbial origin; Nutraceuticals and cancer protection.

**Module III: 18 lecture hours**

**Nutraceuticals production** by metabolic engineering of lactic acid bacteria, transfer of plant biosynthetic pathways to microbes for nutraceuticals, Plants as bioreactors to produce nutraceuticals, concept of free radicals and antioxidants.

**Therapeutic benefits of nutraceuticals:** arthritis, sleeping disorder, digestive issues, cancer, osteoporosis, blood pressure, cholesterol, Obesity and depression. Medicinal uses and health benefits of nutraceuticals/functional foods: Spirulina, Soybean, Ginseng, Garlic, Broccoli, Gingko, Flaxseeds. Safety guidelines for nutraceuticals by fssai.
**Designer foods**: designer egg, milk, grains, probiotics, proteins. Safety guidelines for designer foods.

**Text Books :**


1. Gupta, Ramesh C., Ajay Srivastava, Anita Sinha, and Rajiv Lall. 'Biomarkers of Foods and Nutraceuticals: Applications in Efficacy, Safety, and Toxicity'. In *Nutraceuticals in Veterinary Medicine*, 693–710. Cham: Springer International Publishing, 2019.
2. Saarela, Maria, ed. *Functional Foods*. 2nd ed. Woodhead Publishing Series in Food Science, Technology and Nutrition. Cambridge, England: Woodhead Publishing, 2016.


**Reference Books :**


1. Christopher, T., and Yi Walsh. *Natural Product Biosynthesis: Chemical Logic and Enzymatic Machinery*. Royal Society of Chemistry, 2017.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 45% | 20% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY448L** | Industrial Phytochemicals | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:
CO1 : Demonstrate the understanding of phytochemicals and their types
CO2 : Understand the safety and toxicity of phytochemicals
CO3 : Understand the Industrial applications of phytochemicals
CO4 : Acquire knowledge of the industrial production of phytochemicals

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 1 | 1 | - | - | 1 | - | - | - | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| CO2 | 1 | 2 | 3 | 2 | 1 | 1 | - | - | 2 | 3 | 1 | 3 | 2 | 2 | 3 |
| CO3 | 1 | 2 | 3 | 2 | 1 | 1 | 2 | - | 2 | 3 | 3 | 3 | 3 | 3 | 2 |
| CO4 | 3 | 3 | 1 | 3 | 3 | 1 | 3 | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I:** **15 lecture hours**

Introduction to the phytochemicals, Families of phytochemicals. Introduction to food additives, Types of food additives. Preservatives, Sweeteners- Phytochemical and Pharmacological Importance of Stevia, Food colourings, flavorings, stabilisers, emulsifiers. Sources and extraction processes. Antioxidants in food industry applications. Anti-microbial essential oils - Chemical Composition and mechanism of action. Phytochemicals in cosmetics –uses and examples. Phytochemicals as biopesticides- examples and recent developments.

**Module II: 10 lecture hours**

Historical perspective of plant derived drugs. Role of phytochemicals as anti-cancer and chemo-preventive agents. Importance of Catechins and lutein as phytochemicals. Mechanism of chemoprevention by phytochemicals.

**Module III: 17 lecture hours**

Process of industrial phytochemical production. Extraction, isolation, and identification of bioactive compounds from Plant Extracts. Taxol- natural and synthetic production. Asiaticoside- as medicine, process of industrial production. Introduction to pesticidal, microbial and heavy metal contamination free extraction process. Podophyllotoxin-biosynthesis and production by fermentation. Industrial applications of phytochemicals.

**Text Books :**


1. Md Asaduzzaman, Toshiki Asao, *Phytochemicals -Source of Antioxidants and Role in Disease Prevention*, IntechOpen, 2018.
2. Megh R. Goyal, Masood Sadiq Butt, Hafiz Ansar Rasul Suleria, *Phytochemicals from Medicinal Plants Scope, Applications, and Potential Health Claims*, Apple Academic Press, 2019.


**Reference Books :**


1. James A. Duke, *Database Manual of Biologically Active Phytochemicals and Their Activities*, Taylor & Francis Group, 2020.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY345L** | Phytopharmaceuticals: Engineering & Production | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Food & Agriculture Biotechnology | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Remember the phytocompounds and different classes of phytocompounds.

CO2 : Understand the role of phytocompounds as prebiotics, anti-inflammatory, anti-virals.

CO3 : Understand the phytocompounds that are used as commercial medicines.

CO4 : Apply the knowledge to engineering metabolic pathway for production of phytocompounds.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 1 | - | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 1 | 3 | 2 | 3 | 3 | 3 | 3 |
| CO3 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |
| CO5 | 3 | 2 | 1 | 1 | - | 2 | - | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 3 |
| CO6 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 1 | 2 | 1 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 12 lecture hours**

**Introduction of phytochemicals:** Definition, history of use, primary and secondary metabolites, Secondary metabolites as phytopharmaceuticals, classification of phytopharmaceuticals: Phenolics, terpenoids & steroids, Alkaloids, phytoalexins and their role in health care.

**Module II: 15 lecture hours**

**Phytopharmaceuticals/herbal therapeutics:** Plant derived prebiotics, anti-inflammatory compounds (Aspirin, Bromelain, Harpogoside), plants derived antioxidative compounds, plant compounds with anti-cancer properties (Colchicine, podophyllotoxin, Taxol, vincristine and vinblastine; sitosterol), active compounds of Indian berries with potential of cancer prevention, anticancer phytocompounds: experimental and clinical updates, essential oils in prevention of pathogenic biofilm, Plant derived molecules for management of HIV infection and malaria (Quinine), phytochemicals as antipathogenic drugs, immunomodulators, for curing diabetes, cardiovascular diseases (Digitoxin), hay fever, mental health (Ginkgolides, Hyoscyamine), sleep disorder, liver diseases, eye disorder (Atropine) Development of standardized phytopharmaceuticals.

**Module III: 15 lecture hours**

**Engineering to produce phytopharmaceuticals:** Pathway engineering of the healthy phytochemicals for biosynthesis in edible parts of the plants, improved phytochemical production by plant cell culture, organ cultures, genetic engineering, hairy roots with biosynthetic potentials of new phytochemicals, metabolic engineering and synthetic biology to produce phytochemicals.

**List of Experiments :**

Due to pandemic the lab will not run in the electives. So, experiments have not been designed yet.

**Text Books :**

1. Sajjad, Mohd, Ahmad Khan, Iqbal Ahmad, and Debprasad Chattopadhyay. *New Look to Phytomedicine: Advancements in Herbal Products as Novel Drug Leads*. Academic Press, 2018.

2. Chandra, Suman, Hemant Lata, and Ajit Varma. *Biotechnology for Medicinal Plants: Micropropagation and Improvement*. Berlin, Heidelberg: Springer, 2013.

**Reference Books :**

Online publications will be provided to students to get an idea about the recent research on the topics.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 30% | 30% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY346L** | Introduction to Pharmaceutical Sciences | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs):**

On completion of this course, the students will be able to:

CO1 : Demonstrate the understanding of Pharmaceutical Technology.

CO2 : Design and develop solutions to pharmaceutical problems using integrated methods.

CO3 : Understand the chemistry of drugs with respect to their pharmacological activity.

CO4 : Acquire knowledge for the criteria for the selection, formulation, and evaluation of drugs and polymers for the development of novel drug-delivery systems.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 1 | 1 | - | - | 1 | - | - | - | 2 | 1 | 1 | 3 | 3 | 2 | 2 |
| CO2 | 2 | 3 | 3 | 2 | 2 | 1 | - | - | 2 | 3 | 1 | 3 | 3 | 2 | 3 |
| CO3 | 2 | 2 | 2 | 3 | 2 | 1 | - | - | 1 | 3 | 2 | 3 | 3 | 3 | 2 |
| CO4 | 2 | 3 | 1 | 3 | 2 | 1 | 1 | - | 2 | 3 | 1 | 3 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 16 lecture hours**

Introduction to Pharmaceuticals, Pharmacognosy, Sources of Drugs, Medicinal Chemistry, Drugs classification- Antibiotics, Analgesics, Antipyretics, Antiseptics, Anti-inflammatory, Radiopharmaceuticals, Chemotherapy etc., Chemical properties, Mechanism of action, Pharmaceutical excipients, Routes of administration, Posology. Pharmaceutical Technology: Dosage forms- Solid, Liquid, Semi-solid, Aerosols, Ophthalmic, Blood and Plasma Substitutes, Cosmetology. Bioassay of Drugs and Biological Standardization. Concepts of Prodrugs. Drug toxicity.

**Module II: 16 lecture hours**

Introduction to Pharmacology, Combined effect of drugs, Pharmacokinetics and Pharmacodynamics, Pharmacogenetics. Absorption, Distribution, Metabolism and Excretion of drugs (ADME), ADME drug interactions, Adverse Drug Reactions and treatment of poisoning.

Principles of Basic and Clinical pharmacokinetics- Drug passage across biological barriers, factors influencing absorption, plasma protein binding, Plasma drug concentration and volume

of distribution. Concept of clearance- Renal, Hepatic. Clearance ratio, extraction ratio. Concept of Bioequivalence and Bioavailability.

**Module III: 10 lecture hours**

Pathophysiological Pharmacology: Peripheral and Central Nervous System, Cardiovascular System, Hemopoietic System, Urinary system, Respiratory System, Gastrointestinal Tract and Endocrine System.

Nuclear pharmacy, Pharmaceutical Biotechnology, Community Pharmacy, Regulatory agencies, Indian and International Pharmacopoeia, Pharmaceutical Jurisprudence and Ethics.

**Text Books :**


1. Stevens, Craig. 'Brenner and Stevens, Pharmacology'. *Pharmacology*, n.d.
2. Al-Achi, A., M. R. Gupta, and W. C. Stagner. *Integrated Pharmaceutics: Applied Preformulation, Product Design, and Regulatory Science*. John Wiley & Sons, 2022.


**Reference Books :**


1. Müllertz, A., T. Rades, and Y. Perrie. *Analytical Techniques in the Pharmaceutical Sciences*. New York: Springer, 2016.
2. Gibson, Mark, and Walkiria S. Schlindwein. *Pharmaceutical Quality by Design: A Practical Approach*. United Kingdom, Wiley, 2018.
3. Batchelor, H. *Biopharmaceutics: From Fundamentals to Industrial Practice*. John Wiley & Sons, 2021.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 35% | 30% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY347L** | Drug Design and Discovery | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Students will be able to understand the concept of drug design.

CO2 : Students will be able to understand the drug interactions and lead identifications.

CO3 : Students will get conceptual understanding of drug action.

CO4 : Students will be familiar with structure based drug design.

CO5 : Understand the basis for ligand-based drug design by pharmacophore modelling

CO6 : Understand the drug receptor interactions and basis of drug action and apply it in corresponding case studies.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 3 | 3 | 3 | 2 |
| CO2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | - | 2 | 2 | 2 | 3 | 3 | 3 | 2 |
| CO3 | 3 | 3 | 2 | 2 | 3 | 2 | 2 | - | 2 | 2 | 2 | 3 | 3 | 3 | 2 |
| CO4 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 1 | 3 | 2 | 2 | 3 | 3 | 3 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 3 | 2 | 3 | 3 | 3 | 3 | 2 |
| CO6 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | - | 3 | 2 | 3 | 3 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 7 lecture hours**

**Introduction of drug design and developmental technologies**. Introduction, Drug discovery as a process. Target Identification and Validation: Introduction to membrane proteins and classification. Key regulators of cellular function: receptors, ion channels and transporters. Drug targets: Membrane proteins, DNA, RNA, Enzymes. Receptorology: Drug-receptor interactions, Receptor theories and drug action. Lead Identification and Modification: Biological Assays, Lead Identification and High Throughput Screening.

**Module II: 12 lecture hours**

**Basics of drug action**. Interactions: Inter- and intramolecular interactions. Weak interactions in drug molecules. Chirality and drug action. Covalent, ion-ion, ion-dipole, Hydrogen bonding, C-H hydrogen bonding, dihydrogen bonding, Van der Waals interactions and the associated energies. Topological and stereochemical consideration. Structure: 2D vs 3D Structure vs. Electronic structures and importance in reactivity. Energy concept and its importance in drug action. First, Second and Third laws of thermodynamics. Enzyme kinetics and role in drug action. Enzyme Inhibition: Drug action through enzyme inhibition. Drug likeness. Drug action after Metabolism. Concept of hard and soft drugs. Toxicity properties of drugs.

**Module III: 9 lecture hours**

**Introduction to structure based drug design.** Structure Activity Relationships in drug design: Qualitative versus quantitative approaches- advantages and disadvantages. Random screening, non-random screening, drug metabolism studies, clinical observations, rational approaches to lead discovery. Homologation, chain branching, ring-chain transformations, bioisosterism. Insights into molecular recognition phenomenon. Structure based drug design, ligand based drug design Molecular docking: Autodock and Dock softwares, with successful examples. Molecular dynamics: Dynamics of drugs, biomolecules, drug-receptor complexes. Introduction to AI based drug design.

**Text Books :**


1. Stromgaard, Kristian, Povl Krogsgaard-Larsen, and Ulf Madsen. 'A Tesxt Book of Drug Design and Discovery'. *A Tesxt Book of Drug Design and Discovery*, 2016.
2. Hongmao, Sun. *A Practical Guide to Rational Drug Design*. Cambridge, England: Woodhead Publishing, 2016.
3. Klebe, Gerhard. *Drug Design -Methodology, Concepts and Mode of Action*. Springer, 2013.


**Reference Books :**


1. Parikesit, Arli Aditya, ed. *Molecular Insight of Drug Design*. London, England: IntechOpen, 2018.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 30% | 30% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY349L** | Microbiome in Health & Disease | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Microbes & Immune System | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1: Understand the fundamental concepts and composition of the human microbiome in various sites and its development over time.

CO2: Analyze the role of the gut microbiome in health and disease, including its composition, functions along the gastrointestinal tract, and its association with various disorders.

CO3 : Evaluate the impact of the microbiome on host immunity, dysbiosis, and strategies to modify the microbiome.

CO4 : Familiarize with the methods used to study the microbiome and explore its applications in various fields.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 2 | 3 | 2 | 2 | - | 2 | 2 | 1 | 3 | 3 | 3 | 2 |
| CO2 | 3 | 3 | 2 | 3 | 3 | 2 | 2 | - | 2 | 2 | 1 | 3 | 3 | 3 | 2 |
| CO3 | 3 | 3 | 2 | 3 | 3 | 2 | 2 | - | 2 | 2 | 1 | 3 | 3 | 3 | 2 |
| CO4 | 3 | 3 | 2 | 3 | 3 | 2 | 2 | - | 2 | 2 | 2 | 3 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 4 lecture hours**

**Introduction to the human microbiome:**

The human microbiome, composition at various sites in health.

Source of the organisms in the human microbiome. development of the microbiome, life changing events, personal microbiota development.

**Module II: 8 lecture hours**

**Gut Microbiome:** Composition and function of microbiome along the GI tract such as stomach, ileum and stool.

Gut microbiome changes in various diseases including liver diseases, obesity, diabetes, and other disorders.

Effects of diet and medications on the gut microbiome. Role of the gut microbiome in inflammatory bowel diseases, irritable bowel syndrome and colitis.

The gut-brain axis-effects of the gut microbiome on behavior, mood, cognition, and role in nervous system diseases.

**Module III: 8 lecture hours**

**Microbiome in health and disease:**

Role of microbiome in health. Influence of microbiome on the host immunity.

Dysbiosis. Transmission of microbiome between generation.

Effects of antibiotics. Probiotics and prebiotics.

Strategies to modify the microbiome at various sites: Fecal transplant.

The mycome and virome in health and disease.

The interaction of the components of the microbiome including bacterial-phage interactions and bacterial-fungal interactions. Impact of such interactions on host.

**Module IV: 8 lecture hours**

**Investigations and applications of microbiome:**

How the Microbiome is Studied: DNA-based analysis of microbial communities, 16S rRNA gene amplicon sequencing and shotgun metagenomics sequencing methods. Functional analysis of the microbiome from DNA sequence functional analysis, metatranscriptome, metabolome, proteome, and glycome.

Applications of microbiome: microbial therapies, microbiome in forensics, personalized therapies and diagnostics. pharmacy, nutritional companies, probiotic production and the food chain.

**Text Books :**

1. Wilson, Michael. 'The Human Microbiota in Health and Disease: An Ecological and Community-Based Approach'. In *Garland Science*, 2018.

**Reference Books :**

1. Yong Ed. *I contain multitudes: The microbes within us and a grander view of life*. Lian Pu Wen Hua, 2023.
2. Human Microbiome in Health and Disease - Part A. United States: Elsevier Science, 2022.
3. Das, Bhabatosh, and Vijai Singh. Human Microbiome in Health and Disease-Part B. Academic Press, 2022.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY351L** | Personalized Medicine & Therapeutics | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand and define the principles and applications of personalized medicine to differentiate it from conventional medicine. Explain the molecular basis of personalized medicine, including drug metabolism, pharmacological effects, and genetic variability of drug-metabolizing enzymes. Analyse the role of OMICS technologies and biomarkers in personalized medicine. Assess the ethical, legal, and social issues related to personalized medicine.

CO2 : Apply personalized management strategies to various diseases and assess the personalized management approaches for cardiovascular, neuronal, immunological disorders, and Cystic Fibrosis. Utilize molecular diagnostic technologies to identify disease biomarkers and guide personalized treatment plans. Evaluate the heterogeneity of drug response and its implications for personalized medicine.

CO3 : Understand and analyse nucleic acid therapeutics and gene editing approaches. Describe different approaches to nucleic acid therapeutics, including antisense, aptamers, miRNA, siRNA, mRNA, and gene therapy. They will also be able to explain the fundamental chemistry

and biology of delivery methods used for nucleic acid therapeutics. Evaluate the role and limitations of gene editing approaches like CRISPR/Cas, ZFN, and TALEN in personalized medicine and analyse the status of nucleic acid therapeutics in clinical trials.

CO4 : Evaluate the role of protein therapeutics in personalized medicine and assess the therapeutic selectivity achieved through molecular recognition techniques such as bacterial display, phage display, and flow cytometry. Analyse the application of antibody therapeutics in personalized medicine, including biosimilars and case studies of specific antibodies. Evaluate the use of engineered protein scaffolds (non-antibody) in personalized medicine, such as stapled peptides, cyclic peptide toxins, and proteins based on the 10th Human Fibronectin Type III Domain. Understand the challenges and opportunities of mammalian cell-based recombinant protein therapeutics.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 1 | - | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 1 | 3 | 2 | 3 | 3 | 3 | 3 |
| CO3 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |
| CO5 | 3 | 2 | 1 | 1 | - | 2 | - | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 3 |
| CO6 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 1 | 2 | 1 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 9 lecture hours Introduction to Personalized Medicine**

Conventional Medicine vs Personalized Medicine, Molecular Basis of Personalized Medicine, Drug Metabolism and Pharmacological Effects, Enzymes relevant to Drug Metabolism, Polymorphisms of Drug Transporters and Drug Targets, Drug Response Heterogeneity and the Genetic Variability of Cytochrome P450–Metabolizing Enzymes, OMICS and Personalized Medicine, Molecular Diagnostic Technologies, Biomarkers, Ethical, Legal, and Social Issues related to Personalized Medicine.

Personalized management of miscellaneous diseases (cardiovascular, Neuronal, Immunological disorders, Cystic Fibrosis, etc.).

**Module II: 9 lecture hours**

**Nucleic Acid Therapeutics**

Nucleic acid therapeutics: Brief introduction to approaches: antisense; aptamer; miRNA and siRNAs, Circular RNAs, ribozymes; mRNA; protein interacting nucleic acids; gene therapy; fundamental chemistry/biology of delivery methods used for nucleic acid therapeutic approaches; direct delivery; viral lvectors; non-viral methods (lipid based, nanoparticle based, dendrimer based, peptide based), Molecules in clinical trials. Gene editing approaches (CRISPR/ZFN/TALEN): Methods for delivering genome-editing tools, New modifications of the CRISPR–Cas platforms, status in clinical trials.

**Module III: 10 lecture hours**

**Proteins therapeutics**

Therapeutic selectivity by molecular recognition: bacterial display; flow cytometry; phage display; ex vivo and in vivo phage display for organ specific delivery; Antibody therapeutics: Biosimilars: origin and policy; Case studies: Amjevita and Humira; Mvasi and Avastin, TNF-α antagonists, Reslizumab.

Stapled Peptides, Cyclic Peptide Toxins, Designed Ankyrin Repeat Proteins (DARPins), Proteins Based on the 10th Human Fibronectin Type III Domain: T Cell Receptor Engineering, Engineering Knottins. Other engineered protein scaffolds (non-antibody): homogenous

secondary structure and their generation – how to engineer them; mechanism; Mammalian cell based recombinant protein therapeutics; case study 1 – Kunitz domain.

**List of Experiments :**

1. Project on Aptamer based diagnostic design.
2. Project on phage display.

**Text Books :**

1. Vaughan, Tristan, Jane Osbourn, Bahija Jallal, and Raimund Mannhold. *Gerd Folkers and Helmut Buschmann, Protein Therapeutics*. Wiley-VCH, 2017.
2. Patrinos, G. P., P. B. Danielson, and W. J. Ansorge. 'Molecular Diagnostics'. In *Molecular Diagnostics*, 1–11. Elsevier, 2017.

**Reference Books :**

1. Kewal, K. 'Textbook of Personalized Medicine'. *), Humana* 9781493925520 (2015).

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 40% | 30% | 30% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY353L** | Biorefinery & Bioeconomy | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Bioprocess Design & Upscaling | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:
CO1 : Understand basic concept of bioeconomy, biorefinery and biofuels.
CO2 : Understand upcoming new markets in the field of biotechnology.
CO3 : Develop skills of advanced technologies involved in biofuel production.
CO4 : Acquire advanced knowledge about different types of bulk and high-value bio-based products, their production methods.
CO5 : Develop necessary skills to work with the most recent bioprocesses involved in platform chemical development.
CO6 : Design new biochemical engineering processes relevant to biorefinery.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 2 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 2 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 2 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 1 | 3 | 3 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 1 | 3 | 3 | 3 |
| CO6 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 14 lecture hours**

**Bio-economy and bio-based feedstock:** Basic concept of bio-economy and circular economy. Potential impact of bio-economy on food market and deforestation. Current commercial food grade feedstock in bio-economy: Sugarcane, corn and vegetable oils. Industrial wastes as potential feedstock in bio-economy: Crude glycerol, molasses, sugarcane bagasse, paper and pulp industry waste, apple pomace. Agricultural wastes as potential feedstock in bio-economy: Wheat straw, rice straw, rice husks, maize stover (stalks, leaves, husks, and cobs), corn stover. Lignocellulosic forest residues, algae and seaweeds as feedstock. Feedstock pre-treatment and hydrolysis techniques.

**Module II: 14 lecture hours**

**Bio-fuels and biorefinery:** Concept of biorefinery and sustainable development. Production methods, downstream processing and commercial potential of biofuels: bioethanol, farnesene, biodiesel, biogas, biobutanol, biohydrogen, microbial fuel cell technology, pyrolysis, biooil, syngas. Integrated biofuel and industrial chemical production under biorefinery framework. Petroleum based refinery vs. biorefinery. Algal biorefinery.

**Bulk bio-products:** Production of biopolymers: Polyhydroxyalkanoate (PHA), nanocrystalline cellulose (NCC), polylactic acid (PLA), bio-based polyamides (PA). Bio-based propylene glycol (PG). Bio-based 1,3-Propanediol (PD). Bio-based epichlorohydrin. Bio-based glycols. Bioplastics. Drop-in chemicals.

**Phyto-chemicals:** Alkaloids (coffeine, nicotine, quinine, imidazole, isoquinoline), monoterpene (picrocrocin/ safranal), sesquiterpene (solanesol), diterpene, triterpene, tetraterpenoids/carotenoids (crocin), flavonoids.

**Module III: 14 lecture hours**

**Bio-based platform chemicals:** Recent advances on production and purification of top 12 bio-based platform chemicals. Succinic acid, fumaric acid, malic acid, 2,5-furan dicarboxylic acid (FDCA), 3-hydroxypropionic acid (3-HPA), glucaric acid, glycerol, aspartic acid, itaconic acid, 3-hydroxybutyrolactone, sorbitol, xylitol/arabinitol, glutamic acid, levulinic acid. Application of metabolic engineering for enhanced production of platform chemicals.

**Text Books :**


1. Wittmann, Christoph, and James C. Liao, eds. *Industrial Biotechnology*. PDF. Advanced Biotechnology. Weinheim, Germany: Wiley-VCH Verlag, 2017.
2. Brar, S. K., S. J. Sarma, and K. Pakshirajan. 'Platform Chemical Biorefinery: Future Green Industry'. *), Elsevier,* 2016.
3. Okafor, Nduka, and Benedict C. Okeke. *Modern Industrial Microbiology and Biotechnology*. 2nd ed. London, England: CRC Press, 2021.


**Reference Books :**


1. Shuler, M. L., and F. Kargi. *Bioprocess Engineering-Basic Concepts*. Prentice Hall, 2004.
2. Doran, Pauline M. *Bioprocess Engineering Principles*. 2nd ed. Academic Press, 2012.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY348L** | Computational Genomics | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 2 | 0 | 2 | 3 |
| **Pre-requisites/Exposure** | Introduction to Bioinformatics | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand, use, and analyze the algorithms used for motif discovery, gene finding, and phylogenetic tree construction.

CO2 : Understand genomic sequence alignment methods

CO3 : Apply appropriate methods and algorithms for the analysis of diverse types of genomics information.

CO4 : Understand and perform genome assembly, variant calling, and variant annotation from the NGS dataset.

CO5 : Understand Data compression techniques used in NGS

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 3 | 3 | 3 | 2 |
| CO2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | - | 2 | 2 | 2 | 3 | 3 | 3 | 2 |
| CO3 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | - | 2 | 2 | 2 | 3 | 3 | 3 | 2 |
| CO4 | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 1 | 3 | 2 | 2 | 3 | 3 | 3 | 2 |
| CO5 | 3 | 3 | 2 | 2 | 3 | 2 | 2 | 1 | 3 | 2 | 3 | 3 | 3 | 3 | 2 |
| CO6 | 3 | 3 | 2 | 2 | 3 | 2 | 2 | - | 3 | 2 | 3 | 3 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents :**

**Module I: 7 lecture hours**

Basics of genome analysis: Gene panels (QC, troubleshooting). Representations and Basic Algorithms; Motif discovery algorithms; Gene finding methods; Special cases of sequence alignments; Probabilistic models of multiple sequence alignment; BLAST Algorithms and Programs; Molecular evolution and Phylogenetic Analysis: Distance and character-based methods.

**Module II: 8 lecture hours**

NGS file formats: Raw data files: fasta and fastq; Alignment files: SAM and BAM; Bed format; Variant call format; Format for representing density data; Algorithms and data structures for NGS.

NGS Read mapping: Read mapping problem; Aligning reads; Allowing a small number of mismatches and indels; Seed and Extension approach; Filter based approach; Paired-end alignment.

Genome Assembly: Whole-genome shotgun sequencing; Whole-genome sequencing; Mate-pair sequencing; De novo genome assembly for short reads; Spectral alignment approach; k-mer counting; Base by base extension approach; De Bruijn graph approach; Scaffolding; Gap-filling; De novo genome assembly for long reads; Assemble long reads assuming long reads have a low sequencing error rate; Use mate-pair reads and long reads to improve the assembly from short reads; Use short reads to correct errors in long reads; Long read approach; Evaluating goodness of assembly.

**Module III: 8 lecture hours**

Single nucleotide variation calling: Single locus SNV calling; Single locus somatic SNV calling; General pipeline for calling SNVs; Local realignment; Duplicate and marking; Base quality score recalibration; Rule-based filtering; Computational methods to identify small indels; Correctness of existing SNV and indel callers.

Structural variation calling: CNV calling; SV calling pipeline; Identifying candidate SVs from paired-end reads; Verifying the SVs.

RNA-seq: RNA-seq read mapping; Transcript model; Splice junction signals; Exon-first approach; Seed and extend approach; Construction of isoforms; Estimating expression level of each transcript.

**Module IV: 5 lecture hours**

Peak calling methods: Model fragment length; Modeling noise using control library; Noise in sample library; Determination of peak significance; Unannotated high copy number regions; Constructing a signal profile by Kernel methods; Sequencing depth of ChiP-seq libraries.

Data compression techniques used in NGS: Techniques to compress DNA bases; Statistical approach; BWT based approach; Reference-based approach; Assembly based approach; Quality score compression methods; Lossless compression; Lossy compression.

**List of Experiments :**

1. Motif search algorithms
2. Understanding BLAST algorithm
3. Phylogenetics tree construction
4. Understanding the fastq format: QC and alignment of reads
5. WES and WGS analysis
6. RNA-seq analysis
7. ChIP-seq analysis

**Text Books :**


1. Rocha, M., and P. G. Ferreira. *Bioinformatics Algorithms: Design and Implementation in Python*. Academic Press, 2018.
2. Sung, W. K., *Algorithms for Next-Generation Sequencing*, CRC Press, 2017.
3. Kappelmann-Fenzl, M., *Next-Generation Sequencing and Data Analysis*, Springer Nature, 2021.


**Reference Books :**


1. Lambert, C., Baker, D., & Patrinos, G. P. (Eds.), *Human Genome Informatics: Translating Genes Into Health*, Academic Press, 2018.


**Assessment Scheme :**

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 50% | 25% | 25% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY350L** | Fundamentals of Neuroscience | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Cellular and Molecular Biology | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Explain the nervous system, parts of the brain, and their functions.

CO2 : Define neurophysiology, types, and the role of neurotransmitters and different sensory systems.

CO3 : Understand cognitive activities of the brain and techniques used to measure those activities.

CO4 : Discuss information on different neurological disorders, databases, and animal models.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 1 | - | - | 2 | - | - | - | 1 | - | 3 | 3 | 1 | - |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO2 | 2 | 2 | 1 | - | - | 2 | - | - | - | 2 | - | 3 | 3 | 1 | - |
| CO3 | 2 | 2 | 2 | 2 | 3 | 3 | - | 1 | 1 | 2 | - | 3 | 3 | 3 | 1 |
| CO4 | 2 | 2 | 2 | 2 | 3 | 3 | - | 1 | 1 | 2 | - | 3 | 3 | 3 | 1 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 12 lecture hours**

Historical perspectives of neuroscience, an outline of the nervous system, organization of the brain, parts, and their functions, brain cells, blood-brain barrier, neurophysiology: membrane potential and the passive electrical properties of the neuron, action and resting potential, synaptic transmission, and neurotransmitters.

**Module II: 18 lecture hours**

Sensory systems: receptors of the somatosensory system and mechanism; vision: visual processing for attention and action; hearing: auditory processing by the central nervous system; olfaction: smell and taste: the chemical senses; and motor system: sensory-motor integration in the spinal cord. Techniques used to monitor neurological activities.

**Module III: 12 lecture hours**

The immune system of the brain. Learning, Memory, Language and Cognition, Decision-Making and Consciousness, Diseases of the Nervous System- Prion diseases, Neurodegenerative diseases, Brain Tumors, Stroke Biology, Disorders of Mood and Anxiety. Databases for neurological disorders. Therapeutics and animal models for neurological disorders.

**Text Books :**


1. Kandel, Eric R., John D. Koester, Sarah H. Mack, and Steven A. Siegelbaum. *Principles of Neural Science, Sixth Edition*. 6th ed. McGraw-Hill Education/Medical, 2021.
2. Bear, Mark F., Barry W. Connors, and Michael A. Paradiso. *Neuroscience*. 3rd ed. Philadelphia, PA: Lippincott Williams and Wilkins, 2006.


**Reference Books :**


1. Stein, J. F., and Catherine Stoodley. 'Neuroscience an Introduction'. *Neuroscience an Introduction*, 2006.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 40% | 25% | 35% | 100% |

# OPEN ELECTIVE

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY181L** | Genetics and Genes | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand and predict the ratio of a specific genotype and/or phenotype from a cross.
CO2 : Understand, perform and interpret the results of a Chi-square analysis.
CO3 : Interpret the most likely mode of inheritance based on pedigree chart.
CO4 : Understand the molecular basis of genetic diseases and repair mechanisms.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 1 | - | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 1 | 3 | 2 | 3 | 3 | 3 | 3 |
| CO3 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |
| CO5 | 3 | 2 | 1 | 1 | - | 2 | - | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 3 |
| CO6 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 1 | 2 | 1 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 15 lecture hours**

Mendel's laws of heredity. Chromosomal theory of heredity, Morgan's work, Beyond Mendelian Genetics, Genotype and Phenotype ratios, Probability-Definition, Sum and

Multiplication rules. Binomial Expansion Equation and its application in genetics, Test of hypothesis using Chi-square test.

**Module II:** **15 lecture hours**

**Gene, Mutations and Genetic Disorders:** Concept of gene, Structure of prokaryotic and Eukaryotic genes, Mutations and their classification, spontaneous, induced, lethal, Mutagens: their types and actions, Detection of Mutation: PCR, Agarose Gel Electrophoresis, RFLP, Introduction to inheritance patterns, Pedigree Analysis, Examples and case study for genetic diseases, Congenital vs Hereditary Diseases.

