# SYLLABUS OF INTEGRATED UG PG PROGRAMME

Department of Biotechnology, Bodoland University, Kokrajhar, Assam

**18th JUNE, 2024**
**BODOLAND UNIVERSITY,**
**KOKRAJHAR, ASSAM**

**PROGRAMME OUTCOME OF INTEGRATED UG-PG PROGRAMME:: DEPT. OF BIOTECHNOLOGY, BU**

PO1: The integrated UG-PG programme in biotechnology will enable the aspirants to demonstrate skill based knowledge to identify, formulate and solve the issues related to bio-industry, pharma industry, health driven technology, regulatory agency and also academia

PO2: The integrated UG-PG programme in biotechnology will enable the aspirants to pursue higher studies and research in biotechnology in blue biotechnology/white biotechnology/green biotechnology/red biotechnology

PO3: The integrated UG-PG programme in biotechnology will enable the aspirants to disseminate the principles of bioprocess engineering in design, analysis, optimization and simulation of bioprocess operations in various sectors

P.O 4: The integrated UG-PG programme in biotechnology will enable the aspirants to gain fundamental knowledge in animal and plant biotechnology and their applications.

P.O 5: The Students perusing the integrated UG-PG programme will find employment opportunities in pharma sectors, agri-sectors, environmental conservation, animal husbandry, ecology, textile industry, space technology etc

P.O 6: The students perusing the integrated UG-PG programme will be equipped to focus for creating new products from biological systems for human and animal welfare .

P.O 7: The Students perusing integrated UG-PG programme will be equipped to harnesses cellular and biomolecular process driven energy to develop or to improvise technologies, products or servies to help improve lives, health and for welfare of human and animals

P.O 8: The Students perusing the integrated UG-PG programme will popularise biotechnology in rural masses to aware general mass about recent trends in biotechnology and its application in day to day life

P.O 9: The students perusing the integrated UG-PG programme will purse biotechnological ventures to boost bio-economy and to heal, feed, and fuel the world in sustainable way

# COURSE STRUCTURE
# INTEGRATED UG-PG PROGRAMME
# BIOTECHNOLOGY

| Paper Code | Paper type | Paper Name | Credits | Hours/Week | | | Total Marks (T50+P20+IA30) |
|---|---|---|---|---|---|---|---|
| | | | | L | T | P | |
| **SEMESTER I** | | | | | | | |
| BITMAJ1014 | MAJOR | Cell structure and dynamics | 4 | 3 | 0 | 1 | 100 |
| BITMIN1014 | MINOR | Introduction to Biotechnology | 4 | 3 | 0 | 1 | 100 |
| BITIDC1013 | IDC | Bio-entrepreneurship | 3 | 2 | 0 | 1 | 100 |
| BITAEC1012 | AEC | Language/ Regional language | 2 | 2 | 0 | 0 | 100 |
| BITSEC1013 | SEC | Instrumentation in Biotechnology | 3 | 2 | 0 | 1 | 100 |
| BITVAC1014 | VAC | VAC-1 | 4 | | | | 100 |
| | | **Total Credits** | **20** | | | | |
| **SEMESTER II** | | | | | | | |
| BITMAJ1024 | MAJOR | Biomolecules | 4 | 3 | 0 | 1 | 100 |
| BITMIN1024 | MINOR | Basic Biochemistry | 4 | 3 | 0 | 1 | 100 |
| BITIDC1023 | IDC | Bioethics and Biosafety | 3 | 2 | 0 | 1 | 100 |
| BITAEC1022 | AEC | Language/ Regional language | 2 | 2 | 0 | 0 | 100 |
| BITSEC1023 | SEC | Plant and animal tissue culture techniques | 3 | 2 | 0 | 1 | 100 |
| BITVAC1024 | VAC | VAC-2 | 4 | | | | 100 |
| | | **Total Credits** | **20** | | | | |
| **SEMESTER III** | | | | | | | |
| BITMAJ2014 | MAJOR | Cell Biology | 4 | 3 | 0 | 1 | 100 |
| BITMAJ2024 | MAJOR | Microbiology | 4 | 3 | 0 | 1 | 100 |
| BITMIN2014 | MINOR | Biodiversity and Taxonomy | 4 | 3 | 0 | 1 | 100 |
| BITIDC2013 | IDC | Intellectual Property Rights | 3 | 2 | 0 | 1 | 100 |
| BITAEC2012 | AEC | Language/ Regional language | 2 | 2 | 0 | 0 | 100 |
| BITSEC2013 | SEC | Microbial Techniques | 3 | 2 | 0 | 1 | 100 |
| | | **Total Credits** | **20** | | | | |
| **SEMESTER IV** | | | | | | | |
| BITMAJ2034 | MAJOR | Molecular Biology | 4 | 3 | 0 | 1 | 100 |
| BITMAJ2044 | MAJOR | Immunology | 4 | 3 | 0 | 1 | 100 |
| BITMAJ2054 | MAJOR | Genetics | 4 | 3 | 0 | 1 | 100 |
| BITMIN2024 | MINOR | Plant Biotechnology | 4 | 3 | 0 | 1 | 100 |
| BITAEC2022 | AEC | Language/ Regional language | 2 | 2 | 0 | 0 | 100 |
| BITINT2012 | | Internship | 2 | - | - | - | 100 |
| | | **Total Credits** | **20** | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **SEMESTER V** | | | | | | | |
| BITMAJ3014 | MAJOR | rDNA Technology | 4 | 3 | 0 | 1 | 100 |
| BITMAJ3024 | MAJOR | Bioinformatics | 4 | 3 | 0 | 1 | 100 |
| BITMAJ3034 | MAJOR | Developmental Biology | 4 | 3 | 0 | 1 | 100 |
| BITMAJ3044 | MAJOR | Biostatistics | 4 | 3 | 0 | 1 | 100 |
| BITMIN3014 | MINOR | Animal Biotechnology | 4 | 3 | 0 | 1 | 100 |
| | | **Total Credits** | **20** | | | | |
| **SEMESTER VI** | | | | | | | |
| BITMAJ3054 | MAJOR | Genomics and Proteomics | 4 | 3 | 0 | 1 | 100 |
| BITMAJ3064 | MAJOR | Industrial Biotechnology | 4 | 3 | 0 | 1 | 100 |
| BITMAJ3074 | MAJOR | Environmental Biotechnology | 4 | 3 | 0 | 1 | 100 |
| BITMAJ3084 | MAJOR | Agriculture Biotechnology | 4 | 3 | 0 | 1 | 100 |
| BITMIN3024 | MINOR | Bioprocess Technology | 4 | 3 | 0 | 1 | 100 |
| | | **Total Credits** | **20** | | | | |
| **SEMESTR VII** | | | | | | | |
| BITADL14014 | MAJOR | Cell and Molecular Biology | 4 | 2 | 1 | 1 | 100 |
| BITADL14024 | MAJOR | Advanced Biochemistry | 4 | 2 | 1 | 1 | 100 |
| BITADL14034 | MAJOR | Advanced Immunology | 4 | 2 | 1 | 1 | 100 |
| BITADL14044 | MAJOR | Advanced Genetics | 4 | 2 | 1 | 1 | 100 |
| BITADL14054 | MAJOR | Research Methodology/MOOCs | 4 | 2 | 1 | 1 | 100 |
| | | **Total Credits** | **20** | | | | |
| **SEMESTER VIII** | | | | | | | |
| BITSPL15064 | MAJOR | Microbial Biotechnology | 4 | 2 | 1 | 1 | 100 |
| BITSPL15074 | MAJOR | Computational Biology and Drug Designing | 4 | 2 | 1 | 1 | 100 |
| BITSPL15084 | MAJOR | Emerging Technologies | 4 | 2 | 1 | 1 | 100 |
| BITSPL15094 | MAJOR | Genetic Engineering | 4 | 2 | 1 | 1 | 100 |
| BITSPL15104 | MAJOR | Plant and Animal Biotechnology | 4 | 2 | 1 | 1 | 100 |
| | | **Total Credits** | **20** | | | | |

**Note:** After completion of four years of UG-PG Integrated Programme, a student can opt for any of the three options to obtain their Degree.

**Option A:** Only Coursework

**Option B:** Only Research

**Option C:** Coursework + Research

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Option A- (Only Coursework)** | | | | | | | |
| **SEMESTER IX** | | | | | | | |
| BITSPL25014 | MAJOR | Stem Cell Biology | 4 | 2 | 1 | 1 | 100 |
| BITSPL25024 | MAJOR | Medical Biotechnology | 4 | 2 | 1 | 1 | 100 |
| BITSPL25034 | MAJOR | Bioprocess Engineering and Technology | 4 | 2 | 1 | 1 | 100 |
| BITSPL25044 | MAJOR | Vaccine Biology | 4 | 2 | 1 | 1 | 100 |
| BITSPL25054 | MAJOR | Molecular Diagnostics/Moocs | 4 | 2 | 1 | 1 | 100 |
| **Total Credits** | | | **20** | | | | |
| **SEMESTER X** | | | | | | | |
| BITSPL25064 | MAJOR | Bio-entrepreneurship | 4 | 2 | 1 | 1 | 100 |
| BITSPL25074 | MAJOR | Enzyme Technology | 4 | 2 | 1 | 1 | 100 |
| BITSPL25084 | MAJOR | IPR, Biosafety and Bioethics | 4 | 2 | 1 | 1 | 100 |
| BITSPL25094 | MAJOR | Protein Engineering | 4 | 2 | 1 | 1 | 100 |
| BITSPL25104 | MAJOR | Nanobiotechnology | 4 | 2 | 1 | 1 | 100 |
| **Option B- (Only Research)** | | | | | | | |
| **SEMESTER IX and X** | | | Dissertation | | | | |
| **Total Credits** | | | **40** | | | | |
| **Option C- (Coursework + Research)** | | | | | | | |
| **SEMESTER IX** | | | | | | | |
| BITSPL25014 | MAJOR | Stem Cell Biology | 4 | 2 | 1 | 1 | 100 |
| BITSPL25024 | MAJOR | Medical Biotechnology | 4 | 2 | 1 | 1 | 100 |
| BITSPL25034 | MAJOR | Bioprocess Engineering and Technology | 4 | 2 | 1 | 1 | 100 |
| BITSPL25044 | MAJOR | Vaccine Biology | 4 | 2 | 1 | 1 | 100 |
| BITSPL25054 | MAJOR | Molecular Diagnostics/MOOCs | 4 | 2 | 1 | 1 | 100 |
| **Total Credits** | | | **20** | | | | |
| **SEMESTER X** | | | Dissertation | | | | |
| **Total Credits** | | | **20** | | | | |

| Paper Name: CELL STRUCTURE AND DYNAMICS | |
|---|---|
| **Paper Code: BITMAJ1014** | **Semester: I** |
| **Type: MAJOR** | **Credit: 4 (3L+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Course Objective:**

To gain the knowledge related to the basics of different types cell structure and morphology

**Course Outcomes (CO):**

**CO1:** Upon completion of the course, the student will be able to understand the structural organization of a prokaryotic and eukaryotic cell.

**CO2:** The learner shall know the origin/biogenesis of the cell components

**Theory: 45 lectures**

**Unit 1: Origin of life on Earth** **5 lectures**

The theory of Extra-terrestrial contact - import of life through meteorites. Theory of Chemical Evolution, Abiotic formation of sugars, amino acids, organic acids, purines, pyrimidines, glycerol and formation of nucleotides and their polymerization to RNA on reactive Surfaces, polymerization of amino acids to Polypeptides and Proteins. Ribozymes and RNA World. Formation of DNA, Formation of nucleoproteins, Prions, Natural Selection of Self-replicating Polymers.

**Unit 2: Basic cell structure** **5 lectures**

Discovery of cell and Cell Theory; Prokaryotic and Eukaryotic cell.

**Unit 3: Prokaryotic cell and its components** **10 lectures**

The Slime and the cell wall of bacteria containing peptidoglycan and related molecules; the outer membrane of Gram-negative bacteria, the cytoplasmic membrane. Water and ion transport, mesosomes, flagella, Pilus, fimbriae, ribosomes, carboxysomes, sulphur granules, glycogen, polyphosphate bodies, fat bodies, gas vesicles; endospores, exospores, cysts. Mycelia of fungi and Actinomycetes, Cytoskeleton filament, heterocysts and akinetes of Cyanobacteria, Gliding and motility.

**Unit 4: Eukaryotic cell and its components** **15 lectures**

Comparison between plant and animal cells; Cell wall; Plasma membrane; Models of membrane structure; Cytoskeleton; Protoplasm; Mitochondria; Chloroplast; ER; Golgi complex; Lysosome, endosome and microbodies; Ribosome; Centriole; Nucleus. Biogenesis of Cellular organelles viz mitochondria, chloroplast, ER, Golgi complex;

**Practical:** **15 lectures**

1. To study the structure of any prokaryotic cell under the microscope
2. To study the structure of any plant cell under the microscope
3. To study the structure of any plant cell under the microscope
4. Observation of vacuoles (using onion epidermis/rose leaf etc)
5. Observation of mitochondria (using onion epidermis/root tips etc)
6. Study the effect of temperature and organic solvents on semi permeable membrane.

***Suggested readings:***


- *Microbiology- Prescott LM, Harley JP, Klein DA, Wm. C. Brown Publishers*
- *Microbiology: Tortora, G.J., Funke, B.R. and Case, C.L An Introduction Pearson Education.*
- *Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons. Inc.*
- *De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8$^{th}$ edition. Lippincott Williams and Wilkins, Philadelphia.*
- *Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.*
- *Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009. The World of the Cell. 7$^{th}$ edition. Pearson Benjamin Cummings Publishing, San Francisco.*

| Paper Name: INTRODUCTION TO BIOTECHNOLOGY | |
|---|---|
| **Paper Code: BITMIN1014** | **Semester: I** |
| **Type: MINOR** | **Credit: 4 (3L+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Course Objective:**

To provide foundation in biotechnology by offering students with theoretical and working knowledge of the various principles and techniques employed in biotechnology.

**Course Outcomes (CO):**

**CO1:** Shall learn to apply various tools of biotechnology in agriculture, environment and food sciences.

**CO2:** Understand and solve biological and ecological problems and harness potential of living systems for the benefit of human mankind.

**Theory: 45 lectures**

**Unit 1: Scope and Introduction to Biotechnology** **10 lectures**

Historical perspective & Definitions of Biotechnology, Traditional and Modern Biotechnology, Overview of Branches of Biotechnology: Plant, Animal Biotechnology, Marine Biotechnology, Agriculture, Healthcare, Industrial Biotechnology, Pharmaceutical Biotechnology, Environmental Biotechnology, Medical Biotechnology.

**Unit 2: Applications of Biotechnology in Agriculture** **15 lectures**

Overview of Applications of Biotechnology in Agriculture: GM Food, GM Papaya, GM Tomato, Fungal and Insect Resistant Plants, BT Crops, BT Cotton and BT Brinjal, Pros and Cons. Biotechnological applications in enhancement of Food Quality, Quality Factors in Pre-processed Food, Microbial role in food products (Yeast and Bacterial based process and products).

**Unit 3: Applications of Biotechnology in Environment** **10 lectures**

Overview of Applications of Biotechnology in Environment: Solid Waste Management, Biopesticides, Biofertilizers and Biofuels, Bioremediation.

**Unit 4: Research in Biotechnology** **10 lectures**

Overview of Biotechnology Research in India. Ethical Issues in Biotechnology. Biosensors and Tissue engineering. Overview of Biotechnology Institutions in India (Public and Private Sector)

**Practical:** **15 lectures**

1. Safety, Check-in, Laboratory record keeping
2. Introduction to various laboratory instruments
3. Pipetting techniques
4. Preparation of Solutions, buffers etc
5. Sterilization techniques

***Suggested Readings:***


- *McGregor, C.W.; Membrane separation in Biotechnology; Marcel Dekker, Inc, New York.*
- *Frieferder, S.; Physical Biochemistry; Freeman and Co., New York.*
- *Biotol Series (I - IV); Techniques used in Bioproduct Analysis; Buterworth Heineman,U.K.*
- *Work, T.S.; Lab. Techniques in Biochemistry and Molecular Biology, Elsevier, New York.*
- *Microbiology: Michael J. Pelczar Jr., E. C. S Chan, Noel R. Krieg*
- *Smith J. E., Biotechnology, 3rd Edition, Cambridge University Press (2006 )*

| Paper Name: BIO-ENTREPRENEURSHIP | |
|---|---|
| **Paper Code: BITIDC1013** | **Semester: I** |
| **Type: IDC** | **Credit: 3 (2L+1P)** |
| **Total classes: 45= 30+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Course Objectives:** This bioentrepreneurship course equips students to navigate the world of launching bio-based ventures. They'll gain hands-on skills in producing and analyzing microbial products while learning to strategically apply these products for societal benefit. The course also explores the essential skills and support systems available to bioentrepreneurs and highlights the wealth of entrepreneurial opportunities in the industry.

**Course Outcome:**

**CO1:** Understand skills and the role of various institutional support for an entrepreneur.

**CO2:** Understand the procedure for preparing various microbial products.

**CO3:** Acquire knowledge and analyze the applications of microbial products for human well being.

**CO4:** Retain knowledge of microbiology in entrepreneur development.

**CO5:** Understand formulate the strategy to apply the industrially important products in society.

**Theory: 30 lectures**

**Unit I: INTRODUCTION TO ENTREPRENEUR 6 lectures**

Evolution of the concept of entrepreneur – Entrepreneurship; Definitions- concept of Entrepreneurship, development- need- role of resource, talent and spirits – process of Entrepreneurship to socio- economic gains.

**Unit II: SCHEMES FOR ENTREPRENEUR 6 lectures**

Institution and schemes of government of India- scheme and programmes, department of science and technology schemes, nationalized banks – other financial institution- SIDBI- NSIC- NABARD- IDBI- IFCI and ICICI.

**Unit III: NEGOTIATIONS/STRATEGY 6 lectures**

With financiers, bankers etc.; with government/law enforcement authorities; with companies/Institutions for technology transfer; Dispute resolution skills; External environment/changes;Crisis/ Avoiding/Managing; Broader vision–Global thinking.

**Unit IV: MICROBIAL PRODUCTS 6 lectures**

Bread baking bread – leavening- baking process- idli- dosa, fermented products, mushroom cultivation and composting, preparation of compost, filling tray beds – spawing, maintaining

optimum temperature, casing, watering, harvesting, storage. Biofertilizer – historical background, chemical fertilizer versus biofertilizer, organic farming, Rhizobium sp, Azospirullumsp, Azotobactersp as biofertilizer.

**Unit V: ROLE OF KNOWLEDGE CENTRE AND R&D 6 lectures**

Support mechanism for entrepreneurship in India; Knowledge centres like universities and research institutions; Role of technology and upgradation; Assessment of scale of development of Technology; Managing Technology Transfer; Regulations for transfer of foreign technologies; Technology transfer agencies.

**Practicals 15 lectures**

1. Preparation of Proposal with novel idea
2. Preparation of SWOT analysis of the proposed idea
3. Preparation of a comprehensive report on the funding sources in India
4. Preparation of a comprehensive report on the funding sources in abroad
5. Preparation of documents needed for Grand-Aid/Extramural/Seed grant requirements from various agencies
6. Identification of novel products from Bacteria
7. Identification of novel products from Fungi
8. Identification of novel products from Plants
9. Development of product and analysis the strategy
10. Preparation of patent application with five claims

***Suggested Readings:***


1. *Mohanty, S.K., ―Fundamentals of Entrepreneurship‖, Sixth Edition, Prentice Hall India Private Limited, New Delhi, 2005.*
2. *Saxena, S., ―Applied Microbiology‖, Springer, New York, 2015.*
3. *Bhatia, B.S. and Batra, G.S., ―Entrepreneurship and small business management‖, Deep & Deep Publications, New Delhi, 2003.*
4. *Hisrich, D.R., ―Entrepreneurship‖, Sixth Edition, Tata McGraw Hill Private Limited, New Delhi, 2008.*
5. *Nagendra, S., ―Entrepreneurship and Management‖, Sanguine technical Publishers, New Delhi, 2008.*
6. *Okafor, N., ―Modern Industrial Microbiology and Biotechnology‖, Second Edition, Science Publishers, New Hampshire, 2007.*

| Paper Name: INSTRUMENTATION IN BIOTECHNOLOGY | |
|---|---|
| **Paper Code: BITSEC1013** | **Semester: I** |
| **Type: SEC** | **Credit: 3 (2L+1P)** |
| **Total Classes: 45= 30+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Course Objective**:

This paper will provide an in-depth understanding of various scientific instruments used for analysis of biological samples.

**Course Outcomes (CO)**:

**CO1:** Apply the analytical methods in Biotechnology Industries

**CO2:** Understand the principle and trouble shootings in the analytical instruments.

**Theory: 30 lectures**

**Unit 1: Microscopy** **10 lectures**

Basic Principles and application of Simple Microscope, Compound Microscope, Transmission and Scanning Electron Microscopes; Principles of Fixation and Staining.

**Unit 2: Optical Methods of Analysis** **2 lectures**

Beer-Lambart Law, Basic Principles and application of Colorimeter and UV-Visible Spectrophotometer.

**Unit 3: Chromatographic Methods of Analysis** **5 lectures**

Working Principle, instrumentation and Application of Paper, Thin Layer, Column and High-Pressure Liquid Chromatography

**Unit 4: Electrophoretic Techniques** **10 lectures**

Principle and factors affecting Electrophoresis-pH, voltage, supporting medium in Agarose Gel Electrophoresis, PAGE, SDS-PAGE

**Unit 5: Centrifugation** **3 lectures**

Principle of Centrifugation, differential and density gradient centrifugation, ultracentrifugation, sedimentation analysis and RCF

**Practical:** **15 lectures**

1. Sample preparation, Plant and Animal Tissue fixation and staining technique and microscopic study
2. Quantitative analysis of biological samples by colorimetric/ spectrophotometric methods
3. Separation of amino acids by Paper and Thin Layer Chromatography
4. Electrophoretic separation of nucleic acids/ proteins.

***Suggested Readings**:*

- *Wilson and Walker: Principles and Techniques in Practical Biochemistry, Cambridge University Press*
- *Jayaram: Laboratory Manual in Biochemistry, New Age International Publications.*

| Paper Name: WASTE AND ENERGY MANAGEMENT | |
|---|---|
| **Paper Code: BITVAC1014** | **Semester: I** |
| **Type: VAC** | **Credit: 4**<br>**NCC/NSS-2 + 2 (1L+1P)** |
| **Total Contact hours: 30= 15+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Objective:**

The objective of the paper is to encourage trash to gold and the concept shall explore the genesis of circular economy.

**Course Outcomes (CO):**

**CO1:** The paper shall enable the students to learn utilize the waste material for initiating entrepreneurship

**CO2:** The paper shall enable the student to understand how important is waste and how waste can be cheaper raw materials to initiate a process

**Theory: 15 lectures**

**Unit 1: Introduction and future perspectives of waste and energy management**

**5 lectures**

Identification of waste streams in your area, mushroom cultivation on different agricultural wastes, Gobar Gas, Vermicompost, Bioleaching and biohydrometallurgy, pyrolysis, biofertilizers from organic wastes.

**Unit 2: Waste sources, classification and characterization 7 lectures**

Waste production in domestic, industrial, agriculture, postconsumer waste etc. Classification of waste – agro based, forest residues, domestic waste, industrial waste (hazardous and non-hazardous). Characterization of waste for energy utilization. Waste Selection criteria.

**Unit 3: Identifying alternative source of energy and mitigation 3 lectures**

Biofuel, Bioethanol production, hydroenergy, green energy, solar energy

**Practical: 15 Lectures**

1. Cultivation of Banana and the stem of the Banana in utilization of Vermicomposting
2. Culture of Earthworm *(Eisenia fetida)*
3. Gobar and utilization in methane gas genesis
4. Areaca nut leaf plate making
5. Formation of ethanol from waste of sugarcane

*Suggested readings:*


1. *Industrial and Urban Waste Management in India, TERI Press.*
2. *Wealth from Waste: Trends and Technologies by Banwari Lal and Patwardhan, TERI Press.*
3. *Fundamentals of waste and Environmental Engineering, S.N Mukhopadhyay, TERIPress.*
4. *Gazette Notification on Waste Management Rules 2016.*
5. *Report of the task Force on Waste to Energy, Niti Ayog (Formerly Planning Commission) 2014.*
6. *Municipal Solid Waste Management Manual, CPHEEO, 2016*

| Paper Name: BIOMOLECULES | |
|---|---|
| **Paper Code: BITMAJ1024** | **Semester: II** |
| **Type: MAJOR** | **Credit: 4 (3L+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**COURSE OBJECTIVE:**

This course aims to equip students with a foundational understanding of life's building blocks, exploring the structures and functions of various molecules. It delves into the fundamentals of biochemistry and molecular biology, ultimately enabling students to grasp genetic principles.

**COURSE OUTCOME:**

**CO1:** After the completion of the course students will understand significance water as a solvent of life and know the relationship with biomolecules.

**CO2:** Understand the structure and function of proteins as building block of life.

**CO3:** Understand the knowledge on carbohydrates as monosaccharides and polysaccharides.

**CO4:** Understand the structures, function, and classification of lipids.

**CO5:** Understand the structure of nucleic acids, along with basic steps in the processing of genetic engineering.

**Theory: 45 lectures**

**Unit I: Chemical bonds and biomolecules** **5 lectures**

Physical properties and hydrogen bonding of water; structure of water and its solvent properties; hydrophobic interactions. Ionization of water and ion product of water; the pH scale; relationship between pH and pKa (HendersonHasselbalch equation); buffers and its properties.

**Unit II: Protein** **10 lectures**

Biological functions of proteins; structure of alpha-amino acids, abbreviations and classification of 20 amino acids; zwitterion nature of amino acid in aqueous solutions; essential amino acids; peptide bond formation; backbone structure of Proteins/polypeptides; basic understanding of primary, secondary, tertiary, and quaternary structure of proteins/peptides; fibrous and globular proteins; elementary ideas on protein denaturation and renaturation.

**Unit III: Carbohydrates** **10 lectures**

Definition and biological functions of carbohydrates; classification into monosaccharides, oligosaccharides and polysaccharides; optical isomerism, open chain and ring structures of carbohydrates; mutarotation; structure of biologically important carbohydrates (D-glucose, D-galactose, D-mannose, Dfructose, D-ribose, D-2-deoxyribose, D-maltose, D-lactose, D-sucrose); polysaccharides starch, cellulose, glycogen and mucopolysaccharides; suitability of polysaccharides as storage material.

**Unit IV: Lipids** **10 lectures**

Introduction of lipids, biological functions; general formulae, nomenclature and properties of fatty acids; essential and non-essential fatty acids; classification of lipids; general structure and function of major lipid subclasses: acylglycerols, phosphoglycerides, sphingolipids, waxes, terpenes, steroids and prostaglandins; saponifiable and non-saponifiable lipids; suitability of triglycerides as storage lipids; saponification number and iodine number; bio membranes structure.

**Unit V: Nucleic acid** **10 lectures**

Nucleosides and nucleotides; generalized structural plan of nucleic acids. Evidence of DNA as genetic material; Watson-Crick model of DNA; size of DNA in prokaryotic and eukaryotic cells. Central dogma of molecular biology; gene, genome and chromosome. Basic ideas of DNA replication, transcription and protein biosynthesis; genetic code and codons. RNA structure and functions, types of DNA and RNA.

**Practicals** **15 lectures**

1. Preparation of Phosphate Buffer Saline at pH7.
2. Qualitative analysis of proteins from given samples.
3. Qualitative analysis of carbohydrates from given samples
4. Qualitative analysis of Lipids from given samples
5. Qualitative analysis of Nucleic acid from given samples
6. Protein estimation by Lowry’s method.

***Suggested Readings:***


1. *Lehninger: Principles of Biochemistry (2017) by Nelson and Cox. Seventh edition. WH Freeman and Co. 2. Biochemistry (2015) by Berg, Tymoczko, Gatto, Stryer. Eighth Edition. WH Freeman and Co.*
2. *Outlines of Biochemistry by Conn and Stumpf (5th Edition, 1987) Wiley, New Delhi.*
3. *Introducing Biochemistry (1982) by Wood and Pickering. ELBS/John Muray.*
4. *Nelson D. L, Cox M. M. Lehninger's Principle of Biochemistry. 5th Ed.,W. H. Freeman, 2008.*

5. *Martin D. W, Mayer P. A. and Rodwell V. W. Harper's Review of Biochemistry 30th Ed., Maruzen Asian Lange Med.,2010.*
6. *Dixon M, Webb E. C,Thorne C.J.R and Tipton K.F.Enzymes. 3rd Ed., Longmans, Green &Co.,Academic Press, New York, 1979.*
7. *Wilson K., Walker J, Practical biochemistry Fifth Edition Cambridge Press.*
8. *R David Freifelder., Physical biochemistry: Application to biochemistry and Molecular biology Second edition. W.H. Freeman and Company, New York.*

| Paper Name: BASIC BIOCHEMISTRY | |
|---|---|
| **Paper Code: BITMIN1024** | **Semester: II** |
| **Type: MINOR** | **Credit: 4 (3L+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

This course dives into core principles and experimental foundations of biochemistry. Students gain specialized knowledge through lectures and research projects. The curriculum explores energy pathways (glycolysis, TCA cycle, gluconeogenesis) , fatty acid metabolism, and the mechanics of photosynthesis

**COURSE OUTCOME:**

**CO1:** Provide an advanced understanding of the core principles and topics of Biochemistry and their experimental basis

**CO2:** Enable students to acquire a specialized knowledge and understanding of selected aspects by means of a stem/branch lecture series and a research project.

**CO3:** Studentss acquire knowledge in energy yielding pathways such as Glycogen metabolsim, TCA cycles and Gluconeogenesis

**CO4:** Students will acquire knowledge in fatty acid metabolism

**CO5:** Students will learn the mechanism of photosynthetic process

**Theory: 45 lectures**

**Unit I: Water, acids, bases and buffer 10 lectures**

Dissociation of water, ionic product of water, concepts of pH, pOH, simple numerical problems of pH, determination of pH using indicators, pH meter and theoretical calculations. Dissociation of weak acids and electrolytes, Brönsted theory of acids and bases, shapes of titration curve of strong and weak acids and bases. Meaning of Ka and pKa values, buffers and buffer action. Buffers in biological system, Henderson -Hasselbalch equation with derivation, simple numerical problems involving application of this equation, simple numerical problems on buffer composition.

**Unit II: Metabolism I: Glycolysis and Gluconeogenesis 8 lectures**

Carbohydrate metabolism: Embden-Meyerhof pathway, regulation of glycolysis in Liver and Muscles, fermentation, anaerobic fate of pyruvate, Entry of different sugars in glycolysis, gluconeogenic pathway and its regulation,

**Unit III: Metabolism II: Glycogen metabolism, TCA cycle and electron transport chain**

**7 lectures**

Glycogen metabolism (glycogenolysis and glycogenesis), regulation of glycogen metabolism, TCA cycle and its regulation- ATP production. Electron transport chain system: ATP synthase structure and function, Boyer's conformational model.

**Unit IV: Fatty acid and amino acid metabolism** **10 lectures**

Lipid Metabolism: Lipolysis, β-oxidation, energy yield, role of Carnitine. Essential aminoacids, nonessential aminoacids, glucogenic and ketogenic amino acids, amino acids biosynthesis (glutamate, glutamine, alanine, aspartate, asparagine serine, glycine, praline, cysteine, tyrosine), pathways of amino acids degradation (acetyl CoA family α-ketoglutarate family, succinyl CoA family), Urea cycle.

**Unit V: Photosynthesis** **10 lectures**

Introduction, Significance, Historical aspects, Photosynthetic pigments, Concept of two photosystems, Light phase: Cyclic and Non cyclic photophosphorylation (z scheme), Dark phase: Calvin cycle (C3), Hatch and slak cycle (C4) and CAM pathway, Photorespiration (C2 cycle), significance of Photosynthesis.

**Practicals** **15 lectures**

1. Introductory class for biochemistry lab instrumentations.
2. pH measurements and preparation of buffers.
3. Qualitative tests for Carbohydrates.
4. Estimation of reducing sugars.
5. Estimation of proteins by Biuret method
6. Estimation of cholesterol by Zak's method.

***Suggested Readings:***


1. *Biochemistry by LubertStryer. W. H. Freeman & Company, NY, 2000 2. Biochemistry by Lehninger. McMillan publishers, 2003 3.*
2. *Biochemistry by Zubey. Wm. C. Brown publishers, 2007*

| Paper Name: BIOETHICS AND BIOSAFETY | |
|---|---|
| **Paper Code: BITIDC1023** | **Semester: II** |
| **Type: IDC** | **Credit: 3 (2L+1P)** |
| **Total Classes: 45= 30+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Course Objectives:**

To introduce basic concepts of ethics and safety that is essential for Life Science Labs.

**Course Outcomes (CO):**

**CO1:** Know about the biosafety regulations and ethical concepts in biotechnology.

**CO2:** Understand the importance of bioethics and biosafety procedures to be followed, with knowledge of the basic concepts, its principles, and use.

**CO3:** Recognize the importance of biosafety practices and guidelines in research.

**Theory: 30 lectures**

**Unit 1: Bioethics** **10 lectures**

Bioethics – Necessity of Bioethics, different paradigms of Bioethics – National & International. Ethical issues against the molecular technologies. Legal and socioeconomic impacts of biotechnology, health and safety issues.

**Unit 2: Biosafety** **10 lectures**

Biosafety– Introduction to biosafety and health hazards concerning biotechnology. Objectives, Risk assessment in biotechnological research and their regulation, physical and biological contaminants, field trial and planned introduction of GMOs.

**Unit 3: Biosafety Guidelines** **10 lectures**

Biosafety guidelines in India, Biosafety levels for plant, animal and microbial researches. Introduction to the concept of containment level and Good Laboratory Practices (GLP) and Good Manufacturing Practices (GMP).

**Practical:** **15 lectures**

1. General safety measures and study of safety notices
2. Study of symbols and warnings on reagent bottles
3. Study of preventive measures and first aid during laboratory hazards
4. Demonstration of handling of fire extinguisher
5. Case study on handling and disposal of radioactive waste
6. Case study on handling and disposal of medical/microbial waste
7. Study of components and design of a Biosafety laboratory

***Suggested Readings / Books***

- *Bioethics and Biosafety in Biotechnology by Sree Krishna V., New Age International (P) Ltd., Publ., Mumbai. 2007*
- *The Indian Environmental Protection Act (EPA), 1986*
- *Rules for manufacture, use/import/export and storage of hazardous microorganisms or cells Act, 1989*
- *Food Safety and Standards act (Government of India), 2006*

| Paper Name: PLANT AND ANIMAL TISSUE CULTURE TECHNIQUES | |
|---|---|
| **Paper Code: BITSEC1023** | **Semester: II** |
| **Type: SEC** | **Credit: 3 (2L+1P)** |
| **Total Classes: 45= 30+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Course Objective:**

This paper shall enable the students to understand the plant and animal tissue-based application and utility which opens the scope for various scale ups and start-ups.

**Course Outcomes (CO):**

**CO1:** Learners will be acquainted with the laboratory knowledge and skill for plant tissue culture-based research

**CO2:** This course shall help the students to know about the functional utility of various animal tissue application including insights in medical biotechnology and diagnostics

**Theory: 30 lectures**

**Unit 1**: **Introduction to tissue culture** **8 lectures**

Introductory history, Laboratory organization, Cell culture, Cellular Totipotency, Somatic Embryogenesis.

Composition of culture media, Growth hormones, Vitamins, Unidentified supplements, selection of media

**Unit 2:Plant tissue culture techniques** **7 lectures**

Preparation steps for tissue culture, surface sterilization of plant tissue material, sterilization of medium components, basic procedure for aseptic tissue transfer, incubation of culture. Callus Culture, Cell Suspension Culture, Organ Micro-culture, plant micro-propagation, Somatic Embryogenesis, Artificial seed.