**Module III:** **12 lecture hours**

**Changes in Chromosome number and structure:** Chromosomes and Chromatin, Dosage compensation, Ploidy and its types, Chromosomal Aberrations- deletion, duplication, inversion, and translocation, Prenatal diagnosis of chromosomal abnormalities: Amniocentesis, Chorionic Villus sampling, Karyotyping, Examples and case study for genetic diseases.
DNA damage, Repair Mechanisms and Recombination.

**Text Books :**


1. Robert, Brooker. 'Genetics: Analysis and Principles' 9781259616020 (2017).
2. Snustad, D. Peter, and Michael J. Simmons. *Principles of Genetics, 7e Binder Ready Version with WileyPLUS Blackboard Card Set*. Nashville, TN: John Wiley & Sons, 2016.


**Reference Books :**


1. Goldberg, Michael, Janice Fischer, Leroy Hood, and Leland Hartwell. *Loose Leaf for Genetics: From Genes to Genomes*. 8th ed. McGraw-Hill Companies, 2023.


**Assessment Scheme :**

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 30% | 30% | 40% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY183L** | Biological Machines | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Explain the role of different cell organelles working as individual machines and their action in a highly coordinated fashion to maintain cellular activities.

CO2 : Understand the cellular machinery required for protein synthesis, transport of molecules across cellular membranes, protein folding, and degradation.

CO3 : Understand the electrical properties of cell membranes and the mechanism for muscle contraction.

CO4 : Understand the consequences of malfunctioning of cellular machinery leading to diseases.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 1 | - | - | - | 2 | - | - | 2 | 2 | 1 | 2 | 3 | 3 | 2 |
| CO2 | 2 | 1 | - | - | - | 2 | - | - | 2 | 2 | 1 | 2 | 3 | 3 | 2 |
| CO3 | 2 | 1 | - | - | - | 2 | - | - | 2 | 2 | 1 | 2 | 3 | 3 | 2 |
| CO4 | 2 | 1 | - | - | - | 2 | - | - | 2 | 3 | 1 | 2 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 15 lecture hours**

**Cell as a Machine:** Introduction to Prokaryotic & eukaryotic cells, Different cell components as individual machines: Plasma membrane, Cell wall, Nucleus, Nucleolus, Ribosomes, Mitochondria, Chloroplast, Vacuoles, Centrioles, Glyoxisomes, Peroxisomes Endoplasmic reticulum, Golgi apparatus and Lysosomes, Cytoskeleton: Role in transport of cells and Organelles. Proteins as major functional molecules: Introduction to amino acids and protein synthesis. Machinery for the protein Transport to their site of action.

**Module II: 15 lecture hours**

**Cellular Transport Machinery:** Cellular Transport machinery: Simple diffusion, Active and passive transport of molecules across membrane, Electrical properties of membranes and Action potential, Muscle contraction: motor proteins, myosin and actin, kinesin and dynein. The GroEL/GroEs Chaperonin machine, ATP synthase – a paradigmatic molecular machine, ATP-dependent proteases: The degradation machines.

**Module III: 12 lecture hours**

**Malfunctioning of Cellular Machinery and their effects:** Malfunctioning of protein synthesis/transport mechanisms/folding mechanisms: Cause and effects of Progeria, Diabetes, Cystic Fibrosis, Sickle Cell Anemia, Parkinson, Prion Diseases, Kuru, Alzheimer's disease, Schizophrenia.

**Text Books :**


1. Sheetz, Michael, and Hanry Yu. *Cambridge Texts in Biomedical Engineering: The Cell as a Machine*. Cambridge, England: Cambridge University Press, 2018.
2. Karp, Gerald. *Cell and Molecular Biology: Concepts and Experiments 8e Binder Ready Version + WileyPLUS Learning Space Registration Card*. 8th ed. Nashville, TN: John Wiley & Sons, 2016.


**Reference Books :**


1. Alberts, Bruce, Rebecca Heald, Alexander Johnson, David Morgan, Martin Raff, Keith Roberts, and Peter Walter. *Molecular Biology of the Cell (Seventh Edition)*. New York, NY: WW Norton, 2022.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 45% | 20% | 35% | 100% |

# MINOR COURSES

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY281M** | Principles of Genetics | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 4 | 0 | 0 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand basic principles of Mendelian inheritance and to predict the ratio of a specific genotype and/or phenotype from a cross.

CO2 : Able to perform and interpret the results of a Chi Square analysis.

CO3 : Apply the knowledge to decide the most likely mode of inheritance based on pedigree chart.

CO4 : Understand the molecular basis of genetic diseases and repair mechanisms.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 1 | 3 | 1 | 1 | - | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 1 | 3 | 2 | 3 | 3 | 3 | 3 |
| CO3 | 1 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 20 lecture hours**

**Mendelian Genetics:** Monohybrid, Dihybrid crosses. laws of heredity. Chromosomal theory of heredity, Non-Mendelian Genetics, Probability: Sum and Multiplication Rules, Application of Binomial Expansion Equation in genetics, Chi-square test and its application in analysis of genetic data.

**Module II: 18 lecture hours**

**Mutations and Genetic Disorders:** Mutations and their classification, spontaneous, induced, lethal, Mutagens: their types and actions, Detection of Mutation: PCR, Agarose Gel Electrophoresis, RFLP. Congenital vs Hereditary Diseases, Introduction to inheritance patterns, Pedigree Analysis, Examples and case study for genetic diseases.

**Module III: 18 lecture hours**

**Changes in Chromosome number and structure:** Chromosomes and Chromatin, X-chromosome Inactivation, Chromosomal Aberrations, Polyploidy, Aneuploidy, Chromosomal rearrangements - deletion, duplication, inversion, and translocation, Karyotyping. Examples and case study for genetic diseases. DNA damage, Repair Mechanisms and Recombination.

**Text Books :**


1. Robert, Brooker. *Genetics: Analysis and Principles*. Vol. 9781259616020. McGraw-Hill Education, 2017.
2. Snustad, D. Peter, and Michael J. Simmons. *Principles of Genetics*. 7th ed. Nashville, TN: John Wiley & Sons, 2015.


**Reference Books :**


1. Goldberg, Michael, Janice Fischer, Leroy Hood, and Leland Hartwell. *Loose Leaf for Genetics: From Genes to Genomes*. 8th ed. McGraw-Hill Companies, 2023.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 45% | 20% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY282M** | Basic Molecular Biology | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 4 | 0 | 0 | 4 |
| **Pre-requisites/Exposure** | Principles of Genetics | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the mechanisms of DNA replication, transcription, and translation.
CO2 : Apply the regulatory mechanisms of gene expression for solving problems.
CO3 : Remember the post-translational modifications and applications of proteins.
CO4 : Apply knowledge to make gene knockdown using RNA interference.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 1 | 3 | 1 | 1 | - | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 1 | 3 | 2 | 3 | 3 | 3 | 3 |
| CO3 | 1 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 20 lecture hours**

**DNA and its Replication:** Discovery of structure of DNA, Physicochemical properties of DNA, DNA packaging: Role of Histone proteins, Genome organization in prokaryotes and eukaryotes, structure of eukaryotic and prokaryotic gene, Central dogma of Molecular Biology, DNA Replication: Models of DNA replication, DNA replication in prokaryotes and eukaryotes.

**Module II: 20 lecture hours**

**Transcription and Post-transcriptional Processing:** Types and structure of RNA, Mechanism of transcription in prokaryotes and eukaryotes, Regulation of gene expression: Induction and repression, Concept of operon model with example of Lac Operon, Post transcriptional processing of mRNA – 5'capping, splicing, polyadenylation. Regulation of gene expression in eukaryotes.

**Module III: 16 lecture hours**

**Translation and Application of proteins:** The genetic code and amino acids, Selenocysteine and Pyrrolysine as amino acids, Wobble Hypothesis, Codon usage, Translation in Prokaryotes and Eukaryotes, Post-translational modifications and their importance. Applications of proteins. RNAi regulatory mechanisms.

**Text Books :**


1. Lodish, Harvey, Arnold Berk, Chris Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Kelsey Martin, Michael Yaffe, and Angelika Amon. *Molecular Cell Biology*. 9th ed. New York, NY: W.H. Freeman, 2021.
2. Karp, Gerald. *Cell and Molecular Biology: Concepts and Experiments 8e Binder Ready Version + WileyPLUS Learning Space Registration Card*. 8th ed. Nashville, TN: John Wiley & Sons, 2016.


**Reference Books :**


1. Krebs, Jocelyn E., Elliott S. Goldstein, and Stephen T. Kilpatrick. *Lewin's GENES XII*. 12th ed. Sudbury, MA: Jones and Bartlett, 2017.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 45% | 20% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY381M** | rDNA Technology & Genomics | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 4 | 0 | 0 | 4 |
| **Pre-requisites/Exposure** | Principles of Genetics | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the basic concepts of recombinant DNA technology and different types of cloning methods that are used for making recombinant DNA.

CO2 : Apply different enzymes for designing recombinant DNA for making transgenic organisms.

CO3 : Explain different type of PCR techniques that can be used to develop rDNA technology.

CO4 : Apply the knowledge to select different vectors and host systems to generate genetically modified organisms.

CO5 : Explain technologies available to make different DNA libraries for genome sequencing.

CO6 : Create genetically modified organisms, transgenic bacteria and yeast.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | 1 | - | 2 | - | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 1 | 1 | 2 | 3 | 3 | 3 | 3 | 2 |
| CO3 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |
| CO5 | 3 | 2 | 1 | 1 | - | 2 | - | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO6 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 1 | 2 | 1 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 22 lecture hours**

**Introduction to Cloning:** Introduction and History of rDNA technology, Enzymes used in gene cloning, Cloning and Expression Vectors, Host cells: Prokaryotic hosts, Eukaryotic hosts, Different methods for introduction of recombinant DNA into the host cells and selection methods. Analysis and expression of cloned gene in host cells: Blotting Techniques, Q-PCR.

**Module II: 18 lecture hours**

**Sequencing and Editing of Genome:** Genome Sequencing Projects, DNA Sequencing Technologies: Shotgun Method of Sequencing, Sanger Dideoxy sequencing method, Automated DNA Sequencing, Pyrosequencing; Construction and Screening of genomic and cDNA libraries, Gene Silencing (RNAi) and Genome Editing tools: TALEN, ZFN, CRISPR-Cas.

**Module III: 16 lecture hours**

**Applications of rDNA Technology and Genomics.** Applications of rDNA technology in industry, medicine and agriculture, Production of recombinant proteins and therapeutics (insulin, somatostatin, interferons, vaccines etc), GMOs: Generation, biosafety, ethics and controversy, Gene therapy, Pharmacogenomics: Concepts and Applications in Healthcare.

**Text Books :**

1. Brown, T. A.. Gene Cloning and DNA Analysis: An Introduction. United Kingdom: Wiley, 2020.
2. Brown, T. A.. Gene Cloning and DNA Analysis: An Introduction. Germany: Wiley, 2016.

**Reference Books :**

1. Primrose, Sandy B.., Twyman, Richard. Principles of gene manipulation and genomics. Hong Kong: Wiley, 2006.
2. Glick, Bernard R.., Patten, Cheryl L.. Molecular Biotechnology: Principles and Applications of Recombinant DNA. India: Wiley, 2017.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 45% | 20% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY382M** | GMOs & Industry | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 4 | 0 | 0 | 4 |
| **Pre-requisites/Exposure** | rDNA Technology & Genomics | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the concept of genetically modified organisms (GMOs)

CO2 : Explain methods for GMO production, and their use in the production of proteins in microorganisms, higher organisms, and transgenic animals and plants.

CO3 : Explain the use of GMOs in the production of primary metabolites, enzymes, small molecules, bio-degradable plastics, and plants with improved nutrition and understand regulatory policies for GMOs.

CO4 : Discuss the policy issues related to genetically modified crops.

CO5 : Analyze applications of genetic engineering technologies in research and therapy to produce antibiotics, anti-tumor agents, and biopharmaceuticals from GMOs.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 1 | 1 | - | - | 2 | 2 | - | 2 | 2 | 2 | 2 | 3 | 3 | 2 |
| CO2 | 2 | 1 | 1 | - | - | 2 | 2 | - | 2 | 2 | 2 | 2 | 3 | 3 | 2 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO3 | 2 | 1 | 1 | - | - | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 2 |
| CO4 | 2 | 1 | 1 | - | - | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | 2 |
| CO5 | 2 | 1 | 1 | - | - | 2 | 2 | 1 | 2 | 3 | 2 | 2 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 20 lecture hours**

Introduction of GMOs: Microbial GMOs, protein production by genetically modified microorganisms, mammalian GMO's, protein production in higher organisms, transgenic animals, plant GMO's, itvalue creation in transgenic plants. Different methods of GMOs production.

**Module II: 18 lecture hours**

GMOs for primary metabolites production: amino acids, vitamins, nucleotides, citric acids, acetic acid; GMOs for enzyme production, rapamycin, artemisinin, Spinosad, Xanthan Gum, trypsin; GMOs for better nutrition; GMOs for bio-degradable plastics; regulations of GMOs, Policy Issues in Genetically Modified Crops.

**Module III: 18 lecture hours**

Genetic Engineering in Research and Therapy, GMOs for antibiotics production; anti-tumor agents; GMOs for biopharmaceuticals production: vaccines, antibiotics, insulin, erythropoietin, factor VIII, tissue plasminogen activator, edible vaccines.

**Text Books :**


1. Parekh, Sarad R., ed. *The GMO handbook: genetically modified animals, microbes, and plants in biotechnology*. Springer Science & Business Media, 2004.
2. Piguet, Pascale, and Philippe Poindron. "Genetically modified organisms: concepts and methods." In *Genetically Modified Organisms and Genetic Engineering in Research and Therapy*, vol. 3, pp. 1-32. Karger Publishers, 2012.
3. Policy Issues in Genetically Modified Crops: A Global Perspective. Netherlands: Elsevier Science, 2020.


**Reference Books :**


1. https://www.who.int/health-topics/food-genetically-modified#tab=tab_1


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 40% | 25% | 35% | 100% |

# SPECIALIZATIONS

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY361L** | Biomedical Technologies in diagnostic and Therapy | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 4 | 0 | 0 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:
CO1 : Demonstrate an understanding of the principles and approaches utilized in tissue engineering for regenerative medicine applications.
CO2 : Comprehend the underlying principles of various biomedical technologies used in diagnostics, therapeutics, and biomedical research.
CO3 : Gain knowledge regarding the principles governing biomedical devices, their development process, and their applications across different healthcare domains.
CO4 : Recognize and address the challenges and considerations associated with the aforementioned fields.
CO5 : Apply acquired knowledge to real-world scenarios and practical applications.
CO6 : Employ critical thinking skills to evaluate and interpret scientific literature effectively.
CO7 : Stay updated with emerging trends and advancements in the field.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 2 | 2 | 3 | 1 | - | 1 | 2 | 2 | 1 | 3 | 3 | 2 | 1 |
| CO2 | 3 | 2 | 2 | 2 | 3 | 1 | - | 2 | 2 | 2 | 1 | 3 | 3 | 2 | 1 |
| CO3 | 3 | 1 | 2 | 3 | 3 | 1 | - | 1 | 2 | 2 | 1 | 3 | 3 | 2 | 1 |
| CO4 | 3 | 1 | 2 | 2 | 3 | 1 | - | 2 | 2 | 2 | 1 | 3 | 3 | 2 | 1 |
| CO5 | 3 | 1 | 2 | 2 | 3 | 1 | - | 2 | 2 | 3 | 1 | 3 | 3 | 2 | 1 |
| CO6 | 3 | 2 | 3 | 3 | 3 | 1 | - | 1 | 2 | 3 | 1 | 3 | 3 | 2 | 2 |
| CO7 | 3 | 1 | 2 | 1 | 3 | 1 | - | 1 | 2 | 2 | 2 | 3 | 3 | 2 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 20 lecture hours**
Introduction to stem cells and tissue engineering, current advances, applications, and limitations. Tissue engineering- Fabrication and manufacturing techniques. Scaffolds for Tissue Engineering, Electrospinning for scaffold fabrications. Current status of tissue engineered organs. Hydrogels based materials for tissue engineering, Tissue engineered skin grafts, cardiac tissue engineering, engineered bone, cartilage and ligaments. Ethical and regulatory issues and safety considerations.

**Module II: 16 lecture hours**
Introduction to Biomedical Technologies. Introduction to 3D Bioprinting process, technologies and tools. Development of printable materials- material characteristics, biomaterials and Cell sources. Non-biological- fused deposition modeling (FDM), stereolithography. Introduction to electronic implants. Lasers and their applications in medicine and biology. Introduction to radiation oncology, Applications and clinical guidelines for success. Introduction to Electrocardiography (ECG) and Electroencephalography (EEG) system.

**Module III: 20 lecture hours**
Introduction to biomedical devices and diagnostic development process. Delivery devices, pre-filled syringes, autoinjectors-wearable, pumps. micro needles- fabrication and their applications towards biomedical engineering. Skin patches and types, topical skin applications-plain dressings, Advanced biomaterials, nanocellulose, chitosan and synthetic polymers. Cardiovascular devices- artificial heart valve, Pacemaker, Vascular stent. Skeleton devices. Introduction to hearing devices. Introduction to medical devices industry. Diathermy-

shortwave, microwave and ultrasound. Active ingredients delivery- drugs, peptides and proteins, metals, natural compounds.

**Text Books :**

1. Kalaskar, Deepak M., ed. *3D printing in medicine*. Woodhead Publishing, 2022.
2. Paladini, Federica. and Pollini, Mauro. *Bio-Inspired Materials for Biomedical Applications*. Switzerland: MDPI AG, 2021.

**Reference Books :**

1. Street, Laurence J. *Introduction to Biomedical Engineering Technology: Health Technology Management*. CRC press, 2022.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY362L** | Bioimaging | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 4 | 0 | 0 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the fundamentals of bioimaging and medical imaging techniques used in biomedical research, clinical diagnostics, and other relevant fields

CO2 : Comprehend the advantages and limitations associated with different bioimaging modalities

CO3 : Gain an understanding of the procedures and safety guidelines related to imaging techniques

CO4 : Demonstrate the ability to effectively select and apply suitable bioimaging methods and protocols for acquiring image data

CO5 : Develop proficiency in conducting fundamental image pre-processing and segmentation tasks

CO6 : Understand the principles and methods used for accurate and efficient image classification through machine learning.

CO7 : Possess the requisite knowledge and skills to pursue advanced studies or embark on careers in the field of medical imaging.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 1 | 3 | 1 | 1 | - | 3 | 1 | - | 3 | 3 | 2 | 1 |
| CO2 | 3 | 2 | 2 | 1 | 3 | 1 | 1 | - | 3 | 1 | - | 3 | 3 | 2 | 1 |
| CO3 | 3 | 2 | 2 | 2 | 3 | 1 | 1 | - | 3 | 2 | - | 3 | 3 | 2 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | - | 3 | 2 | - | 3 | 3 | 2 | 2 |
| CO5 | 3 | 2 | 2 | 1 | 3 | 1 | 1 | - | 3 | 2 | - | 3 | 3 | 2 | 2 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO6 | 3 | 2 | 2 | 2 | 3 | 1 | 1 | - | 3 | 2 | - | 3 | 3 | 2 | 2 |
| CO7 | 3 | 3 | 2 | 2 | 3 | 1 | 1 | - | 3 | 2 | - | 3 | 3 | 2 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Content**

**Module I: 20 lecture hours**

Bioimaging and Medical imaging overview. Procedures and safety guidelines towards imaging techniques. Retinal imaging and Basics of image and texture analysis. Bioimgaing in Computer-aided detection and diagnosis. of diabetic retinopathy

Optical coherence tomography tissue characterization. Optical microscopy and confocal microscopy: instrumentation and image analysis, Histopathology image analysis, (semi)automatic mitotic figure detection methods on regions extracted from whole-slide pathology images, live-cell studies, automatic approaches for cell tracking.

**Module II: 18 lecture hours**

X-ray imaging and Mammogram. Ultrasound imaging. Digitized ECG image analysis.

Introduction to Tomography with historical perspective and basic principles of tomography. Computed tomography (CT) imaging, CT Reconstruction, and segmentation of blood vessels in the lungs from CT images.

Nuclear Medicine- Radiotracers, Pillcam, PET/SPECT imaging.

**Module III: 18 lecture hours**

Introduction to Magnetic Resonance Imaging (MRI), fundamental principles of MRI, and basic overview of MRI applications. Potential, limitations, and pitfalls of MRI. MRI imaging procedure and safety. Digital image processing – Methodology and Applications. Applications of nanotechnology in medical imaging.

**Text Books :**


1. Vadivambal, Rajagopal, and Digvir S. Jayas. *Bio-imaging: principles, techniques, and applications*. CRC Press, 2015.
2. Rangayyan, Rangaraj M.. Biomedical image analysis. United Kingdom: Taylor & Francis, 2005.


**Reference Books :**


1. Shukla, Ashutosh Kumar, ed. *Medical Imaging Methods: Theory and Applications*. CRC Press, 2021.
2. Wheeler, Ann, and Ricardo Henriques, eds. *Standard and super-resolution bioimaging data analysis: a primer*. John Wiley & Sons, 2017.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY461L** | Medical Innovations | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 4 | 0 | 0 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the technological trends in healthcare industry.

CO2 : Explain different techniques employed for therapeutic, monitoring and diagnostic purposes.

CO3 : Understand the applications of innovations in healthcare

CO4 :Acquire knowledge of applications of Biotechnology in healthcare.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 1 | 3 | - | - | - | - | - | - | - | 1 | 1 | 3 | 3 | 2 | 2 |
| CO2 | 2 | 2 | - | 2 | - | 1 | - | - | 1 | 3 | 1 | 3 | 3 | 2 | 3 |
| CO3 | 1 | 3 | - | 3 | 1 | - | - | 1 | - | 3 | 2 | 3 | 3 | 3 | 2 |
| CO4 | 2 | 2 | 1 | 2 | 1 | 1 | - | 2 | 3 | 3 | 1 | 3 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Content**

**Module I: 6 lecture hours**

The medical innovation process: development, implementation and validation of an idea. Protecting the idea. Regulatory frameworks. Commercialization.

**Module II: 10 lecture hours**

Innovations in preventive healthcare: Vaccines. Disease screening techniques: precision medicine (genome-based screening): case studies in diseases. Prenatal screening. Digital resources for disease prevention.

**Module III: 20 lecture hours**

Innovations in biochemical diagnostics. High throughput blood screening: AI based pathological tests, DNA and protein-based diagnostics Microbiome as diagnostic markers.
Digital resources: Project ECHO, Live 3D Brain Function Mapping, AI in brain injury diagnosis, AI in cancer diagnosis as case studies.

**Module IV: 20 lecture hours**

Innovations in therapeutics: T Cell Receptor Engineering. Microbial cancer therapies. Stem cell therapy, Implantable defibrillators, nanobots in vascular surgery and neural regenaration. Microbiome as therapy.

**Text Books :**

1. Mannhold, Raimund, Gerd Folkers, and Helmut Buschmann. *Protein Therapeutics*. John Wiley & Sons, 2017.
2. Wilson, Mike. *The Human Microbiota in Health and Disease: An Ecological and Community-based Approach*. Garland Science, 2018.
3. Dong, Haidong. and Markovic, Svetomir N. *The Basics of Cancer Immunotherapy*, Springer International Publishing, 2018.

**Reference Books :**

1. Brown, Stuart M., John G. Hay, and Harry Ostrer. *Essentials of medical genomics*. John Wiley & Sons, 2008.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 35% | 30% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY363L** | Drug Discovery and Molecular Process | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand and analyse the therapeutic molecules for their Stability, Structure Confirmation

CO2 : Understand the Principle and characteristics of drug receptor interactions

CO3 : Understand the concepts of the pharmacodynamics and pharmacokinetics ( ADME ).

CO4 : Apply the practical knowledge to identify novel drug targets associated with the specific disease.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 1 | 3 | - | - | - | 1 | - | 2 | - | 1 | 1 | 3 | 3 | 3 | 3 |
| CO2 | 2 | 3 | - | 2 | - | 1 | - | - | 1 | 3 | 1 | 3 | 3 | 3 | 3 |
| CO3 | 3 | 3 | - | 3 | 1 | - | 1 | 1 | - | 3 | 3 | 3 | 3 | 3 | 3 |
| CO4 | 3 | 3 | 1 | 3 | 3 | 3 | - | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 15 lecture hours**

**Fundamentals of Drug Discovery:** History of Drug Discovery: Past, Present and Future, Serendipity: Acetanilide vs Naphthalene**,** Case study of Aspirin, Dyes and Pharmaceuticals, Rearrangements leading to the medicines. Controversial Drugs: LSD, Anaesthetics and sedatives. Concept of receptors as a drug target, GPCR- Classification, structure, drug receptor interaction, G-protein, receptor characterization, receptor theories, agonist, antagonist. Ion channels and their classification.

Drug-receptor interactions: Principle and characteristics of drug receptor interactions, Lead Identification and Modification: Biological Assays, Lead Identification and High Throughput Screening.

**Module II: 15 lecture hours**

**Disease Biology and Drug Targets:** Introduction to major classes for drugs, Diversity of Molecular Drug Targets, Introduction to human diseases and disorders. Approaches to drug development. Classes of anti-cancer compounds. Disorders of the central nervous system (CNS) and development of novel compounds. Case studies on the development of a class of compounds.

**Module III: 12 lecture hours**

**Pharmacokinetics:** Principles of pharmacokinetics, Relationship - dynamics and kinetics. Approaches towards pharmacokinetics, Absorption, Distribution, Metabolism, and Excretion (ADME), Drug transportation, Factors affecting absorption, Bioavailability. Biotransformation: Metabolism of drugs, Factors affecting biotransformation. Kinetics of elimination. ADME assays. Drug likeness. CNS Penetration. Therapeutic optimization, Metabolic stability, Structure-guided lead optimization. Common drug side effects- types and regulations, Toxicology studies. Drug metabolite analysis. Introduction to regulatory component.

**List of Experiments :**

1. Proteomics: Introduction to databases, software, tools, websites to retrieve information regarding therapeutic protein target
2. Retrieval and analysis of protein sequences from protein database
3. Structural analysis of protein motifs
4. Case Study: Ion channel structure analysis
5. Case Study: To understand the antitumour activity of compound towards cancer
6. Case Study: Pharmacokinetic analysis, an approach to understanding the mechanism of action of drug
7. In Silico Analysis of Phytochemicals as Potential Anti-cancer Agents
8. Cytotoxicity and Cell viability Assay
9. Investigating the anti-proliferative effects of drug

**Text Books :**


1. Stromgaard, Kristian, Povl Krogsgaard-Larsen, and Ulf Madsen, eds. *Textbook of Drug Design and Discovery*. 5th ed. London, England: CRC Press, 2022.
2. Hongmao, Sun. 'Structures, Limitations, and Pitfalls'. In *A Practical Guide to Rational Drug Design*, 3–14. Elsevier, 2016.
3. Klebe, Gerhard, ed. 'Drug Design'. Berlin, Heidelberg: Springer Berlin Heidelberg, 2013.


**Reference Books :**


1. Parikesit, Arli Aditya, ed. *Molecular Insight of Drug Design*. London, England: IntechOpen, 2018.


**Assessment Scheme :**

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY364L** | Rational Drug Design and Structure Determination | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the structure determination of biomolecules via the X-ray crystallography

CO2 : Build the 3D model of biomolecules

CO3 : Apply QSAR, pharmacophore mapping and molecular docking for drug discovery

CO4 : Apply 3D structure modeling and MD simulation for drug discovery

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 1 | 2 | - | - | - | - | - | 1 | 3 | 3 | 2 | 2 |
| CO2 | 3 | 1 | - | 2 | 2 | - | - | - | 1 | 1 | 1 | 3 | 3 | 2 | 2 |
| CO3 | 3 | 1 | - | 2 | 3 | - | - | - | 1 | 1 | 1 | 3 | 3 | 2 | 2 |
| CO4 | 3 | 1 | 1 | 2 | 3 | 1 | - | - | 2 | 1 | 3 | 3 | 3 | 2 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 21 lecture hours**

**Structure Determination**

Introduction to different protein expression systems and protein purification methods.

X-ray crystallography: Overview of X-ray crystallography; Crystallisation: different methods of protein crystallization; X-ray data collection: indexing, strategy, processing; Structure factor; Introduction to phase problem; Introduction to fitting, refinement and validation; Molecular replacement method.

NMR Spectroscopy: Chemical Shift; Spin-Spin Coupling; Time Domain NMR Signal; Frequency Convention; Carbon-13 NMR; Decoupling; Population Inversion; Practical Considerations of sample preparations; Solid-state NMR.

Cryo-Electron Microscopy: Basic anatomy of the electron microscope; Introduction to Fourier Transforms and Reciprocal Space; Image Formation; Challenges in Biological EM; Single Particle Analysis; Tomography.

**Module II: 21 lecture hours**

**Rational Drug Design**

Structure modeling of proteins and nucleic acids: Modeling of 3D structure of proteins; modeling 3D structures of DNA/RNA; validation of models. AlphaFold: AI in 3D structure prediction. Analysis of protein and nucleic acid structures.

Stages of drug discovery and development; rational approaches to lead discovery; random screening, non-random screening, serendipitous drug discovery, lead discovery based on drug metabolism, lead discovery based on clinical observations. Drug databases and extracting structures. Covalent drugs and fragment-based drug discovery.

Quantitative Structure-Activity Relationship (QSAR): Classes of physicochemical descriptors, experimental and computational approaches for physicochemical descriptor prediction; Hammet's substituent constant and Taft's steric parameter; Hansch analysis; Free Wilson analysis.

Virtual Screening techniques: Drug likeness screening; pharmacophore-based Screening; ADMET-based screening.

Molecular docking: Rigid docking; flexible docking; covalent docking; binding site similarity and off-target prediction.
Molecular Simulation: Normal Mode Analysis; Force fields; Molecular Dynamics; MM-PBSA/GBSA methods; Free Energy Calculations.

**List of Experiments**

1. Protein expression and purification
2. Crystal tray setup via Hanging drop and Sitting drop methods
3. Data collection methodology and analysis
4. Development of 3D structure model from X-ray diffraction data
5. Analysis of NMR spectra of proteins
6. Building and evaluation of QSAR model
7. Building and refinement of 3D structure using homology modeling
8. Molecular docking of drug to target
9. Force fields and parameterization
10. Setting up the MD simulation of protein-drug complex
11. Analysis of MD simulation data.

**Textbooks:**


1. Roy, K., Kar, S., & Das, R. N., *Understanding the basics of QSAR for applications in pharmaceutical sciences and risk assessment*. Academic press, 2015.
2. Andrew, R. L., *Molecular modeling principles and applications*, Prentice Hall, London, 2001.
3. Rhodes, G., *Crystallography made crystal clear: a guide for users of macromolecular models*, Elsevier, 2010.


**Reference Books:**


1. *X-ray Crystallography*, (2021, May 1). https://chem.libretexts.org/@go/page/316
2. Raja, P. M. V., & Barron, A. R. (2021, March 21), *NMR Spectroscopy*. Rice University. https://chem.libretexts.org/@go/page/55887
3. *Proteins*. (2020, August 13), College of Saint Benedict/Saint John's University. https://chem.libretexts.org/@go/page/189779
4. *Molecular Dynamics Simulations*, (2021, April 8). University of Utah. https://chem.libretexts.org/@go/page/17634.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY463L** | Biotherapeutics | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the modern therapeutic approaches

CO2 : Understand the basic concepts of biologics and vaccine development

CO3 : Apply computational method for biotherapeutic design and optimization

CO4 : Use PK/PD modeling for optimizing the pharmacokinetic profile of biotherapeutics

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 1 | - | - | - | - | - | - | - | - | 3 | 2 | 2 |
| CO2 | 2 | 1 | - | 1 | 1 | - | - | - | - | 1 | 1 | 1 | 3 | 2 | 2 |
| CO3 | 2 | 3 | 3 | 3 | 3 | - | - | 2 | 1 | 3 | 2 | 3 | 3 | 3 | 3 |
| CO4 | 3 | 1 | 3 | 3 | 3 | - | - | - | 1 | 3 | 3 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 15 lecture hours**

Introduction to biotherapeutic approaches. Biologics, biosimilar and biobetters. Biologics: Basic characteristics –Temperature, pressure and solvant sensitivity, storage stability, aggregation behavior, degradation pattern. Stabilization of protein, carbohydrate, lipids and nucleic acids. Approaches for design and optimization of biotherapeutics: Predicting Potential Physicochemical Degradation Sites, Computational tools to understand the aggregation mechanism, Computational methods for Protein therapeutic optimization. Role of excipients and additives on stabilizing biologicals. Examples of biosimilars and biobetters in biotherapeutics. Characterization via immunological techniques.

**Module II: 15 lecture hours**

Introduction to Vaccines. Active and passive immunization; live, killed, attenuated, subunit vaccines; vaccine technology- role and properties of adjuvants, recombinant DNA and protein-based vaccines. Case studies in vaccinology e.g. COVID19, Polio, Small pox and DPT. Computational assessments of adverse immunogenicity prediction. Pharmacokinetic–pharmacodynamic modeling for biotherapeutics, Estimating high-concentration-solution behavior, challenges in high concentration biopharmaceutical drug delivery.

**Module III: 12 lecture hours**

**Introduction to noval biologics. Examples of Noval biologics.** Discovery, development and delivery strategies for engineered live biotherapeutic products. Clinical implementation of live biotherapeutic products (LBP). Research tools for LBP risk documentation, Safety considerations in clinical trials with LBPs. Strategies leading to stable biotherapeutics, post-translational modifications in biotherapeutics, T-Cell and B-Cell epitope prediction. Best practices in assessment of developability of biotherapeutic candidates. Guidance, Compliance & Regulatory Information.

**List of Experiments :**

1. Identification and optimization of protein expression conditions
2. Protein expression confirmation and protein stability Assay
3. Large scale therapeutic protein production
4. Drug screening
5. Cytotoxicity assay
6. Aggregation prediction using sequence and structure
7. MD simulation for understanding aggregation
8. PK/PD modeling
9. In-silico mutational scanning for therapeutic optimization

10. Case studies of post-translational modifications in biotherapeutics.

**Text Books :**

1. Singh, M., and M. Salnikova. *Novel Approaches and Strategies for Biologics, Vaccines and Cancer Therapies*. Academic Press, 2014.
2. Kumar, Sandeep, and Satish Kumar Singh, eds. *Developability of biotherapeutics: computational approaches*. CRC Press, 2015.

**Reference Books :**

1. Grewal, Iqbal S. *Emerging Protein Biotherapeutics*. Edited by Iqbal S. Grewal. London, England: CRC Press, 2009.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY365L** | Human Genetics | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | Genetics & Molecular Biology | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Define the basic concept of human genetics, types of inheritance, and model of inheritance.

CO2 : Explain the concept of chromosomal abnormalities and cytogenetic aspects of cell division.

CO3 : Demonstrate the techniques to study chromosome and their applications.

CO4 : Describe complex and rare genetic disorders case studies.

CO5 : Explain the different animal models of genetic diseases.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 1 | 1 | 1 | 1 | 1 | - | - | - | - | - | 3 | 3 | 1 | - |
| CO2 | 2 | 1 | 1 | 1 | 3 | 1 | - | - | - | - | - | 3 | 3 | 1 | - |
| CO3 | 3 | 2 | 3 | 2 | 3 | 3 | - | - | - | - | - | 3 | 3 | 2 | 2 |
| CO4 | 3 | 2 | 2 | 2 | 1 | 3 | - | - | - | 2 | - | 3 | 3 | 2 | - |
| CO5 | 3 | 2 | 2 | 2 | 1 | 2 | - | - | - | 2 | - | 3 | 3 | 2 | - |

1=weakly related 2= moderately related 3=strongly relat

**Course Contents:**

**Module I: 20 lecture hours**

Introduction to human genetics: history of human genetics. Human Genome Sequence and Variation. From Genes to Genomics to Proteomics understanding information flow. Human genetic inheritance: Models of inheritance. Linkage: Concepts, recombination, gene mapping, fine structure mapping.

Sex-linked inheritance: Conceptual basis, sex influenced traits, mechanism of sex determination.

Quantitative inheritance – Concept, Genes and Environment - heritability, penetrance and expressivity. Epistasis.
Cytoplasmic inheritance – Basis and mechanism, role of organellar genes.

**Module II: 10 lecture hours**

History and Development of Human Cytogenetics. Chromosomal disorders: types, detection and case studies. Cytogenetic aspects of cell division: Chromosome labelling and cell cycle analysis, regulation of mitosis and meiosis, sister chromatid cohesion remodelling, regulation of exit from metaphase, chromosome movement at anaphase. Genetic control of meiosis.
Techniques in the study of chromosomes and their applications.

**Module III: 12 lecture hours**

Genetics of complex and single gene disorders, Neglected, rare and orphan diseases with case studies. Diagnosis and Molecular basis of metabolic disorders, Mitochondrial and rare disorders. Signal transduction and human diseases, Case studies.

Animal models of human diseases.

**List of Experiments :**

1. Introduction to principle and utility of microscopy
2. Study of Cytogenetic aspects of cell division- I
3. Study of Cytogenetic aspects of cell division- II
4. Karyotyping
5. RFLP analysis
6. VNTR typing using PCR
7. Introduction to Diagnosis via RT PCR I
8. Introduction to Diagnosis via RT PCR II
9. SNP analysis.

**Text Books :**

1. Krebs, Jocelyn E, Benjamin Lewin, Stephen T Kilpatrick, and Elliott S Goldstein. *Lewin's Genes XI*. 2014.
2. Strachan, Tom, and Andrew Read. *Garland Science*, n.d.2018

**Reference Books :**

1. Lodish, Harvey, Arnold Berk, Chris Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Kelsey Martin, Michael Yaffe, and Angelika Amon. *Molecular Cell Biology*. 9th ed. New York, NY: W.H. Freeman, 2021.
2. Pasternak, Jack J. *An Introduction to Human Molecular Genetics*. 2nd ed. New York, NY: Wiley-Liss, 2008.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Demonstrate a comprehensive understanding of the principle and concept of genetic counselling, including the role of genetic counsellors in healthcare

CO2 : Understand the significance of genetic counseling and its role in providing support and guidance to individuals and families dealing with genetic conditions and hereditary diseases.

CO3 : Familiarize with various methods and approaches employed in genetic counseling, including the use of genetic testing and family history assessment to assess and communicate genetic risks.

CO4 : Understand the ethical, legal, and social implication associated with genetic counselling

CO5 : Analyze real-world case studies and ethical dilemmas in genetic counseling, honing critical thinking skills and developing strategies for approaching complex genetic situations.

CO6 : Recognize the potential career prospects in genetic counseling and develop an informed understanding of the responsibilities and ethical considerations involved in this field.

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY368L** | Genetic Counselling | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 4 | 0 | 0 | 4 |
| **Pre-requisites/Exposure** | Human Genetics | | | | |

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 1 | 2 | 2 | - | 2 | 3 | 3 | - | 3 | 3 | 2 | 1 |
| CO2 | 3 | 2 | 1 | 1 | 2 | 2 | - | 2 | 3 | 3 | - | 3 | 3 | 2 | 1 |
| CO3 | 3 | 2 | 1 | 1 | 3 | 2 | - | 2 | 3 | 3 | - | 3 | 3 | 3 | 1 |
| CO4 | 3 | 2 | 1 | 1 | 2 | 2 | - | 3 | 3 | 3 | - | 3 | 3 | 1 | 1 |
| CO5 | 3 | 3 | 1 | 3 | 3 | 2 | - | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 1 |
| CO6 | 3 | 1 | 1 | 1 | 2 | 1 | - | 2 | 3 | 3 | - | 3 | 3 | 2 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 18 lecture hours**

1. Causes and factors for seeking counseling,
2. Risks evaluation,
3. Risks associated with invasive procedures,
4. Foetal sampling procedure and related counseling
5. Analysing ultrasounds results,
6. Counselling recurrent pregnancy loss.
7. Actively Engaging with Patients in Decision-Making,
8. A Genetic Counselor's Guide towards mental health.

**Module II: 18 lecture hours**

1. Therapeutic benefits of dietary management and various counseling approaches;
2. Peri-conceptional counseling; pre-marital counseling.
2. Ethical and legal issues in genetic counseling.
3. Standardized test panels used in IVF clinics including tests for orphan and rare diseases through SNP analysis.
4. Supporting Family Communication About Genetic Conditions.

**Module III: 20 lecture hours**

1. Cultural Competency: Application to Genetic Counselling,
2. Genetic counseling strategies for working with families,
3. The Impacts of Genetic Literacy and Adult Learning.

4. Development of the Genetic Counselling Profession: A Professionalization Process.
5. Pre- and Post-Test Cancer Genetic Counselling.
6. Case studies.
7. Mock sessions with genetic counselors.
8. Visit to counseling centers.

**Text Books :**

1. Callanan, Nancy P., ed. *Genetic Counseling Practice: Advanced Concepts and Skills*. Wiley- Blackwell, 2020.
2. Peter, S. 'Practical Genetic Counselling'. *Practical Genetic Counselling*, 2004.

**Reference Books :**

1. Kewal, K. 'Textbook of Personalized Medicine'. *), Humana* 9781493925520 (2015).

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY465L** | Genomics and Personalized Medicine | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | Human Genetics | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to

CO1 : Understand the fundamental principles of genomics and its relevance in personalized medicine, including the roles of Pharmacogenetics, Pharmacogenomics, Pharmacoproteomics, Nutrigenomics, Metabolomics, and Microbiome fingerprinting in individualized healthcare.

CO2 : Comprehend the significance of biomarkers in personalized medicine and how genomic risk profiling is utilized to tailor treatments for individual patients.

CO3 : Demonstrate proficiency in using *in silico* tools for genomic analysis, interpretation, and exploring human genome structure and variations through the Genome Browser.

CO4 : Analyze case studies illustrating personalized medicine applications in various diseases, fostering critical thinking and problem-solving abilities in the field of genomics and precision medicine.

CO5 : Comprehend the ethical, social, and economic challenges associated in integrating the genomics into clinical practice

CO6 : Gain practical skills in using genome browsers, analyzing variation databases, performing variant calling, and conducting in silico genome analysis for personalized medicine applications.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 1 | 3 | 1 | - | 3 | 2 | 3 | - | 3 | 3 | 2 | 1 |
| CO2 | 3 | 2 | 2 | 1 | 3 | 1 | - | 3 | 2 | 3 | - | 3 | 3 | 2 | 1 |
| CO3 | 3 | 2 | 3 | 2 | 3 | 1 | - | 3 | 2 | 3 | - | 3 | 3 | 3 | 1 |
| CO4 | 3 | 3 | 2 | 3 | 3 | 2 | - | 3 | 3 | 3 | - | 3 | 3 | 3 | 2 |
| CO5 | 3 | 2 | 1 | 2 | 3 | 2 | - | 3 | 3 | 3 | - | 3 | 3 | 1 | 1 |
| CO6 | 3 | 3 | 3 | 3 | 3 | 2 | - | 3 | 3 | 3 | 1 | 3 | 3 | 2 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 12 lecture hours**

The human genome, types of variations found in human genome, DNA sequencing technologies for the detection of Human Genome Variations and Polymorphisms, The Personal Genome Project, in silico tools for analysis and visualization of variations in genome, genome-wide association studies, databases of human genome variations, in vitro tools for analysis of genetic variations, Monogenic and complex genetic diseases, effect of environment on genome.

**Module II: 18 lecture hours**

Molecular Basis of Personalized Medicine, polymorphisms of Drug Transporters, Drug Targets, Drug metabolizing enzymes, role of biomarkers in personalized medicine, genomic risk profiling, gene editing tools (CRISPR-Cas9, etc.), case studies on gene therapy, personalized management of neurological, cardiovascular, and miscellaneous disorders, genomics for Cancer diagnostics and treatment (microarray based gene expression in cancer cells for personalized treatment), Ethical, Legal, and Social issues related to implementation of Personalized Medicine.

**Module III: 12 lecture hours**

Omics technologies in personalized medicine: Pharmacogenetics, Pharmacogenomics, Proteomics, Nutrigenomics, Metabolomics, Microbiome fingerprinting, Application of genomic studies for a healthy person.

**List of Experiments :**

1. Understanding human genome (Genome Browser).
2. Understanding human genome variation databases such as ClinVar, dbSNP, dbVar.
3. Introduction to softwares for variant calling.
4. In silico genome sequence analysis to identify structural variations.
5. Visit to human genome DNA sequencing/data analysis facilities
6. Case studies to illustrate application of personalized medicine for diseases such as cystic fibrosis, Marfan syndrome, neuropsychiatric diseases, and diabetes.
7. Case studies to illustrate application of genome analysis for diagnosis and treatment of cancer.

**Text Books :**

1. Ginsburg, Geoffrey, and Huntington Willard. *Genomic and Precision Medicine, Foundations, Translation, and Implementation*, 2016.

2. Lambert, Christophe G., J. Darrol, and George P. Baker. *Human Genome Informatics- Translating Genes Into Health*, 2018.

**Reference Books :**

1. Kewal, K. 'Textbook of Personalized Medicine'. *), Humana* 9781493925520 (2015).

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY367L** | Enzyme Technology | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand enzyme theories and enzyme kinetics.
CO2 : Understand various methods to produce and purify industrially important enzymes.
CO3 : Understand various industrial applications of enzymes
CO4 : Apply various methods to produce and purify industrially important enzymes.
CO5 : Apply different methods for immobilization of enzymes.
CO6 : Design and create commercially relevant enzymatic processes and products.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 3 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 3 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 2 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 1 | 3 | 3 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| CO6 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 12 lectures hours**

Introduction to enzymes. Enzyme classification & nomenclature. Mechanisms of enzyme catalysed reactions. Introduction to bioenergetics and kinetics, kinetics of single and multi-substrate bioreactions. Estimation of Michaelis - Menten's parameters: Km, Vmax, L.B Plot, Turnover number, Kcat. Enzyme inhibitions - kinetics of competitive, non-competitive & uncompetitive inhibitions; nucleophilic & electrophilic attack; role of metal ions in enzymetic reactions. Factors affecting the enzyme activity. Functions of coenzymes. Quantum tunneling in enzyme-catalysed reaction.

**Module II: 10 lectures hours**

Production, extraction, purification, and preservation of enzyme by various methods. Enzyme production by submerged and solid-state fermentation. Introduction to large scale production

of enzymes and process optimization. Batch, Fed-batch, and continuous processes for enzyme production.

**Module III:** **10 lectures hours**

Immobilized enzymes. Methods of enzyme immobilization- adsorption, matrix entrapment, encapsulation, cross-linking, covalent binding. Immobilized enzyme in industrial processes. Reactor engineering for immobilized enzymes. Enzyme electrodes and their application as biosensors.

**Module IV:** **10 lectures hours**

Industrial applications of enzymes: food industries, bio-detergents, biofuel industries, waste management, pharmaceuticals industries. Enzymes in R&D. Therapeutic enzymes. Enzymes in biotransformation. Improvement of enzymes for industrial applications, site directed mutagenesis, directed evolution of enzymes.

**List of Experiments :**

1. Production and purification of extra cellular enzymes.
2. Production and purification of intra cellular enzymes.
3. Production and purification of membrane bound enzymes.
4. Extraction of crude enzyme from plants.
5. Assay of enzyme activity.
6. Effect of substrate concentration on enzyme kinetics and determination of Km and Vmax.
7. Effect of pH and temperature on enzyme kinetics.
8. Immobilization of enzyme by matrix entrapment.
9. Immobilization of enzyme by encapsulation.
10. Immobilization of enzyme by cross-linking and covalent binding.
11. Enzyme production by submerged fermentation.
12. Enzyme production by solid state fermentation.
13. Application of enzyme in food and detergent industries.

**Text Books :**

1. Palmer, Trevor, and Philip L. Bonner. *Enzymes: biochemistry, biotechnology, clinical chemistry*. Elsevier, 2007.
2. Price, Nicholas C., and Lewis Stevens. "Fundamentals of enzymology." (1989).

**Reference Books :**

1. Wiseman, *Enzyme Biotechnology*, Ellis Horwood Pub.
2. James. E. Bailey and David F. Ollis, *Biochemical Engineering Fundamentals*, McGraw Hill.
3. Faber K , *Biotransformations in Organic Chemistry* (4th ed.), Springer.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 45% | 20% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY370L** | Green chemicals & Sustainable products | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the basic concept of green and sustainable products.

CO2 : Understand different types of technologies, the application of sustainable products, and their global market standards.

CO3 : Understand the status and challenges of setting-up green product industries and their commercialization.

CO4 : Apply biotechnological skills to produce green platform chemicals.

CO5 : Apply biotechnological skills to produce green bioplastics and biopolymers.

CO6 : Design and create new methods for production of green and sustainable chemicals

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 3 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 1 | 2 | 3 | 3 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 1 | 2 | 3 | 3 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| CO6 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 14 lectures hours**

Concept of sustainability and SDGs. Concept of Green chemicals, types of green chemicals and their use. Carbon credit & carbon tax. Lifecycle analysis (LCA) & cost-benefit analysis. Smart drop-in chemicals. Fossil-based chemicals vs. biobased chemicals. Techno-economic status of green chemicals. Green product market size and demand. Impact of green chemicals on food market. Green solvents: supercritical fluids, ionic liquids, PEG, fluorinated hydrocarbons. Green paints, renewable adhesives, sustainable glue, green pigments. Sustainable products: biodegradable cutlery, reusable paper towel alternatives, waterless laundry detergent.

**Module II: 14 lectures hours**

Biobased bulk chemicals. Bio-platform chemicals. Specialty chemicals. Biobased fragrance and aroma compounds. Biobased active pharmaceutical ingredients (APIs) and high-value products. Antibiotics. Biobased steroids & derivatives. Bioplastics and polymers. Biodegradable vs. non-biodegradable bioplastics. Natural vs. synthetic biopolymers. Green catalysts, nanotechnology for green products.

**Module III: 14 lectures hours**

Case studies of industrial production of green chemicals. Current status of green chemicals research. Bioresources as feedstock for green products. Challenges of green product industry in terms of translational aspects such as, power cost, feedstock issues, challenges in identifying the appropriate enzymes for biofuel production. Commercialization potential and challenges of using sustainable products. Environmental, social, and economic benefits in the life cycle of sustainable products.

## List of Experiments :

1. Green chemical production from carbohydrates.
2. Green fuel production from potato starch.
3. Bio-based production of biopolymer precursor Polyhydroxy alkenoate.
4. Bio-surfactant preparation using cellulose and glycerol
5. Green pigment purification from plant biomass
6. Bio-based steroid formation from corn oil phytosterols

7. Speciality green chemical production from renewable oil

**Text Books :**

1. Sanker P Dey & Nayim Sepay, *A Text Book Of Green Chemistry* (1st ed.), Techno World Publication, 2021.
2. Juan Gabriel Segovia-Hernandez, Eduardo Sanchez-Ramirez, Cesar Ramirez-Marquez, Gabriel Contreras-Zarazúa, *Improvements in Bio-Based Building Blocks Production Through Process Intensification and Sustainability Concepts*, Elsevier, 2021.

**Reference Books :**

1. Kavita Shakya, Chahal. 'Green Chemistry for the Development of Eco-Friendly Products'. *IGI Global*, 2022.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 45% | 20% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY467L** | Biofuels and Biorefinery | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the concept of biorefinery and biobased industry.
CO2 : Understand the types of feedstocks available for biorefinery and potential products.
CO3 : Apply biorefinery concept to obtain multiple products from one type of biomass.
CO4 : Apply technologies to recover energy and resources from low value biomass.
CO5 : Design and create new technologies for biofuel production.
CO6 : Design and create new commercially important technologies for biorefineries.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 2 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 1 | 3 | 3 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 2 | 3 | 2 | 3 | 3 |
| CO6 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 14 lecture hours**

Introduction to World energy scenario, consumption pattern, fossil fuel depletion and environmental issues. Biorefinery: Basic concept, types of biorefineries, biorefinery feedstocks, properties, and economics. Barriers in lignocellulosic biomass conversion, pre-treatment technologies. Physical and Thermal Conversion Processes: Types, fundamentals, equipment, and applications; thermal conversion products, commercial success stories. Microbial

Conversion Process: Types, fundamentals, equipment and applications, products, commercial success stories. Biodiesel: Diesel from vegetable oils, microalgae, and syngas; transesterification. Introduction to Fischer-Tropsch (FT) process.

**Module II: 14 lecture hours**

Bioethanol and Biobutanol: Corn ethanol, lignocellulosic ethanol, microorganisms for fermentation, current industrial ethanol production technology, cellulases and their role in hydrolysis, concepts of simultaneous saccharification fermentation (SSF) and Consolidated bioprocessing (CBP), Acetone–butanol–ethanol (ABE) fermentation pathway and kinetics, product recovery technologies. Biohydrogen generation, metabolic basics, feedstocks, dark fermentation by strict anaerobes, facultative anaerobes, thermophilic microorganisms, integration of biohydrogen with fuel cell; fundamentals of biogas technology, fermenter designs, biogas purification, methanol production and utilization. Organic Commodity Chemicals from Biomass: succinic acid, acetic acid, butyric acid, 1,3-propanediol, 2,3-butanediol. Microbial fuel cell. Bio-aviation fuels.

**Module III: 14 lecture hours**

Extraction and purification of high value phytochemicals under biorefinery framework. Biofuel production and simultaneous waste management. Metabolic engineering for biofuel production. Biofuel production process simulation. Scale-up of biofuel production processes. Case studies of biofuel production. Current status of biofuel research and job opportunities. Integrated Biorefinery: Concept, aquaculture and algal biorefinery, waste biorefinery, hybrid chemical and biological conversion processes, techno- economic evaluation and life-cycle assessment.

**List of Experiments :**

1. Production of ethanol from lignocellulosic materials with the help of simultaneous saccharification and fermentation (SSF).
2. Biorefinery framework for production of Biodiesel and platform chemical (1,3-propanediol)
3. Production of acetone, butanol, and ethanol in a biorefinery framework.
4. Production of biogas.
5. Production of bioelectricity via Microbial Fuel Cell.
6. Production of platform chemicals (succinic acid, acetic acid, fumaric acid etc.)

**Text Books :**


1. Klass, Donald L. *Biomass for Renewable Energy, Fuels, and Chemicals*. San Diego, CA: Academic Press, 1998.
2. Yang, Shang-Tian, Hesham A. El Ensashy, and Nuttha Thongchul, eds. *Bioprocessing Technologies in Biorefinery for Sustainable Production of Fuels, Chemicals, and Polymers*. EPUB. Hoboken, NJ: Wiley-Blackwell, 2013.


**Reference Books :**


1. Basu, Prabir, and Priyanka Kaushal. *Biomass Gasification, Pyrolysis, and Torrefaction*. 4th ed. San Diego, CA: Academic Press, 2023.
2. Vertes, Alain A., Nasib Qureshi, Hideaki Yukawa, and Hans P. Blaschek, eds. *Biomass to Biofuels*. PDF. Hoboken, NJ: Wiley-Blackwell, 2010.
3. Yang, Shang-Tian, ed. *Bioprocessing for Value-Added Products from Renewable Resources*. London, England: Elsevier Science, 2006.
4. Drapcho, Caye M., Nghiem Phu Nhuan, and Terry H. Walker. *Biofuels Engineering Process Technology, Second Edition*. 2nd ed. McGraw-Hill Education, 2020.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 45% | 20% | 35% | 100% |

| Name of Program | B. Tech. Biotechnology | | | | |
|---|---|---|---|---|---|
| EBTY369L | Nanomedicine | L | T | P | C |
| Owning School/Department | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| Pre-requisites/Exposure | Chemistry of Biomolecules, Introduction to Biomaterials | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Design the strategies to make polymeric nanoparticles.

CO2 : Analyze the size, surface charge, and encapsulation efficiency of cargo.

CO3 : Design the experiment for functional screening of nanocarriers in vitro and in vivo model systems.

CO4 : Compare the types of nanoparticles, their biological properties, and their uses.

CO5 : Understand the hurdles in delivering nanocarriers to the target and how to overcome them from a physiological standpoint.

CO6 : Describe the wide applications of nanomedicine and their commercial importance and aspects.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO11 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 2 | - | 3 | - | - | - | 2 | - | - | 3 | 3 | 3 | 1 |
| CO2 | 3 | 2 | 3 | 3 | 3 | 1 | - | - | - | - | - | 3 | 3 | 3 | 1 |
| CO3 | 3 | 1 | 3 | 1 | 3 | 2 | - | 1 | 2 | - | 3 | 3 | 3 | 3 | 3 |
| CO4 | 3 | 3 | 2 | 1 | 3 | - | - | - | - | - | - | 3 | 3 | 3 | 2 |
| CO5 | 3 | 2 | 3 | 3 | 3 | - | - | 2 | 1 | - | - | 3 | 3 | 3 | 2 |
| CO6 | 3 | 2 | 1 | 1 | 2 | 3 | - | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 14 lecture hours**

**Formulation Strategies and physicochemical characterization:** Principles and concepts, Biomaterials classification (polymeric, lipid etc.), preparation methods, surface modification. Characterization- Size, Surface charge, stability, characterization of cargo- drug/ gene/ protein/ antibody: Encapsulation rate, Release- slow or burst.

**Module II: 14 lecture hours**

**Functional Characterization:** Types- nanoparticles/ liposomes/ lipid nanoparticles/ micelles/ dendrimers/ nanocapsules, Endosomal escape, Cell-specific delivery, in vitro- toxicity and bioactivity, permeation across biological barriers, delivery route, pharmacokinetics and biodistribution.

**Module III: 14 lecture hours**

**Applications:** Infectious Disease (bacterial, viral, fungal), Gene therapy, Cancer therapy, Surgery, Wound healing, Vaccine, Eye disease (Macular degeneration), Cardiovascular disease, Rheumatoid Arthritis, Personalized Medicine, Tissue engineering, Bone Regeneration, Phytonanomedicine, Non-clinical applications: Cosmetics industry, Regulatory aspects, Commercialization examples.

**List of Experiments :**

1. Formulation of polymeric nanoparticles with Rhodamine.
2. Evaluation of percent Rhodamine encapsulation in nanoparticles.
3. Release kinetics of Rhodamine from nanoparticles.
4. Tracing Rhodamine-loaded nanoparticles in cells/ time kinetics using Fluorescence Microscopy.
5. Evaluation of cytotoxicity of Rhodamine-loaded nanoparticles on cancer cells (treatment dose calculation- free drug/ encapsulated drug).

**Text Books :**


1. Niemeyer, Christof M., and Chad A. Mirkin. 'Nanobiotechnology: Concepts, Applications and Perspectives'. *Nanobiotechnology: Concepts, Applications and Perspectives*, 2004.
2. Burgess, Rob. *Understanding Nanomedicine: An Introductory Textbook*. CRC Press, 2012.


**Reference Books :**


1. Ramakrishna, Seeram, Murugan Ramalingam, TS Sampath Kumar, and Winston O. Soboyejo. *Biomaterials: a nano approach*. CRC press, 2016.
2. Sahu, Saura C., and Daniel A. Casciano, eds. *Handbook of nanotoxicology, nanomedicine and stem cell use in toxicology*. Hoboken, NJ, USA: Wiley, 2014.


**Assessment Scheme** :

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY376L** | Introduction to Biosensors and Bioelectronics | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | Bio-Analytical Techniques Lab, Chemistry of Biomolecules, Introduction to Biomaterials, rDNA Technology | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Design basic biosensors for nucleic acid and protein detection.
CO2 : Compare different types of biosensors, their fabrication and applications.
CO3 : Carry out industrially relevant isothermal amplification techniques.
CO4 : Understand the fundamental experimental aspects of basic wearable devices.
CO5 : Describe the multiple bioelements used to prepare biosensors.
CO6 : Understand the commercialization pathways of biosensors.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 3 | 3 | 3 | 3 | - | - | 1 | 1 | 1 | 3 | 3 | 1 | 1 |
| CO2 | 3 | 1 | 1 | - | 3 | - | - | 2 | 1 | 1 | - | 3 | 3 | 1 | - |
| CO3 | 3 | 3 | 3 | 3 | 3 | 3 | - | - | 2 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO4 | 3 | 1 | 1 | - | 3 | 3 | - | - | - | 2 | - | 3 | 3 | 3 | - |
| CO5 | 3 | 1 | 1 | - | 3 | - | - | - | - | 2 | - | 3 | 3 | 1 | - |
| CO6 | 3 | 3 | 1 | 3 | 3 | 3 | - | 2 | - | 2 | - | 3 | 3 | 2 | - |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 14 lecture hours**

Introduction to biosensor design principles; Various types of sensing, transducer, and readout modules and their working principles; Thermal and electronic biosensors: organic and transition metal based MOSFETs, electrochemical biosensors, terahertz spectroscopy, QCM sensors; Fabrication, characterization, and application in detection of bioanalytes; Role of sensing elements.

**Module II: 16 lecture hours**

Optical biosensors: surface plasmon, optical fibres, fluorescence based, LFA strips; Fabrication, characterization and detection of bioanalytes; Applications in DNA sequencing; Combination with nucleic acid and protein sensing modules; Regulatory aspects; Commercialization examples

Mechanical biosensors: microfluidics – basic introduction to basic microfluidic concepts, fabrication methods, examples; Immobilization methods; Readout choices; Applications in biosensing of nucleic acid, antigen, and small molecule analytes; Combination with nucleic acid and protein sensing modules.

**Module III: 12 lecture hours**

Bioelement- Enzyme/ Antibody/ Nucleic Acid/ Tissue/ Polysaccharide/ Microbe. Principles of Biorecognition, Sample preparation and challenges. Cancer Theranostics, live sensors. Regulatory aspects; Commercialization examples- (Clinical & Non clinical). Clinical- Home based/ Pathological. Non-clinical- Pollution/ Industrial production/ Agriculture/ Defense/ Water purification/portable.

**List of Experiments :**

1. Introduction to real-time PCR (principles and primer design).
2. Introduction to real-time PCR (experiment).
3. Introduction to loop-mediated isothermal amplification (principles and primer design).
4. Introduction to loop-mediated isothermal amplification (experiment).
5. Introduction to electrochemical biosensors – experimental principles of amperometric and SWV sensors.
6. Electrochemical biosensors – nucleic acid detection using amperometric and SWV sensors.
7. Working principle of LFA biosensors.
8. LFA biosensor design for *S aureus*.
9. Nucleic acid extraction biosensors principles.
10. Building a nucleic acid extraction biosensor and application in downstream rt-PCR pathways.
11. Glucometer and working principle – determining LoD (2 h).

**Text Books :**

1. Brian R Eggins, *Biosensors an Introduction* (1st ed.), John Wiley & Sons Publishers, 1996.

2. Graham Ramsay, *Commercial Biosensors* (1st ed.), John Wiley & Sons, Inc. 1998.

**Reference Books :**

1. Donald G. Buerk, *Biosensors Theory and Applications* (1st ed.), Technomic Publishing. Co, Inc, 1993.
2. Loïc J. Blum, Pierre R. Coulet, *Biosensor Principles and Applications* (1st ed.), Taylor and Francis, CRC Press, 1991.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 50% | 15% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY469L** | Digital Healthcare, Theranostics and LAB-On-A-Chip | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | Bio-Analytical Techniques Lab, Chemistry of Biomolecules, Introduction to Biomaterials, rDNA Technology | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand principles and designs behind Chip fabrication.
CO2 : Discuss the processes of Chip fabrication and their applications.
CO3 : Understand the fundamentals of microfluidic devices and their operation.
CO4 : Explain the concept of Organ-On-Chip designing.
CO5 : Understand the current state-of-the-art and industrial applications.
CO6 : Define multiple disease models where organ-on-chip can be used.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | - | 2 | - | - | 3 | 3 | - | - |
| CO2 | 3 | 2 | 2 | 3 | 3 | 2 | - | - | - | 1 | - | 3 | 3 | 3 | 1 |
| CO3 | 3 | 2 | 3 | 2 | 3 | 3 | 2 | - | - | - | - | 3 | 3 | - | - |
| CO4 | 3 | 2 | 3 | 2 | 3 | 2 | - | - | - | 1 | - | 3 | 3 | 3 | 3 |
| CO5 | 3 | 3 | 2 | 3 | 3 | 3 | - | - | 1 | - | 1 | 3 | 3 | - | - |
| CO6 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 8 lecture hours**

Sensing and actuation principle, Introduction to Micro-Electromechanical Systems (MEMS) and its applications, Silicon wafer, doping (thermal diffusion and ion implantation, thermal oxidation), Thin-film deposition, Sputtering, Evaporation, Photolithography, Etching, packaging and bonding, BioMEMS.

**Module II: 6 lecture hours**

Soft-lithography, fabrication of Microfluidic devices, Lab-On-Chip, Point-Of-Care diagnostics and imaging, Applications of Microfluidic systems. Digital Healthcare- Telemedicine & Wearable devices.

**Module III:** **14 lecture hours**

History of organ-On-Chip, Organ-On-Chip for drug screening, Organoid Model- Brain, Cardiovascular- heart/ vessel model, Lung, liver, kidney, bone and gastric organ models.

**Module IV:** **14 lecture hours**

Multi-Organ-On-Chip, Disease models- cancer, infectious disease, injury, genetic disease, Tissue Regeneration and Tissue Engineering.

**List of Experiments :**

1. Demonstration of semiconductor fabrication process
2. Demonstration of Microfluidic Device Fabrication
3. Electrochemical sensing- Dr. Soumyendu
4. Preparation of culture plates for 3D cell culture
5. Initiating 3D spheroid culture
6. Spheroid growth kinetics
7. Drugs screening in 2D vs 3D cell cultures
8. Introduction to co-culture
9. Introduction to organoids
10. Gastrointestinal transport model (Transwell culture).

**Text Books :**


1. Raman, Ritu. *Biofabrication*. The MIT Press Essential Knowledge Series. London, England: MIT Press, 2021.
2. Hoeng, Julia, David Bovard, and Manuel Peitsch. *Organ-On-Chip: Engineered Microenvironments for Safety and Efficacy Testing*. Elsevier, 2019.


**Reference Books :**


1. Grewal, Iqbal S. *Emerging Protein Biotherapeutics*. Edited by Iqbal S. Grewal. London, England: CRC Press, 2009.
2. Folch, Albert. *Introduction to BioMEMS*. London, England: CRC Press, 2019.
3. Rasponi, Marco. 2022. *Organ-On-a-Chip : Methods and Protocols*. New York, NY: Humana Press.