**Unit 3: Introduction to laboratory set up for animal tissue culture** **7 lectures**

Understanding Laboratory set up for animal tissue culture. Various media of animal tissue culture. Understanding various instruments like Laminar Air Flow Cabinet, Bio safety Cabinet, Autoclave, Centrifuge, CO2 Incubator etc.

**Unit 4:Animal tissue culture** **8 lectures**

Karyotype, soma clonal studies. Primary and Secondary culture, monolayer and suspension culture. Various hormones and bioactive components and their utility. Application of animal tissue culture. Tissue grafting

**Practical:** **15 lectures**

1. Handling of autoclave, LAF, centrifuge etc
2. Preparation of different types of plant tissue culture media
3. Preparation of various media for animal tissue culture.
4. Sterilization of medium components and other tools used in plant and animal tissue culture.
5. Initiate a callus culture
6. Preparation of artificial seed
7. Culture of lymphocyte for karyotype

***Suggested readings:***


- *Bhojwani, S.S. and Razdan 2004 Plant Tissue Culture and Practice.*
- *Reinert, J. and Bajaj, Y.P.S. 1997 Applied and Fundamental Aspects of Plant Cell, Tissue and Organ Culture. Narosa Publishing House.*
- *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications: R. Ian Freshney:: John Wiley & Sons, Inc.*
- *Animal Cell Culture: A Practical Approach: John Masters:: Publisher : OUP Oxford*
- *Animal Cell Culture: Concept and Application: Sheelendra M. Bhatt :Publisher : Alpha Science International Ltd*
- *Animal Tissue Culture: P Ramadass and A Wilson Aruni: Publisher : Mjp Publishers*

| Paper Name: SERICULTURE | |
|---|---|
| **Paper Code: BITVAC1024** | **Semester: II** |
| **Type: VAC** | **Credit: 4**<br>**NCC/NSS-2 + 2 (1L+1P)** |
| **Total Contact hours: 30= 15+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Course Objective:**

The objective of the paper is to encourage students to know about host plant of silk and also various species of silk worm including weaving

**Course Outcomes (CO):**

**CO1:** The paper shall enable the students to learn and utilize the bioresource for production of silk.

**CO2:** The students shall be equipped with the knowledge of sericulture starting from rearing to post-cocoon technology and weaving.

**CO3:** The paper shall enable the student to understand the utility of host plant of silk work

**Theory: 15 lectures**

**Unit 1: Introduction to Sericulture** **5 Lectures**

Origin and history of sericulture, Characteristic features of the order Lepidoptera, Life cycle of *Samiacynthia ricini* (Eri) and *Antheraea assama* (Muga), anatomical structure of silk gland, Food habits of silkworms, different varieties of mulberry with special reference to Assam, silkworm as food, thread spinning, Diseases of silkworm and its control, Perspectives of sericulture and textile industry, Role of women in sericulture.

**Unit 2: Silkworm Rearing** **5 lectures**

Rearing appliances, disinfection, disinfectants, bed cleaning, feeding of worms. Maintaining optimum condition of rearing, brushing, frequency of spacing, care during mounting. Mounting and mountage, process of spinning, cocoon harvesting. Rearing method: chawki rearing or young age worm rearing. Late age Silkworm rearing.

**Unit 3: Post Cocoon Technology and Silk Technology** **5 lectures**

Cocoon stifling (sun drying, steam stifling, hot air stifling), storage of cocoon, sorting of cocoons. Deflossing, cocoon riddling, mixing or blending, cocoon cooking, brushing. Concept of different reeling machines, reeling operation, reeling end formation. Degumming, bleaching, dyeing of silk yarn. Twisting, Reeling, Re-reeling, lacing, skeining and testing of raw silk material.Weaving of silk.

**Practical:** **15 lectures**

1.Selection and plantation of host plant of Silk worm

2.Rearinig of silk worm.

3.Spining of thread of cocoon

4. Weaving cloths with the threads spined from the silk

***Suggested Readings:***


1. *Rangaswami, G.; Narasimhanna, M.N.; Kasiviswanathan, K., Sastry, C.R. And Jolly, M.S. (1976) Sericulture Manual-1- Mulberry Cultivation. Agriculture Services Bulletin, FAO, Rome.*
2. *Rajanna, L., Das, P.K., Ravindran, S., Bhogesha, K., Mishra, R.K., Singhvi, N.R., Katiyar, R.S. and Jayaram, H. (2005) Mulberry Cultivation and Physiology. Central Silk Board, Bangalore.*

| Paper Name: CELL BIOLOGY | |
|---|---|
| **Paper Code: BITMAJ2014** | **Semester: III** |
| **Type: MAJOR** | **Credit: 4 (3L+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Course Objective:**

The objective of the cell biology course is to provide students with a comprehensive understanding of the fundamental principles and mechanisms of cellular organization, function, and communication.

**Course Outcomes (CO):**

**CO1:** Understand the basic structure and functions of cells, including the plasma membrane, organelles, and cytoskeleton.

**CO2:** Explain the process of cell division and cell differentiation.

**CO3:** Describe the mechanism of cellular communication and signaling, including the role of receptors, hormones, and second messengers.

**CO4:** Discuss the cellular basis of disease, including the mechanism of cell death and the role of cellular process in disease pathogenesis.

**CO5:** Understand the fundamental practical experiments that are conducted in the field of cell biology, particularly those that pertain to significant topics.

**Theory: 45 lectures**

**Unit 1: Introduction to cell structure** **10 Lectures**

History of the discovery of the cell, cell as the structural and functional unit of life, cell theory, the structure of prokaryotic, and eukaryotic cells, microscopic techniques for the study of cells, plasma membrane structure and functions, membrane composition and dynamics, transport of ions and macromolecules, membrane vacuolar system.

**Unit 2**: **Cell Organelles** **10 Lectures**

Cell organelles and their structure and functions: structure and functions of Mitochondria, Chloroplast, Nucleus, Gogi body, Endoplasmic reticulum, Lysosome, Peroxisome, and Ribosome. Origin of Mitochondria and Chloroplast.

**Unit 3:Cell Division and Cell Death:** **9 Lectures**

Mitosis, Meiosis, Cell Cycle, and its regulation, Diseases caused due to the dysregulation of cell division and cell cycle, Cell division in prokaryotes; Cell death mechanisms: Necrosis, Apoptosis, Autophagy; Clearance of dead cells: Efferocytosis.

**Unit 4**: **Extracellular Matrix and Cell Signalling** **16 Lectures**

Composition, molecules that mediate cell adhesion, membrane receptors for extracellular matrix, macromolecules, regulation of receptor expression and function. Cell-to-cell communications; overview- types of cell-signaling- mechanism of various types of signal transduction pathways of cells.

**Practical:** **15 Lectures**

1. Study of the structure of any Prokaryotic and Eukaryotic cell.
2. Study the effect of temperature and organic solvents on the plasma membrane.
3. Preparation of Nuclear, Mitochondrial & Cytoplasmic fractions.
4. Study of mitosis.
5. Study of meiosis.
6. Total cell count by suitable method

***Suggested readings:***


- *Watson et al., Molecular Biology of the gene, 5th Edition, Pearson Prentice Hall. USA, 2003.*
- *Lodish et al., Molecular cell Biology, 4th Edition, W.H. Freeman & Company, 2000.*
- *Benjamin Lewin, Gene IX, 9th Edition, Jones and Barlett Publishers, 2007*
- *Karp, G, Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons. Inc, 2010.*
- *Becker, W.M et al., The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco, 2009.*
- *Albert Bruces et al., Molecular Biology of the Cell. 5$^{th}$ edition. Garland Science, 2008.*

| Paper Name: MICROBIOLOGY | |
|---|---|
| **Paper Code: BITMAJ2024** | **Semester: III** |
| **Type: MAJOR** | **Credit: 4 (3L+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Course Objective:**

To acquaint the students with history, classification and role of microbiology in agriculture, food and environment.

**Course Outcomes (CO):**

**CO1:** Classify microbes through basic techniques and know their evolutionary relationship.

**CO2:** Analyze the diversity, distribution and demonstrate the morphology and structure of microbial cells.

**CO3:** Culture microbes and demonstrate microbial growth kinetics and metabolic pathways.

**CO4:** Discuss on bacterial recombination techniques of bacterial reproduction.

**CO5:** Gain knowledge on microflora associated to the human body and the environment.

**CO6:** Gain hands on experience to prepare culture media, isolate, identify microbes and perform microbial cell count.

**Theory: 45 lectures**

**Unit 1: Microbial classification** **15 Lectures**

History of microbiology. Classification of Bacteria and Archaea, Fungi, Algae, Protozoa, Helminthes and Viruses. Basic principles and techniques used in bacterial classification Evolutionary relationship among prokaryotes. Phylogenetic and numerical taxonomy. Use of DNA and r-RNA sequencing in classifications.

**Unit 2: Microbial growth and Metabolism** **10 Lectures**

Cultivation and Maintenance of microorganisms: Nutritional categories of micro-organisms, methods of isolation, Purification and preservation; Growth curve, Generation time, synchronous batch and continuous culture, measurement of growth and factors affecting growth of bacteria; Metabolic pathways, amphi-catabolic and biosynthetic pathways

**Unit 3: Bacterial Reproduction** **10 Lectures**

Bacteriophages: Morphology and Life cycles, Conjugation, Transformation and Transduction. Endospores and sporulation in bacteria.

**Unit 4: Normal microflora** **10 Lectures**

Bacterial pollutants of water, coliforms and non coliforms

Microorganism in food: Moulds, Yeasts, bacteria. Major food born infections and intoxications. Symptoms, pathogenesis and transmission of bacterial, viral, protozoan and fungal diseases in plants and animals;Control of Microorganisms: By physical, chemical and chemotherapeutic Agents

**Practical:** **15 Lectures**

1. Preparation of culture media (solid and liquid) and sterilization
2. Pure culture techniques (Spread, pure, streak)
3. Determination of air microflora
4. Determination of soil microflora
5. Determination of water microflora
6. Gram staining technique.

***Suggested Readings:***


- *Microbiology – Pelczar, Chan, Krieg, Tata McGraw Hill Publications.*
- *Microbiology- Prescott LM, Harley JP, Klein DA, Wm. C. Brown Publishers*
- *Microbiology: Tortora, G.J., Funke, B.R. and Case, C.L An Introduction Pearson Education.*
- *Brock Biology of Microorganisms- Madigan MT, Martinko JM and Parker J. Pearson/Benjamin Cummings.*
- *General Microbiology- Stainier RY, Ingraham JL, Wheelis ML & Painter PR. MacMillan*

| Paper Name: BIODIVERSITY AND TAXONOMY | |
|---|---|
| **Paper Code: BITMIN2014** | **Semester: III** |
| **Type: MINOR** | **Credit: 4 (3L+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Course Objective:**

To gain the knowledge related to the basic concept of biodiversity and conservation and also different types taxonomy

**Course Outcomes (CO):**

**CO1:** Upon completion of this course, Students will gain knowledge about biodiversity exploration, estimation and conservation.

**CO2:** Upon completion of this course, Students will know the concept of methodology in taxonomy.

**CO3:** Upon completion of this course, Students will learn about the different tools in the taxonomy so that they can relocate the phylogenetic position of plant or taxa.

**Theory: 45 Lectures**

**Unit 1: Basic concept and global pattern of Biodiversity 13 Lectures**

What is Biodiversity, why should we conserve it, Elements of Biodiversity - Ecosystem Diversity, Genetic Diversity, Species Abundance & Diversity, Patterns of Species Diversity. Measuring biodiversity, Cataloguing and Discovering Species, Geographical Patterns of Species Richness, Biogeography, Importance of Distribution Patterns (Local Endemics, Sparsely Distributed Species, and Migratory Species), GAP Analysis.

**Unit 2: Biodiversity & Conservation 14 Lectures**

Overexploitation threatening living species, International Trade, Animals threatened by international trade, Problems in Controlling International Trade (Enforcement, Reservations, Illegal Trade), Free Trade & the Environment, Free Trade & Conservation, Common patterns of Overexploitation. The US Endangered Species Act, State Endangered Species Acts Successes and Failures of the Endangered Species Act Role of ESA in Habitat Protection, Critical Habitat, Problems with the Endangered Species Act, Habitat Conservation Plans.

**Unit 3: Basic concept of Taxonomy 8 Lectures**

Classification, Construction of Phylogenetic tree, Systematics, Cladistics, Cladograms, Phenetics, Nomenclature.

**Unit 4: Molecular Taxonomy in relation to DNA characteristics & Protein sequences**

**10 Lectures**

Modes of molecular evolution, Neutral theory of Molecular evolution, genetic markers for taxonomic purposes, comparing total genome by DNA-DNA hybridization, comparing DNA sequences, Cladistics, biological identification through DNA barcodes, chromosome painting, establishing molecular homology using protein sequences.

**Practical:** **15 classes**

1. Acquaintance with open-source databases of biodiversity.
2. Sampling of plant and animal biodiversity of the College/University campus
3. Determine species location in a given study area.
4. Microtome technique to study the biological characters of the samples.
5. Taxonomic identification of wild and cultivated plants represented in local flora.
6. Pollen preparations by Acetolysis method (Semi-permanent) and study of different pollen morphophytes.

***Suggested readings:***


- *Plant Taxonomy (2nd Edition McGraw Hill Education) by O.P. Sharma*
- *Plant taxonomy (1st Edition Eastern Book House, Guwahati) by Akhil Baruah*
- *Plant Taxonomy & Biodiversity (Santra Publications Pvt. Ltd.) by N.D. Paria*
- *Textbook of Biodiversity (Notion Press) by Anupam Rajak*

| Paper Name: INTELLECTUAL PROPERTY RIGHTS | |
|---|---|
| **Paper Code: BITIDC2013** | **Semester: III** |
| **Type: IDC** | **Credit: 3 (2L+1P)** |
| **Total Classes: 45= 30+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Course Objectives:**

The course is designed to provide comprehensive knowledge to the students regarding the general concepts and importance of IPR.

**Course Outcomes (CO):**

**CO1:** Acquaint the learners with the basic concepts of Intellectual Property Rights and the types of IPRs.

**CO2:** Acquire the knowledge on world trade organization, trade agreements and investments.

**CO3:** Understand the process of patenting and patent laws in India.

**CO4:** Learn the role of IPR in biodiversity protection.

**Theory: 30 Lectures**

**Unit 1: Introduction to Intellectual Property Right: 7 Lectures**

Introduction, intellectual property and on, types of Intellectual Property Rights: Patent, copyright, Trademark, Design, trade secret, Traditional Knowledge and Geographical indication. Commercial Exploitation, and Protection of IPR.

**Unit 2: National and International agencies: 6 Lectures**

WIPO, World Trade Organization (WTO), Trade- Related Aspects of Intellectual Property Rights (TRIPS), General Agreement on Tariffs and Trade (GATT).

**Unit 3: Patents 10 Lectures**

Basics of patents - Types of patents; Patentable and Non-Patentable inventions, Process Product patent, Utility Patent (Short term patent). Indian Patent Act 1970; Recent amendments; Patent Cooperation Treaty (PCT) and implications. Process of patenting. Types of patent applications: Provisional and complete specifications; Concept of "prior art", patent databases (USPTO, EPO, India). Financial assistance, schemes, and grants for patenting.

**Unit 4: Protection of Biodiversity 7 Lectures**

Indian Biodiversity Act, Plant variety protection, plant breeder's rights, Protection of Plant Varieties and Farmer's Right Act (2001) , Choice and management of IPRs, advantage and limitations of IPRs.

**Practical and Field Visits:** **15 Lectures**

1. Patent infringement-Case Studies (Basmati rice, Turmeric, Neem)
2. Proxy filing of Indian Product patent
3. Proxy filing of Indian Process patent
4. Exploring patent database

***Suggested readings/books:***


- *Intellectual Property Rights by Deborah E. Bouchoux., Delmar Cenage Learning. 2005*
- *Intellectual Property Rights on Biotechnology by Singh, KC, BCIL, New Delhi*
- *Fundamentals of lP for Engineers: K.Bansl& P.Bansal*
- *Intellectual property right, Deborah, E. Bochoux, Cengage learning.*
- *Intellectual property right - Unleashing the knowledge economy, Prabuddha Ganguli, Tata McGraw Hill Publishing Company Ltd.*

| Paper Name: MICROBIAL TECHNIQUES | |
|---|---|
| **Paper Code: BITSEC2013** | **Semester: III** |
| **Type: SEC** | **Credit: 3 (2L+1P)** |
| **Total Classes: 45= 30+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Course Objective:**

The objective of the course is to train the students on the various aspects of a microbiology laboratory.

**Course Outcomes (CO):**

**CO1:** Learners with get acquainted with the various tools, equipment's, instruments used in a microbiology laboratory.

**CO2:** They will be able to identify microorganisms based on various parameters such as size, shape, morphology, biochemical**.**

**CO3:** The students will be able to culture, sub-culture and also to preserve the microorganisms.

**Theory: 30 Lectures**

**Unit 1: Microscopy-Principles, part and function 10 Lectures**

Light microscope (Bright-field microscope, Phase-Contrast Microscope, Dark-field Microscope, Fluorescence Microscope and Differential Interference Contrast (DIC) microscope).

Electron Microscope (Transmission electron microscope and Scanning electron microscope)

**Unit 2: Dyes and staining techniques 5 Lectures**

Types of dyes (acidic and basic), simple staining (positive staining & negative staining), differential staining (Gram's stain, acid fast stain), special staining (endospore stain)

**Unit 3: Media for culture of microorganisms and sterilizing techniques 5 Lectures**

Basic components of a microbial growth media, Dry heat (red heat, incineration, hot air) and moist heat sterilization (autoclave)

**Unit 4: Techniques for enumeration of microorganisms, Pure culture & Maintenance and preservation 10 Lectures**

Shape of the microorganism and arrangement of the cells (microscopic), colonial morphology (macroscopic)

Serial dilution, pour plate method, spread plate method, sub-culturing (streak plate method), Culture plate, culture tube, freeze drying (lyophilisation)

Characterization using different biochemical analysis

**Practical: 15 Lectures**

1. Preparation of slides
2. Observe the different classes of Microbes for morphology and arrangement under a microscope after appropriate staining procedures
    i. Bacteria
    ii. Fungi
    iii. Yeast
3. Preparation of microbial media for bacteria, fungi, yeast and algae
4. Enumerate the microorganisms from soil, water and air sample
5. Obtain a pure culture of bacteria, fungi and yeast
6. Characterization of microbes based on various biochemical test.

***Suggested readings:***


- *Microbiology: A laboratory manual. James Cappuccino and Natalie Sherman.*
- *Microbiology- Prescott LM, Harley JP, Klein DA, Wm. C. Brown Publishers*
- *Microbiology: Tortora, G.J., Funke, B.R. and Case, C.L An Introduction Pearson Education.*
- *Brock Biology of Microorganisms- Madigan MT, Martinko JM and Parker J. Pearson/Benjamin Cummings.*

| Paper Name: MOLECULAR BIOLOGY | |
|---|---|
| **Paper Code: BITMAJ2034** | **Semester: IV** |
| **Type: MAJOR** | **Credit: 4 (3L+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Course Objective:**

The objective of the molecular biology course is to equip students with a deep understanding of the molecular processes that underlie the organization, replication, and expression of genetic information in living organisms.

**Course outcomes (CO):**

**CO1**: Understand the basic structure and significance of DNA.

**CO2:** Understand the basic principles of molecular biology, including the central dogma of biology, DNA replication, transcription, and translation.

**CO3:** Describe the mechanisms of gene expression, including transcriptional and post-transcriptional regulation.

**CO4:** Explain the techniques used to study DNA, RNA, and proteins, such as PCR, gel electrophoresis, DNA sequencing, and protein purification.

**CO5:** Discuss the role of molecular biology in biotechnology, medicine, and other fields of science.

**CO6:** Understand the fundamental practical experiments that are conducted in the field of molecular biology.

**Theory: 45 lectures**

**Unit 1: Nucleic Acids and their organization** **7 lectures**

Watson and Crick model of DNA structure, A, B & Z forms of DNA, Nucleic acid as the genetic material, Genome and its organization in prokaryotes, eukaryotes, and viruses.

**Unit 2: DNA Replication** **10 lectures**

DNA replication in prokaryotes, eukaryotes, and viruses. Proteins and enzymes involved in DNA replication.

**Unit 3: Expression Studies** **14 lectures**

Transcription in prokaryotes and eukaryotes. Proteins and enzymes involved in transcription**.** Post-transcriptional modification of RNAs, translation in prokaryotes and eukaryotes. Proteins and enzymes involved in translation. Post-translational modification, analysis of transcription, translation,

**Unit 4: Gene Regulation**, **Recombination, and its application** **14 lectures**

Gene regulation in prokaryotes, eukaryotes, and viruses. Gene regulation by non- coding RNAs, DNA-protein interactions, Recombination and its molecular mechanism, gene targeting (Cre-Lox*p*, Flp-Frt, CRISPER-Cas9) and antisense RNAs, Site-directed mutagenesis, model organisms in molecular biology.

**Practical:** **15 Lectures**

1. Preparation of solutions/buffers for Molecular Biology experiments.
2. Isolation of DNA from bacterial cells/plant cells/animal cells.
3. Estimation of DNA.
4. Agarose gel electrophoresis of DNA
5. Preparation of restriction enzyme digestion of DNA.
6. Preparation and transformation of competent cells.
7. Protein estimation and preparation of SDS-PAGE.

***Suggested readings:***


- *Watson JD, Baker TA, Bell SP, Gann A, Levine M and Losick R (2008) Molecular Biology of the Gene, 6th edition, Cold Spring Harbour Laboratory Press, Pearson Publication.*
- *Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. VI Edition. John*
- *Wiley & Sons. Inc.*
- *De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. VIII*
- *Edition. Lippincott Williams and Wilkins, Philadelphia.*
- *Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell.*
- *VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.*
- *Jocelyn E Krebs (2009). Genes X, Jones & Bartlett Learning.*
- *Review articles.*

| Paper Name: IMMUNOLOGY | |
|---|---|
| **Paper Code: BITMAJ2044** | **Semester: IV** |
| **Type: MAJOR** | **Credit: 4 (3L+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Course Objective:**

This paper shall enable the student to understand various processes of immune system

**Course Outcomes (CO):**

**CO1**. Enables the students for understanding of basic immunological process in the mammalian body.

**CO2.** Enable the students for understanding of humoral immunity.

**CO3**. Enables better understanding of Antigens and immunogenicity

**CO4**. Enables the student to understand disorders and cancer immunology

**Theory: 45 Lectures**

**Unit 1: Introduction to Immune System 15 Lectures**

Immune system of vertebrate and invertebrate. Components of innate and acquired immunity. Organs and cells of the immune system- primary and secondary lymphoid organs. Humoral and cellular immune response.

**Unit 2: Antibody 15 Lectures**

Immunoglobulins-basic structure, classes & subclasses of immunoglobulins. Class switching and allelic exclusion of antibodies. B cell receptor and T cell receptor

**Unit 3: Antigen and Immunogenicity 10 Lectures**

Antigen, types, MHC molecules. Antigen processing and presentation. Hapten-carrier system. Self and non-self-recognition. Precipitation and agglutination

**Unit 4: Disorders Related to Immunity 5 Lectures**

Autoimmune disorders, immune deficiency, Tuberculosis, Vaccines and edible vaccines. Cancer immunology

**Practical: 15 Lectures**

1. Total blood Count
2. Separation of serum and plasma from blood
3. Practical leading to agglutination and precipitation
4. Demonstration of Double diffusion and immunoprecipitation
5. Determination of blood group
6. Demonstration of ELISA, Western Blotting

7. Determination of microbial load

***Suggested readings:***


- *Immunology, Janis Kuby, Freeman.*
- *Essentials of Immunology, I.M. Roitt, Wiley-Blackwell.*
- *Immunology, Nandini Sethi.*
- *Essential Clinical Immunology: John B Zabriskie: Cambridge Medicine Publishing*
- *Immunology and Evolution of Infectious Diseases: Stevan A Frank*

| Paper Name: GENETICS | |
|---|---|
| **Paper Code: BITMAJ2054** | **Semester: IV** |
| **Type: MAJOR** | **Credit: 4 (3L+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Course Objective**:

To understand how genes, chromosomes and different genetic information function and also to understand the pathways related to functionality of traits

**Course Outcomes (CO):**

**CO1:** Enable students to understand the basic of genetic and flow of genetic information

**CO2:** Enable students to understand macromolecules, its mutation, its repair and genetic markers

**CO3:** Enable students to understand population and population genetics

**CO4:** Enables students to understand molecular genetics, gene expression and gene regulation

**Theory: 45 Lectures**

**Unit 1: Introduction to Genetics: 10 Lectures**

Mendelian Genetics (Mendelian Laws, concept of alleles and multiple alleles, dominance, incomplete dominance, co-dominance), Genomes Organization (Prokaryotes and Eukaryotes), Organelle genome, genome mapping and genome evolution, Non-Mendelian Genetics (Gene interaction)

**Unit 2: Nucleic Acid, mutation, repair and markers: 15 Lectures**

Structural aspects – Components of DNA and RNA, Nucleosides & Nucleotides, Double helical structure of DNA (Watson-Crick model), Various forms of DNA. Kinds of Mutation, Mutagens, influence of Mutation, Molecular basis of Mutation, Significance of Mutation. Concept of DNA Repair. Concept of markers, molecular markers, gene mapping, use of molecular Marker

**Unit 3: Population Genetics 10 Lectures**

Phenotype & Genotype. Genetic Drift, Gene flow, Migration, Island Effect, Bottle Neck Effect, Human Genetic Diversity. Hardy Wenberg Law, & Population Genetics.

**Unit 4: Molecular Genetics 10 Lectures**

DNA Replication, Protein Expression, Genetic Code, Comparative genomics, molecular phylogenetics, Molecular Taxonomy

**Practical: 15 Lectures**

1. Study of chromosome in suitable metaphase plate
2. DNA Isolation and quantification
3. Staining of nucleus and cytoplasm of animal and plant cells
4. Estimation of DNA by suitable method.
5. Study of different Karyotypes
6. Blood group determination
7. Study of mitosis and meiosis

***Suggested readings:***


- *Genetics: A Conceptual Appraoch, B. A. Pierce, W.H. Freeman and Company.*
- *Cell Biology; G. Karp; John Wiley and Sons, Inc.*
- *New Clinical Genetics, Andrew Read and Dian Donnai, Scion Publishing Ltd.*
- *Human Molecular Genetics, T. Strachal and A. Read, Garland Science.*
- *Human Genetics: Concepts and Applications, R. Lewis, McGraw Hill Higher Education.*
- *Genetics: Monroe W. Strickberger. Prentice-Hall India, Publication.*
- *Principles of Genetics: Gardner, Simmons, Snustad. Wiley Publications*

| Paper Name: PLANT BIOTECHNOLOGY | |
|---|---|
| **Paper Code: BITMIN2024** | **Semester: IV** |
| **Type: MINOR** | **Credit: 4 (3L+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Course Objective:**

The objective of the course is to familiarize and train the students on various techniques involved in plant tissue culture.

**Course Outcomes (CO):**

**CO1:** Have a clear theoretical concept on micropropagation, tissue culture media, sterilization techniques and different techniques for culturing shoot tip, embryo, pollen, anther and ovary etc. and developing haploids, hybrids and homozygous lines.

**CO2:** Have an understanding about the different plant transformation terms and technology viz. Ti-plasmid & Ri-plasmid, binary vectors, vector-less DNA transfer, promoters for plant transformation and chloroplast transformation.

**CO3:** Have a concept on the application of plant transformation technologies on developing herbicide resistance, insecticide resistance, disease resistance, nematode resistance and for increased productivity and performance.

**CO4:** Understand and apply the knowledge of transformation technologies for the production and purification of industrially significant products from genetically engineered plants.

**CO5:** Explain and apply the knowledge of recombinant DNA technology for plant breeding. Also have a clear concept on techniques involved in germplasm conservation.

**Theory: 45 Lectures**

**Unit 1: Introduction to plant tissue culture** **15 Lectures**

Scope of plant tissue culture, Composition of plant tissue culture media, Callus and suspension culture. Plant tissue culture techniques: Seed, Embryo, Callus, Organs, Cell and Protoplast culture, anther, Meristem and shoot tip culture. Organogenesis, Embryogenesis, Micropropagation, advantages and disadvantages of micropropagation.

**Unit 2: Hybridization and significance** **10 Lectures**

Methods of protoplast isolation and fusion, Somatic hybridization, identification and selection of hybrid cells, Cybrids, Potential of somatic hybridization limitations. Soma-clonal variation and their significance. Artificial seeds and their application.

**Unit 3: Plant transformation technology** **10 Lectures**

Ti and Ri plasmid, *Agrobacterium* mediated gene transformation, Direct DNA transfer methods to plants. Application of Plant transformation technology in herbicide resistance & insect resistance. Plant secondary metabolites and their production using transgenic plants.

**Unit 4: Molecular Markers** **10 Lectures**

Plant molecular markers - RFLP, RAPD, AFLP, microsatellites, SNP, SSCP, SCAR.

**Practical: 15 Classes**

1. Preparation of plant tissue culture media (Murashige & Skoog's medium)
2. Methods of sterilization of glassware, media
3. To select, prune, sterilize and prepare an explant for culture.
4. Micropropagation of selected plants using nodal explants
5. Preparation of artificial seeds
6. To demonstrate various steps of Micropropagation.

***Suggested reading***


- *Bhojwani, S.S. and Razdan 2004 Plant Tissue Culture and Practice.*
- *Reinert, J. and Bajaj, Y.P.S. 1997 Applied and Fundamental Aspects of Plant Cell, Tissue and Organ Culture. Narosa Publishing House.*
- *Russell, P.J. 2009 Genetics – A Molecular Approach. 3rdedition. Benjamin Co.*
- *Sambrook & Russel. Molecular Cloning: A laboratory manual. (3rd edition)*
- *Slater, A., Scott, N.W. & Fowler, M.R. 2008 Plant Biotechnology: The Genetic Manipulation of Plants, Oxford University Press.*

| Paper Name: rDNA TECHNOLOGY | |
|---|---|
| **Paper Code: BITMAJ3014** | **Semester: V** |
| **Type: MAJOR** | **Credit: 4 (3L+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Course Objective:**

The objective of the recombinant DNA technology course is to educate students on the principles and techniques used to manipulate genetic material and create genetically modified organisms for research, biotechnology, and therapeutic purposes.

**Course Outcomes (CO):**

**CO1:** Understand the basic principles of recombinant DNA technology, including DNA cloning, restriction enzymes, and DNA sequencing.

**CO2:** Explain the techniques used to create and manipulate recombinant DNA molecules, such as PCR, gel electrophoresis, and DNA sequencing.

**CO3:** Describe the methods used to express recombinant proteins in bacteria, yeast, and other systems.

**CO4:** Understand the principles of gene editing and the use of CRISPR/Cas9, and Cre-LoxP technology to modify the genome of cells and organisms.

**CO5:** Discuss the applications of recombinant DNA technology in biotechnology, medicine, and other fields, including the development of genetically modified organisms, gene therapy, and vaccine production.

**CO6:** Understand the fundamental practical experiments that are conducted in the recombinant DNA technology.

**Theory: 45 Lectures**

**Unit 1**: **Restriction enzymes** **8 Lectures**

Types of restriction enzymes, cohesive and blunt end ligation, linkers, adaptors, and homopolymeric tailing.

**Unit 2**: **Gene Cloning** **10 Lectures**

Concept of gene cloning and its importance, proteins, and enzymes involved in gene cloning, the concept of vectors, and different types of vectors for gene cloning, the concept of cloning vectors and expression vectors.

**Unit 3**: **Transformation methods and library preparation** **10 Lectures**

Different ways of insertion of foreign DNA into host cells, Cloning, and expression in E. coli, yeasts (Saccharomyces, Pichia), DNA Libraries: Construction of cDNA libraries in plasmids and screening methodologies.

**Unit 4**: **Concept of Polymerase Chain Reaction**, **Sequencing, and Application**

**17 Lectures**

Primer designing, Concept of PCR and its importance, different types of PCR, and their applications. DNA sequencing and its importance, different types of DNA sequencing, and its mechanism, Application of rDNA technology in medicine, agriculture, veterinary sciences, and protein engineering.

**Practical:** **15 Lectures**

1. Isolation of DNA from plant cells/E.coli/Animal cells
2. DNA estimation.
3. Agarose gel electrophoresis
4. Plasmid DNA isolation
5. Demonstration of PCR
6. Restriction digestion of DNA
7. Preparation of rDNA
8. Preparation and transformation of competent cells with plasmid
9. Screening of transformed cells

***Suggested readings:***

*1. Brown TA. (2006). Gene Cloning and DNA Analysis. 5th edition. Blackwell Publishing, Oxford, U.K.*

*2. Clark DP and Pazdernik NJ. (2009). Biotechnology-Applying the Genetic Revolution. Elsevier Academic Press, USA.*

*3. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.*

*4. Primrose SB and Twyman RM. (2006). Principles of Gene Manipulation and Genomics, 7th edition. Blackwell Publishing, Oxford, U.K.*

*5. Sambrook J, Fritsch EF and Maniatis T. (2001). Molecular Cloning-A Laboratory Manual. 3rd*

*edition. Cold Spring Harbor Laboratory Press.*

| Paper Name: BIOINFORMATICS | |
|---|---|
| **Paper Code: BITMAJ3024** | **Semester: V** |
| **Type: MAJOR** | **Credit: 4 (3L+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Course Objective:**

To understand basic and applied aspects in Bioinformatics and to know how the biological data can be extracted for solving biological problems.

**Course Outcomes (CO):**

**CO1:** Understand the basic concepts in Bioinformatics and its applications in various fields

**CO2**: Understand biological databases available online and sequence alignment using bioinformatics tools

**CO3**: Understand algorithms used for the computational calculations

**CO4:** Understand the concepts of genes, genomes and Human Genome Project.

**Theory: 45 Lectures**

**Unit 1: Bioinformatics- 5 Lectures**

Definition, History, Scope and Applications. Opportunities in Bioinformatics. Emerging areas of Bioinformatics

**Unit 2: Biological databases- 10 Lectures**

Nucleotide and protein sequence databases- secondary database, Specialized database, Protein Structure Database- PDB, Genomic Databases, metabolic pathway database- KEGG. Database Search Tools- Entrez, SRS

**Unit 3: Sequence alignment**: **10 Lectures**

Pair-wise sequence alignment, Dotplot. Global and local alignment: methods, Dynamic Programming- Local and Global Alignment, Needleman Wunsch Algorithm, Smith Waterman Algorithm, scoring matrices (PAM, BLOSUM). Database similarity searching- FASTA and BLAST.

**Unit 4: Sequence analysis and Phylogeny 10 Lectures**

Multiple sequence alignment: methods, tools and applications. Phylogenetic analysis. Distance and Character based methods for phylogenetic tree construction: UPGMA, Neighbour joining, Ultrametric and Min ultrametric trees

**Unit 5: Human Genome Project**: **10 Lectures**

Genomes, Need of Human Genome Project, goals of HGP, uses and application with examples.

**Practical**: **15 Lectures**

1. Introduction to Bioinformatics software and different databases
2. Introduction to NCBI, EMBL, KEGG, DDBJ, SwissProt and PDB servers
3. Analysis of phylogeny and construction of phylogenetic trees.
4. Sequence alignment studies, *In silico* primer designing

***Suggested readings:***

- *Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery by Rastogi, Mendiratta and Rastogi; PHI publications.*

| Paper Name: DEVELOPMENTAL BIOLOGY | |
|---|---|
| **Paper Code: BITMAJ3034** | **Semester: V** |
| **Type: MAJOR** | **Credit: 4 (3L+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Course Objective:**

The objective of the developmental biology course is to provide students with a comprehensive understanding of the cellular and molecular processes involved in the growth, differentiation, and morphogenesis of organisms, from fertilization to adulthood.