**Assessment Scheme :**

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 50% | 15% | 35% | 100% |

# Semester VII

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY491J** | Mini Project-II | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 0 | 0 | 6 | 3 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Apply core subjects knowledge to identify a research area and research topic.

CO2 : Design and conduct experiments according to the selected problem.

CO3 : Analyse data obtained from the experiment and communicate it through the presentation.

CO4 : Evaluate the shortcomings of the project and future research in the field.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | - | 3 | 1 | - | 1 | - | - | 3 | - | 3 | 3 | 3 | 2 | 3 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 1 | - | 3 | 3 | - | 2 | 3 | 3 | 3 | 3 |
| CO3 | 3 | 3 | 2 | 3 | 3 | - | - | 3 | 3 | 3 | 2 | 3 | 1 | 3 | 3 |
| CO4 | 3 | 3 | 1 | 1 | - | - | - | - | 2 | 3 | 3 | 3 | 1 | 2 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents :**

This is a lab-based course.

**List of Experiments :**

The experiments will vary from individual project to project.

**Text Books :**

Research papers as assigned by the project supervising faculty.

**Reference Books :**

Research papers as assigned by the project supervising faculty.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 60% | - | 40% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | Integrated B.Tech. – M. Tech. Biotechnology | | | | |
| **Course code -----** | Advanced Tools and Techniques in Biotechnology | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Bioanalytical Techniques EBTY104P | | | | |

Course Outcomes (COs)

On completion of this course, the students will be able to:

CO1: Understanding the concepts of the NMR, CryoEM and X-ray crystallography

CO2: Understand basics of surface characterization and related analytical techniques

CO3: Understand the techniques and its implementation towards the sample analysis and applicability

CO4: To understand and apply various analytical techniques for industrial applications

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | - | 2 | - | - | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 2 |
| CO2 | 3 | 2 | 2 | 2 | - | 2 | - | - | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 2 |
| CO3 | 3 | 2 | 2 | 2 | - | 2 | - | - | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 2 |
| CO4 | 3 | 3 | 3 | 3 | - | 2 | - | - | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

Course Contents:

**Module I: (15 hrs.)**

Nuclear Magnetic Resonance. Overview of NMR principles. Chemical shifts. Theory of Nuclear Magnetic Resonance, Applications of Proton NMR, Carbon-13 NMR.

Cryo Electron Microscopy: Overview of electron microscopy and its evolution. Applications and significance of CryoEM in biology and medicine. Sample handling and grid preparation. Cryoprotection. Image Acquisition and Data Collection. CryoEM in Drug Discovery and Disease Mechanisms.

X-ray Diffraction (XRD): Introduction to X-ray Crystallography, Basic principles of X-ray interaction with matter. Crystallization conditions. Different Methods of Crystallization. X-ray Diffraction and Data Collection.

**Module II: (12 Hrs.)**

Fluorescence microscopy: Confocal imaging, High-throughput imaging, Live-cell imaging, Image processing and quantitative analysis.

Surface Characterization Techniques: Scanning Tunnelling Microscopy (STM), Atomic Force Microscopy (AFM), Cantilever design and application, Various Modes of Imaging, Force Spectroscopy, High-Speed Imaging, Piezo Force Microscopy (PFM), Nanomechanical analysis of soft surfaces, biological imaging and related applications.

**Module III: (15 Hrs.)**

Electrochemical spectroscopy: Introduction to electrochemistry – basic concepts and requirements, Cyclic voltametric, Amperometry, Potentiometry, Impedance spectroscopy, Electrochemical circuit elements, 3-electrode measurements, challenges and artefacts.

Infrared Spectroscopy: Theory, Infrared Sources and Transducers, Instruments, Adsorption and Reflection Spectrometry, Photoacoustic Infrared Spectrometry, Near and Far Infrared Spectrometry, Emission Spectroscopy, Microspectrometry.

Mass Spectroscopy: Fundamentals of mass spectrometry, principles and components of the mass spectrometer and sample analysis, mass spectrometry: Ionization sources, Mass analysers, MALDI, sample preparation and analysis.

**Experimental section:**

1. Protein crystallization: Crystal tray set up
2. Differential analysis of crystalline and amorphous sample on XRD
3. FTIR measurements of powders and thin films
4. Electrochemical: Cyclic voltametric (CV) sample analysis and CV cure preparation
5. Fluorescence microscopy: Sample imaging with multiple parameter and filter channel
6. Post processing of Multi-channel Fluorescence Image using Imagej Software
7. Mass Spectroscopy: MALDI-TOF analysis of proteins

Text Books:


1. Skoog, Holler, Nieman, (2017), Principles of Instrumentation Analysis, Harcourt
2. Roop B, (2009) Biomolecular Crystallography: Principles, Practice, and Application to Structural Biology, Garland Science; 1st edition
3. Rhodes, G. (2010). Crystallography made crystal clear: a guide for users of macromolecular models. Elsevier.
4. Robert M Glaeser, Eva Nogales, Wah Chiu, (2021) Single-particle Cryo-EM of Biological Macromolecules, Biophysical Society, IOP publishing
5. Bhushan B, editor. Springer handbook of nanotechnology. Springer; 2017 Nov 5.
6. Oldham K, Myland J. Fundamentals of electrochemical science. Elsevier; 2012 Dec 2.


Reference Books:


1. X-ray Crystallography. (2021, May 1). https://chem.libretexts.org/@go/page/316
2. Raja, P. M. V., & Barron, A. R. (2021, March 21). NMR Spectroscopy. Rice University. https://chem.libretexts.org/@go/page/55887
3. Proteins. (2020, August 13). College of Saint Benedict/Saint John's University. https://chem.libretexts.org/@go/page/189779
4. Wilson and Walker, (2000), Practical Biochemistry: Principles and Techniques, Cambridge Low Price Editions
5. Bagotsky VS, editor. Fundamentals of electrochemistry. John Wiley & Sons; 2005 Dec 2.
6. Dietzek B, Cialla D, Schmitt M, Popp J. Introduction to the fundamentals of Raman spectroscopy. InConfocal Raman Microscopy 2010 Aug 31 (pp. 21-42). Berlin, Heidelberg: Springer Berlin Heidelberg.


Assessment Scheme:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 20% | 40% | 100% |

# Semester VIII

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| EBTY4096J | M. Tech Research Project on Specialization | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 0 | 0 | 20 | 10 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the scientific concepts of their project.

CO2 : Critically evaluate a research area to identify a research topic.

CO3 : Design and conduct experiments.

CO4 : Analyse data and conclude.

CO5 : Present experimental data.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 1 | - | - | - | - | - | 3 | 1 | 3 | 3 | 3 | 2 | 2 |
| CO2 | 3 | 1 | - | 1 | 1 | - | - | - | - | 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| CO3 | 3 | 3 | 3 | 3 | 3 | - | - | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 3 | 3 |
| CO4 | 3 | 1 | 3 | 3 | 3 | - | - | - | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| CO5 | 1 | 1 | - | - | 1 | 1 | - | 1 | - | 3 | - | 1 | 1 | 2 | 1 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents :**

This is a research-based course.

**List of Experiments :**

The experiments will vary from individual project to project.

**Text Books :**

Material will be assigned by the project supervisor.

**Reference Books :**

Study material as assigned by the project supervisor.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 50% | - | 50% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | Integrated B.Tech.-M.Tech. Biotechnology | | | | |
| **EBTY4095J** | M. Tech. Research Project | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 0 | 0 | 12 | 6 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1: Critically evaluate a research area to identify research gaps.

CO2: Define a research problem and create hypothetical solutions.

CO3: Design and conduct experiments to find evidence.

CO4: Analyse data, prepare a scientific report, and present the findings.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 3 | 3 | 2 | 3 | 1 | 3 | 2 | 2 | 2 | 3 | 3 | 2 | 3 | 3 | 2 |
| CO2 | 3 | 2 | 3 | 2 | 3 | 2 | 3 | 2 | 1 | 2 | 2 | 3 | 2 | 1 | 3 | 2 |
| CO3 | 2 | 2 | 3 | 3 | 3 | 1 | 3 | 2 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| CO4 | 3 | 2 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

This is a research-based course.

**List of Experiments**

The experiments will vary from individual project to project.

**Text Books :**

Material will be assigned by the project supervisor.

**Reference Books :**

Study material as assigned by the project supervisor.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 50% | - | 50% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | M.Tech. Biotechnology | | | | |
| **Course Code:** | Medical Microbiology | L | T | P | C |
| **Owning School/Department** | SEAS/ Biotechnology | 4 | 0 | 4 | 6 |
| **Pre-requisites/Exposure** | Microbes and Immune System | | | | |

**Course Outcomes (COs)**

On completion of this course, students should be able to:

CO1: Understand the structure, classification, growth and identification of various microorganisms including bacteria, fungi, parasite and virus.

CO2: Describe different types of pathogens, infectious diseases and their mechanisms of pathogenesis.

CO3: Understand the role of host in infectious disease, including natural barriers to infection, innate and acquired immune responses to infection, and inflammation.

CO4: Apply various diagnostic and therapeutic interventions against various infectious diseases and Antimicrobial resistant (AMR) pathogens.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 2 | 3 | 1 | 3 | 1 | 2 | 3 | - | - | 2 | 3 | 3 | 1 |
| CO2 | 3 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 3 | - | - | 2 | 3 | 3 | 1 |
| CO3 | 3 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 3 | - | - | 2 | 3 | 3 | 1 |
| CO4 | 3 | 2 | 1 | 3 | 2 | 1 | 1 | 1 | 2 | 3 | - | - | 2 | 3 | 3 | 1 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 22 lecture hours**

**Microbial Pathogenesis**

The structure, classification, growth and identification of pathogens. Intracellular and extracellular bacterial pathogens, Superficial, Cutaneous, Sub-cutaneous; Types of Mycoses (with specific example of causative fungi) - Endemic and Opportunistic. Viral pathogens. Infectious diseases, Mechanism of pathogenesis and major virulence factors for various pathogens including Bacteria, Fungi, Viruses and Protozoa. Adaptation strategies of pathogen- impact of host- and pathogen- metabolism on immunity and pathogen survival. Immune evasion mechanisms of pathogens; Mechanisms of Chronic/Latent infections – host-pathogen interactions. Human microbiome and its role in Health Disease.

**Module II: 11 lecture hours**

**Advanced Diagnostics Methods for Infectious Diseases**

Diagnostics methods and their advancements to detect Bacterial, Fungal Viral and Protozoan pathogens. Modern approaches for diagnosis of infectious diseases: Basic concepts of gene probes, dot hybridization and PCR based assays, Lateral Flow Assays, Interferon Gamma Release Assay (IGRA), Tuberculin Skin Test (TST) and X-ray based diagnosis of infections. Various methods of phenotypic drug susceptibility testing, Modern methods of detection of AMR, passive and active prophylactic measures. Principles of biosafety and biomedical waste management.

**Module III: 10 lecture hours**

**Therapeutic Interventions against Infectious Diseases**

Classes and mechanism of action of currently available drugs and new inhibitors in the pipeline to targeting bacterial, fungal, Viral and Protozoan infections. Antiviral chemotherapy, Killed and attenuated vaccines, Neutralizing Antibodies, Reverse transcriptase inhibitor, protease inhibitor, Interferons, fusion inhibitor *etc.*

**List of Experiments**

1. Bacterial agglutination test to differentiate between various serotypes of bacterial pathogens.
2. Alamar Blue assay to test the screen antimicrobial compounds.
3. Vital staining for determining bacterial viability using fluorescence Microscopy.
4. Acid Fast Staining and Smear Microscopy.
5. To screen auxotrophic mutants to determine the mutagenicity of a compound using AMES test.
6. To Perform bacterial conjugation to understand the naturally occurring transfer of antibiotic resistance from one bacterium to another.
7. Widal Test to detect the presence of Salmonella genus which causes enteric or Typhoid Fever.
8. Endotoxin LPS detection by ELISA.
9. Triple Sugar Iron Agar protocol to differentiate bacteria based on their fermentation of lactose, glucose and sucrose and on the production of hydrogen sulfide.
10. Viral Plaque Assay.
11. Visit to Clinical Diagnostics labs at GIMS Hospital, Greater Noida.

**Text Books :**

1. Greenwood D., Slack, R, Barer, M.R. & Irving, W.L. (2012). Medical Microbiology E- Book: A Guide to Microbial Infections: Pathogenesis, Immunity, Laboratory Diagnosis and control.

2. Michael Pelczar Jr. *Microbiology* (5th ed.). McGraw Hill Education, 2001. ISBN-10: 0074623206, ISBN-13: 978-0074623206.
3. Prescott, Harley, And Klein's Microbiology, Seventh Edition Published by McGraw-Hill, ISBN 978–0–07–299291–5.
4. Michael T. Madigan , John M. Martinko, David A. Stahl. *Brock Biology of Microorganisms* (14th ed.). Pearson Education, 2017. ISBN-10: 9332586861, ISBN13: 978-9332586864.
5. Ananthanarayan and Paniker's Textbook of Microbiology, Universities Press (India) Pvt. Ltd.; 13th edition (28 August 2024). ISBN-10: 9393330654 ISBN-13: 978-9393330659.

**Reference Books :**

1. IT Kudva, NA. Cornick, PJ Plummer, Q Zhang, TL Nicholson, JP Bannantine and BH Bellaire. *Virulence Mechanisms of Bacterial Pathogens*, (2016) 5th edition, ASM Press.
2. Levinson, W. & Jawetz E. (1996). Medical Microbiology and immunology: examination and board review. Appleton & Lange.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 40% | 20% | 40% | 100% |

| Name of Program | Integrated B.Tech.-M.Tech. Biotechnology | | | | |
|---|---|---|---|---|---|
| EBTY | Computational Biology | L | T | P | C |
| Owning School/Department | SEAS/Biotechnology | 3 | 0 | 4 | 5 |
| Pre-requisites/Exposure | Computational Thinking and Programming (ECSE105L)<br>Introduction to Bioinformatics (EBTY202L) | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1: Apply computational techniques to analyze biological data, including genomic sequences, protein structures, and molecular interactions.

CO2: Understand the basic principles of computational biology, focusing on the modeling and simulation of biological systems.

CO3: Integrate computational methods for predicting protein structures and dynamics to gain insights into structure, function, and disease mechanisms.

CO4: Analyze and interpret the concept of network and system biology. Understand the QSAR-based drug discovery.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | 1 | - | 2 | - | 1 | 1 | 2 | 1 | - | 3 | 3 | 3 | 1 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 1 | 1 | 2 | 3 | 2 | 3 | 3 | 3 | 2 |
| CO3 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 1 | 1 | 2 | 3 | - | 3 | 3 | 3 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | - | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

Medium /

**Module I: 8 lecture hours**

**Introduction to Computational Biology:** Biological database, sequence alignment and phylogenetics, genomic data analysis, structural bioinformatics: protein and nucleic acid structure prediction

**Module II: 17 lecture hours**

**Molecular Dynamics and Simulations:** Introduction to Molecular Dynamics (MD): principles of MD simulations, force fields (AMBER, CHARMM, GROMOS), and applications in studying biomolecular dynamics. Simulating Protein-Ligand Interactions: Setting up and running MD simulations for protein-ligand complexes, analyzing trajectories, and extracting insights from the results. Advanced Simulation Techniques: steered MD, umbrella sampling, and free energy perturbation. Introduction to Quantum Mechanics/Molecular Mechanics (QM/MM): combining quantum mechanics with molecular mechanics to study complex biological systems. Applications of MD simulations: investigating protein folding, conformational changes, and the impact of mutations on protein function.

**Module III: 17 lecture hours**

**Network and Systems Biology:** Applications in drug discovery and development.
Multi-omics-based biomarker identification. Introduction to cheminformatics and QSAR-based screening of natural compounds for drug discovery. AI-driven drug repurposing strategies. Translational approaches for integrating computational models into real-world therapeutic development.

**List of Experiments:**

1. Linux commands and shell scripting
2. Rigid and flexible docking
3. Protein structure prediction
4. Nucleic acid structure prediction
5. Generating MD simulations input using web utilities
6. Case study: MD simulations on a protein-drug complex (part-1)
7. Case study: MD simulations on a protein-drug complex (part-2)
8. Case study: MD simulations on a protein-drug complex (part-3)
9. Cytoscape to visualize and analyze protein-protein interaction (PPI) networks
10. Predict drug targets using STITCH interaction networks
11. QSAR for drug discovery

**Text Books :**

1. Wünschiers, Röbbe. *Computational Biology*. Berlin, Heidelberg: Springer Berlin Heidelberg, 2013.

**Reference Books :**

1. Fenyö, David, ed. *Computational Biology*. Humana Press, 2010.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 40% | 20% | 40% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | Integrated B.Tech. – M. Tech. Biotechnology | | | | |
| **Course code -----** | Nano-Biotechnology | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Biomaterials - EBTY207L | | | | |

Course Outcomes (COs)

On completion of this course, the students will be able to:

CO1: Understand the principles and Fundamentals of nanomaterial and nanotechnology

CO2: Describe the process for synthesis of nanomaterial and their applications.

CO3: Understand the fundamentals of analytical techniques used for interactions and their operation on nanomaterial and biotechnology.

CO4: Understand the current state-of-the-art of nanobiotechnology and its industrial applications.

## CO-PO/PSO Mapping

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | - | 2 | - | - | 3 | 3 | - | - |
| CO2 | 3 | 2 | 3 | 3 | 3 | 3 | - | - | - | 1 | - | 3 | 3 | 3 | 1 |
| CO3 | 2 | 2 | 3 | 2 | 3 | 3 | 2 | - | - | - | - | 3 | 3 | - | - |
| CO4 | 3 | 2 | 3 | 2 | 3 | 2 | - | - | - | 1 | - | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

## Course Contents:

Module I: 14 lecture hours

Introduction to nanotechnology, Special properties of nanomaterials, past and present of advancement in nanotechnology, Nanomaterial fabrication methods, Various types of nanomaterials (metal and semiconductor nanoparticles, polymeric nanoparticles, etc.), intermolecular interaction at nanoscale and surface properties of nanomaterial.

Module II: 14 lecture hours

An overview of nano-biosensing: Bio-sensors and their various components, applications (molecular analysis, food safety, biomedical and environmental monitoring, etc.) lab-on-a-chip sensing and detection systems, BioMEMS/Biosensors for diagnostics. Nanomedicine: Concepts and toxicology of nanomaterials, nanoparticle dynamics and interaction in biological environment.

Module III: 14 lecture hours

Nanostructured biocompatible material and Interactions with Biomolecules, Bio-functional nanomaterial for diagnostic application. (Targeted drug delivery, aptamer-based therapy, Implants; wound healing etc.) Bioimaging and signal enhancement with nanoparticles, Point-of-Care systems.

Text & Reference Books:

1. Nanotechnology: An Introduction, by Jeremy Ramsden, 2011, *Elsevier Publishers*.
2. Nanobiotechnology: Concepts, Applications and Perspectives, edited by C.M. Niemeyer and C. A. Mirkin, 2012, Wiley-VCH Verlag GmbH & Co.
3. Nanomedicine, edited by Huw Summers, 2013, *Elsevier Publishers*.
4. Nano-Bio-Sensing, edited by Sandro Carrara, 2011, Springer Publishers
5. Additionally, other latest research articles related to the topic will be discussed.

Reference Books :


1. Sengupta A, Sarkar CK, editors. Introduction to nano: basics to nanoscience and nanotechnology. Springer; 2015 Jul 1.
2. Alshamrani, M. (2022). Broad-spectrum theranostics and biomedical application of functionalized nanomaterials. *Polymers*, *14*(6), 1221.
3. Bhushan B. Introduction to nanotechnology. In Springer handbook of nanotechnology 2017 (pp. 1-19). Berlin, Heidelberg: Springer Berlin Heidelberg.
4. Balaji S. Nanobiotechnology. MJP Publisher; 2019 Jun 7.
5. Klefenz H. Nanobiotechnology: from molecules to systems. Engineering in life sciences. 2004 Jun;4(3):211-8.


Assessment Scheme :

| **Components** | **Internal Assessment** | **Mid Term Exam** | **End Term Exam** | **Total** |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 20% | 40% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | Integrated B.Tech. – M. Tech. Biotechnology | | | | |
| **Course code -----** | Immunotechnology | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Microbes & Immune System | | | | |

Course Outcomes (COs)

On completion of this course, the students will be able to:

CO1: Understand the applications of immune system mediators for diagnostics.

CO2: Describe the process of vaccine development, their types, and processes for vaccine production, efficacy and safety assessment.

CO3: Describe immunotherapeutic strategies cancer vaccines, adoptive cell therapies, monoclonal antibodies, and immune checkpoint inhibitors, along with their mechanisms.

CO4: Design immunotherapeutic strategies to address various diseases.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | - | 2 | - | - | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 2 |
| CO2 | 3 | 2 | 2 | 2 | - | 2 | - | - | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 2 |
| CO3 | 3 | 2 | 2 | 2 | - | 2 | - | - | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 2 |
| CO4 | 3 | 3 | 3 | 3 | - | 2 | - | - | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

Course Contents:

**Module I: (15 hours)**

**Introduction to the immune system and its components-**general overview of mediators of immune system

**Introduction to Immunodiagnostics**

Antibody-based immunodiagnostic tests (with case studies) - Enzyme-linked immunosorbent assays (ELISA), Western blot, radioimmunoassays, lateral flow assays; immunohistochemistry and immunofluorescence in tissue-based diagnostics; flow cytometry for quantitative analysis of cell populations; immunophenotyping and minimal residual disease detection, multiplex bead array, and proximity ligation assays.

T cell-based diagnostic assays (with case studies): ELISPOT assay, intracellular cytokine staining, T Cell proliferation assay, mixed lymphocyte reaction, T Cell receptor sequencing, T cell cytotoxicity assay, T Cell memory assessment using activation-induced marker assay, tetramer staining, T Cell subset analysis, and cytokine release assay.

**Module II: (12 hours)**

**Vaccine development**

Overview of vaccines and historical perspective, basic principle of the vaccine development process, types of vaccines (live attenuated vaccines, inactivated vaccines, subunit, recombinant, polysaccharide, and conjugate vaccines, toxoid vaccines, mRNA vaccines, and viral vector vaccines), criteria for the selection of target antigen, vaccine adjuvants, vaccine delivery systems and administration routes, concept of reverse vaccinology, vaccine production pipeline (case studies), vaccine safety and efficacy assessment (case study), vaccine hesitancy.

**Module III: (15 hours)**

Introduction to immunotherapy, types of immunotherapeutic strategies - cancer vaccines (therapeutic versus preventive cancer vaccines), tumor antigen identification, adoptive cell therapies (CAR-T cell therapy, NK cell therapy, macrophage-based cell therapy, tumor-infiltrating lymphocyte therapy), monoclonal antibodies (mechanisms of action, antibody-drug conjugates, bispecific antibodies, nanobodies), cytokine-based therapies, oncolytic viruses (mechanisms of action, examples of oncolytic viruses in trials), inhibitors targeting immune checkpoints (PD-1 and PD-L1 inhibitors, CTLA-4 inhibitors, new checkpoint targets in development), Toll-like Receptor agonists.

Clinical applications of immunotherapy (case studies) - immunotherapy for cancer, autoimmune diseases, infectious diseases, transplantation.

Limitations and challenges in immunotherapy, regulatory processes, emerging areas in immunotherapy.

Text Books:

1. Suman, P., Chandra. *Immunodiagnostic Technologies from Laboratory to Point-Of-Care Testing, Springer Nature Singapore. 2021. ISBN:* 978-981-15-5822-1.

2. Ashfield, R., Oli, A. N., Esimone, C., and Anagu, L. *Vaccinology and Methods in Vaccine Research*. Academic Press, 2022. ISBN: 978-0-323-91146-7.
3. Naing, A., Hajjar, J., *Immunotherapy*. Cham: Springer International Publishing, 2021.

Reference Books:

1. Stranford, S., Owen, J., Jones, P., & Punt, J. Kuby's Immunology, Media Update (8th ed.). W.H. Freeman, 2023. ISBN: 9781319498658.

Assessment Scheme:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 20% | 40% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | Integrated B.Tech. – M. Tech. Biotechnology | | | | |
| **Course code** | Environmental Biotechnology | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Environment and Sustainability (ESEA301L)<br>Bioprocess Design and Upscaling (EBTY304L) | | | | |

Course Outcomes (COs)

On completion of this course, the students will be able to:

CO1: Understand the fundamental principles of ecosystem dynamics and environmental microbiology

CO2: Evaluate and analyse environmental pollution and its impact

CO3: Apply bioremediation techniques to address environmental contaminants

CO4: Utilize microbial and biotechnological innovations for environmental protection and sustainability

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 1 | 1 | 1 | 3 | 1 | 1 | 1 | 2 | 3 | 3 | 3 | 3 | 3 |
| CO2 | 3 | 2 | 3 | 1 | 1 | 2 | 3 | 1 | 1 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| CO3 | 3 | 3 | 3 | 2 | 1 | 3 | 3 | 1 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| CO4 | 3 | 3 | 3 | 2 | 1 | 3 | 3 | 1 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |

1 = weakly related 2 = moderately related 3 = strongly related

Course Contents:

**Module I: (15 hours)**

**Introduction to Environment, ecosystem and sustainability**: Overview of environment and sustainability, Sustainable Development goals (SDGs), Basics of ecosystem structure and function, Concepts of energy transfer and nutrient cycling in an ecosystem.

**Sources and types of pollution**: Soil, air and water pollution, Measurement of pollution (techniques and instrumentation), Environmental health and ecotoxicology, Indices of

toxicity. Microbial biosensors in environmental monitoring, Carbon footprint, Risk assessment, Environmental impact assessment, Life cycle analysis.

**Basics of environmental microbiology**: Microbial ecology, growth and metabolism, Respiration and energy generation, Microbial transformation, degradation reactions and kinetics, Culture dependent and independent analyses of microbial communities (Environmental metagenomics).

**Module II: (15 hours)**

**Bioremediation technology**: Scope and characteristics of contaminates, Types of bioremediations (Phyto, microbial, and genetically modified microbes), Engineered strategies for bioremediation (insitu and exsitu bioremediation), Biomining, Landfarming, Microbial cleaning of gases (biofiltration and bioscrubbing), Bioreactors for waste management.

**Microbial detoxification of hazardous chemicals**: Synthetic detergents, Pesticides, Hydrocarbons, Chlorinated hydrocarbons, Explosives, Microbial interaction with plastics, Antibiotics and others emerging pollutants.

**Module III: (12 hours)**

**Biological energy and nutrient recovery from waste:** Biological phosphorus and nitrogen removal and recovery from wastewater, Biofuels (Case studies), Biofertilizers, Biocompost, vermicompost and Bio-pesticides production.

**Microbial role in carbon storage and capture:** Carbon sequestration (Case studies), Conversion to valuable products (fuels, chemicals, and material).

**Role of biotechnology in environmental protection:** Application of biotechnological innovations in environmental conservation and sustainability, Waste valorization (Case studies of various startups), Green chemistry, BioE3 policy.

**Textbooks:**


1. B. Rittmann and P. L. McCarty, *Environmental Biotechnology: Principle & Applications*, 2nd Edition, McGraw Hill Companies Incorporated, 2012. ISBN 0-470-84373-X.
2. G. M. Evans and J. C. Furlong, *Environmental Biotechnology: Theory and Applications*, 2nd Edition, Wiley Publishers, 2010. ISBN 0-470-84372-1.
4. P.K. Mohapatra, *Textbook of Environmental Biotechnology*, 1st Edition, IK International Publishing House Pvt. Ltd, 2013. 978-8188237548.
3. B. C. Bhattacharya and R. Banerjee, *Environmental Biotechnology*, Oxford University Press, USA, 2007. 978-0195687828.


**Reference Books:**


1. Scragg, A, *Environmental Biotechnology*, 2nd Edition, Oxford University Press, USA, 2007. ISBN 9780013032984.
2. Metcalf and Eddy Inc, *Wastewater Engineering: Treatment and Resource recovery*, McGraw-Hill publication, 5th Edition, 2013. ISBN10: 0073401188.


**Assessment Scheme:**

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 40% | 20% | 40% | 100% |

# Electives

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY341L** | AMR Theory and Methods | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Microbes & Immune System | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the historical development of antibiotics and their impact on human health. Analyse the global emergence of antimicrobial resistance (AMR) and its consequences for public health. Understand the mechanisms of AMR, including target modification, drug modification, and efflux pumps. Investigate the occurrence of AMR in bacteria, fungi, viruses, and parasites.

CO2 : Understand the One Health approach and its significance in combating AMR in humans, animals, and the environment (One Health). Explore the concept of antimicrobial stewardship and its role in preserving the effectiveness of antibiotics. Differentiate between multidrug resistance (MDR), extensively drug-resistant (XDR), and totally drug-resistant (TDR) pathogens. Analyse the cycle of AMR and its perpetuation in ESKAPE pathogens and their significance in healthcare-associated infections.

CO3 : Understand the principles of antimicrobial susceptibility testing (AST) and its role in detecting AMR. Understand the role of resistome in understanding the genetic basis of AMR at a global scale. Familiarize with AMR databanks and their role in surveillance and research. Discuss quality assurance procedures in AST, including the use of QC strains. Explore various approaches and technologies for developing novel therapeutics including phage therapy, immunotherapy etc. and their potential in overcoming AMR challenges. Understand the mechanisms of action of novel therapeutics against AMR. Discuss the challenges and prospects of implementing novel therapeutics in clinical practice.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 3 | 3 | 2 | 3 | 1 | 3 | 2 | 1 | 2 | - | 2 | 3 | 3 | 2 |
| CO2 | 2 | 2 | 3 | 3 | 3 | 1 | 3 | 2 | 1 | 2 | - | 2 | 3 | 3 | 2 |
| CO3 | 2 | 2 | 3 | 3 | 3 | 1 | 3 | 2 | 1 | 2 | - | 2 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 14 lecture hours**

History of antibiotic use since 1945. Discovery of antibiotics and antibiotic resistance. Global burden of AMR. Modes of bacterial resistance. Antibiotic Classes and Mechanisms. Mechanisms of resistance: target modification, drug modification, efflux pumps. AMR in fungi, viruses and parasites.

**Module II: 14 lecture hours**

Reservoirs of antimicrobial resistance: soil, water, agricultural practices. One health approach. Antimicrobial stewardship and monitoring. National Action Plan. Multidrug resistance: MDR, XDR and TDR. ESKAPE pathogens. AMR in community and hospital. Cycle of AMR.

**Module III: 14 lecture hours**

Detection of AMR: antimicrobial susceptibility testing. Resistome. AMR databank, Quality assurance of AMR using QC strains to assure the quality of AST. Novel therapeutics to target AMR.

**Text Books :**

1. Weber, Todd, Ed. *Antimicrobial Resistance: Beyond The Breakpoint: 06 (Issues In Infectious Diseases)*, N.D.
2. 2.Drlica, Karl, Ed. *Antimicrobial Resistance In The 21st Century (Emerging Infectious Diseases Of The 21st Century)*, N.D.

**Reference Books :**

1. Dr. Himanshu Baweja, *Anti-Microbial Resistance Crisis In Current Medical Era A Pandemic*, ASIN B081RKMQHL.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

| **Name of Program** | B.Tech. Biotechnology | | | | |
|---|---|---|---|---|---|
| **EBTY342L** | Gene Therapy | L | T | P | C |

| | | | | | |
|---|---|---|---|---|---|
| **Owning School/Department** | SEAS/Biotechnology | 2 | 0 | 2 | 3 |
| **Pre-requisites/Exposure** | rDNA Technology | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Describe different methods of gene transfer techniques and gene therapy types.

CO2 : Apply and define advanced genome editing methods and molecular medicine.

CO3 : Evaluate ethical concerns associated with novel methods of gene therapy.

CO4 : Compare methods, ethical concerns, and safety issues of gene therapy available for different diseases.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | - | - | - | 1 | - | - | 3 | 2 | 1 | - |
| CO2 | 3 | 3 | 3 | 3 | 3 | - | - | - | 1 | - | - | 3 | 2 | 1 | - |
| CO3 | 3 | - | - | - | - | 3 | - | 3 | - | - | - | 3 | - | - | 2 |
| CO4 | 3 | 3 | - | 3 | 3 | 3 | - | 3 | - | - | - | 3 | - | 1 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 10 lecture hours**

Introduction of gene therapy: Basic mechanisms and approaches in gene therapy, Gene therapy in germline vs. somatic cells; In vivo and ex vivo gene therapy; Vectors used for gene therapy, Retroviral vector, Adenovirus vector, Adeno-associated virus, Lentiviral vectors, and non-viral gene transfer techniques.

**Module II: 10 lecture hours**

Advanced methods of gene therapy, how to target vector to the particular cell; Genome Editing, Gene therapy using CRISPR/Cas9 Technology, use of RNAi and other non-coding RNAs, ethical considerations in all these novel methods of therapy; Recent advancement in Molecular Medicine and Gene Therapy; Genetically altered mice as models for gene therapy.