**Course outcomes (CO):**

**CO1:** Understand the basic principles of developmental biology, including embryonic development, morphogenesis, and cell differentiation.

**CO2:** Explain the molecular mechanisms that control developmental processes, including gene regulation, signalling pathways, and epigenetic modifications.

**CO3:** Describe the methods used to study developmental biology, including imaging techniques, genetic analysis, and cell culture.

**CO4:** Understand the developmental processes that occur in different organisms.

**CO5:** Discuss the role of developmental biology in understanding and treating developmental disorders and diseases.

**CO6:** Understand the fundamental practical experiments that are conducted in the field of developmental biology.

**Theory: 45 Lectures**

**Unit 1: Introduction to Developmental Biology** **10 Lectures**

History, Anatomical tradition, Principles of development-life cycles, Role of genes in development, Amniocentesis, Development of C. elegans, Concept of Gametogenesis – Spermatogenesis, Oogenesis, Fertilization - Definition, mechanism, types of fertilization, Different types of eggs.

**Unit 2: Stages of Development** **7 Lectures**

Cleavage and its types, pattern, and mechanisms, early development of Xenopus, mechanism of blastulation, gastrulation, primary germ layers.

**Unit 3: Mechanism of Differentiation** **10 Lectures**

Cell commitment and determination, model of determination and differentiation, control of differentiation at the level of genome,

transcription and post-translation level, Concept of embryonic induction: Primary, secondary & tertiary embryonic induction, Neural induction, and induction of vertebrate lens.

**Unit 4: Mechanism of Organogenesis and Cell Cycle** **18 Lectures**

Neurulation, notogenesis, development of the vertebrate eye, Fate of different primary germ layers, Development of behaviour: constancy & plasticity, Extra embryonic membranes, the concept of metamorphosis, placenta in mammals. Concept and mechanism of programmed cell death, aging, and senescence, model organisms for developmental biology, medical implications of developmental biology.

**Practical:** **15 Lectures**

1. Study of developmental stages of frog/chick/drosophila.
2. Demonstration of developmental stages of Anopheles.
3. Examination of sperm/ova.
4. Preparation of temporary stained mount of the chick embryo.
5. Study of different types of placenta.

***Suggested readings:***


- *Gilbert, S. F. (2006). Developmental Biology, VIII Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.*
- *Balinsky, B.I. (2008). An introduction to Embryology, International Thomson Computer Press*
- *Kalthoff, (2000). Analysis of Biological Development, II Edition, McGraw-Hill Professional.*
- *Research and Review articles.*

| Paper Name: BIOSTATISTICS | |
|---|---|
| **Paper Code: BITMAJ3044** | **Semester: V** |
| **Type: MAJOR** | **Credit: 4 (3L+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Objectives:**

To study concepts of statistics and its applications in the biotechnology

**Course Outcomes (CO):**

**CO1:** Learn about types of data and collection of data.

**CO2:** Learn how to determine the measures of central tendency and dispersion.

**CO3:** Understand the concept of hypothesis and hypothesis testing.

**CO4:** Learn to test level of significance using t-test, chi-square test and ANOVA

**Theory: 45 Lectures**

**Unit 1:Data and measurement** **15 Lectures**

Types of Data, Collection of data; Primary; Secondary data, Classification and Graphical representation of Statistical data. Measures of central tendency- Mean, Median, Mode. Measures of Dispersion-Standard Deviation, Standard Error. Measures of Skewness and Kurtosis.

**Unit 2: Sampling Techniques** **15 Lectures**

Methods of sampling, confidence level, critical region, testing of hypothesis; large sample test and small sample test. Types of Biological Variables- Measurement Variables, Independent and Dependent Variables, Ratios, Circular Variables, Nominal Variables, Ranked Variables.

**Unit 3: Statistical Analysis** **15 Lectures**

Problems on test of significance, t-test, chi-square test for goodness of fit and analysis of variance (ANOVA). Correlation and Regression. Emphasis on examples from Biological Sciences.

**Practical:** **15 Lectures**

1. Calculation of Mean, Median, Mode
2. Calculation of Standard Error, Standard Deviation
3. T-Test
4. Chi-Square Test
5. ANOVA

6. Correlation and Regression

***Suggested readings:***


- *Fundamentals of Biostatistics; K. Janardhan, P. Hanmanth Rao*
- *Principles and Practice of Biostatistics; B. Antonisamy, Prasanna S. Premkumar*
- *Biostatistics: Basic Concepts and Methodology for the Health Science; Wayne W. Daniel and Chad L. Cross*
- *Biostatistics; Veer Bala Rastogi*

| Paper Name: ANIMAL BIOTECHNOLOGY | |
|---|---|
| **Paper Code: BITMIN3014** | **Semester: V** |
| **Type: MINOR** | **Credit: 4 (3L+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Course Objective:**

This paper shall enable the student to understand different processes of animal biotechnology and their applications.

**Course Outcomes (CO):**

**CO1:** Enables the students about understanding of design and layout of tissue culture lab and basic instrumentation.

**CO2:** Enables the students to understand different medias used for animal tissue culture

**CO3:** Enables the students to understand various types of tissue culture processes

**CO4:** Enables the students to understand various application of animal biotechnology

**Theory: 45 Lectures**

**Unit 1: Cell culture Laboratory design & Equipment-An Introduction 10 Lectures**

Animal cell and tissue culture facility, layout of tissue culture laboratory. Instruments related to animal cell and tissue culture like Cold handling Cabinet, fluid dispensing system, Bio-safety cabinet, Laminar Air flow Cabinet, Air curtain, Air shower, $CO_2$ Incubator, -60 Deep freezer, Cryo-CAN, Inverted Microscope.

**Unit 2: Media and Reagents 10 Lectures**

Types of cell culture media; Ingredients of media; Physiochemical properties; $CO_2$ and bicarbonates; Buffering; Oxygen; Osmolarity; Temperature; Surface tension and foaming; Balance salt solutions; Antibiotics, growth supplements; Foetal bovine serum; Serum free media; Trypsin solution; Selection of medium and serum; Conditioned media; Other cell culture reagents; Preparation and sterilization of cell culture media, serum and other reagents, Knockout media.

**Unit 3: Cell Culture Types 15 Lectures**

Different tissue culture techniques, Types of primary culture, Secondary culture, sub culture, scale up, Trypsinization; Cell separation, Suspension culture. Behavior of growing cells, cell metabolism, cell lines, characterization and maintenance of cell line, cryopreservation, Maintenance of Culture Cell Lines

**Unit 4: Applications** **10 Lectures**

Transfection and transformation of cells, Commercial scale production of animal cells, stem cells and their application; Application of animal cell culture for *in vitro* testing of drugs, IVF, Hybridoma technology, vaccine testing, Assisted Reproductive Technology

**Practical:** **15 Lectures**

1. Demonstration of operation of Autoclave, LAF, Inverted microscope
2. Study of ovulation in fishes, ovine and caprine
3. Lymphocyte Culture and metaphase plate chromosome
4. Animal cell culture media preparation
5. Study of somites in prepared slides

***Suggested Readings:***


- *Animal Cell Culture Techniques, Ed. N. Cynes; Springer.*
- *Animal Cell Culture; R. I. Freshney, Garland Science.*
- *Elements of Biotechnology, P.K. Gupta, Kalyani Publishers.*
- *Fundamentals of Biotechnology, P. Prave, V. Paunt, W. Sitting and D.A. Sukatesh*

| Paper Name: GENOMICS AND PROTEOMICS | |
|---|---|
| **Paper Code: BITMAJ3054** | **Semester: VI** |
| **Type: MAJOR** | **Credit: 4 (3L+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Course Objectives:**

1. To Understand applications of Genomics and Proteomics in clinical settings
2. To introduce the students to pharmacogenomics

**Course Outcome**:

**CO1:** Be able to describe the development of Omics technologies, with emphasis on genomics and proteomics;

**CO2:** Be able to synthesize information to discuss the key technological developments that enabled modern genomic and proteomic studies;

**CO3:** Be able to describe advanced genomics and proteomics technologies and the ways in which their data are stored

**Theory: 45 lectures**

**Unit 1: Introduction to Genomics and Proteomics**: **10 lectures**

Introduction – Organization and structure of genomes, Genome size, Sequence complexity, Introns and Exons, Genome structure in viruses and prokaryotes, Isolation of Chromosomes, chromosome micro dissection, Retrofitting. Introduction to Proteomics – The Proteome, mining proteomes, Bridging Genomics and Proteomics. Proteomics and the new biology.

**Unit 2: Gene Identification and Expression**: **10 lectures**

Genome annotation, traditional routes of gene identification, detecting open-reading Frames, software programs for finding genes, Identifying the function of a new gene, gene ontology, overview of comparative genomics, Protein structural genomics, determining gene function by sequence comparison and through conserved protein structure Global expression profiling – Introduction, traditional approaches to expression profiling, Analysis of RNA expression, applications of genome analysis and genomics.

**Unit 3: Analysis of Proteomes I** **5 lectures**

Analysis of proteomes - Two-dimensional polyacrylamide gel electrophoresis, Sample Preparation, Solubilization, Reduction, Resolution, Reproducibility of 2-DEDetecting proteins in polyacrylamide gels, Image analysis of 2-DE gels.

**Unit 4: Analysis of Proteomes II** **10 lectures**

Mass spectrometry-based methods for protein identification- De novo sequencing using mass spectrometric data- Correlative mass spectrometric based identification strategies, 2-DE gel electrophoresis coupled with mass spectrometry, Micro array techniques- Types of micorarrays, designing a microarray experiment, Microarray Technology in Treating Disease.

**Unit 5: Applications of Genomics and Proteomics Analysis 10 lectures**

Analysis of Genomes – Human, Mouse, *Plasmodium faciparum*, *Saccharomyces cerevisiae*, *Mycobacterium tuberculosis*. Application of proteome analysis- drug development and toxicology, Pharmaceutical Applications, Proteomics in drug Discovery in human, phage antibodies as tools, Glycobiology and Proteomics in plant genetics and breeding.

**Practical: 15 lectures**

1. Phylogenetic analysis of protein and nucleotide sequences, Use of gene prediction methods (GRAIL, Genscan, Glimmer),
2. Use of RNA structure prediction tools
3. Use of various primer designing and restriction site prediction tools,
4. Use of different protein structure prediction databases (PDB, SCOP, CATH).

***Suggested readings:***


- *S. B. Primrose and R.M. Twyman - Principles of Genome Analysis and Genomics, Blackwell Publishing*

| Paper Name: INDUSTRIAL BIOTECHNOLOGY | |
|---|---|
| **Paper Code: BITMAJ3064** | **Semester: VI** |
| **Type: MAJOR** | **Credit: 4 (3L+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Course Objective:**

The objective of this course is to understand the fundamentals of industrial processes for production of various commercially important products.

**Course Outcomes (CO):**

**CO1:** The learner shall know about the fundamentals of operating a bioprocess

**CO2:** The student will be thorough in their knowledge about the various processes for the production of a few industrially important products.

**Theory: 45 lectures**

**Unit 1: Biotechnology: Scope and importance** **10 lectures**

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

**Unit 2:Scale Up Process-I** **10 lectures**

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

**Unit 3: Scale Up Process-II** **10 lectures**

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

**Unit 4:Scale Up Process-III** **15 lectures**

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

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

**Practical:** **15 lectures**

1. Isolation of industrially important microorganism from natural resource.
2. Production and analysis of amylase.

3. Production and analysis of ethanol.
4. Production and analysis of lactic acid.

***Suggested readings:***


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

| Paper Name: ENVIRONMENTAL BIOTECHNOLOGY | |
|---|---|
| **Paper Code: BITMAJ3074** | **Semester: VI** |
| **Type: MAJOR** | **Credit: 4 (3L+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Course Objectives:**

To give an in-depth knowledge in environmental biotechnology and make the learners acquire knowledge on the application and scope of environmental biotechnology.

**Course Outcomes (CO):**

**CO1:** Become aware about the environment and use of biotechnology to solve problems related to biodiversity and pollution.

**CO2:** Understand the concept of biodegradation and role of bacteria in metabolism of xenobiotics.

**CO3:** Learn about renewable and non-renewable sources of energy.

**Theory: 45 lectures**

**Unit 1: Introduction to Environmental Biotechnology 8 lectures**

Role of Biotechnology in Environment Protection and Management. Biotechnological methods for pollution detection, Biological indicators. Waste water treatment. Bioremediation of soil. Phyto-remediation. Treatment of municipal waste and Industrial effluents.

**Unit 2:Pesticides and their hazards 10 lectures**

Biopesticides. Bio-fertilizers. Importance of Biofertilizers in agriculture (Rhizobium, Azotobacter, Mycorrhiza, Actinorhiza) advantages and current status, vermiculture, composting, current practices and production of biofertilizers. Role of symbiotic and asymbiotic nitrogen fixing bacteria in the enrichment of soil. Algal and fungal biofertilizers (VAM)

**Unit 3: Bioremediation 7 lectures**

Bioremediation: Fundamentals, methods and strategies of application (biostimulation, bioaugmentation) – examples, bioremediation of metals (Cr, As, Se, Hg), radionuclides (U, Te), organic pollutants (PAHs, PCBs, Pesticides, TNT etc.), technological aspects of bioremediation (in situ, ex situ). Application of bacteria and fungi in bioremediation.

**Unit 4: Role of microorganisms in bioremediation 10 lectures**

Bioinsecticides: *Bacillus thuringiensis*, Baculoviruses, uses, genetic modifications and aspects of safety in their use; Biofungicides: Description of mode of actions and mechanisms (e.g. Trichoderma, Pseudomonas fluorescens); Biofertilizers: Symbiotic systems between plants – microorganisms (nitrogen fixing symbiosis, mycorrhiza fungi symbiosis), Plant growth promoting rhizobacteria (PGPR) – uses, practical aspects and problems in application.

**Unit 4: Biofuels** **10 lectures**

Conventional fuels and their environmental impact. Renewable and Non-renewable sources of energy; Environmental Biotechnology and biofuels: biogas; bioethanol; biodiesel; biohydrogen; Description of the industrial processes involved, microorganisms and biotechnological interventions for optimization of production; Microbiologically enhanced oil recovery (MEOR); Bioleaching of metals; Production of bioplastics; Production of biosurfactants: bioemulsifiers; Paper production: use of xylanases and white rot fungi.

**Practical:** **15 lectures**

1. Estimation of Total Dissolved Solids (TDS) of water sample.
2. Estimation of BOD of water sample.
3. Estimation of COD of water sample.
4. Bacterial Examination of Water by MPN Method.
5. Determination of Nitrate from the water
6. Determination of Sulphate from the water.
7. Estimation of coliform bacteria from water by MPN test
8. Determination of Turbidity

***Suggested readings/books:***


- *Environmental Biotechnology by Alan Scragg (1999); Longman.*
- *An Introduction to Environmental Biotechnology by Milton Wainwright (1999): Kluwer Academic Press.*
- *Bruce. E.Rittaman and Perry. L. Mc Carty, 2004, "Environmental Biotechnology-Principles and applications" McGraw Hill.*
- *N. Ahmed, F.M. Quershi and D. Y.Khan, 2001, "Industrial Environmental Biotechnology" Horizon press.*

| Paper Name: AGRICULTURAL BIOTECHNOLOGY | |
|---|---|
| **Paper Code: BITMAJ3084** | **Semester: VI** |
| **Type: MAJOR** | **Credit: 4 (3L+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Course Objective:**

To gain the knowledge related to the basic concept of how genetic transformation occurs in plants and the modern methods of farming along with marketing strategy for export.

**Course Outcomes (CO):**

**CO1:** Upon completion of this course, Students will gain knowledge about plant genetic transformation methods.

**CO2:** Upon completion of this course, Students will be acquainted with the modern methods of farming for increasing yield.

**CO3:** Upon completion of this course, Students will know about the marketing strategies for the export of the developed products through agricultural biotechnology.

**Theory: 45 lectures**

**Unit 1: Introduction to agricultural biotechnology and Plant genetic transformation**

**10 lectures**

History of agricultural biotechnology and Plant genetic transformation, Major Discoveries in field of agricultural biotechnology and Plant genetic transformation, Definition and applications of agricultural biotechnology and Plant genetic transformation. Introduction, Principle behind *Agrobacterium* mediated gene transfer, how it is transferred and what are its applications.

**Unit 2: Genetic transformation using *Agrobacterium*, liposome, Polyethylene glycol**

**15 lectures**

Introduction, Principle behind *Agrobacterium* mediated gene transfer, how it is transferred and what are its applications. Introduction, Principle behind liposomes and

PEG gene transfer methods, how it is transferred and what are its applications.

**Unit 3: New Agriculture Technology in Modern Farming** **8 lectures**

Various types and methods in farming and their benefits, issues arising from certain agricultural practices.

**Unit 4: Marketing and Export of Biotechnological Products** **12 lectures**

External trade in Agricultural products, Present status, policy and prospects under WTO regime, Export import policy, Regulation of Agricultural marketing system, Infrastructural facilities for exporting efficiency, Biotechnological Products in India, Quality parameters and quarantine procedures of export. Market integration: Types and effects Marketing costs margins and price spread. Biotech industries & institutes in India & world, Concepts of Biotech park/ Biotech Hub

**Practical:** **15 lectures**

1. *Agrobacterium* mediated gene transfer method.
2. Polyethylene glycol (PEG) can induce genetic transformation in both bacteria (*Escherichia coli*) and yeast (*Saccharomyces cerevisiae*).
3. Visit to different small scale and large scale Agro-based products. Study the production techniques of biotech products. Collecting the information on export import data on biotech products, quality standards for export and their potential. Analyse data in relation to demand and supply.
4. Home assignments/ Projects

***Suggested readings:***


- *New techniques in agricultural biotechnology by Directorate-General for Research and Innovation (European Commission) (DOI: 10.2777/574498)*
- *Biotechnology (Kalyani Publisher) by BD Singh*
- *Science in Agriculture: Advanced Methods for Sustainable Farming (Halcyon House Publishers) by Arden Anderson*
- *Organic Farming: Methods, Economics & Structure (Nova Science Publisers Inc) by Ivan Artamova and Michael Nelson*
- *Agriculture Marketing in India (Oxford IBH, N. Delhi) by Acharya and Agrawal*
- *Principles of Marketing (Prentice-Hall, N. Delhi) by Kotlar and Armstrong*

| Paper Name: BIOPROCESS TECHNOLOGY | |
|---|---|
| **Paper Code: BITMIN3024** | **Semester: VI** |
| **Type: MINOR** | **Credit: 4 (3L+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**Course Objective:**

The objective of this course to learn the basic principles of fermentation process, to understand the basic configuration and parts of a fermenter and to gain an in-depth idea about upstream and downstream processing.