**Module III: 8 lecture hours**

Applications of gene therapy, Gene therapy for cardiovascular/ Neurological disorders, cystic fibrosis, Duchenne Muscular Dystrophy (DMD), Bleeding disorders, HIV infection, cancer, Severe combined immunodeficiency syndrome (SCID), Gene therapy of nonheritable disorders. Clinical trials for diseases, Ethical and safety issues in gene therapy.

**List of Experiments :**

1. Video demonstration of non-viral gene transfer techniques (physical methods).
2. Electroporation system demonstration using Gene Pulsar BioRad X cell.
3. Video demonstration of different chemical methods of gene transfer.
4. PEI mediated gene transfection in mammalian cells.
5. RNA interference technology video demonstration.
6. CRISPR-CAS9, gene-editing technique video demonstration
7. Designing of guide-RNA for CRISPR-CAS9.
8. Viral vector-mediated gene therapy video demonstration.
9. Genetically altered mice models for gene therapy.
10. Cancer gene therapy discussion.

**Text Books :**

1. Friedman, T. *The Development of Human Gene Therapy*. Cold Spring Harbor, NY: Cold Spring Harbor Lab.Press, 1999.

2. Lemoine, Nick. *Understanding Gene Therapy*. London, England: Taylor & Francis, 2023.
3. Giacca, Mauro. *Gene therapy*. Springer Science & Business Media, 2010.

**Reference Books :**

1. Verma, Inder M., and Matthew D. Weitzman. 'Gene Therapy: Twenty-First Century Medicine'. *Annual Review of Biochemistry* 74, no. 1 (2005): 711–38. https://doi.org/10.1146/annurev.biochem.74.050304.091637.
2. Hunt, Kelly K., and Stephan A. Vorburger. *Gene Therapy for Cancer*. PDF. Edited by Kelly K. Hunt, Stephan A. Vorburger, and Stephen G. Swisher. 2007th ed. Cancer Drug Discovery and Development. New York, NY: Humana Press, 2006.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the basics of the immune system and the types of immunity, types of antigens, antigen processing and presentation with MHC, and functions of antibodies in generating the immune responses and activating the complement system.

CO2 : Understand technologies for producing monoclonal and polyclonal antibodies with specific properties, and methods for antibody expression, downstream purification, formulation, and assessing stability.

CO3 : Describe types of antibodies and their functions and strategies for antibody engineering for humanization, and affinity maturation.

CO4 : Explain basic and advanced techniques used for the characterization of antibodies and applications of monoclonal antibodies in clinical diagnosis and treatment.

**CO-PO/PSO Mapping**

| **Name of Program** | B.Tech. Biotechnology | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **EBTY441L** | Antibody Engineering Technologies | | | | | | | | | | | | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | | | | | | | | | | | | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Microbes & Immune System | | | | | | | | | | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO-9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 | |
| CO1 | 3 | 2 | 2 | 2 | - | 2 | - | - | 2 | 2 | 2 | 2 | 3 | 3 | 2 | |
| CO2 | 3 | 2 | 2 | 2 | - | 2 | - | - | 2 | 2 | 2 | 2 | 3 | 3 | 2 | |
| CO3 | 3 | 2 | 2 | 2 | - | 2 | - | - | 2 | 2 | 2 | 2 | 3 | 3 | 2 | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO4 | 3 | 2 | 2 | 2 | - | 2 | - | - | 2 | 2 | 2 | 2 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 15 lecture hours**

**Introduction:** Immunity, Types of immunity, Antigens – Molecular structure, Types of antigens, haptens; Antigenic determinants, Antigen processing pathways. Major Histocompatibility Complex - MHC genes, MHC Types, MHC and immune responsiveness and disease susceptibility, HLA typing.

**Antibody functions:** Role of complement system in immunity; Classical Complement Pathway, Alternative Complement Pathway, Issues with Complement System. Immunological memories: Passive memory, Active Memory.

**Module II: 15 lecture hours**

**Antibody engineering.** Humanization, Affinity maturation, Effector function, Expression vector and Host systems, Cell culture optimization, Downstream processing: Purification, formulation and stability.

**Antibody Discovery Methodologies**: Hybridoma techniques, Phage Display, and Direct B-cell cloning technology. Hybridoma techniques and monoclonal Ab production. Myeloma cell lines, fusion of myeloma cell lines with Ab producing B cells, fusion methods, selection and screening for positive hybrids, production and purification and characterization of MAb. Production of human MAb and their applications. Production of polyclonal Ab with different type of Ag: Ag preparation and modification, adjuvants, dose and route of Ag administration, collection of sera. Antibody genes and antibody engineering- chimeric and hybrid monoclonal antibodies; Catalytic antibodies and generation of immunoglobulin gene libraries.

**Module III: 12 lecture hours**

**Analytical Characterization.** Antigen-Antibody interactions: Immunoprecipitation- mancini method, ouchterloney method, immune electrophoresis, rocket immunoelectrophoresis, crossed immunoelectrophoresis, agglutination and complement mediated immune reactions;

**Advanced techniques**. RIA, ELISA, Western blotting, ELISPOT and ELAST assay, peptide based immuno binding assay, immunohistochemistry, immunofluorescence, flow cytometry and immunoelectron microscopy; detection of molecules in living cells, in situ localization by techniques such as FISH and GISH. Surface plasmon resonance (SPR), Biosenor assays for assessing ligand–receptor interaction, CMI techniques- lymphoproliferation assay, Mixed lymphocyte reaction, Cell Cytotoxicity assays. Antibody Engineering Applications: Application of MAb in biomedical research, in clinical diagnosis and treatment.

**Text Books :**


1. Strohl, William R., and Lila M. Strohl. Therapeutic Antibody Engineering. Woodhead Publishing, 2012.
2. McCafferty, J. Antibody Engineering: A Practical Approach. IRL Press, 1996.


**Reference Books :**


1. Kindt, T. J., Goldsby, R. A., and Osborne, B. A. Kuby Immunology. New York: W.H. Freeman and Co., 2007
2. Murphy, K., Travers, P., and Walport, M. Janeway's Immunobiology. Garland Science, Taylor and Francis Group, LLC, 2008.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 30% | 30% | 40% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY442L** | Biomedical Genomics | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Genetics & Molecular Biology, rDNA Technology | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand Mendelian genetics, inheritance patterns in humans, pedigrees analysis, Hardy-Weinberg Equilibrium, epigenetics, risk and odds ratios, and chi-square tests for analysis of genetic data.

CO2 : Explain cytogenetic and molecular technologies and biochemical screening for genetic testing and understand the use of genetic resources like OMIM and the Genetic Testing Registry.

CO3 : Understand the basics of embryology, dysmorphology, techniques for prenatal defect diagnosis, risks associated with invasive procedures, approaches for diagnosing metabolic diseases, and use of genomics for cancer diagnosis and treatment.

CO4 : Understand ethical issues in biomedical genomics, the future of biomedical genomics, and its potential impact on healthcare through pre-symptomatic detection and prevention and personalized medicine.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | - | - | - | - | - | - | - | 1 | 1 | 3 | 3 | 3 | 1 |
| CO2 | 3 | 2 | - | - | 2 | - | - | - | - | 1 | 1 | 3 | 3 | 3 | 1 |
| CO3 | 3 | 2 | - | - | - | - | - | - | - | 1 | 1 | 3 | 3 | 3 | 1 |
| CO4 | 3 | 2 | - | - | - | - | - | 2 | - | 1 | 1 | 3 | 3 | 3 | 1 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 7 lecture hours**

Review of Mendelian genetics, Inheritance patterns in humans (mendelian and non-mendelian), pedigree analysis, Hardy-Weinberg Equilibrium, risk and odd ratios, Chi-square test and its use in analysis of genetic data. Epigenetics and applications.

**Module II: 15 lecture hours**

Genetic Testing Technologies: Cytogenetic testing technologies (karyotyping, FISH), Molecular testing technologies (microarray; genomic tiling arrays, Next generation sequencing- whole genome, exome; SNP Chips, Gene Panels). Biochemical screening. Genetic Resources: OMIM, Genetic Testing Registry.

**Module III: 20 lecture hours**

Basics of embryology, dysmorphology, Prenatal defect diagnosis techniques, Foetal genome sampling procedures; risks associated with invasive procedures, approaches for diagnosis of metabolic diseases, genomics for cancer diagnosis and treatment.

Ethical Issues in Biomedical Genomics (Genetic discrimination, Gene editing)**.**
Future of Biomedical genomics: rise of clinical DNA sequencing; Pre-symptomatic detection and prevention. Personalized medicine.

**Text Books :**

1. Kumar, Dhavendra. *Hardcover ISBN 9780124201965, eBook ISBN 9780127999227,* 2016.
2. Ginsburg, Geoffrey, and Huntington Willard. *Genomic and Precision Medicine, Foundations, Translation, and Implementation,* 2016.

**Reference Books :**

1. Brown, Stuart M., John G. Hay, and Ostre, H. *Essentials of Medical Genomics*. PDF. 2nd ed. Hoboken, NJ: Wiley-Blackwell, 2008.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY443L** | Stem Cells and Tissue Engineering | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Cell and Tissue Culture Technologies | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:
CO1 : Define the stem cell sources, isolation, typical characteristics, and different types.
CO2 : Explain cancer stem cells and their role as biomarkers and treatment resistance.
CO3 : Understand the concept of tissue engineering and reprogramming.
CO4 : Demonstrate the knowledge of stem cells in regenerative medicine and tissue engineering with different applications and case studies.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 1 | 2 | - | 3 | - | - | 1 | 1 | - | - | 3 | 2 | 3 | - |
| CO2 | 2 | 1 | 2 | 1 | 3 | - | - | 1 | - | - | - | 3 | 2 | 3 | - |
| CO3 | 2 | 1 | - | 1 | 3 | 1 | - | 3 | - | 1 | - | 3 | 2 | 3 | 1 |
| CO4 | 2 | 2 | 1 | 3 | - | 2 | - | 3 | 2 | - | - | 3 | 2 | 3 | 1 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 15 lecture hours**

**Introduction:** History: Development in the field over the years, Dolly the sheap introduction , Pollices affecting the stem cell research.

**Types of stem cells:** Embryonic stem cells, Induced pluripotent stem cells, Perinatal stem cells and adult stem cells. Adult stem cells: Hematopoietic stem cells, Mesenchymal stem

cells- Bone marrow derived mesenchymal stem cells and adipose derived stem cells. Advantages and disadvantages of embryonic versus adult Stem Cells.

**Stem cell sources:** including human umbillical cord, bone marrow, adipose tissue and amniotic fluid. Typical characteristics of stem cells and types. Stem cell properties: Self-renewal and potency. Functional potency. Different routes of cell administration**.**

**Cancer stem cells:** The Role of Epithelial – Mesenchymal Transition in Cancer Metastasis, and cancer stem cell biomarkers.

**Module II: 16 lecture hours**

**Tissue engineering:** Tissue Architecture, Stable Connections between cells and the Maintenance of Tissue Structure, Morphogenesis and the dynamics of cell adhesion, Basis of growth and differentiation. Micro- and Nanotechnologies and tissue and organ fabrication. Tissue development and dynamics.

Stem cell culture methods: Basic pluripotent stem cell culture protocols, Mechanisms in Stem Cell Biology, Quality control of cell cultures. Stem cells Niches.

Reprogramming: Reprogramming of stem cells, Reprogramming of iPS Cells. Cell proliferation and Epigenetics, Epigenetic and microRNA mediated Regulation in Stem Cells. Molecular mediators of reprogramming and pluripotency. Concept of pioneer transcription factors in stem cell's differentiation/pluripotency, Scaffolds used in Tissue Engineering.

Ethical aspects of stem cell research. Ethical issues surrounding embryonic stem cells.

**Module III: 11 lecture hours**

**Applications of Stem cells in regenerative medicine/Tissue engineering**. Regenerative medicine, Therapeutic Cloning (somatic cell nuclear transfer) and its benefit, Cells as Therapeutic Agents, Gene Therapy. Biomaterials in Tissue Engineering: Improving synthetic materials, Naturally derived materials. Host response to biomaterials. Applications of biomaterials in pediatric tissue engineering. Tissue Engineering Applications of 3-dimensional bioprinting. Types of 3D Bioprinting Technologies.

**Case Studies of Tissue Engineering.** Therapeutic applications to treat diabetes, towards cardiovascular research and neurodegenerative disease. Potential problems with using embryonic stem cells in humans.

**Regulatory controls towards Stem cell Culture.**

**Text Books :**


1. Burgess, Rob. *Stem Cells: A Short Course*. Wiley-Blackwell, 2015.
2. Jonathan, M. W. 'The Science of Stem Cells'. *The Science of Stem Cells*, 2018.


**Reference Books :**


1. Marek, J., Andrzej Łos, and Emilia Hudecki. 'Stem Cells and Biomaterials for Regenerative Medicine'. *Stem Cells and Biomaterials for Regenerative Medicine*, 2020.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 45% | 25% | 30% | 100% |

| Name of Program | B.Tech. Biotechnology | | | | |
|---|---|---|---|---|---|
| EBTY444L | Forensic Sciences | L | T | P | C |

| | | | | | |
|---|---|---|---|---|---|
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Develop a foundational understanding of forensic science and its scope, including the use of molecular techniques and analytical methods in forensic sciences.

CO2 : Acquire knowledge of data management in forensics, encompassing the collection, organization, and analysis of forensic data.

CO3 : Analyze case studies to comprehend the practical applications of forensic science techniques in solving criminal cases.

CO4 : Familiarize themselves with the areas where biotechnology can be applied in forensic sciences.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 3 | 3 | 2 | - | 1 | 2 | 3 | - | 3 | 3 | 2 | 1 |
| CO2 | 3 | 2 | 2 | 3 | 3 | 2 | - | 1 | 2 | 3 | - | 3 | 3 | 2 | 1 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 2 | - | 1 | 2 | 3 | - | 3 | 3 | 2 | 1 |
| CO4 | 3 | 3 | 2 | 2 | 3 | 2 | - | 2 | 3 | 3 | - | 3 | 3 | 2 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 6 lecture hours**

Introduction to forensic science and its scope. Branches of forensic science. Application and limitations of forensic science. Sample collection and preservation. Locard's Exchange Principle.

**Module II: 18 lecture hours**

Use of molecular techniques in forensic sciences: DNA fingerprinting, Restriction fragment length polymorphism (RFLP); Random amplified polymorphic DNA (RAPD); Amplified fragment length polymorphism (AFLP); Microsatellites; PCR amplifications; Single nucleotide polymorphism (SNPs); Genetic linkage mapping. Short Tandem Repeat (STR) Analysis, Mitochondrial DNA (mtDNA) Analysis. Microbiome in forensics.

**Module III: 18 lecture hours**

Analytical techniques in forensic sciences: GC and HPLC, Spectrometry and chromatography, Blood analysis: Tests for Blood, Precipitin test, blood spatter analysis. Toxicology: Toxins & Biological Poisons, Alcohol, Thallium, Barium, Nerve Agents. Case studies. Data management in forensics.

**Text Books :**


1. Dr, Rukmani. *An Introduction to Forensic Science in Criminal Investigation*, n.d.
2. Wolstenholme, Rosalind. 'The Electromagnetic Spectrum'. *Analytical Techniques in Forensic Science*. Wiley, 5 January 2021.


**Reference Books :**


1. Rudin, Norah, and Keith Inman. *An Introduction to Forensic DNA Analysis, Second Edition*. 2nd ed. Boca Raton, FL: CRC Press, 2001.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY343L** | Protein Engineering and Applications | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 2 | 0 | 2 | 3 |
| **Pre-requisites/Exposure** | Genetics & Molecular Biology | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the concepts and strategies used in protein engineering

CO2 : Understand and the constructs

CO3 : Describe the different expression systems

CO4 : Explain the industrial applications of protein engineering

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 1 | 3 | 2 | 1 | - | - | 2 | - | 1 | 3 | 3 | 3 | 3 |
| CO2 | 3 | 3 | - | 3 | - | 1 | - | - | - | - | 3 | 3 | 3 | 3 | 3 |
| CO3 | 3 | 3 | 1 | 3 | 1 | 1 | 2 | 1 | 1 | 2 | 3 | 3 | 3 | 3 | 3 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 10 lecture hours**

**Recombinant DNA and Gene Cloning:** Cloning vectors for recombinant DNA: Plasmids as vectors; Bacteriophage. Expression vectors: Elements for expression; Fusion tags; Tag cleavage; examples of expression vectors in different expression systems; pET vectors.

**Introduction to proteins:** Introduction. Soluble proteins. Membrane proteins: Integral membrane proteins and Peripheral membrane proteins. Integral membrane proteins: Type I, Type II, and Type III. Transmembrane region: alpha helices and beta barrels. Lipid composition of membrane proteins. Transmembrane proteins as drug targets; examples and diffculties. Protein sequencing. Post translational modifications: PTMs involving addition of functional groups such as enzymatic and non enzymatic addition; Other proteins or peptides; Chemical modifications; examples of post translational modifications.

**Protein homology:** Homology; kind of homology; Sequence conservation; Pairwise alignment and sequence identity.

**Mutagenesis:** Introduction. Types: Random mutagenesis; Site-directed mutagenesis; Combinatorial mutagenesis, Insertional mutagenesis. CRISPR-Cas9: Introduction; Gene expression regulation; Advantages and limitations.

**Module II: 8 lecture hours**

**Protein design:** Rational protein design; Directed evolution; Examples. Methods for selection: Bacterial, phage or ribosome display.

**Heterologous overexpression systems:** DNA transformation into expression host; Strong promoters; Prokaryotic and eukaryotic systems for protein production; Choice of host organisms; Examples; Bioreactors; Uses of cleavable fusion proteins.

**Protein purification:** Protein Extraction by Cell Disruption: Physical disruption of cells; Enzymatic disruption of cells; Chemical cell lysis. Initial purification. Membrane protein purification: Surfactants; Detergent solubilization. Protein separation techniques; General

concepts of chromatography: Affinity chromatography; Size exclusion chromatography; Ion exchange chromatography. Polyacrylamide gel electrophoresis.

**Module III: 10 lecture hours**

**Protein characterization:** Homogeneity and purity. Stability: TM. Denaturation: Urea. Aggregation. Protein Fluorescence. Western Blotting. DLS. CD. ITC and SPR.

**Protein structure and function:** Protein structure; Protein folding; Protein and peptide design and engineering; Relationship of structure and function.

**Methods of structure determination:** X-ray crystallography; NMR and CryoEM. Computational approach. Homology modeling.

**Applications across diverse industry**: Medical applications. Antibody engineering. Food and detergent industry applications, Environmental applications, Nanobiotechnology applications, Biosensors, Other applications.

**List of Experiments :**

1. Introduction to the rational designing of the protein, in-silico designing and online computation tools and online practice of protein information resources.
2. Introduction to buffer characteristics and selection criteria. Introduction to buffer pH ranges and additives for the stability of proteins.
3. Introduction to role of detergents in protein solubilization, types of detergents and their role in protein and lipid interactions and to prepare buffer containing detergent.
4. To learn about the role and need of signal sequence in natural conditions, the different tags and spacer, and the options & advantages of Fusion tags (MBP, GST, GFP).
5. Rational construct designing.
6. Introduction to different methods of crystallization and setup hanging drop crystal tray.
7. Introduction to protein concentrators.
8. Introduction to buffer exchange and dialysis.
9. Protein expression characterization: Affinity Chromatography.
10. Data analysis based on SDS PAGE: Fusion tag comparison.
11. Study pure versus impure sample and study protein sample stability.
12. Introduction to site-directed mutagenesis (SDM) strategy and Site-directed mutagenesis (SDM).
13. Case Study: Identify the catalytic residue (Based on structure analysis).
14. Case Study: Based on structure analysis: Mutational role study in disease biology.

**Text Books :**


1. Sheehan, Mallorie N. *Protein Engineering: Design, Selection, and Applications: Protein Biochemistry, Synthesis, Structure and Cellular Functions*. Nova Science Publishers, Inc, 2013.
2. Torres, Anton. *Protein Engineering and Design*. Syrawood Publishing House, 2017.


**Reference Books :**


1. Mus-Veteau, Isabelle, ed. *Heterologous Expression of Membrane Proteins*. 2nd ed. Methods in Molecular Biology (Clifton, N.J.) 1432. New York, NY: Humana Press, 2016.


## Assessment Scheme:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 45% | 25% | 30% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY445L** | Bioenergy and Biofuels | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand various renewable feedstocks, their availability, and attributes for biofuels production.

CO2 : Understand the broad concept of second and third generation biofuel production from biomass and various low-cost agri-residues and biowastes.

CO3 : Understand the increasing role of renewable energy engineers to address growing energy needs.

CO4 : Develop engineering skills to produce and purify different biofuels.

CO5 : Design novel processes for biofuel production.

CO6 : Design new industrial facility for biofuel production.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 2 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 3 | | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 3 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 1 | 3 | 3 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| CO6 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 14 lecture hours**

Introduction to bioenergy. Oil economy of the world. Road map of bioenergy. Basics of Biomass Technologies. Relation between photosynthesis and bioenergy. Electron Transport Process in Light Reaction. Hill Reaction. Carbon Dioxide Conversion to Carbohydrate. Photorespiration and Calvin Cycle. C3 and C4 Plant Structure and Photosynthesis Process. Biomass Production System and their Categorization. Important Parameters to Select Biomass.

**Module II: 14 lecture hours**

Different conversion technologies of Biomass to biofuel: thermochemical conversion, syngas fermentation. Classification of Pyrolysis. Bio-oil. Biomass conversion to heat and power. Introduction to Gasification. Thermochemical Process of Gasification. Feedstock Treatment of Gasification. Anaerobic Digestion. Fischer Tropsch Synthesis for Liquid Fuels. Biomass Torrefaction. Hydrothermal Technology for Biofuel. Biodiesel production from oil seeds, waste oils and algae. Environmental impacts of biofuel production.

**Module III: 14 lecture hours**

Concept of bioenergy in greenhouse gas emission reduction and commercial production. Production methods, global market, current research, and development activities in the field of various biofuels: bioethanol, biodiesel, biobutanol, biogas and biooil. Feedstock pre-treatment and hydrolysis. Algae as a feedstock for biofuel production and its market potential.

**Text Books :**

1.Brown, Robert C., and Tristan R. Brown. *Biorenewable Resources: Engineering New Products from Agriculture*. Wiley-Blackwell, 2013.

**Reference Books :**


1. Klass, Donald L. *Biomass for Renewable Energy, Fuels, and Chemicals*. San Diego, CA: Academic Press, 1998.
2. Klass, Donald L. *Biomass for Renewable Energy, Fuels, and Chemicals*. San Diego, CA: Academic Press, 1998.

3. Drapcho, Caye M., Nghiem Phu Nhuan, and Terry H. Walker. *Biofuels Engineering Process Technology, Second Edition*. 2nd ed. McGraw-Hill Education, 2020.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 45% | 20% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY446L** | Waste Management & By-Products | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Bioprocess Design & Upscaling | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand basic concepts of different waste management technologies.

CO2 : Understand the applications of biotechnology in solid & hazardous waste management and wastewater treatment.

CO3 : Apply the most recent bioprocesses engineering technologies in solid waste management.

CO4 : Apply the most recent bioprocesses engineering technologies in wastewater management.

CO5 : Apply the most recent bioprocesses engineering technologies in hazardous waste management.

CO6 : Design and create new technologies for simultaneous waste management and by-product recovery.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 2 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 1 | 3 | 3 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO6 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 14 lecture hours**

**Solid waste management:** Types of solid waste. Agricultural solid waste. Forest residues. Industrial solid waste. Municipal solid waste. Biological treatment of solid waste. Biochemical treatment of solid waste. Composting methods. Anaerobic treatment of solid waste. Solid-state fermentation. Slurry phase bioreactor. Current challenges of solid waste management. Solid waste management and bio-based product development technologies. Case studies on biotechnology for solid waste management and by-product recovery. Landfill design for solid wastes.

**Module II: 18 lecture hours**

**Wastewater management:** Water pollution and human health. Municipal wastewater treatment methods. Industrial wastewater treatment methods. Characterization of wastewater. Significance of BOD, COD, suspended solids and volatile solids. Reactors for wastewater treatment and reactors analysis. Primary and secondary treatment of wastewater. Activated sludge process. Modifications of activated sludge process. Trickling filter. Bio-towers. Rotating biological contactors. Stabilization ponds. Sludge disposal. Sludge thickeners. Sludge volume reduction. Sludge conditioning and digestion. Advanced wastewater treatment methods. Nitrification and Denitrification processes. Biological phosphorous removal. ANAMOX process. Effluent disinfection. Wastewater treatment and by product recovery.

**Module III: 10 lecture hours**

**Hazardous waste management:** Sources of hazardous waste. Electronic waste. Biomedical waste. Management of Covid-19 related wastes. Radioactive Waste. Industrial hazardous waste. Fate and environmental effects of hazardous chemicals. Physico-chemical treatment of hazardous waste. Biological treatment of hazardous waste. In-situ treatment of hazardous waste. Bioremediation. Case studies on biotechnology for hazardous waste management. Landfill design for hazardous wastes.

**Text Books :**


1. Tchobanoglous, George, and Frank Kreith. *Handbook of Solid Waste Management*. 2nd ed. McGraw-Hill Education, 2002.
2. Inamuddin, Anish. *Sustainable Bioconversion of Waste to Value Added Products*. Springer, n.d.
3. Whittaker, Dave. 'Integrated Waste Management: A Sustainable Approach', 2018, 978–1632399571.


**Reference Books :**


1. Loehr, Raymond. *Agricultural Waste Management: Problems, Processes, and Approaches*. Elsevier, 2007.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY344L** | Plant-microbe Interactions | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Agriculture Biotechnology | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the symbiotic interaction of microbes and plants.

CO2 : Explain the immune responses of the plants.

CO3 : Undwerstand the molecules that play important roles during plant defense.

CO4 : Apply knowledge to genetically modify plants with enhanced immune response.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 1 | - | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 1 | 3 | 2 | 3 | 3 | 3 | 3 |
| CO3 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |
| CO5 | 3 | 2 | 1 | 1 | - | 2 | - | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 3 |
| CO6 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 1 | 2 | 1 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 14 lecture hours**

Introduction to plant Microbe Interactions: Introduction on the impact of microbial diseases on the global agricultural productivity; Interactions between plants and microbes- pathogenic interaction and their effect on productivity and symbiotic interactions and contribution to plant health. Concept of plant immunity- Pattern Triggered Immunity (PTI), mechanism of PTI and signalling molecules of PTI; Effector Triggered Immunity (ETI), mechanism and signalling molecules involved in immune response.

**Module II: 18 lecture hours**

Plant pathogens: Pathogenic organisms- bacterial, viral, fungal and nematodes, necrotrophs, biotroph; hypersensitive response (HR) and role of reactive oxygen species during HR; systemic infection; Infection mechanisms- process of infection from surface attachment and structural modifications during infection, enzymes involved, the role of toxins and other compounds, invasion of plant tissue, virulence factors, plant hormones and their role during microbial interaction; plant defense and stress responses against pathogens; host and non-host resistance.

Symbiosis: Establishment of symbiotic relations (mycorrhiza, rhizobium). Endophytes.

Impact of pathogens: major concerns in agriculture and horticulture regarding pathogenic interaction, genetic modifications of crop for improved disease resistance.

**Module III: 10 lecture hours** Defense molecules: Role of secondary metabolites during plant-microbe interaction and metabolic engineering to enhance the production of secondary metabolites for prevention of disease; plantibodies and disease resistance; defense proteins, phytoanticipins and phytoalexins.

**Text Books :**

1. Schirawski, Jan, and Michael H. Perlin. 'Plant Microbe Interaction 2017, MDPI St'. *MDPI St.Alban-Anlage* 66 (2017).

**Reference Books :**

1. Lugtenberg, Ben. *Principles of Plant-Microbe Interactions*. Springer International Publishing Switzerland, 2015.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 45% | 20% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY447L** | Nutraceuticals & Health | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Demonstrate understanding of nutraceuticals, including their sources, classifications, and functions in promoting human health, as well as knowledge of nutraceutical production through metabolic engineering and biosynthetic pathway transfer

CO2 : Comprehend the therapeutic benefits of nutraceuticals and grasp the concept of designer foods.

CO3 : Understand the regulatory and safety considerations, including quality control, standardization, and compliance with guidelines, for both nutraceuticals and designer foods.

CO4 : Apply critical thinking skills to evaluate scientific literature, clinical studies, safety assessments, and effectively communicate the principles, advancements, and potential health benefits of nutraceuticals and designer foods.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 1 | 3 | 1 | 1 | - | 2 | 3 | 1 | 3 | 3 | 3 | 1 |
| CO2 | 3 | 2 | 2 | 1 | 3 | 1 | 1 | - | 2 | 3 | 1 | 3 | 3 | 3 | 1 |
| CO3 | 3 | 2 | 2 | 1 | 3 | 1 | 2 | - | 2 | 3 | 1 | 3 | 3 | 3 | 2 |
| CO4 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | - | 2 | 3 | 2 | 3 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 10 lecture hours**

**Nutraceuticals:** Introduction to nutraceuticals, Properties, structure, classification: Traditional and non-traditional; Dietary, herbal, and supplementary; functions of nutraceuticals in human health: disease prevention, Health promotion.

**Module II: 14 lecture hours**

Functional foods as source of nutraceuticals; Anti-nutritional factors present in foods and methods to overcome; traditional foods as nutraceuticals; Nutritive and non-nutritive food components with potential health effects; Nutraceuticals in fruits, vegetables, nuts, grains, herbs and their impact on health, nutraceuticals of animal, algae and microbial origin; Nutraceuticals and cancer protection.

**Module III: 18 lecture hours**

**Nutraceuticals production** by metabolic engineering of lactic acid bacteria, transfer of plant biosynthetic pathways to microbes for nutraceuticals, Plants as bioreactors to produce nutraceuticals, concept of free radicals and antioxidants.
**Therapeutic benefits of nutraceuticals:** arthritis, sleeping disorder, digestive issues, cancer, osteoporosis, blood pressure, cholesterol, Obesity and depression. Medicinal uses and health benefits of nutraceuticals/functional foods: Spirulina, Soybean, Ginseng, Garlic, Broccoli, Gingko, Flaxseeds. Safety guidelines for nutraceuticals by fssai.
**Designer foods**: designer egg, milk, grains, probiotics, proteins. Safety guidelines for designer foods.

**Text Books :**


1. Gupta, Ramesh C., Ajay Srivastava, Anita Sinha, and Rajiv Lall. 'Biomarkers of Foods and Nutraceuticals: Applications in Efficacy, Safety, and Toxicity'. In *Nutraceuticals in Veterinary Medicine*, 693–710. Cham: Springer International Publishing, 2019.
2. Saarela, Maria, ed. *Functional Foods*. 2nd ed. Woodhead Publishing Series in Food Science, Technology and Nutrition. Cambridge, England: Woodhead Publishing, 2016.


**Reference Books :**


1. Christopher, T., and Yi Walsh. *Natural Product Biosynthesis: Chemical Logic and Enzymatic Machinery*. Royal Society of Chemistry, 2017.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 45% | 20% | 35% | 100% |

| Name of Program | B. Tech. Biotechnology | | | | |
|---|---|---|---|---|---|
| EBTY448L | Industrial Phytochemicals | L | T | P | C |
| Owning School/Department | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| Pre-requisites/Exposure | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:
CO1 : Demonstrate the understanding of phytochemicals and their types
CO2 : Understand the safety and toxicity of phytochemicals
CO3 : Understand the Industrial applications of phytochemicals
CO4 : Acquire knowledge of the industrial production of phytochemicals

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 1 | 1 | - | - | 1 | - | - | - | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| CO2 | 1 | 2 | 3 | 2 | 1 | 1 | - | - | 2 | 3 | 1 | 3 | 2 | 2 | 3 |
| CO3 | 1 | 2 | 3 | 2 | 1 | 1 | 2 | - | 2 | 3 | 3 | 3 | 3 | 3 | 2 |
| CO4 | 3 | 3 | 1 | 3 | 3 | 1 | 3 | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I:** **15 lecture hours**

Introduction to the phytochemicals, Families of phytochemicals. Introduction to food additives, Types of food additives. Preservatives, Sweeteners- Phytochemical and Pharmacological Importance of Stevia, Food colourings, flavorings, stabilisers, emulsifiers. Sources and extraction processes. Antioxidants in food industry applications. Anti-microbial essential oils - Chemical Composition and mechanism of action. Phytochemicals in cosmetics –uses and examples. Phytochemicals as biopesticides- examples and recent developments.

**Module II:** **10 lecture hours**

Historical perspective of plant derived drugs. Role of phytochemicals as anti-cancer and chemo-preventive agents. Importance of Catechins and lutein as phytochemicals. Mechanism of chemoprevention by phytochemicals.

**Module III:** **17 lecture hours**

Process of industrial phytochemical production. Extraction, isolation, and identification of bioactive compounds from Plant Extracts. Taxol- natural and synthetic production. Asiaticoside- as medicine, process of industrial production. Introduction to pesticidal, microbial and heavy metal contamination free extraction process. Podophyllotoxin-biosynthesis and production by fermentation. Industrial applications of phytochemicals.