**Course Outcomes (CO):**

**CO1:** Understand the general requirements of a fermentation process.

**CO2:** Understand the basic configuration of a fermentor and its ancillaries.

**CO3:** Demonstrate an ability to design good media.

**CO4:** Explain the sterilization kinetics and design the sterilization equipments for batch and continuous process.

**CO5:** Able to model microbial growth, substrate utilization and product formation.

**Theory: 45 lectures**

**Unit 1: Introduction and development of bioprocess technology 8 lectures**

Types of fermentation, Modes of fermentation (Batch, continuous, fed-batch culture), Submerged and Solid-State fermentation.

**Unit 2: Bioreactors 10 lectures**

Design of a bioreactor. Significance of various parts of a bioreactor.

Types of submerged and solid-state Bioreactors

**Unit 3: Principles of upstream processing 15 lectures**

Media preparation: Criteria for good medium, medium requirements for fermentation processes, carbon, nitrogen, minerals, vitamins and other complex nutrients, oxygen requirements, medium formulation of optimal growth and product formation, examples of simple and complex media. Sterilization of media, air and equipment; Inoculum development, Introduction to oxygen requirement in bioprocess, $K_La$.

**Unit 4: Principles of downstream processing 12 lectures**

Bio-separation techniques: filtration, centrifugation, sedimentation, flocculation; Storage and packaging

**Practical:** **15 lectures**

1. Establishing a bacterial growth curve
2. Effect of different substrates on the growth/biomass production of a bacteria/fungi
3. Effect of pH on the growth/biomass production of a bacteria/fungi
4. Comparative study of ethanol production using different substrates.

***Suggested readings:***


1. *Peter F. Stanbur., Stephen J. Hall., A. Whitaker., "Principles of Fermentation Technology" Science & Technology Books.*
2. *Shuler., Michael L., Fikret Kargi. "Bioprocess Engineering", Prentice Hall.*

**SEMESTER VII**

| Paper Name: CELL AND MOLECULAR BILOGY | |
|---|---|
| **Paper Code: BITADL14014** | **Credit: 4 (2L++1T+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**COURSE OBJECTIVE:**

The objectives of this course are to sensitize the students to the fact that as we go down the scale of magnitude from cells to organelles to molecules, the understanding of various biological processes becomes deeper and inclusive.the context of each topic.

**COURSE OUTCOMES:**

Student should be equipped to understand three fundamental aspects in biological phenomenon: a) what to seek; b) how to seek; c) why to seek?

**CO1:** Students shall get an insight into the structure and organization of the cell and the cellular organelles.

**CO2:** Have a conceptual knowledge about DNA as a genetic material, Structure and function of RNA, the concept of central dogma and know the importance of genetic code and Wobble hypothesis.

**CO3:** Students shall obtain knowledge about various activities taking place at the cellular level such as cell-cell interactions, cellular transportations, cell-communications and cell-signaling.

**CO4:** Learn about the cell cycle and its regulation.

**CO5:** Explain the various tools and techniques used in manipulating ans studying cells.

**COURSE CONTENT:**

**Unit I: Dynamic organization of cell** **8 lectures**

Universal features of cells; cell chemistry and biosynthesis: chemical organization of cells; internal organization of the cell - cell membranes: structure of cell membranes and concepts related to compartmentalization in eukaryotic cells; intracellular organelles: endoplasmic reticulum and Golgi apparatus, lysosomes and peroxisomes, ribosomes, cellular cytoskeleton, mitochondria, chloroplasts and cell energetics; nuclear compartment: nucleus, nucleolus and chromosomes.

**Unit II: Chromatin structure and dynamics** **12 lectures**

Chromatin organization - histone and DNA interactome: structure and assembly of eukaryotic and prokaryotic DNA polymerases, DNA-replication, repair and recombination; chromatin control: gene transcription and silencing by chromatin-Writers,-Readers and –Erasers; Transcriptional control: Structure and assembly of eukaryotic and prokaryotic RNA Polymerases, promoters and enhancers, transcription factors as activators and repressors, trancriptional initiation, elongation and termination; post-transcriptional control: splicing and addition of cap and tail, mRNA flow through nuclear envelope into cytoplasm, breakdown of selective and specific mRNAs through interference by small

non-coding RNAs (miRNAs and siRNAs), protein translation machinery, ribosomes-composition and assembly; universal genetic codes, degeneracy of codons, Wobble hypothesis; Iso-accepting tRNA; mechanism of initiation, elongation and termination; co- and post-translational modifications, mitochondrial genetic code translation product cleavage, modification and activation.

**Unit III: Cellular signalling, transport and trafficking 5 lectures**

Molecular mechanisms of membrane transport, nuclear transport, transport across mitochondria and chloroplasts; intracellular vesicular trafficking from endoplasmic reticulum through Golgi apparatus to lysosomes/cell exterior.

**Unit IV: Cellular Processes 8 lectures**

Cell cycle and its regulation; cell division: mitosis, meiosis and cytokinesis; cell differentiation: stem cells, their differentiation into different cell types and organization into specialized tissues; cell-ECM and cell-cell interactions; cell receptors and transmembrane signalling; cell motility and migration; cell death: different modes of cell death and their regulation.

**Unit V: Manipulating and studying cells 4 lectures**

Isolation of cells and basics of cell culture; observing cells under a microscope, different types of microscopy; analyzing and manipulating DNA, RNA and proteins.

**Unit VI: Genome instability and cell transformation 8 lectures**

Mutations, proto-oncogenes, oncogenes and tumour suppressor genes, physical, chemical and biological mutagens; types of mutations; intra-genic and inter-genic suppression; transpositions-transposable genetic elements in prokaryotes and eukaryotes, role of transposons in genome; viral and cellular oncogenes; tumor suppressor genes; structure, function and mechanism of action; activation and suppression of tumor suppressor genes; oncogenes as transcriptional activators.

**Practical: 15 lectures**

1. Isolation of animal cells from animal tissue/plant tissue and check their viability.
2. Prepare culture media with various supplements for plant and animal tissue culture.
3. Study cell division in animal/plant/microbial cells.
4. Isolation and quantification of nucleic acids.
5. Demonstration of PCR.
6. Isolation and quantification of total proteins.
7. Prepare agarose gel and SDS-PAGE.

**Suggested Readings:**


1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008). *Molecular Biology of the Cell* (5th Ed.). New York: Garland Science.
2. Lodish, H. F. (2016). *Molecular Cell Biology* (8th Ed.). New York: W.H. Freeman.
3. Krebs, J. E., Lewin, B., Kilpatrick, S. T., Goldstein, E. S. (2014). *Lewin's Genes XI*. Burlington, MA:

Jones & Bartlett Learning.

4. Cooper, G. M., & Hausman, R. E. (2013). *The Cell: a Molecular Approach* (6th Ed.). Washington: ASM ; Sunderland.
5. Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2012). *Becker's World of the Cell*. Boston (8th Ed.). Benjamin Cummings.
6. Watson, J. D. (2008). *Molecular Biology of the Gene* (5th ed.). Menlo Park, CA: Benjamin/Cummings.

| Paper Name: ADVANCED BIOCHEMISTRY | |
|---|---|
| **Paper Code: BITADL14024** | **Credit: 4 (2L++1T+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**COURSE OBJECTIVE:**

The objectives of this course are to build upon undergraduate level knowledge of biochemical principles with specific emphasis on different metabolic pathways. The course shall make the students aware of various disease pathologies within the context of each topic.

**COURSE OUTCOME:**

**CO1**: Gain fundamental knowledge in biochemistry

**CO2**: Understand the molecular basis of various pathological conditions from the perspective of biochemical reactions.

**COURSE CONTENT:**

**Unit I: Protein Structure** **8 lectures**

Amino acids – structure and functional group properties, peptides and covalent structure of proteins, elucidation of primary and higher order structures, Ramachandran plot, evolution of protein structure, protein degradation and introduction to molecular pathways controlling protein degradation, structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin etc. Protein folding: Anfinsen's Dogma, Levinthal paradox, cooperativity in protein folding, free energy landscape of protein folding and pathways of protein folding, molten globule state, chaperons, diseases associated with protein folding, introduction to molecular dynamic simulation.

**Unit II: Enzyme Kinetics** **7 lectures**

Enzyme catalysis – general principles of catalysis; quantitation of enzyme activity and efficiency; enzyme characterization and Michaelis-Menten kinetics; relevance of enzymes in metabolic regulation, activation, inhibition and covalent modification; single substrate enzymes; concept of catalytic antibodies; catalytic strategies with specific examples of proteases, carbonic anhydrases, restriction enzymes and nucleoside monophosphate kinase; regulatory strategies with specific example of hemoglobin; isozymes; role of covalent modification in enzymatic activity; zymogens.

**Unit III: Glycobiology** **5 lectures**

Sugars - mono, di, and polysaccharides with specific reference to glycogen, amylose and cellulose, glycosylation of other biomolecules - glycoproteins and glycolipids; lipids - structure and properties of important members of storage and membrane lipids; lipoproteins.

**Unit IV: Structure and functions of DNA & RNA and lipids** **5 lectures**

Self-assembly of lipids, micelle, biomembrane organization - sidedness and function; membrane bound proteins - structure, properties and function; transport phenomena; nucleosides, nucleotides, nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical

structure; difference in RNA and DNA structure and their importance in evolution of DNA as the genetic material.

**Unit V: Bioenergetics** **8 lectures**

Bioenergetics-basic principles; equilibria and concept of free energy; coupled interconnecting reactions in metabolism; oxidation of carbon fuels; recurring motifs in metabolism; Introduction to GPCR, Inositol/DAG//PKC and Ca++ signaling pathways; glycolysis and gluconeogenesis; reciprocal regulations and non-carbohydrate sources of glucose; Citric acid cycle, entry to citric acid cycle, citric acid cycle as a source of biosynthetic precursors; Oxidative phosphorylation; importance of electron transfer in oxidative phosphorylation; F1-F0 ATP Synthase; shuttles across mitochondria; regulation of oxidative phosphorylation; Photosynthesis – chloroplasts and two photosystems; proton gradient across thylakoid membrane

**Unit VI: Role of vitamins and cofactors in metabolism** **12 lectures**

Calvin cycle and pentose phosphate pathway; glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, roles of epinephrine and glucagon and insulin in glycogen metabolism; Fatty acid metabolism; protein turnover and amino acid catabolism; nucleotide biosynthesis; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and mevalonate pathway; elucidation of metabolic pathways; logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; principles of metabolic regulation; steps for regulation; target of rapamycin (TOR) & Autophagy regulation in relation to C & N metabolism, starvation responses and insulin signaling

**Practical:** **15 lectures**

1. Preparation of buffers, various stock solutions and working solutions that will be needed for the course.
2. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law.
3. Quantification of Carbohydrates/Proteins/Nucleic acids.
4. Blood test by SGPT
5. Demonstration of Mass Spectrometry, Circular Dichroism Spectroscopy and Fluorescence Microscopy if available

**Suggested Readings**


1. Stryer, L. (2015). *Biochemistry*. ($8^{th}$ ed.) New York: Freeman.
2. Lehninger, A. L. (2012). *Principles of Biochemistry* ($6^{th}$ ed.). New York, NY: Worth.
3. Voet, D., & Voet, J. G. (2016). *Biochemistry* ($5^{th}$ ed.). Hoboken, NJ: J. Wiley & Sons.
4. Dobson, C. M. (2003). *Protein Folding and Misfolding*. Nature, 426(6968), 884-890. doi:10.1038/nature02261.
5. Richards, F. M. (1991). *The Protein Folding Problem*. Scientific American, 264(1), 54-63. doi:10.1038/scientificamerican0191-54.

| Paper Name: ADVANCED IMMUNOLOGY | |
|---|---|
| **Paper Code: BITADL14034** | **Credit: 4 (2L++1T+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**COURSE OBJECTIVE:**

The objectives of this course are to learn about structural features of components of immune system as well as their function. The major emphasis of this course will be on development of immune system and mechanisms by which our body elicits immune response. This will be imperative for students as it will help them to predict about nature of immune response that develops against bacterial, viral or parasitic infection, and prove it by designing new experiments.

**Course Outcomes:**

**CO1:** Evaluate usefulness of immunology in different pharmaceutical companies.

**CO2**: Identify proper research lab working in area of their own interests.

**CO3:** Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses and figure out kind of immune responses in the setting of infection (viral or bacterial).

**Course Content:**

**Unit I: Immunology: fundamental concepts 7 lectures**

Components of innate and acquired immunity; phagocytosis; complement and inflammatory responses; pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP); innate immune response; mucosal immunity; antigens: immunogens, haptens; Major Histocompatibility Complex: MHC genes, MHC and immune responsiveness and disease susceptibility, Organs of immune system, primary and secondary lymphoid organs.

**Unit II: Immune responses generated by B and T lymphocytes 8 lectures**

Immunoglobulins - basic structure, classes & subclasses of immunoglobulins, antigenic determinants; multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; principles of cell signaling; basis of self & non-self discrimination; kinetics of immune response, memory; B cell maturation, activation and differentiation; generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; functional T Cell subsets; cell-mediated immune responses, ADCC; cytokines: properties, receptors and therapeutic uses; antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; cell-cell co-operation, Hapten-carrier system.

**Unit III: Antigen-antibody interactions 7 lectures**

Precipitation, agglutination and complement mediated immune reactions; advanced immunological techniques: RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence microscopy, flow cytometry and immunoelectron microscopy; surface plasmon resonance, biosensor assays for

assessing ligand –receptor interaction; CMI techniques: lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays, apoptosis, microarrays, transgenic mice, gene knock outs.

**Unit IV: Vaccinology** **8 lectures**

Active and passive immunization; live, killed, attenuated, subunit vaccines; vaccine technology: role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines; antibody genes and antibody engineering:chimeric, generation of monoclonal antibodies, hybrid monoclonal antibodies; catalytic antibodies and generation of immunoglobulin gene libraries, idiotypic vaccines and marker vaccines, viral-like particles (VLPs), dendritic cell based vaccines, vaccine against cancer, T cell based vaccine, edible vaccine and therapeutic vaccine.

**Unit V: Clinical Immunology** **9 lectures**

Immunity to infection : bacteria, viral, fungal and parasitic infections (with examples from each group); hypersensitivity: Type I-IV; autoimmunity; types of autoimmune diseases; mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; treatment of autoimmune diseases; transplantation: immunological basis of graft rejection; clinical transplantation and immunosuppressive therapy; tumor immunology: tumor antigens; immune response to tumors and tumor evasion of the immune system, cancer immunotherapy; immunodeficiency: primary immunodeficiencies, acquired or secondary immunodeficiencies, autoimmune disorder, anaphylactic shock, immunosenescence, immune exhaustion in chronic viral infection, immune tolerance, NK cells in chronic viral infection and malignancy.

**Unit VI: Immunogenetics** **6 lectures**

Major histocompatibility complex genes and their role in autoimmune and infectious diseases, HLA typing, human major histocompatibility complex (MHC), Complement genes of the human major histocompatibility complex: implication for linkage disequilibrium and disease associations, genetic studies of rheumatoid arthritis, systemic lupus erythematosus and multiple sclerosis, genetics of human immunoglobulin, immunogenetics of spontaneous control of HIV, KIR complex.

**Practical:** **15 lectures**

1. Study of animal models used for generating immune responses.
2. Preparation of plasma and serum.
3. Demonstration of ELISA and ELISPOT.
4. SDS-PAGE and Immunoblotting.
5. Blood smear identification of leucocytes by Giemsa stain.
6. Separation of leucocytes by Dextran method.

**Suggested Readings**

1. Kindt, T. J., Goldsby, R. A., Osborne, B. A., & Kuby, J. (2006). *Kuby Immunology*. New York:

W.H. Freeman
2. Brostoff, J., Seaddin, J. K., Male, D., & Roitt, I. M. (2002). *Clinical Immunology.* London: Gower Medical Pub.
3. Murphy, K., Travers, P., Walport, M., & Janeway, C. (2012). *Janeway's Immunobiology.* New York: Garland Science.
4. Paul, W. E. (2012). *Fundamental Immunology*. New York: Raven Press.
5. Goding, J. W. (1996). *Monoclonal Antibodies: Principles and Practice: Production and Application of Monoclonal Antibodies in Cell Biology, Biochemistry, and Immunology.* London: Academic Press.
6. Parham, P. (2005). *The Immune System*. New York: Garland Science.

| Paper Name: ADVANCED GENETICS | |
|---|---|
| **Paper Code: BITADL14044** | **Credit: 4 (2L++1T+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**COURSE OBJECTIVE:**

The objectives of this course are to take students through basics of genetics and classical genetics covering prokaryotic/ phage genetics to yeast and higher eukaryotic domains. On covering all classical concepts of Mendelian genetics across these life-forms, students will be exposed to concepts of population genetics, quantitative genetics encompassing complex traits, clinical genetics and genetics of evolution.

**Course Outcomes:**

**CO1:** Describe fundamental molecular principles of genetics;

**CO2:** Understand relationship between phenotype and genotype in human genetic traits;

**CO3:** Describe the basics of genetic mapping;

**CO4:** Understand how gene expression is regulated.

**Course Content:**

**Unit I: Genetics of Bacteria and Bacteriophages 13 lectures**

Concept of a gene in pre-DNA era; mapping of genes in bacterial and phage chromosomes by classical genetic crosses; fine structure analysis of a gene; genetic complementation and other genetic crosses using phenotypic markers; phenotype to genotype connectivity prior to DNA-based understanding of gene.

**Unit II: Yeast genetics 10 lectures**

Meiotic crosses, tetrad analyses, non-Mendelian and Mendelian ratios, gene conversion, models of genetic recombination, yeast mating type switch; dominant and recessive genes/mutations, suppressor or modifier screens, complementation groups, transposon mutagenesis, synthetic lethality, genetic epistasis

**Unit III: *Drosophilla* genetics as a model of higher eukaryotes 6 lectures**

Monohybrid & dihybrid crosses, back-crosses, test-crosses, analyses of autosomal and sex linkages, screening of mutations based on phenotypes and mapping the same, hypomorphy, genetic mosaics, genetic epistasis in context of developmental mechanism.

**Unit IV: Population genetics and genetics of evolution 8 lectures**

Introduction to the elements of population genetics: genetic variation, genetic drift, neutral evolution; mutation selection, balancing selection, Fishers theorem, Hardy- Weinberg equilibrium, linkage disequilibrium; in-breeding depression & mating systems; population bottlenecks, migrations, Bayesian statistics; adaptive landscape, spatial variation & genetic fitness.

**Unit V: Quantitative genetics of complex traits (QTLs) 3 lectures**

Complex traits, mapping QTLs, yeast genomics to understand biology of QTLs.

**Unit VI: Plant genetics 5 lectures**

Laws of segregation in plant crosses, inbreeding, selfing, heterosis, maintenance of genetic purity, gene pyramiding

**Practical: 15 lectures**

1. Demonstrate Mendelian inheritance patterns.
2. Isolation of DNA from biological samples.
3. PCR Amplification and Gel Electrophoresis.
4. Karyotyping and Chromosome Analysis.
5. Bacterial transformation.
6. Quantitative Trait Analysis in Plants.

**Suggested Readings:**


1. Hartl, D. L., & Jones, E. W. (1998). *Genetics: Principles and Analysis*. Sudbury, MA: Jones and Bartlett.
2. Pierce, B. A. (2005). *Genetics: a Conceptual Approach*. New York: W.H. Freeman.
3. Tamarin, R. H., & Leavitt, R. W. (1991). *Principles of Genetics*. Dubuque, IA: Wm. C. Brown.
4. Smith, J. M. (1998). *Evolutionary Genetics*. Oxford: Oxford University Press.

| Paper Name: Research Methodology/MOOCs | |
|---|---|
| **Paper Code: BITADL14054** | **Credit: 4 (2L++1T+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T70+IA30)** |

**COURSE OBJECTIVE:**

The objectives of this course are to give background on history of science, emphasizing methodologies used to do research, use framework of these methodologies for understanding effective lab practices and scientific communication and appreciate scientific ethics.

**COURSE OUTCOME:**

**CO1:** Understand history and methodologies of scientific research, applying these to recent published papers;

**CO2:** Understand and practice scientific reading, writing and presentations;

**CO3:** Appreciate scientific ethics through case studies.

**COURSE CONTENT:**

**Unit I: Defining the Research Problem** **5 Lectures** Defining Research Problem, Selection of research Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem, An Illustration Conclusion.

**Unit II: Literature Collection** **5 Lectures**

Need for review of literature, Review process and bibliography, Research Reading, Discriminative Reading, Consulting Source Material, Working Bibliography, Index Card and Reference Card, Different system of Citing References.

**Unit III**: **Research Design/ Experimental Design** **15 Lectures**

Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs, Developing a Research Plan

**Sampling Design:** Census and Sample Survey, Implications of a Sample Design, Steps in Sampling Design, Criteria of Selecting a Sampling Procedure, Characteristics of a Good Sample Design, Different Types of Sample Designs, Selection of Random Sample, Random Sample from an Infinite Universe, Complex Random Sampling Designs.

**Methods of Data Collection:** Collection of Primary Data, Observation Method, Interview Method,Collection of Data through Questionnaires, Collection of Data through Schedules, Difference between Questionnaires and Schedules, Some Other Methods of Data Collection, Collection of Secondary Data.

**Unit IV: Interpretation and Report Writing** **8 Lectures**

Meaning of Interpretation, importance of Interpretation, Technique of Interpretation, Precaution in

Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports.

**Unit V Process of communication 7 Lectures**

Presentation skills - formal presentation skills, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions; Computing skills for scientific research - web browsing for information search; search engines and their mechanism of searching; hidden Web and its importance in scientific research; internet as a medium of interaction between scientists; effective email strategy using the right tone and conciseness.

**Unit VI Scientific Communication 5 lectures**

Technical writing skills - types of reports; layout of a formal report; scientific writing skills - importance of communicating science; problems while writing a scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers - peer review process and problems, recent developments such as open access and non- blind review; plagiarism; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.

**Practicals:**

1. Perform Literature Review and Bibliography Construction
2. Study on the Formulation of Research Questions and Hypotheses
3. Demonstrate on Designing a Survey Questionnaire
4. Demonstrate Data Collection and Entry
5. Demonstrate the use Basic Statistical Analysis Using Software
6. Demonstrate on Writing a Research Proposal

**Suggested readings:**


1. Valiela, I. (2001). *Doing Science: Design, Analysis, and Communication of Scientific Research.* Oxford: Oxford University Press.
2. *On Being a Scientist: a Guide to Responsible Conduct in Research.* (2009). Washington, D.C.: National Academies Press.
3. Gopen, G. D., & Smith, J. A. *The Science of Scientific Writing*. American Scientist, 78 (Nov-Dec 1990), 550-558.
4. Mohan, K., & Singh, N. P. (2010). *Speaking English Effectively*. Delhi: Macmillan India.

**SEMESTER VIII**

| Paper Name: MICROBIAL BIOTECHNOLOGY | |
|---|---|
| **Paper Code: BITSPL15064** | **Credit: 4 (2L++1T+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**COURSE OBJECTIVE:**

The objectives of this course are to introduce students to developments/ advances made in field of microbial technology for use in human welfare and solving problems of the society.

**COURSE OUTCOME:**

**CO1:** On completion of this course, students would develop deeper understanding of the various aspects of microbial technology and its applications.

**CO2:** The students would be able to use their skills learned in the course at industrial level

**COURSE CONTENT**

**Unit I: Introduction to microbial technology 11 lectures**

Microbial technology in human welfare; Isolation and screening of microbes important for industry – advances in methodology and its application; Advanced genome and epigenome editing tools (*e.g.*, engineered zinc finger proteins, TALEs/TALENs, and the CRISPR/Cas9 system as nucleases for genome editing, transcription factors for epigenome editing, and other emerging tools) for manipulation of useful microbes/ strains and their applications; Strain improvement to increase yield of selected molecules, *e.g.*, antibiotics, enzymes, biofuels.

**Unit II: Environmental applications of microbial technology 6 lectures**

Environmental application of microbes; Ore leaching; Biodegradation - biomass recycle and removal; Bioremediation - toxic waste removal and soil remediation; Global Biogeochemical cycles; Environment sensing (sensor organisms/ biological sensors); International and National guidelines regarding use of genetically modified organisms in environment, food and pharmaceuticals.

**Unit III: Pharmaceutical applications of microbial technology 10 lectures**

Recombinant protein and pharmaceuticals production in microbes – common bottlenecks and issues (technical/operational, commercial and ethical); Attributes required in industrial microbes (*Streptomyces* sp., Yeast) to be used as efficient cloning and expression hosts (biologicals production); Generating diversity and introduction of desirable properties in industrially important microbes (*Streptomyces*/Yeast); Microbial cell factories; Downstream processing approaches used in industrial production process (*Streptomyces* sp., Yeast).

**Unit IV: Food applications of microbial technology 10 lectures**

Application of microbes and microbial processes in food and healthcare industries - food processing and food preservation, antibiotics and enzymes production, microbes in targeted delivery application – drugs and vaccines (bacterial and viral vectors); Non- recombinant ways of introducing desirable

properties in Generally recognized as safe (GRAS) microbes to be used in food (*e.g.*, Yeast) - exploiting the existing natural diversity or the artificially introduced diversity through conventional acceptable techniques (mutagenesis, protoplast fusion, breeding, genome shuffling, directed evolution *etc.*).

**Unit V: Advances in microbial technology** **8 lectures**

Microbial genomics for discovery of novel enzymes, drugs/ antibiotics; Limits of microbial genomics with respect to use in human welfare; Metagenomics and metatranscriptomics – their potential, methods to study and applications/use (animal and plant health, environmental clean-up, global nutrient cycles & global sustainability, understanding evolution), Global metagenomics initiative - surveys/projects and outcome, metagenomic library construction and functional screening in suitable hosts – tools and techniques for discovery/identification of novel enzymes, drugs (*e.g.*, protease, antibiotic) *etc.*

**Practical:** **15 lectures**

1. Isolation and Identification of Microorganisms from Environmental Samples
2. Antibiotic Production by Soil Bacteria
3. Plasmid DNA Isolation and Restriction Digestion
4. Bioremediation: Degradation of Pollutants by Microorganisms
5. Fermentation Technology: Production of Ethanol by Yeast
6. Microbial Enzyme Production and Activity Assay

**Suggested readings:**


1. Lee, Y. K. (2013). *Microbial Biotechnology: Principles and Applications*. Hackensack, NJ: World Scientific .
2. Moo-Young, M. (2011). *Comprehensive Biotechnology*. Amsterdam: Elsevier.
3. Nelson, K. E. (2015). Encyclopedia of Metagenomics. *Genes, Genomes and Metagenomes: Basics, Methods, Databases and Tools*. Boston, MA: Springer US.
4. *The New Science of Metagenomics Revealing the Secrets of Our Microbial Planet*. (2007). Washington, D.C.: National Academies Press.

| Paper Name: COMPUTATIONAL BIOLOGY AND DRUG DESIGNING | |
|---|---|
| **Paper Code: BITSPL15074** | **Credit: 4 (2L++1T+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**COURSE OBJECTIVE:**

The objective of this course is to provide students with theory and practical experience of essentials to aid for genomic, proteomic and metabolomics courses and drug design program.

**COURSE OUTCOME:**

**CO1:** Develop an understanding of the basic theory of these computational tools;

**CO2:** Develop required database extraction, integration, coding for computational tools and methods necessary for all Omics;

**CO3:** Create hypothesis for investigating specific contemporary biological questions, provide help to experiment with or develop appropriate tools;

**CO4:** Critically analyze and interpret results of their study with respect to whole systems.

**COURSE CONTENT:**

**Unit I: Introduction to computational biology basics and biological databases**

**8 lectures**

Computers in biology and medicine; Overview of biological databases, nucleic acid & protein databases, primary, secondary, functional, composite, structural classification database, Sequence formats & storage, Access databases, Extract and create sub databases, limitations of existing databases.

**Unit II: Pairwise and multiple sequence alignments** **7 lectures**

Local alignment, Global alignment, Scoring matrices - PAM, BLOSUM, Gaps and penalties, Dot plots. Dynamic programming approach: Needleman and Wunsch Algorithm, Smith and Waterman Algorithm, Hidden Markov Model: Viterbi Algorithm. Heuristic approach: BLAST, FASTA. Building Profiles, Profile based functional identification.

**Unit III: Genome analysis** **6 lectures**

Polymorphisms in DNA sequence, Introduction to Next Generation Sequencing technologies, Whole Genome Assembly and challenges, Sequencing and analysis of large genomes, Gene prediction, Functional annotation, Comparative genomics, Probabilistic functional gene networks, Human genome project, Genomics and crop improvement. Study available GWAS, ENCODE, HUGO projects, extract and build sub databases; Visualization tools including Artemis and Vista for genome comparison; Functional genomics case studies.

**Unit IV: Structure visualization** **6 lectures**

Retrieving and drawing structures, Macromolecule viewing platforms, Structure validation and

correction, Structure optimization, Analysis of ligand-protein interactions; Tools such as PyMol or VMD.

**Unit V: Molecular Modelling** **6 lectures**

Significance and need, force field methods, energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; mapping properties onto surfaces; RMS fit of conformers and protein chains, assigning secondary structures; sequence alignment: methods, evaluation, scoring; protein curation: backbone construction and side chain addition; different types of protein chain modelling: ab initio, homology, hybrid, loop; Template recognition and alignments; Modelling parameters and considerations; Model analysis and validation; Model optimization; Substructure manipulations, annealing, protein folding and model generation; loop generating methods; loop analysis; Analysis of active sites using different methods in studying protein–protein interactions.

**Unit VI: Structure based drug development** **6 lectures**

Molecular docking: Types and principles, Semi-flexible docking, Flexible docking; Ligand and protein preparation, Macromolecule and ligand optimization, Ligand conformations, Clustering, Analysis of docking results and validation with known information. Extra- precision docking platforms, Use of Small-molecule libraries, Natural compound libraries for virtual high throughput screenings.

**Unit VII: Ligand-based drug development** **6 lectures**

Quantitative structure activity relationships; Introduction to chemical descriptors like 2D, 3D and Group-based; Radar plots and contribution plots and Activity predictions, Pharmacophore modeling, Pharmacophore-based screenings of compound library, analysis and experimental validation.

**Practical:** **15 lectures**

1. Introduction to Bioinformatics: Tools and Databases
2. Protein Structure Visualization and Analysis
3. Molecular Docking Studies
4. Demonstrate drug designing by ligand based, structure based and pharmacophore modeling and virtual Screening
5. Gene Expression Data Analysis
6. Pathway Analysis and Network Biology

**Suggested readings:**


1. Mount, D. W. (2001). *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
2. Bourne, P. E., & Gu, J. (2009). *Structural Bioinformatics*. Hoboken, NJ: Wiley-Liss.
3. Lesk, A. M. (2004). *Introduction to Protein Science: Architecture, Function, and Genomics*. Oxford: Oxford University Press.
4. Campbell, M & Heyer, L. J. (2006), *Discovering Genomics, Proteomics and Bioinformatics*, Pearson Education.
5. Oprea, T. (2005). C*hemoinformatics in Drug Discovery,* Volume 23. Wiley Online Library.
6. Gasteiger, J. & Engel,T. (2003), *Chemoinformatics: a Textbook*, Wiley Online Library.

| Paper Name: Emerging Technologies | |
|---|---|
| **Paper Code: BITSPL15084** | **Credit: 4 (2L++1T+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**COURSE OBJECTIVE:**

The objectives of this course are to teach basics of the new principles to students so as to appreciate current-day research tool-kit better.

**COURSE OUTCOMES:**

1. Learn history, theoretical basis and basic understanding of latest technologies in area of biotechnology.
2. Students will be able to explain the fundamental principles and advancements in emerging biotechnologies.
3. Learn about various applications of these technologies.
4. Students will acquire hands-on experience with advanced biotechnological tools and techniques.

**COURSE CONTENT:**

**Unit I: Optical microscopy methods 10 Lectures**

Basic Microscopy: Light Microscopy: lenses and microscopes, resolution: Rayleigh's Approach, Darkfield; Phase Contrast; Differential Interference Contrast; fluorescence and fluorescence microscopy.

Advanced Microscopy: Confocal microscope: scanning optical microscope, confocal principle, resolution and point spread function. Advanced fluorescence techniques: FLIM, FRET, and FCS, Fluorescence Lifetime, Fluorescence Resonant Energy Transfer (FRET), Fluorescence Correlation Spectroscopy (FCS), Evanescent Wave Microscopy; Near-Field and Evanescent Waves, Total Internal Reflection Microscopy; Near-Field Microscopy; Super-Resolution Imaging with Stochastic Optical Reconstruction Microscopy (STORM) and Photoactivated Localization Microscopy (PALM).

**Unit II: Mass spectroscopy 7 Lectures**

Ionization techniques; mass analyzers/overview MS; FT-ICR and Orbitrap, fragmentation of peptides; proteomics, nano LC-MS; Phospho-proteomics; interaction proteomics, mass spectroscopy in structural biology; imaging mass spectrometry.

**Unit III: Systems biology 7 Lectures**

High throughput screens in cellular systems, target identification, validation of experimental methods to generate the omics data, bioinformatics analyses, mathematical modelling and designing testable predictions.

**Unit IV: Structural Biology 6 Lectures**

X-ray diffraction methods, solution & solid-state NMR, cryo-electron microscopy, small- angle X-ray scattering, Atomic force microscopy.

**Unit IV: CRISPR-CAS** **7 Lectures**

History of its discovery, elucidation of the mechanism including introduction to all the molecular players, development of applications for *in vivo* genome engineering for genetic studies, promise of the technology as a next generation therapeutic method.

**Unit V: Nanobodies** **8 Lectures**

Introduction to nanobodies, combining nanobody with phage-display method for development of antibody against native proteins, nanobody as a tool for protein structure-function studies, use of nanobodies for molecular imaging, catabolic antibodies using nanobodies.

**Practical:** **15 Lectures**

1. Demonstration of working principle of basic microscopy (light microscopy) and advanced microscopy (Confocal microscopy).
2. Demonstration of Mass spectroscopy, X-Ray Crystallography, NMR and System Biology
3. CRISPR-Cas9 Gene Editing Simulation
4. DNA Barcoding for Species Identification
5. Bioinformatics Analysis of Next-Generation Sequencing Data

**Suggested Readings:**


1. Campbell, I. D. (2012). *Biophysical Techniques*. Oxford: Oxford University Press.
2. Serdyuk, I. N., Zaccai, N. R., & Zaccai, G. (2007). *Method in Molecular Biophysics: Structure, Dynamics, Function*. Cambridge: Cambridge University Press.
3. Phillips, R., Kondev, J., & Theriot, J. (2009). P*hysical Biology of the Cell*. New York: Garland Science.
4. Nelson, P. C., Radosavljević, M., & Bromberg, S. (2004). *Biological Physics: Energy, Information, Life*. New York: W.H. Freeman.
5. Huang, B., Bates, M., & Zhuang, X. (2009). *Super Resolution Fluorescence Microscopy.* Annual Review of Biochemistry, 78(1), 993-1016.

| Paper Name: GENETIC ENGINEERING | |
|---|---|
| **Paper Code: BITSPL15094** | **Credit: 4 (2L++1T+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**COURSE OBJECTIVE:**

The objectives of this course are to teach students with various approaches to conducting genetic engineering and their applications in biological research as well as in biotechnology industries.