**Text Books :**


1. Md Asaduzzaman, Toshiki Asao, *Phytochemicals -Source of Antioxidants and Role in Disease Prevention*, IntechOpen, 2018.
2. Megh R. Goyal, Masood Sadiq Butt, Hafiz Ansar Rasul Suleria, *Phytochemicals from Medicinal Plants Scope, Applications, and Potential Health Claims*, Apple Academic Press, 2019.


**Reference Books :**


1. James A. Duke, *Database Manual of Biologically Active Phytochemicals and Their Activities*, Taylor & Francis Group, 2020.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY345L** | Phytopharmaceuticals: Engineering & Production | L | T | P | C |

| | | | | | |
|---|---|---|---|---|---|
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Food & Agriculture Biotechnology | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Remember the phytocompounds and different classes of phytocompounds.

CO2 : Understand the role of phytocompounds as prebiotics, anti-inflammatory, anti-virals.

CO3 : Understand the phytocompounds that are used as commercial medicines.

CO4 : Apply the knowledge to engineering metabolic pathway for production of phytocompounds.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 1 | - | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 1 | 3 | 2 | 3 | 3 | 3 | 3 |
| CO3 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |
| CO5 | 3 | 2 | 1 | 1 | - | 2 | - | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 3 |
| CO6 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 1 | 2 | 1 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 12 lecture hours**

**Introduction of phytochemicals:** Definition, history of use, primary and secondary metabolites, Secondary metabolites as phytopharmaceuticals, classification of phytopharmaceuticals: Phenolics, terpenoids & steroids, Alkaloids, phytoalexins and their role in health care.

**Module II: 15 lecture hours**

**Phytopharmaceuticals/herbal therapeutics:** Plant derived prebiotics, anti-inflammatory compounds (Aspirin, Bromelain, Harpogoside), plants derived antioxidative compounds, plant compounds with anti-cancer properties (Colchicine, podophyllotoxin, Taxol, vincristine and vinblastine; sitosterol), active compounds of Indian berries with potential of cancer prevention, anticancer phytocompounds: experimental and clinical updates, essential oils in prevention of pathogenic biofilm, Plant derived molecules for management of HIV infection and malaria (Quinine), phytochemicals as antipathogenic drugs, immunomodulators, for curing diabetes, cardiovascular diseases (Digitoxin), hay fever, mental health (Ginkgolides, Hyoscyamine), sleep disorder, liver diseases, eye disorder (Atropine) Development of standardized phytopharmaceuticals.

**Module III: 15 lecture hours**

**Engineering to produce phytopharmaceuticals:** Pathway engineering of the healthy phytochemicals for biosynthesis in edible parts of the plants, improved phytochemical production by plant cell culture, organ cultures, genetic engineering, hairy roots with biosynthetic potentials of new phytochemicals, metabolic engineering and synthetic biology to produce phytochemicals.

**List of Experiments :**

Due to pandemic the lab will not run in the electives. So, experiments have not been designed yet.

**Text Books :**

1. Sajjad, Mohd, Ahmad Khan, Iqbal Ahmad, and Debprasad Chattopadhyay. *New Look to Phytomedicine: Advancements in Herbal Products as Novel Drug Leads*. Academic Press, 2018.
2. Chandra, Suman, Hemant Lata, and Ajit Varma. *Biotechnology for Medicinal Plants: Micropropagation and Improvement*. Berlin, Heidelberg: Springer, 2013.

**Reference Books :**

Online publications will be provided to students to get an idea about the recent research on the topics.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 30% | 30% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY346L** | Introduction to Pharmaceutical Sciences | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs):**

On completion of this course, the students will be able to:

CO1 : Demonstrate the understanding of Pharmaceutical Technology.

CO2 : Design and develop solutions to pharmaceutical problems using integrated methods.

CO3 : Understand the chemistry of drugs with respect to their pharmacological activity.

CO4 : Acquire knowledge for the criteria for the selection, formulation, and evaluation of drugs and polymers for the development of novel drug-delivery systems.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 1 | 1 | - | - | 1 | - | - | - | 2 | 1 | 1 | 3 | 3 | 2 | 2 |
| CO2 | 2 | 3 | 3 | 2 | 2 | 1 | - | - | 2 | 3 | 1 | 3 | 3 | 2 | 3 |
| CO3 | 2 | 2 | 2 | 3 | 2 | 1 | - | - | 1 | 3 | 2 | 3 | 3 | 3 | 2 |
| CO4 | 2 | 3 | 1 | 3 | 2 | 1 | 1 | - | 2 | 3 | 1 | 3 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 16 lecture hours**

Introduction to Pharmaceuticals, Pharmacognosy, Sources of Drugs, Medicinal Chemistry, Drugs classification- Antibiotics, Analgesics, Antipyretics, Antiseptics, Anti-inflammatory, Radiopharmaceuticals, Chemotherapy etc., Chemical properties, Mechanism of action, Pharmaceutical excipients, Routes of administration, Posology. Pharmaceutical Technology: Dosage forms- Solid, Liquid, Semi-solid, Aerosols, Ophthalmic, Blood and Plasma Substitutes, Cosmetology. Bioassay of Drugs and Biological Standardization. Concepts of Prodrugs. Drug toxicity.

**Module II: 16 lecture hours**

Introduction to Pharmacology, Combined effect of drugs, Pharmacokinetics and Pharmacodynamics, Pharmacogenetics. Absorption, Distribution, Metabolism and Excretion

of drugs (ADME), ADME drug interactions, Adverse Drug Reactions and treatment of poisoning.

Principles of Basic and Clinical pharmacokinetics- Drug passage across biological barriers, factors influencing absorption, plasma protein binding, Plasma drug concentration and volume of distribution. Concept of clearance- Renal, Hepatic. Clearance ratio, extraction ratio. Concept of Bioequivalence and Bioavailability.

**Module III: 10 lecture hours**

Pathophysiological Pharmacology: Peripheral and Central Nervous System, Cardiovascular System, Hemopoietic System, Urinary system, Respiratory System, Gastrointestinal Tract and Endocrine System.

Nuclear pharmacy, Pharmaceutical Biotechnology, Community Pharmacy, Regulatory agencies, Indian and International Pharmacopoeia, Pharmaceutical Jurisprudence and Ethics.

**Text Books :**

1. Stevens, Craig. 'Brenner and Stevens, Pharmacology'. *Pharmacology*, n.d.
2. Al-Achi, A., M. R. Gupta, and W. C. Stagner. *Integrated Pharmaceutics: Applied Preformulation, Product Design, and Regulatory Science*. John Wiley & Sons, 2022.

**Reference Books :**

1. Müllertz, A., T. Rades, and Y. Perrie. *Analytical Techniques in the Pharmaceutical Sciences*. New York: Springer, 2016.
2. Gibson, Mark, and Walkiria S. Schlindwein. *Pharmaceutical Quality by Design: A Practical Approach*. United Kingdom, Wiley, 2018.
3. Batchelor, H. *Biopharmaceutics: From Fundamentals to Industrial Practice*. John Wiley & Sons, 2021.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 35% | 30% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY347L** | Drug Design and Discovery | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Students will be able to understand the concept of drug design.

CO2 : Students will be able to understand the drug interactions and lead identifications.

CO3 : Students will get conceptual understanding of drug action.

CO4 : Students will be familiar with structure based drug design.

CO5 : Understand the basis for ligand-based drug design by pharmacophore modelling

CO6 : Understand the drug receptor interactions and basis of drug action and apply it in corresponding case studies.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 3 | 3 | 3 | 2 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | - | 2 | 2 | 2 | 3 | 3 | 3 | 2 |
| CO3 | 3 | 3 | 2 | 2 | 3 | 2 | 2 | - | 2 | 2 | 2 | 3 | 3 | 3 | 2 |
| CO4 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 1 | 3 | 2 | 2 | 3 | 3 | 3 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 3 | 2 | 3 | 3 | 3 | 3 | 2 |
| CO6 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | - | 3 | 2 | 3 | 3 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 7 lecture hours**

**Introduction of drug design and developmental technologies**. Introduction, Drug discovery as a process. Target Identification and Validation: Introduction to membrane proteins and classification. Key regulators of cellular function: receptors, ion channels and transporters. Drug targets: Membrane proteins, DNA, RNA, Enzymes. Receptorology: Drug-receptor interactions, Receptor theories and drug action. Lead Identification and Modification: Biological Assays, Lead Identification and High Throughput Screening.

**Module II: 12 lecture hours**

**Basics of drug action**. Interactions: Inter- and intramolecular interactions. Weak interactions in drug molecules. Chirality and drug action. Covalent, ion-ion, ion-dipole, Hydrogen bonding, C-H hydrogen bonding, dihydrogen bonding, Van der Waals interactions and the associated energies. Topological and stereochemical consideration. Structure: 2D vs 3D Structure vs. Electronic structures and importance in reactivity. Energy concept and its importance in drug action. First, Second and Third laws of thermodynamics. Enzyme kinetics and role in drug action. Enzyme Inhibition: Drug action through enzyme inhibition. Drug likeness. Drug action after Metabolism. Concept of hard and soft drugs. Toxicity properties of drugs.

**Module III: 9 lecture hours**

**Introduction to structure based drug design.** Structure Activity Relationships in drug design: Qualitative versus quantitative approaches- advantages and disadvantages. Random screening, non-random screening, drug metabolism studies, clinical observations, rational approaches to lead discovery. Homologation, chain branching, ring-chain transformations, bioisosterism. Insights into molecular recognition phenomenon. Structure based drug design, ligand based drug design Molecular docking: Autodock and Dock softwares, with successful examples. Molecular dynamics: Dynamics of drugs, biomolecules, drug-receptor complexes. Introduction to AI based drug design.

**Text Books :**


1. Stromgaard, Kristian, Povl Krogsgaard-Larsen, and Ulf Madsen. 'A Tesxt Book of Drug Design and Discovery'. *A Tesxt Book of Drug Design and Discovery*, 2016.
2. Hongmao, Sun. *A Practical Guide to Rational Drug Design*. Cambridge, England: Woodhead Publishing, 2016.
3. Klebe, Gerhard. *Drug Design -Methodology, Concepts and Mode of Action*. Springer, 2013.


**Reference Books :**


1. Parikesit, Arli Aditya, ed. *Molecular Insight of Drug Design*. London, England: IntechOpen, 2018.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 30% | 30% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY349L** | Microbiome in Health & Disease | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Microbes & Immune System | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1: Understand the fundamental concepts and composition of the human microbiome in various sites and its development over time.

CO2: Analyze the role of the gut microbiome in health and disease, including its composition, functions along the gastrointestinal tract, and its association with various disorders.

CO3 : Evaluate the impact of the microbiome on host immunity, dysbiosis, and strategies to modify the microbiome.

CO4 : Familiarize with the methods used to study the microbiome and explore its applications in various fields.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 2 | 3 | 2 | 2 | - | 2 | 2 | 1 | 3 | 3 | 3 | 2 |
| CO2 | 3 | 3 | 2 | 3 | 3 | 2 | 2 | - | 2 | 2 | 1 | 3 | 3 | 3 | 2 |
| CO3 | 3 | 3 | 2 | 3 | 3 | 2 | 2 | - | 2 | 2 | 1 | 3 | 3 | 3 | 2 |
| CO4 | 3 | 3 | 2 | 3 | 3 | 2 | 2 | - | 2 | 2 | 2 | 3 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 4 lecture hours**

**Introduction to the human microbiome:**

The human microbiome, composition at various sites in health.

Source of the organisms in the human microbiome. development of the microbiome, life changing events, personal microbiota development.

**Module II: 8 lecture hours**

**Gut Microbiome:** Composition and function of microbiome along the GI tract such as stomach, ileum and stool.

Gut microbiome changes in various diseases including liver diseases, obesity, diabetes, and other disorders.

Effects of diet and medications on the gut microbiome. Role of the gut microbiome in inflammatory bowel diseases, irritable bowel syndrome and colitis.

The gut-brain axis-effects of the gut microbiome on behavior, mood, cognition, and role in nervous system diseases.

**Module III: 8 lecture hours**

**Microbiome in health and disease:**

Role of microbiome in health. Influence of microbiome on the host immunity.

Dysbiosis. Transmission of microbiome between generation.

Effects of antibiotics. Probiotics and prebiotics.
Strategies to modify the microbiome at various sites: Fecal transplant.
The mycome and virome in health and disease.
The interaction of the components of the microbiome including bacterial-phage interactions and bacterial-fungal interactions. Impact of such interactions on host.

**Module IV: 8 lecture hours**

**Investigations and applications of microbiome:**

How the Microbiome is Studied: DNA-based analysis of microbial communities, 16S rRNA gene amplicon sequencing and shotgun metagenomics sequencing methods. Functional analysis of the microbiome from DNA sequence functional analysis, metatranscriptome, metabolome, proteome, and glycome.

Applications of microbiome: microbial therapies, microbiome in forensics, personalized therapies and diagnostics. pharmacy, nutritional companies, probiotic production and the food chain.

**Text Books :**

1. Wilson, Michael. 'The Human Microbiota in Health and Disease: An Ecological and Community-Based Approach'. In *Garland Science*, 2018.

**Reference Books :**

1. Yong Ed. *I contain multitudes: The microbes within us and a grander view of life*. Lian Pu Wen Hua, 2023.
2. Human Microbiome in Health and Disease - Part A. United States: Elsevier Science, 2022.
3. Das, Bhabatosh, and Vijai Singh. Human Microbiome in Health and Disease-Part B. Academic Press, 2022.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY351L** | Personalized Medicine & Therapeutics | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand and define the principles and applications of personalized medicine to differentiate it from conventional medicine. Explain the molecular basis of personalized medicine, including drug metabolism, pharmacological effects, and genetic variability of drug-metabolizing enzymes. Analyse the role of OMICS technologies and biomarkers in personalized medicine. Assess the ethical, legal, and social issues related to personalized medicine.

CO2 : Apply personalized management strategies to various diseases and assess the personalized management approaches for cardiovascular, neuronal, immunological disorders, and Cystic Fibrosis. Utilize molecular diagnostic technologies to identify disease biomarkers

and guide personalized treatment plans. Evaluate the heterogeneity of drug response and its implications for personalized medicine.

CO3 : Understand and analyse nucleic acid therapeutics and gene editing approaches. Describe different approaches to nucleic acid therapeutics, including antisense, aptamers, miRNA, siRNA, mRNA, and gene therapy. They will also be able to explain the fundamental chemistry and biology of delivery methods used for nucleic acid therapeutics. Evaluate the role and limitations of gene editing approaches like CRISPR/Cas, ZFN, and TALEN in personalized medicine and analyse the status of nucleic acid therapeutics in clinical trials.

CO4 : Evaluate the role of protein therapeutics in personalized medicine and assess the therapeutic selectivity achieved through molecular recognition techniques such as bacterial display, phage display, and flow cytometry. Analyse the application of antibody therapeutics in personalized medicine, including biosimilars and case studies of specific antibodies. Evaluate the use of engineered protein scaffolds (non-antibody) in personalized medicine, such as stapled peptides, cyclic peptide toxins, and proteins based on the 10th Human Fibronectin Type III Domain. Understand the challenges and opportunities of mammalian cell-based recombinant protein therapeutics.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 1 | - | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 1 | 3 | 2 | 3 | 3 | 3 | 3 |
| CO3 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |
| CO5 | 3 | 2 | 1 | 1 | - | 2 | - | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 3 |
| CO6 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 1 | 2 | 1 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 9 lecture hours Introduction to Personalized Medicine**

Conventional Medicine vs Personalized Medicine, Molecular Basis of Personalized Medicine, Drug Metabolism and Pharmacological Effects, Enzymes relevant to Drug Metabolism, Polymorphisms of Drug Transporters and Drug Targets, Drug Response Heterogeneity and the Genetic Variability of Cytochrome P450–Metabolizing Enzymes, OMICS and Personalized Medicine, Molecular Diagnostic Technologies, Biomarkers, Ethical, Legal, and Social Issues related to Personalized Medicine.

Personalized management of miscellaneous diseases (cardiovascular, Neuronal, Immunological disorders, Cystic Fibrosis, etc.).

**Module II: 9 lecture hours**

**Nucleic Acid Therapeutics**

Nucleic acid therapeutics: Brief introduction to approaches: antisense; aptamer; miRNA and siRNAs, Circular RNAs, ribozymes; mRNA; protein interacting nucleic acids; gene therapy; fundamental chemistry/biology of delivery methods used for nucleic acid therapeutic approaches; direct delivery; viral lvectors; non-viral methods (lipid based, nanoparticle based, dendrimer based, peptide based), Molecules in clinical trials. Gene editing approaches (CRISPR/ZFN/TALEN): Methods for delivering genome-editing tools, New modifications of the CRISPR–Cas platforms, status in clinical trials.

**Module III: 10 lecture hours**

**Proteins therapeutics**

Therapeutic selectivity by molecular recognition: bacterial display; flow cytometry; phage display; ex vivo and in vivo phage display for organ specific delivery; Antibody therapeutics:

Biosimilars: origin and policy; Case studies: Amjevita and Humira; Mvasi and Avastin, TNF-α antagonists, Reslizumab.
Stapled Peptides, Cyclic Peptide Toxins, Designed Ankyrin Repeat Proteins (DARPins), Proteins Based on the 10th Human Fibronectin Type III Domain: T Cell Receptor Engineering, Engineering Knottins. Other engineered protein scaffolds (non-antibody): homogenous secondary structure and their generation – how to engineer them; mechanism; Mammalian cell based recombinant protein therapeutics; case study 1 – Kunitz domain.

**List of Experiments :**

1. Project on Aptamer based diagnostic design.
2. Project on phage display.

**Text Books :**

1. Vaughan, Tristan, Jane Osbourn, Bahija Jallal, and Raimund Mannhold. *Gerd Folkers and Helmut Buschmann, Protein Therapeutics*. Wiley-VCH, 2017.
2. Patrinos, G. P., P. B. Danielson, and W. J. Ansorge. 'Molecular Diagnostics'. In *Molecular Diagnostics*, 1–11. Elsevier, 2017.

**Reference Books :**

1. Kewal, K. 'Textbook of Personalized Medicine'. *), Humana* 9781493925520 (2015).

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 30% | 30% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY353L** | Biorefinery & Bioeconomy | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Bioprocess Design & Upscaling | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:
CO1 : Understand basic concept of bioeconomy, biorefinery and biofuels.
CO2 : Understand upcoming new markets in the field of biotechnology.
CO3 : Develop skills of advanced technologies involved in biofuel production.
CO4 : Acquire advanced knowledge about different types of bulk and high-value bio-based products, their production methods.
CO5 : Develop necessary skills to work with the most recent bioprocesses involved in platform chemical development.
CO6 : Design new biochemical engineering processes relevant to biorefinery.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 2 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 2 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 2 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 1 | 3 | 3 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 1 | 3 | 3 | 3 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO6 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 14 lecture hours**

**Bio-economy and bio-based feedstock:** Basic concept of bio-economy and circular economy. Potential impact of bio-economy on food market and deforestation. Current commercial food grade feedstock in bio-economy: Sugarcane, corn and vegetable oils. Industrial wastes as potential feedstock in bio-economy: Crude glycerol, molasses, sugarcane bagasse, paper and pulp industry waste, apple pomace. Agricultural wastes as potential feedstock in bio-economy: Wheat straw, rice straw, rice husks, maize stover (stalks, leaves, husks, and cobs), corn stover. Lignocellulosic forest residues, algae and seaweeds as feedstock. Feedstock pre-treatment and hydrolysis techniques.

**Module II: 14 lecture hours**

**Bio-fuels and biorefinery:** Concept of biorefinery and sustainable development. Production methods, downstream processing and commercial potential of biofuels: bioethanol, farnesene, biodiesel, biogas, biobutanol, biohydrogen, microbial fuel cell technology, pyrolysis, biooil, syngas. Integrated biofuel and industrial chemical production under biorefinery framework. Petroleum based refinery vs. biorefinery. Algal biorefinery.

**Bulk bio-products:** Production of biopolymers: Polyhydroxyalkanoate (PHA), nanocrystalline cellulose (NCC), polylactic acid (PLA), bio-based polyamides (PA). Bio-based propylene glycol (PG). Bio-based 1,3-Propanediol (PD). Bio-based epichlorohydrin. Bio-based glycols. Bioplastics. Drop-in chemicals.

**Phyto-chemicals:** Alkaloids (coffeine, nicotine, quinine, imidazole, isoquinoline), monoterpene (picrocrocin/ safranal), sesquiterpene (solanesol), diterpene, triterpene, tetraterpenoids/carotenoids (crocin), flavonoids.

**Module III: 14 lecture hours**

**Bio-based platform chemicals:** Recent advances on production and purification of top 12 bio-based platform chemicals. Succinic acid, fumaric acid, malic acid, 2,5-furan dicarboxylic acid (FDCA), 3-hydroxypropionic acid (3-HPA), glucaric acid, glycerol, aspartic acid, itaconic acid, 3-hydroxybutyrolactone, sorbitol, xylitol/arabinitol, glutamic acid, levulinic acid. Application of metabolic engineering for enhanced production of platform chemicals.

**Text Books :**


1. Wittmann, Christoph, and James C. Liao, eds. *Industrial Biotechnology*. PDF. Advanced Biotechnology. Weinheim, Germany: Wiley-VCH Verlag, 2017.
2. Brar, S. K., S. J. Sarma, and K. Pakshirajan. 'Platform Chemical Biorefinery: Future Green Industry'. *), Elsevier*, 2016.
3. Okafor, Nduka, and Benedict C. Okeke. *Modern Industrial Microbiology and Biotechnology*. 2nd ed. London, England: CRC Press, 2021.


**Reference Books :**


1. Shuler, M. L., and F. Kargi. *Bioprocess Engineering-Basic Concepts*. Prentice Hall, 2004.
2. Doran, Pauline M. *Bioprocess Engineering Principles*. 2nd ed. Academic Press, 2012.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY348L** | Computational Genomics | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 2 | 0 | 2 | 3 |
| **Pre-requisites/Exposure** | Introduction to Bioinformatics | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand, use, and analyze the algorithms used for motif discovery, gene finding, and phylogenetic tree construction.

CO2 : Understand genomic sequence alignment methods

CO3 : Apply appropriate methods and algorithms for the analysis of diverse types of genomics information.

CO4 : Understand and perform genome assembly, variant calling, and variant annotation from the NGS dataset.

CO5 : Understand Data compression techniques used in NGS

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 3 | 3 | 3 | 2 |
| CO2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | - | 2 | 2 | 2 | 3 | 3 | 3 | 2 |
| CO3 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | - | 2 | 2 | 2 | 3 | 3 | 3 | 2 |
| CO4 | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 1 | 3 | 2 | 2 | 3 | 3 | 3 | 2 |
| CO5 | 3 | 3 | 2 | 2 | 3 | 2 | 2 | 1 | 3 | 2 | 3 | 3 | 3 | 3 | 2 |
| CO6 | 3 | 3 | 2 | 2 | 3 | 2 | 2 | - | 3 | 2 | 3 | 3 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents :**

**Module I: 7 lecture hours**

Basics of genome analysis: Gene panels (QC, troubleshooting). Representations and Basic Algorithms; Motif discovery algorithms; Gene finding methods; Special cases of sequence alignments; Probabilistic models of multiple sequence alignment; BLAST Algorithms and Programs; Molecular evolution and Phylogenetic Analysis: Distance and character-based methods.

**Module II: 8 lecture hours**

NGS file formats: Raw data files: fasta and fastq; Alignment files: SAM and BAM; Bed format; Variant call format; Format for representing density data; Algorithms and data structures for NGS.

NGS Read mapping: Read mapping problem; Aligning reads; Allowing a small number of mismatches and indels; Seed and Extension approach; Filter based approach; Paired-end alignment.

Genome Assembly: Whole-genome shotgun sequencing; Whole-genome sequencing; Mate-pair sequencing; De novo genome assembly for short reads; Spectral alignment approach; k-mer counting; Base by base extension approach; De Bruijn graph approach; Scaffolding; Gap-filling; De novo genome assembly for long reads; Assemble long reads assuming long reads have a low sequencing error rate; Use mate-pair reads and long reads to improve the assembly from short reads; Use short reads to correct errors in long reads; Long read approach; Evaluating goodness of assembly.

**Module III: 8 lecture hours**

Single nucleotide variation calling: Single locus SNV calling; Single locus somatic SNV calling; General pipeline for calling SNVs; Local realignment; Duplicate and marking; Base quality score recalibration; Rule-based filtering; Computational methods to identify small indels; Correctness of existing SNV and indel callers.

Structural variation calling: CNV calling; SV calling pipeline; Identifying candidate SVs from paired-end reads; Verifying the SVs.
RNA-seq: RNA-seq read mapping; Transcript model; Splice junction signals; Exon-first approach; Seed and extend approach; Construction of isoforms; Estimating expression level of each transcript.

**Module IV: 5 lecture hours**

Peak calling methods: Model fragment length; Modeling noise using control library; Noise in sample library; Determination of peak significance; Unannotated high copy number regions; Constructing a signal profile by Kernel methods; Sequencing depth of ChiP-seq libraries.
Data compression techniques used in NGS: Techniques to compress DNA bases; Statistical approach; BWT based approach; Reference-based approach; Assembly based approach; Quality score compression methods; Lossless compression; Lossy compression.

**List of Experiments :**

1. Motif search algorithms
2. Understanding BLAST algorithm
3. Phylogenetics tree construction
4. Understanding the fastq format: QC and alignment of reads
5. WES and WGS analysis
6. RNA-seq analysis
7. ChIP-seq analysis

**Text Books :**

1. Rocha, M., and P. G. Ferreira. *Bioinformatics Algorithms: Design and Implementation in Python*. Academic Press, 2018.
2. Sung, W. K., *Algorithms for Next-Generation Sequencing*, CRC Press, 2017.
3. Kappelmann-Fenzl, M., *Next-Generation Sequencing and Data Analysis*, Springer Nature, 2021.

**Reference Books :**

1. Lambert, C., Baker, D., & Patrinos, G. P. (Eds.), *Human Genome Informatics: Translating Genes Into Health*, Academic Press, 2018.

**Assessment Scheme :**

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 50% | 25% | 25% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B.Tech. Biotechnology | | | | |
| **EBTY350L** | Fundamentals of Neuroscience | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | Cellular and Molecular Biology | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:
CO1 : Explain the nervous system, parts of the brain, and their functions.
CO2 : Define neurophysiology, types, and the role of neurotransmitters and different sensory systems.
CO3 : Understand cognitive activities of the brain and techniques used to measure those activities.

CO4 : Discuss information on different neurological disorders, databases, and animal models.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 1 | - | - | 2 | - | - | - | 1 | - | 3 | 3 | 1 | - |
| CO2 | 2 | 2 | 1 | - | - | 2 | - | - | - | 2 | - | 3 | 3 | 1 | - |
| CO3 | 2 | 2 | 2 | 2 | 3 | 3 | - | 1 | 1 | 2 | - | 3 | 3 | 3 | 1 |
| CO4 | 2 | 2 | 2 | 2 | 3 | 3 | - | 1 | 1 | 2 | - | 3 | 3 | 3 | 1 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 12 lecture hours**

Historical perspectives of neuroscience, an outline of the nervous system, organization of the brain, parts, and their functions, brain cells, blood-brain barrier, neurophysiology: membrane potential and the passive electrical properties of the neuron, action and resting potential, synaptic transmission, and neurotransmitters.

**Module II: 18 lecture hours**

Sensory systems: receptors of the somatosensory system and mechanism; vision: visual processing for attention and action; hearing: auditory processing by the central nervous system; olfaction: smell and taste: the chemical senses; and motor system: sensory-motor integration in the spinal cord. Techniques used to monitor neurological activities.

**Module III: 12 lecture hours**

The immune system of the brain. Learning, Memory, Language and Cognition, Decision-Making and Consciousness, Diseases of the Nervous System- Prion diseases, Neurodegenerative diseases, Brain Tumors, Stroke Biology, Disorders of Mood and Anxiety. Databases for neurological disorders. Therapeutics and animal models for neurological disorders.

**Text Books :**


1. Kandel, Eric R., John D. Koester, Sarah H. Mack, and Steven A. Siegelbaum. *Principles of Neural Science, Sixth Edition*. 6th ed. McGraw-Hill Education/Medical, 2021.
2. Bear, Mark F., Barry W. Connors, and Michael A. Paradiso. *Neuroscience*. 3rd ed. Philadelphia, PA: Lippincott Williams and Wilkins, 2006.


**Reference Books :**


1. Stein, J. F., and Catherine Stoodley. 'Neuroscience an Introduction'. *Neuroscience an Introduction*, 2006.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

# OPEN ELECTIVE

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY181L** | Genetics and Genes | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand and predict the ratio of a specific genotype and/or phenotype from a cross.
CO2 : Understand, perform and interpret the results of a Chi-square analysis.
CO3 : Interpret the most likely mode of inheritance based on pedigree chart.
CO4 : Understand the molecular basis of genetic diseases and repair mechanisms.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 1 | - | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 1 | 3 | 2 | 3 | 3 | 3 | 3 |
| CO3 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |
| CO5 | 3 | 2 | 1 | 1 | - | 2 | - | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 3 |
| CO6 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 1 | 2 | 1 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 15 lecture hours**

Mendel's laws of heredity. Chromosomal theory of heredity, Morgan's work, Beyond Mendelian Genetics, Genotype and Phenotype ratios, Probability-Definition, Sum and Multiplication rules. Binomial Expansion Equation and its application in genetics, Test of hypothesis using Chi-square test.

**Module II: 15 lecture hours**

**Gene, Mutations and Genetic Disorders:** Concept of gene, Structure of prokaryotic and Eukaryotic genes, Mutations and their classification, spontaneous, induced, lethal, Mutagens: their types and actions, Detection of Mutation: PCR, Agarose Gel Electrophoresis, RFLP, Introduction to inheritance patterns, Pedigree Analysis, Examples and case study for genetic diseases, Congenital vs Hereditary Diseases.

**Module III: 12 lecture hours**

**Changes in Chromosome number and structure:** Chromosomes and Chromatin, Dosage compensation, Ploidy and its types, Chromosomal Aberrations- deletion, duplication, inversion, and translocation, Prenatal diagnosis of chromosomal abnormalities: Amniocentesis, Chorionic Villus sampling, Karyotyping, Examples and case study for genetic diseases.
DNA damage, Repair Mechanisms and Recombination.

**Text Books :**


1. Robert, Brooker. 'Genetics: Analysis and Principles' 9781259616020 (2017).
2. Snustad, D. Peter, and Michael J. Simmons. *Principles of Genetics, 7e Binder Ready Version with WileyPLUS Blackboard Card Set*. Nashville, TN: John Wiley & Sons, 2016.


**Reference Books :**


1. Goldberg, Michael, Janice Fischer, Leroy Hood, and Leland Hartwell. *Loose Leaf for Genetics: From Genes to Genomes*. 8th ed. McGraw-Hill Companies, 2023.


**Assessment Scheme :**

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 30% | 30% | 40% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY183L** | Biological Machines | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 0 | 3 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Explain the role of different cell organelles working as individual machines and their action in a highly coordinated fashion to maintain cellular activities.

CO2 : Understand the cellular machinery required for protein synthesis, transport of molecules across cellular membranes, protein folding, and degradation.

CO3 : Understand the electrical properties of cell membranes and the mechanism for muscle contraction.
CO4 : Understand the consequences of malfunctioning of cellular machinery leading to diseases.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | **2** | **1** | - | - | - | **2** | - | - | **2** | **2** | **1** | **2** | **3** | **3** | **2** |
| CO2 | **2** | **1** | - | - | - | **2** | - | - | **2** | **2** | **1** | **2** | **3** | **3** | **2** |
| CO3 | **2** | **1** | - | - | - | **2** | - | - | **2** | **2** | **1** | **2** | **3** | **3** | **2** |
| CO4 | **2** | **1** | - | - | - | **2** | - | - | **2** | **3** | **1** | **2** | **3** | **3** | **2** |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 15 lecture hours**

**Cell as a Machine:** Introduction to Prokaryotic & eukaryotic cells, Different cell components as individual machines: Plasma membrane, Cell wall, Nucleus, Nucleolus, Ribosomes, Mitochondria, Chloroplast, Vacuoles, Centrioles, Glyoxisomes, Peroxisomes Endoplasmic reticulum, Golgi apparatus and Lysosomes, Cytoskeleton: Role in transport of cells and Organelles. Proteins as major functional molecules: Introduction to amino acids and protein synthesis. Machinery for the protein Transport to their site of action.

**Module II: 15 lecture hours**

**Cellular Transport Machinery:** Cellular Transport machinery: Simple diffusion, Active and passive transport of molecules across membrane, Electrical properties of membranes and Action potential, Muscle contraction: motor proteins, myosin and actin, kinesin and dynein. The GroEL/GroEs Chaperonin machine, ATP synthase – a paradigmatic molecular machine, ATP-dependent proteases: The degradation machines.

**Module III: 12 lecture hours**

**Malfunctioning of Cellular Machinery and their effects:** Malfunctioning of protein synthesis/transport mechanisms/folding mechanisms: Cause and effects of Progeria, Diabetes, Cystic Fibrosis, Sickle Cell Anemia, Parkinson, Prion Diseases, Kuru, Alzheimer's disease, Schizophrenia.

**Text Books :**


1. Sheetz, Michael, and Hanry Yu. *Cambridge Texts in Biomedical Engineering: The Cell as a Machine*. Cambridge, England: Cambridge University Press, 2018.
2. Karp, Gerald. *Cell and Molecular Biology: Concepts and Experiments 8e Binder Ready Version + WileyPLUS Learning Space Registration Card*. 8th ed. Nashville, TN: John Wiley & Sons, 2016.


**Reference Books :**


1. Alberts, Bruce, Rebecca Heald, Alexander Johnson, David Morgan, Martin Raff, Keith Roberts, and Peter Walter. *Molecular Biology of the Cell (Seventh Edition)*. New York, NY: WW Norton, 2022.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 45% | 20% | 35% | 100% |

# MINOR COURSES

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY281M** | Principles of Genetics | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 4 | 0 | 0 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand basic principles of Mendelian inheritance and to predict the ratio of a specific genotype and/or phenotype from a cross.

CO2 : Able to perform and interpret the results of a Chi Square analysis.

CO3 : Apply the knowledge to decide the most likely mode of inheritance based on pedigree chart.

CO4 : Understand the molecular basis of genetic diseases and repair mechanisms.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 1 | 3 | 1 | 1 | - | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 1 | 3 | 2 | 3 | 3 | 3 | 3 |
| CO3 | 1 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 20 lecture hours**

**Mendelian Genetics:** Monohybrid, Dihybrid crosses. laws of heredity. Chromosomal theory of heredity, Non-Mendelian Genetics, Probability: Sum and Multiplication Rules, Application of Binomial Expansion Equation in genetics, Chi-square test and its application in analysis of genetic data.

**Module II: 18 lecture hours**

**Mutations and Genetic Disorders:** Mutations and their classification, spontaneous, induced, lethal, Mutagens: their types and actions, Detection of Mutation: PCR, Agarose Gel Electrophoresis, RFLP. Congenital vs Hereditary Diseases, Introduction to inheritance patterns, Pedigree Analysis, Examples and case study for genetic diseases.

**Module III: 18 lecture hours**

**Changes in Chromosome number and structure:** Chromosomes and Chromatin, X-chromosome Inactivation, Chromosomal Aberrations, Polyploidy, Aneuploidy, Chromosomal rearrangements - deletion, duplication, inversion, and translocation, Karyotyping. Examples and case study for genetic diseases. DNA damage, Repair Mechanisms and Recombination.

**Text Books :**


1. Robert, Brooker. *Genetics: Analysis and Principles*. Vol. 9781259616020. McGraw-Hill Education, 2017.
2. Snustad, D. Peter, and Michael J. Simmons. *Principles of Genetics*. 7th ed. Nashville, TN: John Wiley & Sons, 2015.


**Reference Books :**


1. Goldberg, Michael, Janice Fischer, Leroy Hood, and Leland Hartwell. *Loose Leaf for Genetics: From Genes to Genomes*. 8th ed. McGraw-Hill Companies, 2023.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 45% | 20% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY282M** | Basic Molecular Biology | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 4 | 0 | 0 | 4 |
| **Pre-requisites/Exposure** | Principles of Genetics | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:
CO1 : Understand the mechanisms of DNA replication, transcription, and translation.
CO2 : Apply the regulatory mechanisms of gene expression for solving problems.
CO3 : Remember the post-translational modifications and applications of proteins.
CO4 : Apply knowledge to make gene knockdown using RNA interference.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 1 | 3 | 1 | 1 | - | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 1 | 3 | 2 | 3 | 3 | 3 | 3 |
| CO3 | 1 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 20 lecture hours**

**DNA and its Replication:** Discovery of structure of DNA, Physicochemical properties of DNA, DNA packaging: Role of Histone proteins, Genome organization in prokaryotes and eukaryotes, structure of eukaryotic and prokaryotic gene, Central dogma of Molecular Biology, DNA Replication: Models of DNA replication, DNA replication in prokaryotes and eukaryotes.

**Module II: 20 lecture hours**

**Transcription and Post-transcriptional Processing:** Types and structure of RNA, Mechanism of transcription in prokaryotes and eukaryotes, Regulation of gene expression: Induction and repression, Concept of operon model with example of Lac Operon, Post transcriptional processing of mRNA – 5'capping, splicing, polyadenylation. Regulation of gene expression in eukaryotes.

**Module III: 16 lecture hours**

**Translation and Application of proteins:** The genetic code and amino acids, Selenocysteine and Pyrrolysine as amino acids, Wobble Hypothesis, Codon usage, Translation in Prokaryotes and Eukaryotes, Post-translational modifications and their importance. Applications of proteins. RNAi regulatory mechanisms.

**Text Books :**


1. Lodish, Harvey, Arnold Berk, Chris Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Kelsey Martin, Michael Yaffe, and Angelika Amon. *Molecular Cell Biology*. 9th ed. New York, NY: W.H. Freeman, 2021.
2. Karp, Gerald. *Cell and Molecular Biology: Concepts and Experiments 8e Binder Ready Version + WileyPLUS Learning Space Registration Card*. 8th ed. Nashville, TN: John Wiley & Sons, 2016.


**Reference Books :**


1. Krebs, Jocelyn E., Elliott S. Goldstein, and Stephen T. Kilpatrick. *Lewin's GENES XII*. 12th ed. Sudbury, MA: Jones and Bartlett, 2017.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 45% | 20% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY381M** | rDNA Technology & Genomics | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 4 | 0 | 0 | 4 |
| **Pre-requisites/Exposure** | Principles of Genetics | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the basic concepts of recombinant DNA technology and different types of cloning methods that are used for making recombinant DNA.

CO2 : Apply different enzymes for designing recombinant DNA for making transgenic organisms.

CO3 : Explain different type of PCR techniques that can be used to develop rDNA technology.

CO4 : Apply the knowledge to select different vectors and host systems to generate genetically modified organisms.

CO5 : Explain technologies available to make different DNA libraries for genome sequencing.

CO6 : Create genetically modified organisms, transgenic bacteria and yeast.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | 1 | - | 2 | - | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 1 | 1 | 2 | 3 | 3 | 3 | 3 | 2 |
| CO3 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |
| CO5 | 3 | 2 | 1 | 1 | - | 2 | - | 1 | 1 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO6 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 1 | 2 | 1 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 22 lecture hours**

**Introduction to Cloning:** Introduction and History of rDNA technology, Enzymes used in gene cloning, Cloning and Expression Vectors, Host cells: Prokaryotic hosts, Eukaryotic hosts, Different methods for introduction of recombinant DNA into the host cells and selection methods. Analysis and expression of cloned gene in host cells: Blotting Techniques, Q-PCR.

**Module II: 18 lecture hours**

**Sequencing and Editing of Genome:** Genome Sequencing Projects, DNA Sequencing Technologies: Shotgun Method of Sequencing, Sanger Dideoxy sequencing method, Automated DNA Sequencing, Pyrosequencing; Construction and Screening of genomic and cDNA libraries, Gene Silencing (RNAi) and Genome Editing tools: TALEN, ZFN, CRISPR-Cas.

**Module III: 16 lecture hours**

**Applications of rDNA Technology and Genomics.** Applications of rDNA technology in industry, medicine and agriculture, Production of recombinant proteins and therapeutics

(insulin, somatostatin, interferons, vaccines etc), GMOs: Generation, biosafety, ethics and controversy, Gene therapy, Pharmacogenomics: Concepts and Applications in Healthcare.

**Text Books :**


1. Brown, T. A.. Gene Cloning and DNA Analysis: An Introduction. United Kingdom: Wiley, 2020.
2. Brown, T. A.. Gene Cloning and DNA Analysis: An Introduction. Germany: Wiley, 2016.


**Reference Books :**


1. Primrose, Sandy B.., Twyman, Richard. Principles of gene manipulation and genomics. Hong Kong: Wiley, 2006.
2. Glick, Bernard R.., Patten, Cheryl L.. Molecular Biotechnology: Principles and Applications of Recombinant DNA. India: Wiley, 2017.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 45% | 20% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY382M** | GMOs & Industry | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 4 | 0 | 0 | 4 |
| **Pre-requisites/Exposure** | rDNA Technology & Genomics | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the concept of genetically modified organisms (GMOs)

CO2 : Explain methods for GMO production, and their use in the production of proteins in microorganisms, higher organisms, and transgenic animals and plants.

CO3 : Explain the use of GMOs in the production of primary metabolites, enzymes, small molecules, bio-degradable plastics, and plants with improved nutrition and understand regulatory policies for GMOs.

CO4 : Discuss the policy issues related to genetically modified crops.

CO5 : Analyze applications of genetic engineering technologies in research and therapy to produce antibiotics, anti-tumor agents, and biopharmaceuticals from GMOs.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

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

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 20 lecture hours**

Introduction of GMOs: Microbial GMOs, protein production by genetically modified microorganisms, mammalian GMO's, protein production in higher organisms, transgenic animals, plant GMO's, itvalue creation in transgenic plants. Different methods of GMOs production.

**Module II: 18 lecture hours**

GMOs for primary metabolites production: amino acids, vitamins, nucleotides, citric acids, acetic acid; GMOs for enzyme production, rapamycin, artemisinin, Spinosad, Xanthan Gum, trypsin; GMOs for better nutrition; GMOs for bio-degradable plastics; regulations of GMOs, Policy Issues in Genetically Modified Crops.

**Module III: 18 lecture hours**

Genetic Engineering in Research and Therapy, GMOs for antibiotics production; anti-tumor agents; GMOs for biopharmaceuticals production: vaccines, antibiotics, insulin, erythropoietin, factor VIII, tissue plasminogen activator, edible vaccines.

**Text Books :**


1. Parekh, Sarad R., ed. *The GMO handbook: genetically modified animals, microbes, and plants in biotechnology*. Springer Science & Business Media, 2004.
2. Piguet, Pascale, and Philippe Poindron. "Genetically modified organisms: concepts and methods." In *Genetically Modified Organisms and Genetic Engineering in Research and Therapy*, vol. 3, pp. 1-32. Karger Publishers, 2012.
3. Policy Issues in Genetically Modified Crops: A Global Perspective. Netherlands: Elsevier Science, 2020.


**Reference Books :**


1. https://www.who.int/health-topics/food-genetically-modified#tab=tab_1


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 40% | 25% | 35% | 100% |

# SPECIALIZATIONS

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY361L** | Biomedical Technologies in diagnostic and Therapy | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 4 | 0 | 0 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Demonstrate an understanding of the principles and approaches utilized in tissue engineering for regenerative medicine applications.

CO2 : Comprehend the underlying principles of various biomedical technologies used in diagnostics, therapeutics, and biomedical research.

CO3 : Gain knowledge regarding the principles governing biomedical devices, their development process, and their applications across different healthcare domains.

CO4 : Recognize and address the challenges and considerations associated with the aforementioned fields.

CO5 : Apply acquired knowledge to real-world scenarios and practical applications.

CO6 : Employ critical thinking skills to evaluate and interpret scientific literature effectively.

CO7 : Stay updated with emerging trends and advancements in the field.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 2 | 2 | 3 | 1 | - | 1 | 2 | 2 | 1 | 3 | 3 | 2 | 1 |
| CO2 | 3 | 2 | 2 | 2 | 3 | 1 | - | 2 | 2 | 2 | 1 | 3 | 3 | 2 | 1 |
| CO3 | 3 | 1 | 2 | 3 | 3 | 1 | - | 1 | 2 | 2 | 1 | 3 | 3 | 2 | 1 |
| CO4 | 3 | 1 | 2 | 2 | 3 | 1 | - | 2 | 2 | 2 | 1 | 3 | 3 | 2 | 1 |
| CO5 | 3 | 1 | 2 | 2 | 3 | 1 | - | 2 | 2 | 3 | 1 | 3 | 3 | 2 | 1 |
| CO6 | 3 | 2 | 3 | 3 | 3 | 1 | - | 1 | 2 | 3 | 1 | 3 | 3 | 2 | 2 |
| CO7 | 3 | 1 | 2 | 1 | 3 | 1 | - | 1 | 2 | 2 | 2 | 3 | 3 | 2 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 20 lecture hours**

Introduction to stem cells and tissue engineering, current advances, applications, and limitations. Tissue engineering- Fabrication and manufacturing techniques. Scaffolds for Tissue Engineering, Electrospinning for scaffold fabrications. Current status of tissue engineered organs. Hydrogels based materials for tissue engineering, Tissue engineered skin grafts, cardiac tissue engineering, engineered bone, cartilage and ligaments. Ethical and regulatory issues and safety considerations.

**Module II: 16 lecture hours**

Introduction to Biomedical Technologies. Introduction to 3D Bioprinting process, technologies and tools. Development of printable materials- material characteristics, biomaterials and Cell sources. Non-biological- fused deposition modeling (FDM), stereolithography. Introduction to electronic implants. Lasers and their applications in medicine and biology. Introduction to radiation oncology, Applications and clinical guidelines for success. Introduction to Electrocardiography (ECG) and Electroencephalography (EEG) system.

**Module III: 20 lecture hours**

Introduction to biomedical devices and diagnostic development process. Delivery devices, pre-filled syringes, autoinjectors-wearable, pumps. micro needles- fabrication and their applications towards biomedical engineering. Skin patches and types, topical skin applications-plain dressings, Advanced biomaterials, nanocellulose, chitosan and synthetic polymers. Cardiovascular devices- artificial heart valve, Pacemaker, Vascular stent. Skeleton devices. Introduction to hearing devices. Introduction to medical devices industry. Diathermy-

shortwave, microwave and ultrasound. Active ingredients delivery- drugs, peptides and proteins, metals, natural compounds.

**Text Books :**

1. Kalaskar, Deepak M., ed. *3D printing in medicine*. Woodhead Publishing, 2022.
2. Paladini, Federica. and Pollini, Mauro. *Bio-Inspired Materials for Biomedical Applications*. Switzerland: MDPI AG, 2021.

**Reference Books :**

1. Street, Laurence J. *Introduction to Biomedical Engineering Technology: Health Technology Management*. CRC press, 2022.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY362L** | Bioimaging | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 4 | 0 | 0 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the fundamentals of bioimaging and medical imaging techniques used in biomedical research, clinical diagnostics, and other relevant fields

CO2 : Comprehend the advantages and limitations associated with different bioimaging modalities

CO3 : Gain an understanding of the procedures and safety guidelines related to imaging techniques

CO4 : Demonstrate the ability to effectively select and apply suitable bioimaging methods and protocols for acquiring image data

CO5 : Develop proficiency in conducting fundamental image pre-processing and segmentation tasks

CO6 : Understand the principles and methods used for accurate and efficient image classification through machine learning.

CO7 : Possess the requisite knowledge and skills to pursue advanced studies or embark on careers in the field of medical imaging.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 1 | 3 | 1 | 1 | - | 3 | 1 | - | 3 | 3 | 2 | 1 |
| CO2 | 3 | 2 | 2 | 1 | 3 | 1 | 1 | - | 3 | 1 | - | 3 | 3 | 2 | 1 |
| CO3 | 3 | 2 | 2 | 2 | 3 | 1 | 1 | - | 3 | 2 | - | 3 | 3 | 2 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | - | 3 | 2 | - | 3 | 3 | 2 | 2 |
| CO5 | 3 | 2 | 2 | 1 | 3 | 1 | 1 | - | 3 | 2 | - | 3 | 3 | 2 | 2 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO6 | 3 | 2 | 2 | 2 | 3 | 1 | 1 | - | 3 | 2 | - | 3 | 3 | 2 | 2 |
| CO7 | 3 | 3 | 2 | 2 | 3 | 1 | 1 | - | 3 | 2 | - | 3 | 3 | 2 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Content**

**Module I: 20 lecture hours**

Bioimaging and Medical imaging overview. Procedures and safety guidelines towards imaging techniques. Retinal imaging and Basics of image and texture analysis. Bioimgaing in Computer-aided detection and diagnosis. of diabetic retinopathy

Optical coherence tomography tissue characterization. Optical microscopy and confocal microscopy: instrumentation and image analysis, Histopathology image analysis, (semi)automatic mitotic figure detection methods on regions extracted from whole-slide pathology images, live-cell studies, automatic approaches for cell tracking.

**Module II: 18 lecture hours**

X-ray imaging and Mammogram. Ultrasound imaging. Digitized ECG image analysis.

Introduction to Tomography with historical perspective and basic principles of tomography. Computed tomography (CT) imaging, CT Reconstruction, and segmentation of blood vessels in the lungs from CT images.

Nuclear Medicine- Radiotracers, Pillcam, PET/SPECT imaging.

**Module III: 18 lecture hours**

Introduction to Magnetic Resonance Imaging (MRI), fundamental principles of MRI, and basic overview of MRI applications. Potential, limitations, and pitfalls of MRI. MRI imaging procedure and safety. Digital image processing – Methodology and Applications. Applications of nanotechnology in medical imaging.

**Text Books :**


1. Vadivambal, Rajagopal, and Digvir S. Jayas. *Bio-imaging: principles, techniques, and applications*. CRC Press, 2015.
2. Rangayyan, Rangaraj M.. Biomedical image analysis. United Kingdom: Taylor & Francis, 2005.


**Reference Books :**


1. Shukla, Ashutosh Kumar, ed. *Medical Imaging Methods: Theory and Applications*. CRC Press, 2021.
2. Wheeler, Ann, and Ricardo Henriques, eds. *Standard and super-resolution bioimaging data analysis: a primer*. John Wiley & Sons, 2017.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY461L** | Medical Innovations | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 4 | 0 | 0 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the technological trends in healthcare industry.

CO2 : Explain different techniques employed for therapeutic, monitoring and diagnostic purposes.

CO3 : Understand the applications of innovations in healthcare

CO4 :Acquire knowledge of applications of Biotechnology in healthcare.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 1 | 3 | - | - | - | - | - | - | - | 1 | 1 | 3 | 3 | 2 | 2 |
| CO2 | 2 | 2 | - | 2 | - | 1 | - | - | 1 | 3 | 1 | 3 | 3 | 2 | 3 |
| CO3 | 1 | 3 | - | 3 | 1 | - | - | 1 | - | 3 | 2 | 3 | 3 | 3 | 2 |
| CO4 | 2 | 2 | 1 | 2 | 1 | 1 | - | 2 | 3 | 3 | 1 | 3 | 3 | 3 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Content**

**Module I: 6 lecture hours**

The medical innovation process: development, implementation and validation of an idea. Protecting the idea. Regulatory frameworks. Commercialization.

**Module II: 10 lecture hours**

Innovations in preventive healthcare: Vaccines. Disease screening techniques: precision medicine (genome-based screening): case studies in diseases. Prenatal screening. Digital resources for disease prevention.

**Module III: 20 lecture hours**

Innovations in biochemical diagnostics. High throughput blood screening: AI based pathological tests, DNA and protein-based diagnostics Microbiome as diagnostic markers.
Digital resources: Project ECHO, Live 3D Brain Function Mapping, AI in brain injury diagnosis, AI in cancer diagnosis as case studies.

**Module IV: 20 lecture hours**

Innovations in therapeutics: T Cell Receptor Engineering. Microbial cancer therapies. Stem cell therapy, Implantable defibrillators, nanobots in vascular surgery and neural regenaration. Microbiome as therapy.

**Text Books :**

1. Mannhold, Raimund, Gerd Folkers, and Helmut Buschmann. *Protein Therapeutics*. John Wiley & Sons, 2017.
2. Wilson, Mike. *The Human Microbiota in Health and Disease: An Ecological and Community-based Approach*. Garland Science, 2018.
3. Dong, Haidong. and Markovic, Svetomir N. *The Basics of Cancer Immunotherapy*, Springer International Publishing, 2018.

**Reference Books :**

1. Brown, Stuart M., John G. Hay, and Harry Ostrer. *Essentials of medical genomics*. John Wiley & Sons, 2008.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 35% | 30% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY363L** | Drug Discovery and Molecular Process | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand and analyse the therapeutic molecules for their Stability, Structure Confirmation

CO2 : Understand the Principle and characteristics of drug receptor interactions

CO3 : Understand the concepts of the pharmacodynamics and pharmacokinetics ( ADME ).

CO4 : Apply the practical knowledge to identify novel drug targets associated with the specific disease.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 1 | 3 | - | - | - | 1 | - | 2 | - | 1 | 1 | 3 | 3 | 3 | 3 |
| CO2 | 2 | 3 | - | 2 | - | 1 | - | - | 1 | 3 | 1 | 3 | 3 | 3 | 3 |
| CO3 | 3 | 3 | - | 3 | 1 | - | 1 | 1 | - | 3 | 3 | 3 | 3 | 3 | 3 |
| CO4 | 3 | 3 | 1 | 3 | 3 | 3 | - | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 15 lecture hours**

**Fundamentals of Drug Discovery:** History of Drug Discovery: Past, Present and Future, Serendipity: Acetanilide vs Naphthalene**,** Case study of Aspirin, Dyes and Pharmaceuticals, Rearrangements leading to the medicines. Controversial Drugs: LSD, Anaesthetics and sedatives. Concept of receptors as a drug target, GPCR- Classification, structure, drug receptor interaction, G-protein, receptor characterization, receptor theories, agonist, antagonist. Ion channels and their classification.

Drug-receptor interactions: Principle and characteristics of drug receptor interactions, Lead Identification and Modification: Biological Assays, Lead Identification and High Throughput Screening.

**Module II: 15 lecture hours**

**Disease Biology and Drug Targets:** Introduction to major classes for drugs, Diversity of Molecular Drug Targets, Introduction to human diseases and disorders. Approaches to drug development. Classes of anti-cancer compounds. Disorders of the central nervous system (CNS) and development of novel compounds. Case studies on the development of a class of compounds.

**Module III: 12 lecture hours**

**Pharmacokinetics:** Principles of pharmacokinetics, Relationship - dynamics and kinetics. Approaches towards pharmacokinetics, Absorption, Distribution, Metabolism, and Excretion (ADME), Drug transportation, Factors affecting absorption, Bioavailability. Biotransformation: Metabolism of drugs, Factors affecting biotransformation. Kinetics of elimination. ADME assays. Drug likeness. CNS Penetration. Therapeutic optimization, Metabolic stability, Structure-guided lead optimization. Common drug side effects- types and regulations, Toxicology studies. Drug metabolite analysis. Introduction to regulatory component.

**List of Experiments :**

1. Proteomics: Introduction to databases, software, tools, websites to retrieve information regarding therapeutic protein target
2. Retrieval and analysis of protein sequences from protein database
3. Structural analysis of protein motifs
4. Case Study: Ion channel structure analysis
5. Case Study: To understand the antitumour activity of compound towards cancer
6. Case Study: Pharmacokinetic analysis, an approach to understanding the mechanism of action of drug
7. In Silico Analysis of Phytochemicals as Potential Anti-cancer Agents
8. Cytotoxicity and Cell viability Assay
9. Investigating the anti-proliferative effects of drug

**Text Books :**


1. Stromgaard, Kristian, Povl Krogsgaard-Larsen, and Ulf Madsen, eds. *Textbook of Drug Design and Discovery*. 5th ed. London, England: CRC Press, 2022.
2. Hongmao, Sun. 'Structures, Limitations, and Pitfalls'. In *A Practical Guide to Rational Drug Design*, 3–14. Elsevier, 2016.
3. Klebe, Gerhard, ed. 'Drug Design'. Berlin, Heidelberg: Springer Berlin Heidelberg, 2013.


**Reference Books :**


1. Parikesit, Arli Aditya, ed. *Molecular Insight of Drug Design*. London, England: IntechOpen, 2018.


**Assessment Scheme :**

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY364L** | Rational Drug Design and Structure Determination | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the structure determination of biomolecules via the X-ray crystallography

CO2 : Build the 3D model of biomolecules

CO3 : Apply QSAR, pharmacophore mapping and molecular docking for drug discovery

CO4 : Apply 3D structure modeling and MD simulation for drug discovery

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 1 | 2 | - | - | - | - | - | 1 | 3 | 3 | 2 | 2 |
| CO2 | 3 | 1 | - | 2 | 2 | - | - | - | 1 | 1 | 1 | 3 | 3 | 2 | 2 |
| CO3 | 3 | 1 | - | 2 | 3 | - | - | - | 1 | 1 | 1 | 3 | 3 | 2 | 2 |
| CO4 | 3 | 1 | 1 | 2 | 3 | 1 | - | - | 2 | 1 | 3 | 3 | 3 | 2 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 21 lecture hours**

**Structure Determination**

Introduction to different protein expression systems and protein purification methods.

X-ray crystallography: Overview of X-ray crystallography; Crystallisation: different methods of protein crystallization; X-ray data collection: indexing, strategy, processing; Structure factor; Introduction to phase problem; Introduction to fitting, refinement and validation; Molecular replacement method.

NMR Spectroscopy: Chemical Shift; Spin-Spin Coupling; Time Domain NMR Signal; Frequency Convention; Carbon-13 NMR; Decoupling; Population Inversion; Practical Considerations of sample preparations; Solid-state NMR.

Cryo-Electron Microscopy: Basic anatomy of the electron microscope; Introduction to Fourier Transforms and Reciprocal Space; Image Formation; Challenges in Biological EM; Single Particle Analysis; Tomography.

**Module II: 21 lecture hours**

**Rational Drug Design**

Structure modeling of proteins and nucleic acids: Modeling of 3D structure of proteins; modeling 3D structures of DNA/RNA; validation of models. AlphaFold: AI in 3D structure prediction. Analysis of protein and nucleic acid structures.

Stages of drug discovery and development; rational approaches to lead discovery; random screening, non-random screening, serendipitous drug discovery, lead discovery based on drug metabolism, lead discovery based on clinical observations. Drug databases and extracting structures. Covalent drugs and fragment-based drug discovery.

Quantitative Structure-Activity Relationship (QSAR): Classes of physicochemical descriptors, experimental and computational approaches for physicochemical descriptor prediction; Hammet's substituent constant and Taft's steric parameter; Hansch analysis; Free Wilson analysis.

Virtual Screening techniques: Drug likeness screening; pharmacophore-based Screening; ADMET-based screening.

Molecular docking: Rigid docking; flexible docking; covalent docking; binding site similarity and off-target prediction.
Molecular Simulation: Normal Mode Analysis; Force fields; Molecular Dynamics; MM-PBSA/GBSA methods; Free Energy Calculations.

**List of Experiments**

1. Protein expression and purification
2. Crystal tray setup via Hanging drop and Sitting drop methods
3. Data collection methodology and analysis
4. Development of 3D structure model from X-ray diffraction data
5. Analysis of NMR spectra of proteins
6. Building and evaluation of QSAR model
7. Building and refinement of 3D structure using homology modeling
8. Molecular docking of drug to target
9. Force fields and parameterization
10. Setting up the MD simulation of protein-drug complex
11. Analysis of MD simulation data.

**Textbooks:**


1. Roy, K., Kar, S., & Das, R. N., *Understanding the basics of QSAR for applications in pharmaceutical sciences and risk assessment*. Academic press, 2015.
2. Andrew, R. L., *Molecular modeling principles and applications*, Prentice Hall, London, 2001.
3. Rhodes, G., *Crystallography made crystal clear: a guide for users of macromolecular models*, Elsevier, 2010.


**Reference Books:**


1. *X-ray Crystallography*, (2021, May 1). https://chem.libretexts.org/@go/page/316
2. Raja, P. M. V., & Barron, A. R. (2021, March 21), *NMR Spectroscopy*. Rice University. https://chem.libretexts.org/@go/page/55887
3. *Proteins*. (2020, August 13), College of Saint Benedict/Saint John's University. https://chem.libretexts.org/@go/page/189779
4. *Molecular Dynamics Simulations*, (2021, April 8). University of Utah. https://chem.libretexts.org/@go/page/17634.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY463L** | Biotherapeutics | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the modern therapeutic approaches

CO2 : Understand the basic concepts of biologics and vaccine development

CO3 : Apply computational method for biotherapeutic design and optimization

CO4 : Use PK/PD modeling for optimizing the pharmacokinetic profile of biotherapeutics

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 1 | - | - | - | - | - | - | - | - | 3 | 2 | 2 |
| CO2 | 2 | 1 | - | 1 | 1 | - | - | - | - | 1 | 1 | 1 | 3 | 2 | 2 |
| CO3 | 2 | 3 | 3 | 3 | 3 | - | - | 2 | 1 | 3 | 2 | 3 | 3 | 3 | 3 |
| CO4 | 3 | 1 | 3 | 3 | 3 | - | - | - | 1 | 3 | 3 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 15 lecture hours**

Introduction to biotherapeutic approaches. Biologics, biosimilar and biobetters. Biologics: Basic characteristics –Temperature, pressure and solvant sensitivity, storage stability, aggregation behavior, degradation pattern. Stabilization of protein, carbohydrate, lipids and nucleic acids. Approaches for design and optimization of biotherapeutics: Predicting Potential Physicochemical Degradation Sites, Computational tools to understand the aggregation mechanism, Computational methods for Protein therapeutic optimization. Role of excipients and additives on stabilizing biologicals. Examples of biosimilars and biobetters in biotherapeutics. Characterization via immunological techniques.

**Module II: 15 lecture hours**

Introduction to Vaccines. Active and passive immunization; live, killed, attenuated, subunit vaccines; vaccine technology- role and properties of adjuvants, recombinant DNA and protein-based vaccines. Case studies in vaccinology e.g. COVID19, Polio, Small pox and DPT. Computational assessments of adverse immunogenicity prediction. Pharmacokinetic–pharmacodynamic modeling for biotherapeutics, Estimating high-concentration-solution behavior, challenges in high concentration biopharmaceutical drug delivery.

**Module III: 12 lecture hours**

**Introduction to noval biologics. Examples of Noval biologics.** Discovery, development and delivery strategies for engineered live biotherapeutic products. Clinical implementation of live biotherapeutic products (LBP). Research tools for LBP risk documentation, Safety considerations in clinical trials with LBPs. Strategies leading to stable biotherapeutics, post-translational modifications in biotherapeutics, T-Cell and B-Cell epitope prediction. Best practices in assessment of developability of biotherapeutic candidates. Guidance, Compliance & Regulatory Information.

**List of Experiments :**

1. Identification and optimization of protein expression conditions
2. Protein expression confirmation and protein stability Assay
3. Large scale therapeutic protein production
4. Drug screening
5. Cytotoxicity assay
6. Aggregation prediction using sequence and structure
7. MD simulation for understanding aggregation
8. PK/PD modeling
9. In-silico mutational scanning for therapeutic optimization

10. Case studies of post-translational modifications in biotherapeutics.

**Text Books :**

1. Singh, M., and M. Salnikova. *Novel Approaches and Strategies for Biologics, Vaccines and Cancer Therapies*. Academic Press, 2014.
2. Kumar, Sandeep, and Satish Kumar Singh, eds. *Developability of biotherapeutics: computational approaches*. CRC Press, 2015.

**Reference Books :**

1. Grewal, Iqbal S. *Emerging Protein Biotherapeutics*. Edited by Iqbal S. Grewal. London, England: CRC Press, 2009.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY365L** | Human Genetics | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | Genetics & Molecular Biology | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Define the basic concept of human genetics, types of inheritance, and model of inheritance.

CO2 : Explain the concept of chromosomal abnormalities and cytogenetic aspects of cell division.

CO3 : Demonstrate the techniques to study chromosome and their applications.

CO4 : Describe complex and rare genetic disorders case studies.

CO5 : Explain the different animal models of genetic diseases.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 1 | 1 | 1 | 1 | 1 | - | - | - | - | - | 3 | 3 | 1 | - |
| CO2 | 2 | 1 | 1 | 1 | 3 | 1 | - | - | - | - | - | 3 | 3 | 1 | - |
| CO3 | 3 | 2 | 3 | 2 | 3 | 3 | - | - | - | - | - | 3 | 3 | 2 | 2 |
| CO4 | 3 | 2 | 2 | 2 | 1 | 3 | - | - | - | 2 | - | 3 | 3 | 2 | - |
| CO5 | 3 | 2 | 2 | 2 | 1 | 2 | - | - | - | 2 | - | 3 | 3 | 2 | - |

1=weakly related 2= moderately related 3=strongly relat

**Course Contents:**

**Module I: 20 lecture hours**

Introduction to human genetics: history of human genetics. Human Genome Sequence and Variation. From Genes to Genomics to Proteomics understanding information flow. Human genetic inheritance: Models of inheritance. Linkage: Concepts, recombination, gene mapping, fine structure mapping.

Sex-linked inheritance: Conceptual basis, sex influenced traits, mechanism of sex determination.

Quantitative inheritance – Concept, Genes and Environment - heritability, penetrance and expressivity. Epistasis.
Cytoplasmic inheritance – Basis and mechanism, role of organellar genes.

**Module II: 10 lecture hours**

History and Development of Human Cytogenetics. Chromosomal disorders: types, detection and case studies. Cytogenetic aspects of cell division: Chromosome labelling and cell cycle analysis, regulation of mitosis and meiosis, sister chromatid cohesion remodelling, regulation of exit from metaphase, chromosome movement at anaphase. Genetic control of meiosis.
Techniques in the study of chromosomes and their applications.

**Module III: 12 lecture hours**

Genetics of complex and single gene disorders, Neglected, rare and orphan diseases with case studies. Diagnosis and Molecular basis of metabolic disorders, Mitochondrial and rare disorders. Signal transduction and human diseases, Case studies.

Animal models of human diseases.

**List of Experiments :**

1. Introduction to principle and utility of microscopy
2. Study of Cytogenetic aspects of cell division- I
3. Study of Cytogenetic aspects of cell division- II
4. Karyotyping
5. RFLP analysis
6. VNTR typing using PCR
7. Introduction to Diagnosis via RT PCR I
8. Introduction to Diagnosis via RT PCR II
9. SNP analysis.

**Text Books :**

1. Krebs, Jocelyn E, Benjamin Lewin, Stephen T Kilpatrick, and Elliott S Goldstein. *Lewin's Genes XI*. 2014.
2. Strachan, Tom, and Andrew Read. *Garland Science*, n.d.2018

**Reference Books :**

1. Lodish, Harvey, Arnold Berk, Chris Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Kelsey Martin, Michael Yaffe, and Angelika Amon. *Molecular Cell Biology*. 9th ed. New York, NY: W.H. Freeman, 2021.
2. Pasternak, Jack J. *An Introduction to Human Molecular Genetics*. 2nd ed. New York, NY: Wiley-Liss, 2008.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Demonstrate a comprehensive understanding of the principle and concept of genetic counselling, including the role of genetic counsellors in healthcare

CO2 : Understand the significance of genetic counseling and its role in providing support and guidance to individuals and families dealing with genetic conditions and hereditary diseases.

CO3 : Familiarize with various methods and approaches employed in genetic counseling, including the use of genetic testing and family history assessment to assess and communicate genetic risks.

CO4 : Understand the ethical, legal, and social implication associated with genetic counselling

CO5 : Analyze real-world case studies and ethical dilemmas in genetic counseling, honing critical thinking skills and developing strategies for approaching complex genetic situations.

CO6 : Recognize the potential career prospects in genetic counseling and develop an informed understanding of the responsibilities and ethical considerations involved in this field.

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY368L** | Genetic Counselling | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 4 | 0 | 0 | 4 |
| **Pre-requisites/Exposure** | Human Genetics | | | | |

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 1 | 2 | 2 | - | 2 | 3 | 3 | - | 3 | 3 | 2 | 1 |
| CO2 | 3 | 2 | 1 | 1 | 2 | 2 | - | 2 | 3 | 3 | - | 3 | 3 | 2 | 1 |
| CO3 | 3 | 2 | 1 | 1 | 3 | 2 | - | 2 | 3 | 3 | - | 3 | 3 | 3 | 1 |
| CO4 | 3 | 2 | 1 | 1 | 2 | 2 | - | 3 | 3 | 3 | - | 3 | 3 | 1 | 1 |
| CO5 | 3 | 3 | 1 | 3 | 3 | 2 | - | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 1 |
| CO6 | 3 | 1 | 1 | 1 | 2 | 1 | - | 2 | 3 | 3 | - | 3 | 3 | 2 | 2 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 18 lecture hours**

1. Causes and factors for seeking counseling,
2. Risks evaluation,
3. Risks associated with invasive procedures,
4. Foetal sampling procedure and related counseling
5. Analysing ultrasounds results,
6. Counselling recurrent pregnancy loss.
7. Actively Engaging with Patients in Decision-Making,
8. A Genetic Counselor's Guide towards mental health.

**Module II: 18 lecture hours**

1. Therapeutic benefits of dietary management and various counseling approaches;
2. Peri-conceptional counseling; pre-marital counseling.
2. Ethical and legal issues in genetic counseling.
3. Standardized test panels used in IVF clinics including tests for orphan and rare diseases through SNP analysis.
4. Supporting Family Communication About Genetic Conditions.

**Module III: 20 lecture hours**

1. Cultural Competency: Application to Genetic Counselling,
2. Genetic counseling strategies for working with families,
3. The Impacts of Genetic Literacy and Adult Learning.

4. Development of the Genetic Counselling Profession: A Professionalization Process.
5. Pre- and Post-Test Cancer Genetic Counselling.
6. Case studies.
7. Mock sessions with genetic counselors.
8. Visit to counseling centers.

**Text Books :**

1. Callanan, Nancy P., ed. *Genetic Counseling Practice: Advanced Concepts and Skills*. Wiley- Blackwell, 2020.
2. Peter, S. 'Practical Genetic Counselling'. *Practical Genetic Counselling*, 2004.

**Reference Books :**

1. Kewal, K. 'Textbook of Personalized Medicine'. *), Humana* 9781493925520 (2015).

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY465L** | Genomics and Personalized Medicine | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | Human Genetics | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to

CO1 : Understand the fundamental principles of genomics and its relevance in personalized medicine, including the roles of Pharmacogenetics, Pharmacogenomics, Pharmacoproteomics, Nutrigenomics, Metabolomics, and Microbiome fingerprinting in individualized healthcare.

CO2 : Comprehend the significance of biomarkers in personalized medicine and how genomic risk profiling is utilized to tailor treatments for individual patients.

CO3 : Demonstrate proficiency in using *in silico* tools for genomic analysis, interpretation, and exploring human genome structure and variations through the Genome Browser.

CO4 : Analyze case studies illustrating personalized medicine applications in various diseases, fostering critical thinking and problem-solving abilities in the field of genomics and precision medicine.

CO5 : Comprehend the ethical, social, and economic challenges associated in integrating the genomics into clinical practice

CO6 : Gain practical skills in using genome browsers, analyzing variation databases, performing variant calling, and conducting in silico genome analysis for personalized medicine applications.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 1 | 3 | 1 | - | 3 | 2 | 3 | - | 3 | 3 | 2 | 1 |
| CO2 | 3 | 2 | 2 | 1 | 3 | 1 | - | 3 | 2 | 3 | - | 3 | 3 | 2 | 1 |
| CO3 | 3 | 2 | 3 | 2 | 3 | 1 | - | 3 | 2 | 3 | - | 3 | 3 | 3 | 1 |
| CO4 | 3 | 3 | 2 | 3 | 3 | 2 | - | 3 | 3 | 3 | - | 3 | 3 | 3 | 2 |
| CO5 | 3 | 2 | 1 | 2 | 3 | 2 | - | 3 | 3 | 3 | - | 3 | 3 | 1 | 1 |
| CO6 | 3 | 3 | 3 | 3 | 3 | 2 | - | 3 | 3 | 3 | 1 | 3 | 3 | 2 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 12 lecture hours**

The human genome, types of variations found in human genome, DNA sequencing technologies for the detection of Human Genome Variations and Polymorphisms, The Personal Genome Project, in silico tools for analysis and visualization of variations in genome, genome-wide association studies, databases of human genome variations, in vitro tools for analysis of genetic variations, Monogenic and complex genetic diseases, effect of environment on genome.

**Module II: 18 lecture hours**

Molecular Basis of Personalized Medicine, polymorphisms of Drug Transporters, Drug Targets, Drug metabolizing enzymes, role of biomarkers in personalized medicine, genomic risk profiling, gene editing tools (CRISPR-Cas9, etc.), case studies on gene therapy, personalized management of neurological, cardiovascular, and miscellaneous disorders, genomics for Cancer diagnostics and treatment (microarray based gene expression in cancer cells for personalized treatment), Ethical, Legal, and Social issues related to implementation of Personalized Medicine.

**Module III: 12 lecture hours**

Omics technologies in personalized medicine: Pharmacogenetics, Pharmacogenomics, Proteomics, Nutrigenomics, Metabolomics, Microbiome fingerprinting, Application of genomic studies for a healthy person.

**List of Experiments :**

1. Understanding human genome (Genome Browser).
2. Understanding human genome variation databases such as ClinVar, dbSNP, dbVar.
3. Introduction to softwares for variant calling.
4. In silico genome sequence analysis to identify structural variations.
5. Visit to human genome DNA sequencing/data analysis facilities
6. Case studies to illustrate application of personalized medicine for diseases such as cystic fibrosis, Marfan syndrome, neuropsychiatric diseases, and diabetes.
7. Case studies to illustrate application of genome analysis for diagnosis and treatment of cancer.

**Text Books :**

1. Ginsburg, Geoffrey, and Huntington Willard. *Genomic and Precision Medicine, Foundations, Translation, and Implementation*, 2016.

2. Lambert, Christophe G., J. Darrol, and George P. Baker. *Human Genome Informatics- Translating Genes Into Health*, 2018.

**Reference Books :**

1. Kewal, K. 'Textbook of Personalized Medicine'. *), Humana* 9781493925520 (2015).

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY367L** | Enzyme Technology | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand enzyme theories and enzyme kinetics.
CO2 : Understand various methods to produce and purify industrially important enzymes.
CO3 : Understand various industrial applications of enzymes
CO4 : Apply various methods to produce and purify industrially important enzymes.
CO5 : Apply different methods for immobilization of enzymes.
CO6 : Design and create commercially relevant enzymatic processes and products.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 3 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 3 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 2 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 1 | 3 | 3 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| CO6 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 12 lectures hours**

Introduction to enzymes. Enzyme classification & nomenclature. Mechanisms of enzyme catalysed reactions. Introduction to bioenergetics and kinetics, kinetics of single and multi-substrate bioreactions. Estimation of Michaelis - Menten's parameters: Km, Vmax, L.B Plot, Turnover number, Kcat. Enzyme inhibitions - kinetics of competitive, non-competitive & uncompetitive inhibitions; nucleophilic & electrophilic attack; role of metal ions in enzymetic reactions. Factors affecting the enzyme activity. Functions of coenzymes. Quantum tunneling in enzyme-catalysed reaction.

**Module II: 10 lectures hours**

Production, extraction, purification, and preservation of enzyme by various methods. Enzyme production by submerged and solid-state fermentation. Introduction to large scale production

of enzymes and process optimization. Batch, Fed-batch, and continuous processes for enzyme production.

**Module III:** **10 lectures hours**

Immobilized enzymes. Methods of enzyme immobilization- adsorption, matrix entrapment, encapsulation, cross-linking, covalent binding. Immobilized enzyme in industrial processes. Reactor engineering for immobilized enzymes. Enzyme electrodes and their application as biosensors.

**Module IV:** **10 lectures hours**

Industrial applications of enzymes: food industries, bio-detergents, biofuel industries, waste management, pharmaceuticals industries. Enzymes in R&D. Therapeutic enzymes. Enzymes in biotransformation. Improvement of enzymes for industrial applications, site directed mutagenesis, directed evolution of enzymes.

**List of Experiments :**

1. Production and purification of extra cellular enzymes.
2. Production and purification of intra cellular enzymes.
3. Production and purification of membrane bound enzymes.
4. Extraction of crude enzyme from plants.
5. Assay of enzyme activity.
6. Effect of substrate concentration on enzyme kinetics and determination of Km and Vmax.
7. Effect of pH and temperature on enzyme kinetics.
8. Immobilization of enzyme by matrix entrapment.
9. Immobilization of enzyme by encapsulation.
10. Immobilization of enzyme by cross-linking and covalent binding.
11. Enzyme production by submerged fermentation.
12. Enzyme production by solid state fermentation.
13. Application of enzyme in food and detergent industries.

**Text Books :**

1. Palmer, Trevor, and Philip L. Bonner. *Enzymes: biochemistry, biotechnology, clinical chemistry*. Elsevier, 2007.
2. Price, Nicholas C., and Lewis Stevens. "Fundamentals of enzymology." (1989).

**Reference Books :**

1. Wiseman, *Enzyme Biotechnology*, Ellis Horwood Pub.
2. James. E. Bailey and David F. Ollis, *Biochemical Engineering Fundamentals*, McGraw Hill.
3. Faber K , *Biotransformations in Organic Chemistry* (4th ed.), Springer.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 45% | 20% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY370L** | Green chemicals & Sustainable products | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the basic concept of green and sustainable products.

CO2 : Understand different types of technologies, the application of sustainable products, and their global market standards.

CO3 : Understand the status and challenges of setting-up green product industries and their commercialization.

CO4 : Apply biotechnological skills to produce green platform chemicals.

CO5 : Apply biotechnological skills to produce green bioplastics and biopolymers.

CO6 : Design and create new methods for production of green and sustainable chemicals

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 3 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 1 | 2 | 3 | 3 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 1 | 2 | 3 | 3 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| CO6 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 14 lectures hours**

Concept of sustainability and SDGs. Concept of Green chemicals, types of green chemicals and their use. Carbon credit & carbon tax. Lifecycle analysis (LCA) & cost-benefit analysis. Smart drop-in chemicals. Fossil-based chemicals vs. biobased chemicals. Techno-economic status of green chemicals. Green product market size and demand. Impact of green chemicals on food market. Green solvents: supercritical fluids, ionic liquids, PEG, fluorinated hydrocarbons. Green paints, renewable adhesives, sustainable glue, green pigments. Sustainable products: biodegradable cutlery, reusable paper towel alternatives, waterless laundry detergent.

**Module II: 14 lectures hours**

Biobased bulk chemicals. Bio-platform chemicals. Specialty chemicals. Biobased fragrance and aroma compounds. Biobased active pharmaceutical ingredients (APIs) and high-value products. Antibiotics. Biobased steroids & derivatives. Bioplastics and polymers. Biodegradable vs. non-biodegradable bioplastics. Natural vs. synthetic biopolymers. Green catalysts, nanotechnology for green products.

**Module III: 14 lectures hours**

Case studies of industrial production of green chemicals. Current status of green chemicals research. Bioresources as feedstock for green products. Challenges of green product industry in terms of translational aspects such as, power cost, feedstock issues, challenges in identifying the appropriate enzymes for biofuel production. Commercialization potential and challenges of using sustainable products. Environmental, social, and economic benefits in the life cycle of sustainable products.

## List of Experiments :

1. Green chemical production from carbohydrates.
2. Green fuel production from potato starch.
3. Bio-based production of biopolymer precursor Polyhydroxy alkenoate.
4. Bio-surfactant preparation using cellulose and glycerol
5. Green pigment purification from plant biomass
6. Bio-based steroid formation from corn oil phytosterols

7. Speciality green chemical production from renewable oil

**Text Books :**

1. Sanker P Dey & Nayim Sepay, *A Text Book Of Green Chemistry* (1st ed.), Techno World Publication, 2021.
2. Juan Gabriel Segovia-Hernandez, Eduardo Sanchez-Ramirez, Cesar Ramirez-Marquez, Gabriel Contreras-Zarazúa, *Improvements in Bio-Based Building Blocks Production Through Process Intensification and Sustainability Concepts*, Elsevier, 2021.

**Reference Books :**

1. Kavita Shakya, Chahal. 'Green Chemistry for the Development of Eco-Friendly Products'. *IGI Global*, 2022.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 45% | 20% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY467L** | Biofuels and Biorefinery | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand the concept of biorefinery and biobased industry.
CO2 : Understand the types of feedstocks available for biorefinery and potential products.
CO3 : Apply biorefinery concept to obtain multiple products from one type of biomass.
CO4 : Apply technologies to recover energy and resources from low value biomass.
CO5 : Design and create new technologies for biofuel production.
CO6 : Design and create new commercially important technologies for biorefineries.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 2 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 1 | 3 | 3 | 2 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 2 | 3 | 2 | 3 | 3 |
| CO6 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 14 lecture hours**

Introduction to World energy scenario, consumption pattern, fossil fuel depletion and environmental issues. Biorefinery: Basic concept, types of biorefineries, biorefinery feedstocks, properties, and economics. Barriers in lignocellulosic biomass conversion, pre-treatment technologies. Physical and Thermal Conversion Processes: Types, fundamentals, equipment, and applications; thermal conversion products, commercial success stories. Microbial

Conversion Process: Types, fundamentals, equipment and applications, products, commercial success stories. Biodiesel: Diesel from vegetable oils, microalgae, and syngas; transesterification. Introduction to Fischer-Tropsch (FT) process.

**Module II: 14 lecture hours**

Bioethanol and Biobutanol: Corn ethanol, lignocellulosic ethanol, microorganisms for fermentation, current industrial ethanol production technology, cellulases and their role in hydrolysis, concepts of simultaneous saccharification fermentation (SSF) and Consolidated bioprocessing (CBP), Acetone–butanol–ethanol (ABE) fermentation pathway and kinetics, product recovery technologies. Biohydrogen generation, metabolic basics, feedstocks, dark fermentation by strict anaerobes, facultative anaerobes, thermophilic microorganisms, integration of biohydrogen with fuel cell; fundamentals of biogas technology, fermenter designs, biogas purification, methanol production and utilization. Organic Commodity Chemicals from Biomass: succinic acid, acetic acid, butyric acid, 1,3-propanediol, 2,3-butanediol. Microbial fuel cell. Bio-aviation fuels.

**Module III: 14 lecture hours**

Extraction and purification of high value phytochemicals under biorefinery framework. Biofuel production and simultaneous waste management. Metabolic engineering for biofuel production. Biofuel production process simulation. Scale-up of biofuel production processes. Case studies of biofuel production. Current status of biofuel research and job opportunities. Integrated Biorefinery: Concept, aquaculture and algal biorefinery, waste biorefinery, hybrid chemical and biological conversion processes, techno- economic evaluation and life-cycle assessment.

**List of Experiments :**

1. Production of ethanol from lignocellulosic materials with the help of simultaneous saccharification and fermentation (SSF).
2. Biorefinery framework for production of Biodiesel and platform chemical (1,3-propanediol)
3. Production of acetone, butanol, and ethanol in a biorefinery framework.
4. Production of biogas.
5. Production of bioelectricity via Microbial Fuel Cell.
6. Production of platform chemicals (succinic acid, acetic acid, fumaric acid etc.)

**Text Books :**


1. Klass, Donald L. *Biomass for Renewable Energy, Fuels, and Chemicals*. San Diego, CA: Academic Press, 1998.
2. Yang, Shang-Tian, Hesham A. El Ensashy, and Nuttha Thongchul, eds. *Bioprocessing Technologies in Biorefinery for Sustainable Production of Fuels, Chemicals, and Polymers*. EPUB. Hoboken, NJ: Wiley-Blackwell, 2013.


**Reference Books :**


1. Basu, Prabir, and Priyanka Kaushal. *Biomass Gasification, Pyrolysis, and Torrefaction*. 4th ed. San Diego, CA: Academic Press, 2023.
2. Vertes, Alain A., Nasib Qureshi, Hideaki Yukawa, and Hans P. Blaschek, eds. *Biomass to Biofuels*. PDF. Hoboken, NJ: Wiley-Blackwell, 2010.
3. Yang, Shang-Tian, ed. *Bioprocessing for Value-Added Products from Renewable Resources*. London, England: Elsevier Science, 2006.
4. Drapcho, Caye M., Nghiem Phu Nhuan, and Terry H. Walker. *Biofuels Engineering Process Technology, Second Edition*. 2nd ed. McGraw-Hill Education, 2020.


**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 45% | 20% | 35% | 100% |

| Name of Program | B. Tech. Biotechnology | | | | |
|---|---|---|---|---|---|
| EBTY369L | Nanomedicine | L | T | P | C |
| Owning School/Department | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| Pre-requisites/Exposure | Chemistry of Biomolecules, Introduction to Biomaterials | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Design the strategies to make polymeric nanoparticles.

CO2 : Analyze the size, surface charge, and encapsulation efficiency of cargo.

CO3 : Design the experiment for functional screening of nanocarriers in vitro and in vivo model systems.

CO4 : Compare the types of nanoparticles, their biological properties, and their uses.

CO5 : Understand the hurdles in delivering nanocarriers to the target and how to overcome them from a physiological standpoint.

CO6 : Describe the wide applications of nanomedicine and their commercial importance and aspects.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO11 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 2 | - | 3 | - | - | - | 2 | - | - | 3 | 3 | 3 | 1 |
| CO2 | 3 | 2 | 3 | 3 | 3 | 1 | - | - | - | - | - | 3 | 3 | 3 | 1 |
| CO3 | 3 | 1 | 3 | 1 | 3 | 2 | - | 1 | 2 | - | 3 | 3 | 3 | 3 | 3 |
| CO4 | 3 | 3 | 2 | 1 | 3 | - | - | - | - | - | - | 3 | 3 | 3 | 2 |
| CO5 | 3 | 2 | 3 | 3 | 3 | - | - | 2 | 1 | - | - | 3 | 3 | 3 | 2 |
| CO6 | 3 | 2 | 1 | 1 | 2 | 3 | - | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 14 lecture hours**

**Formulation Strategies and physicochemical characterization:** Principles and concepts, Biomaterials classification (polymeric, lipid etc.), preparation methods, surface modification. Characterization- Size, Surface charge, stability, characterization of cargo- drug/ gene/ protein/ antibody: Encapsulation rate, Release- slow or burst.

**Module II: 14 lecture hours**

**Functional Characterization:** Types- nanoparticles/ liposomes/ lipid nanoparticles/ micelles/ dendrimers/ nanocapsules, Endosomal escape, Cell-specific delivery, in vitro- toxicity and bioactivity, permeation across biological barriers, delivery route, pharmacokinetics and biodistribution.

**Module III: 14 lecture hours**

**Applications:** Infectious Disease (bacterial, viral, fungal), Gene therapy, Cancer therapy, Surgery, Wound healing, Vaccine, Eye disease (Macular degeneration), Cardiovascular disease, Rheumatoid Arthritis, Personalized Medicine, Tissue engineering, Bone Regeneration, Phytonanomedicine, Non-clinical applications: Cosmetics industry, Regulatory aspects, Commercialization examples.

**List of Experiments :**

1. Formulation of polymeric nanoparticles with Rhodamine.
2. Evaluation of percent Rhodamine encapsulation in nanoparticles.
3. Release kinetics of Rhodamine from nanoparticles.
4. Tracing Rhodamine-loaded nanoparticles in cells/ time kinetics using Fluorescence Microscopy.
5. Evaluation of cytotoxicity of Rhodamine-loaded nanoparticles on cancer cells (treatment dose calculation- free drug/ encapsulated drug).

**Text Books :**


1. Niemeyer, Christof M., and Chad A. Mirkin. 'Nanobiotechnology: Concepts, Applications and Perspectives'. *Nanobiotechnology: Concepts, Applications and Perspectives*, 2004.
2. Burgess, Rob. *Understanding Nanomedicine: An Introductory Textbook*. CRC Press, 2012.


**Reference Books :**


1. Ramakrishna, Seeram, Murugan Ramalingam, TS Sampath Kumar, and Winston O. Soboyejo. *Biomaterials: a nano approach*. CRC press, 2016.
2. Sahu, Saura C., and Daniel A. Casciano, eds. *Handbook of nanotoxicology, nanomedicine and stem cell use in toxicology*. Hoboken, NJ, USA: Wiley, 2014.


**Assessment Scheme** :

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 40% | 25% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY376L** | Introduction to Biosensors and Bioelectronics | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | Bio-Analytical Techniques Lab, Chemistry of Biomolecules, Introduction to Biomaterials, rDNA Technology | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Design basic biosensors for nucleic acid and protein detection.
CO2 : Compare different types of biosensors, their fabrication and applications.
CO3 : Carry out industrially relevant isothermal amplification techniques.
CO4 : Understand the fundamental experimental aspects of basic wearable devices.
CO5 : Describe the multiple bioelements used to prepare biosensors.
CO6 : Understand the commercialization pathways of biosensors.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 3 | 3 | 3 | 3 | - | - | 1 | 1 | 1 | 3 | 3 | 1 | 1 |
| CO2 | 3 | 1 | 1 | - | 3 | - | - | 2 | 1 | 1 | - | 3 | 3 | 1 | - |
| CO3 | 3 | 3 | 3 | 3 | 3 | 3 | - | - | 2 | 2 | 1 | 3 | 3 | 3 | 1 |
| CO4 | 3 | 1 | 1 | - | 3 | 3 | - | - | - | 2 | - | 3 | 3 | 3 | - |
| CO5 | 3 | 1 | 1 | - | 3 | - | - | - | - | 2 | - | 3 | 3 | 1 | - |
| CO6 | 3 | 3 | 1 | 3 | 3 | 3 | - | 2 | - | 2 | - | 3 | 3 | 2 | - |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 14 lecture hours**

Introduction to biosensor design principles; Various types of sensing, transducer, and readout modules and their working principles; Thermal and electronic biosensors: organic and transition metal based MOSFETs, electrochemical biosensors, terahertz spectroscopy, QCM sensors; Fabrication, characterization, and application in detection of bioanalytes; Role of sensing elements.

**Module II: 16 lecture hours**

Optical biosensors: surface plasmon, optical fibres, fluorescence based, LFA strips; Fabrication, characterization and detection of bioanalytes; Applications in DNA sequencing; Combination with nucleic acid and protein sensing modules; Regulatory aspects; Commercialization examples

Mechanical biosensors: microfluidics – basic introduction to basic microfluidic concepts, fabrication methods, examples; Immobilization methods; Readout choices; Applications in biosensing of nucleic acid, antigen, and small molecule analytes; Combination with nucleic acid and protein sensing modules.

**Module III: 12 lecture hours**

Bioelement- Enzyme/ Antibody/ Nucleic Acid/ Tissue/ Polysaccharide/ Microbe. Principles of Biorecognition, Sample preparation and challenges. Cancer Theranostics, live sensors. Regulatory aspects; Commercialization examples- (Clinical & Non clinical). Clinical- Home based/ Pathological. Non-clinical- Pollution/ Industrial production/ Agriculture/ Defense/ Water purification/portable.

**List of Experiments :**

1. Introduction to real-time PCR (principles and primer design).
2. Introduction to real-time PCR (experiment).
3. Introduction to loop-mediated isothermal amplification (principles and primer design).
4. Introduction to loop-mediated isothermal amplification (experiment).
5. Introduction to electrochemical biosensors – experimental principles of amperometric and SWV sensors.
6. Electrochemical biosensors – nucleic acid detection using amperometric and SWV sensors.
7. Working principle of LFA biosensors.
8. LFA biosensor design for *S aureus*.
9. Nucleic acid extraction biosensors principles.
10. Building a nucleic acid extraction biosensor and application in downstream rt-PCR pathways.
11. Glucometer and working principle – determining LoD (2 h).

**Text Books :**

1. Brian R Eggins, *Biosensors an Introduction* (1st ed.), John Wiley & Sons Publishers, 1996.

2. Graham Ramsay, *Commercial Biosensors* (1st ed.), John Wiley & Sons, Inc. 1998.

**Reference Books :**

1. Donald G. Buerk, *Biosensors Theory and Applications* (1st ed.), Technomic Publishing. Co, Inc, 1993.
2. Loïc J. Blum, Pierre R. Coulet, *Biosensor Principles and Applications* (1st ed.), Taylor and Francis, CRC Press, 1991.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| Weightage (%) | 50% | 15% | 35% | 100% |

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | B. Tech. Biotechnology | | | | |
| **EBTY469L** | Digital Healthcare, Theranostics and LAB-On-A-Chip | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 3 | 0 | 2 | 4 |
| **Pre-requisites/Exposure** | Bio-Analytical Techniques Lab, Chemistry of Biomolecules, Introduction to Biomaterials, rDNA Technology | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1 : Understand principles and designs behind Chip fabrication.
CO2 : Discuss the processes of Chip fabrication and their applications.
CO3 : Understand the fundamentals of microfluidic devices and their operation.
CO4 : Explain the concept of Organ-On-Chip designing.
CO5 : Understand the current state-of-the-art and industrial applications.
CO6 : Define multiple disease models where organ-on-chip can be used.

**CO-PO/PSO Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | - | 2 | - | - | 3 | 3 | - | - |
| CO2 | 3 | 2 | 2 | 3 | 3 | 2 | - | - | - | 1 | - | 3 | 3 | 3 | 1 |
| CO3 | 3 | 2 | 3 | 2 | 3 | 3 | 2 | - | - | - | - | 3 | 3 | - | - |
| CO4 | 3 | 2 | 3 | 2 | 3 | 2 | - | - | - | 1 | - | 3 | 3 | 3 | 3 |
| CO5 | 3 | 3 | 2 | 3 | 3 | 3 | - | - | 1 | - | 1 | 3 | 3 | - | - |
| CO6 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 3 | 3 | 3 | 3 |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

**Module I: 8 lecture hours**

Sensing and actuation principle, Introduction to Micro-Electromechanical Systems (MEMS) and its applications, Silicon wafer, doping (thermal diffusion and ion implantation, thermal oxidation), Thin-film deposition, Sputtering, Evaporation, Photolithography, Etching, packaging and bonding, BioMEMS.

**Module II: 6 lecture hours**

Soft-lithography, fabrication of Microfluidic devices, Lab-On-Chip, Point-Of-Care diagnostics and imaging, Applications of Microfluidic systems. Digital Healthcare- Telemedicine & Wearable devices.

**Module III:** **14 lecture hours**

History of organ-On-Chip, Organ-On-Chip for drug screening, Organoid Model- Brain, Cardiovascular- heart/ vessel model, Lung, liver, kidney, bone and gastric organ models.

**Module IV:** **14 lecture hours**

Multi-Organ-On-Chip, Disease models- cancer, infectious disease, injury, genetic disease, Tissue Regeneration and Tissue Engineering.

**List of Experiments :**

1. Demonstration of semiconductor fabrication process
2. Demonstration of Microfluidic Device Fabrication
3. Electrochemical sensing- Dr. Soumyendu
4. Preparation of culture plates for 3D cell culture
5. Initiating 3D spheroid culture
6. Spheroid growth kinetics
7. Drugs screening in 2D vs 3D cell cultures
8. Introduction to co-culture
9. Introduction to organoids
10. Gastrointestinal transport model (Transwell culture).

**Text Books :**


1. Raman, Ritu. *Biofabrication*. The MIT Press Essential Knowledge Series. London, England: MIT Press, 2021.
2. Hoeng, Julia, David Bovard, and Manuel Peitsch. *Organ-On-Chip: Engineered Microenvironments for Safety and Efficacy Testing*. Elsevier, 2019.


**Reference Books :**


1. Grewal, Iqbal S. *Emerging Protein Biotherapeutics*. Edited by Iqbal S. Grewal. London, England: CRC Press, 2009.
2. Folch, Albert. *Introduction to BioMEMS*. London, England: CRC Press, 2019.
3. Rasponi, Marco. 2022. *Organ-On-a-Chip : Methods and Protocols*. New York, NY: Humana Press.


**Assessment Scheme :**

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 50% | 15% | 35% | 100% |

# Semester IX

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | Integrated B.Tech.-M.Tech. Biotechnology | | | | |
| | M. Tech Dissertation I | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 0 | 0 | 40 | 20 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1: Apply core subjects knowledge to identify a research area and research topic.

CO2: Design and conduct experiments according to the selected problem.

CO3: Analyse data obtained from the experiment and communicate it through the presentation.

CO4: Evaluate the shortcomings of the project and future research in the field.

**COs-POs/PSOs Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | **3** | - | **3** | **1** | - | **1** | - | - | **3** | - | **3** | **3** | **3** | **3** | **2** | **3** |
| CO2 | **3** | **3** | **3** | **3** | **3** | **1** | - | **3** | **3** | - | **2** | **3** | **3** | **3** | **3** | **3** |
| CO3 | **3** | **3** | **2** | **3** | **3** | - | - | **3** | **3** | **3** | **2** | **3** | **3** | **1** | **3** | **3** |
| CO4 | **3** | **3** | **1** | **1** | - | - | - | - | **2** | **3** | **3** | **3** | **3** | **1** | **2** | **3** |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

This is a lab-based course.

**List of Experiments**

The experiments will vary from individual project to project.

**Text Books :**

Research papers as assigned by the project supervising faculty.

**Reference Books :**

Research papers as assigned by the project supervising faculty.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 60% | - | 40% | 100% |

# Semester X

| | | | | | |
|---|---|---|---|---|---|
| **Name of Program** | Integrated B.Tech.-M.Tech. Biotechnology | | | | |
| | M. Tech Dissertation II | L | T | P | C |
| **Owning School/Department** | SEAS/Biotechnology | 0 | 0 | 40 | 20 |
| **Pre-requisites/Exposure** | - | | | | |

**Course Outcomes (COs)**

On completion of this course, the students will be able to:

CO1: Apply core subjects knowledge to identify a research area and research topic.

CO2: Design and conduct experiments according to the selected problem.

CO3: Analyse data obtained from the experiment and communicate it through the presentation.

CO4: Evaluate the shortcomings of the project and future research in the field.

**COs-POs/PSOs Mapping**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PO13 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | **3** | - | **3** | **1** | - | **1** | - | - | **3** | - | **3** | **3** | **3** | **3** | **2** | **3** |
| CO2 | **3** | **3** | **3** | **3** | **3** | **1** | - | **3** | **3** | - | **2** | **3** | **3** | **3** | **3** | **3** |
| CO3 | **3** | **3** | **2** | **3** | **3** | - | - | **3** | **3** | **3** | **2** | **3** | **3** | **1** | **3** | **3** |
| CO4 | **3** | **3** | **1** | **1** | - | - | - | - | **2** | **3** | **3** | **3** | **3** | **1** | **2** | **3** |

1=weakly related 2= moderately related 3=strongly related

**Course Contents:**

This is a lab-based course.

**List of Experiments**

The experiments will vary from individual project to project.

**Text Books :**

Research papers as assigned by the project supervising faculty.

**Reference Books :**

Research papers as assigned by the project supervising faculty.

**Assessment Scheme**:

| Components | Internal Assessment | Mid Term Exam | End Exam | Total |
|---|---|---|---|---|
| **Weightage (%)** | 60% | - | 40% | 100% |

N. Lattha

SCHOOL OF ENGINEERING AND APPLIED SCIENCES ★ BENNETT UNIVERSITY