**COURSE OUTCOMES:**

**CO1:** Students will be able to explain the basic principles and mechanisms of genetic engineering, including recombinant DNA technology, gene cloning, and genome editing techniques.

**CO2:** Students will evaluate the applications of genetic engineering in various fields, including medicine (gene therapy, genetic vaccines), agriculture (GMOs), and industry (biopharmaceuticals).

**CO3:** Students will design, execute, and analyze genetic engineering experiments, demonstrating an understanding of experimental controls, variable manipulation, and data interpretation.

**CO4:** The students shall be able to take up biological research as well as placement in the relevant biotech industry.

**COURSE CONTENT:**

**Unit I: Introduction and tools for genetic engineering 8 lectures**

Impact of genetic engineering in modern society; general requirements for performing a genetic engineering experiment; restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing; labeling of DNA: nick translation, random priming, radioactive and non-radioactive probes, hybridization techniques: northern, southern, south-western and far-western and colony hybridization, fluorescence in situ hybridization.

**Unit II: Different types of vectors 10 lectures**

Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors, hagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Principles for maximizing gene expression expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors; Inclusion bodies; methodologies to reduce formation of inclusion bodies; mammalian expression and replicating vectors; Baculovirus and Pichia vectors system, plant based vectors, Ti and Ri as vectors, yeast vectors, shuttle vectors.

**Unit III: Different types of PCR techniques 9 lectures**

Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, cloning of PCR products; T-vectors; proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; sequencing

methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP, DGGE, RFLP.

**Unit IV: Gene manipulation and protein DNA interaction 8 lectures**

Insertion of foreign DNA into host cells; transformation, electroporation, transfection; construction of libraries; isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; construction of microarrays – genomic arrays, cDNA arrays and oligo arrays; study of protein-DNA interactions: electrophoretic mobility shift assay; DNase footprinting; methyl interference assay, chromatin immunoprecipitation; protein-protein interactions using yeast two-hybrid system; phage display.

**Unit V: Gene silencing and genome editing technologies 10 lectures**

Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy; creation of transgenic plants; debate over GM crops; introduction to methods of genetic manipulation in different model systems *e.g.* fruit flies (*Drosophila*), worms (*C. elegans*), frogs (*Xenopus*), fish (zebra fish) and chick; Transgenics - gene replacement; gene targeting; creation of transgenic and knock-out mice; disease model; introduction to genome editing by CRISPR-CAS with specific emphasis on Chinese and American clinical trials.

**Practicals: 15 lectures**

1. Isolation of DNA from Plant cells/E.coli/Animal cells
2. DNA estimation.
3. Agarose gel electrophoresis
4. Plasmid DNA isolation
5. Demonstration of PCR
6. Restriction digestion of DNA
7. Preparation of rDNA
8. Preparation and transformation of competent cells with plasmid
9. Screening of transformed cells

**Suggested Readings:**


1. Old, R. W., Primrose, S. B., & Twyman, R. M. (2001). Principles of Gene Manipulation: an Introduction to Genetic Engineering. Oxford: Blackwell Scientific Publications.
2. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub.
4. Selected papers from scientific journals, particularly Nature & Science.
5. Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc

| Paper Name: PLANT AND ANIMAL BIOTECHNOLOGY | |
|---|---|
| **Paper Code: BITSPL15104** | **Credit: 4 (2L++1T+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**COURSE OBJECTIVE:**

The objective of this course is to introduce students to the principles, practices and application of animal biotechnology, plant tissue culture, plant and animal genomics, genetic transformation and molecular breeding of plants and animals.

**COURSE OUTCOMES:**

**CO1:** Have a clear theoretical concept on micropropagation, tissue culture media, sterilization techniques and different techniques for culturing shoot tip, embryo, pollen, anther and ovary etc. and developing haploids, hybrids and homozygous lines.

**CO2:** Have an understanding about the different plant transformation terms and technology viz. Ti-plasmid & Ri-plasmid, binary vectors, vector-less DNA transfer, promoters for plant transformation and chloroplast transformation.

**CO3:** Explain and apply the knowledge of recombinant DNA technology for plant breeding. Also have a clear concept on techniques involved in germplasm conservation.

**CO4:** Enables the students about understanding of design and layout of tissue culture lab and basic instrumentation.

**CO5:** Enables the students to understand various application of animal biotechnology.

**COURSE CONTENT:**

**Unit I: Plant tissue culture and animal cell culture 10 lectures**

Plant tissue culture: historical perspective; totipotency; organogenesis; Somatic embryogenesis; establishment of cultures – callus culture, cell suspension culture, media preparation – nutrients and plant hormones; sterilization techniques; applications of tissue culture - micropropagation; somaclonal variation; androgenesis and its applications in genetics and plant breeding; germplasm conservation and cryopreservation; synthetic seed production; protoplast culture and somatic hybridization - protoplast isolation; culture and usage; somatic hybridization - methods and applications; cybrids and somatic cell genetics; plant cell cultures for secondary metabolite production.

Animal cell culture: brief history of animal cell culture; cell culture media and reagents; culture of mammalian cells, tissues and organs; primary culture, secondary culture, continuous cell lines, suspension cultures; application of animal cell culture for virus isolation and in vitro testing of drugs, testing of toxicity of environmental pollutants in cell culture, application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins.

**Unit II: Plant genetic manipulation 11 lectures**

Genetic engineering: Agrobacterium-plant interaction; virulence; Ti and Ri plasmids; opines and their

significance; T-DNA transfer; disarmed Ti plasmid; Genetic transformation - Agrobacterium-mediated gene delivery; cointegrate and binary vectors and their utility; direct gene transfer - PEG-mediated, electroporation, particle bombardment and alternative methods; screenable and selectable markers; characterization of transgenics; chloroplast transformation; marker-free methodologies; advanced methodologies - cisgenesis, intragenesis and genome editing; molecular pharming - concept of plants as biofactories, production of industrial enzymes and pharmaceutically important compounds.

**Unit III: Animal reproductive biotechnology and vaccinology 9 lectures**

Animal reproductive biotechnology: structure of sperms and ovum; cryopreservation of sperms and ova of livestock; artificial insemination; super ovulation, embryo recovery and in vitro fertilization; culture of embryos; cryopreservation of embryos; embryo transfer technology; transgenic manipulation of animal embryos; applications of transgenic animal technology; animal cloning - basic concept, cloning for conservation for conservation endangered species; Vaccinology: history of development of vaccines, introduction to the concept of vaccines, conventional methods of animal vaccine production, recombinant approaches to vaccine production, modern vaccines.

**Unit IV: Plant and animal genomics 7 lectures**

Overview of genomics – definition, complexity and classification; need for genomics level analysis; methods of analyzing genome at various levels – DNA, RNA, protein, metabolites and phenotype; genome projects and bioinformatics resources for genome research – databases; overview of forward and reverse genetics for assigning function for genes.

**Unit V: Molecular mapping and marker assisted selection 8 lectures**

Molecular markers - hybridization and PCR based markers RFLP, RAPD, STS, SSR, AFLP, SNP markers; DNA fingerprinting-principles and applications; introduction to mapping of genes/QTLs; marker-assisted selection - strategies for Introducing genes of biotic and abiotic stress resistance in plants: genetic basis for disease resistance in animals; molecular diagnostics of pathogens in plants and animals; detection of meat adulteration using DNA based methods.

**Practicals: 15 lectures**

1. Preparation of media needed for plant and animal tissue culture.
2. Grow and propagate plant/animal cells.
3. Isolation and quantification of DNA from plant/animal tissues.
4. Electrophoresis of DNA.
5. Isolation and quantification of total proteins from plant/animal tissues
6. Analysis of proteins by SDS -PAGE and Immunoblotting.

**Suggested Readings**


1. Chawla, H. S. (2000). Introduction to Plant Biotechnology. Enfield, NH: Science.
2. 2.Razdan, M. K. (2003). Introduction to Plant Tissue Culture. Enfield, NH: Science.
3. Slater, A., Scott, N. W., & Fowler, M. R. (2008). Plant Biotechnology: an Introduction to Genetic Engineering. Oxford: Oxford University Press.
4. Pörtner, R. (2007). Animal Cell Biotechnology: Methods and Protocols. Totowa, NJ: Humana Press.

**SEMESTER IX**

| Paper Name: STEM CELL BIOLOGY | |
|---|---|
| **Paper Code: BITSPL25014** | **Credit: 4 (2L++1T+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**COURSE OBJECTIVE:**

To equip the students with a foundational understanding of stem cells by demystifying their defining properties – self-renewal, the ability to replicate themselves, and differentiation, the potential to transform into specialized cell types. To introduce students to the diverse landscape of stem cells, focusing on pluripotent and adult stem cells, with a particular emphasis on epithelial stem cells and their crucial role in maintaining tissues throughout the body.

**COURSE OUTCOME:**

**CO1:** Describe the characteristics of stem cells and the different types of stem cells.

**CO2:** Gain an understanding of stem cell regeneration techniques.

**CO3:** Understand basic biology/mechanisms of pluripotency, self-renewal of stem cells and epithelial stem developmental concepts.

**CO4:** Understand the reproductive biology of germ and somatic stem cells.

**CO5:** Describe the immunological aspects of stem cells in diseases and therapy.

**CO6:** Gain knowledge on stem cells tissue engineering techniques and their applications.

**CO7:** Obtain information on therapeutic approaches generated through use of stem cells for medical applications

**COURSE CONTENT:**

**Unit I: Stem cell: An introduction 6 lectures**

Definition and Meaning of Stem Cells, Biological Roles and properties of Stem Cells, Functions and Origin of Stem Cells, Asymmetric Division of Stem Cells, Types of Stem Cells, Therapeutic Cloning of Embryonic Stem Cells. Present Perspective and future challenges.

**Unit II: Ectoderm and mesoderm development 8 lectures**

**Endoderm specification and differentiation**: Molecular basis of Pleuripotency, Mechanism of Stem Cell Self renewal, Tissue and Organ development.The Development of Epithelial Stem Cell concept and adult stem cell concept. Imaging chromatin in embryonic stem. **Mesoderm specification and differentiation:** Niche biology, homing and migration: Hematopoietic stem cell trafficking, The neural stem cell microenvironment.

**Unit III: Germ cell and somatic stem cell biology in reproduction 8 lectures**

Regulation of spermatogonia, piRNA function in germline development, The role of microRNAs in germline differentiation, Germline stem cell niches, Uterine stem cells, Modeling germ cell

differentiation, Lineage analysis of stem cells, Somatic stem cells of the ovary and their relationship to human ovarian cancers, Sex differentiation in mouse and man and subsequent development of the female reproductive organs.

**Unit IV: Stem cell immunology** **6 lectures**

Immunologic targeting of the cancer stem cell, Immunological considerations for cell therapy using human embryonic stem cell derivatives, Mouse models of graft-versus-host disease, Prospects for ensuring acceptance of ES cell-derived tissues.

**Unit V: Tissue engineering** **10 lectures**

Combining stem cells and biomaterial scaffolds for constructing tissues and cell delivery, Autologous approaches to tissue engineering, Flow perfusion culture of mesenchymal stem cells for bone tissue engineering, Engineering microenvironments to control stem cell fate and function, The role of bone marrow-derived stem cells in lung regeneration and repair, Mechanical control of stem cell differentiation, Skin tissue engineering, Molecular imaging of stem cells.

**Unit VI: Therapeutic prospects** **7 lectures**

The hematopoietic stem cell niche, Medical applications of epidermal stem cells, Mesenchymal stromal cells as a drug delivery system, Egress and mobilization of hematopoietic stem and progenitor cells: a dynamic multi-facet process, Cord blood hematopoietic stem cell transplantation, Cell Replacement therapy, Cardiovascular Therapy, Neurological Disorders, Diabetes, Liver Therapy.

**Practicals** **15 lectures**

1. Luteal Cell isolation, culture and characterization in buffaloes
2. Derivation of Embryonic stem cells from IVF derived embryos in goat
3. Generating parthenogenetic embryos in Goat.
4. Cryopreservation of goat oocytes.
5. Lymphocyte isolation and preparation of metaphase plate
6. Amplification of OCT gene.
7. Counting of viable spermatozoa by eosin, necrosin stain
8. Establishment of primary fibroblast culture
9. Preparation of feeder layer
10. Gene Expression Analysis in Stem Cells Using RT-PCR

**Suggested Readings:**


1. Essentials of Stem Cell Biology: Robert Lanza: Elsevier Academic Press
2. Stem Cells. EapanCherian& G Nandhini. Jaypee Publications
3. Stem Cells ( Basic and applications). KaushikD Deb&Satish M Tootey.McGraw Hill Education(India) Private Limited (10 October 2009)
4. The Stem Cell Divide: The Facts, the Fiction, and the Fear Driving the Greatest . MichaelBellomo. Amacom Publishing

| Paper Name: MEDICAL BIOTECHNOLOGY | |
|---|---|
| **Paper Code BITSPL25024** | **Credit: 4 (2L++1T+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**COURSE OBJECTIVE:** To provide students with a multifaceted understanding of cancer biology, drug metabolism, pharmacokinetics, drug design, stem cell biology, and diagnostic microbiology, enabling them to apply theoretical knowledge and practical skills in research, therapy, and disease control.

**COURSE OUTCOME:**

**CO1:** Student will learn the basic concepts of cancer biology, various stages in carcinogenesis, molecular cell biology of cancer, cancer metastasis, and cancer therapy.

**CO2:** Student will learn the concepts of drug metabolism and pharmokinetics, manufacturing principles, and product development and its quality.

**CO3:** Student will learn the basic concepts in the field of drug design followed by advanced methodology in the molecular aspects of drug design.

**CO4:** Student will gain knowledge in 1. Stem cell basics 2. Growing of ES cells in lab 3. Differentiation of stem cells 4. Application of stem cells.

**CO5:** Students will acquire comprehensive knowledge and practical skills in the pathogenesis, laboratory diagnosis, prevention, and control of important microbial diseases, including bacterial, fungal, viral, and protozoan infections, utilizing various diagnostic microbiology techniques

**COURSE CONTENT:**

**Unit I: Fundamentals of cancer biology** **10 lectures**

Regulation of Cell cycle, Mutations that cause changes in signal molecules, effects on receptor, signal switches, tumour suppressor genes, Modulation of cell cycle-in cancer, Different forms of cancers, Diet and cancer**. Principles of carcinogenesis**: Chemical Carcinogenesis, Metabolism of Carcinogenesis, Targets of Chemical Carcinogenesis, Principles of Physical Carcinogenesis, X-Ray radiation – Mechanism of radiation Carcinogenesis. **Molecular cell biology of cancer:** Oncogenes, Identification of Oncogenes, Retroviruses and Oncogenes, detection of Oncogenes, Growth factor and Growth factor receptors that are Oncogenes. Oncogenes / Proto Oncogenes activity. Growth factors related to transformations. **New molecules for cancer therapy**: Different forms of therapy, Chemotherapy, Radiation Therapy, Detection of Cancers, Prediction of aggressiveness of Cancer, Advances in Cancer detection.

**Unit II: Drug and pharmaceutical biotechnology** **10 lectures**

**Development of Drug and Pharmaceutical Industry**: Therapeutic agents, their use and economics; Regulatory aspects. **Drug metabolism and pharmacokinetics**: Drug metabolism-physico-chemical

principles, radio activity-pharmacokinetic action of drugs in human bodies. **Important unit processes and their applications**: Bulk drug manufacturers, Type of reactions in bulk drug manufacture and processes. Special requirement for bulk drug manufacture. **Manufacturing principles:** Compressed table, wet granulation-dry granulation or slugging-direct compression-tablet presses, coating of tablets, capsules, sustained action dosage forms-parental solution-oral liquids-injections-ointment-topical applications, Preservation, analytical methods and test for various drug and pharmaceuticals, packing-packing techniques, quality management, GMP. **Pharmaceutical product and their control:** Therapeutic categories such as vitamins, laxatives, analgesics, non-steroidal contraceptives, Antibiotics, biologicals, hormones.

**Unit III: Molecular modeling and drug design** **10 lectures**

**Empirical force fields molecular mechanism**: Bond Stretching – Angle Bending – Torsional terms – Out plane bonding motions – Electrostatic interactions – Van Der Waals interactions – Effective pair Potentials – Hydrogen Bonding – Simulation of liquid water. **Computer simulation methods** : Calculation of thermodynamic properties – Phase space – Practical aspects pf computer simulation – Boundaries monitoring Equilibrium – Long range Process – Analyzing result of simulation and estimating errors. **Molecular dynamics simulation methods**: Molecular Dynamics using simple modules – Molecular Dynamics with continuous potentials – Running Molecular Dynamics simulation – Constant dynamics – Time dependent properties – Molecular Dynamics at constant temperature and pressure - Monte Carlo simulation methods. **Metropolis methods**: Monte Carlo simulation of molecules – Monte Carlo simulation of polymers – Calculating chemical potentials – Monte Carlo or Molecular Dynamics, Molecular modeling to discover and design new molecules. **Molecular modeling in drug discovery:** Deriving and using 3D Pharma cores – Molecular docking – Structure Based methods to identify lead components- De novo ligand design.

**Unit IV: Stem cells in health care** **10 lectures**

**Stem Cell Basics** : Unique properties of stem cells – embryonic stem cells - adult stem cells – umbilical cord stem cells – similarities and differences between embryonic and adult stem cells. Properties of stem cells – pluripotency – totipotency. **Stem cell in drug discovery and tissue engieering:** Target identification – Manipulating differentiation pathways – stem cell therapy Vs cell protection - stem cell in cellular assays for screening – stem cell based drug discovery, drug screening and toxicology. **Genetic engineering and therapeutic application of stem cells**: Gene therapy – genetically engineered stem cells – stem cells and Animal cloning – transgenic animals and stem cells – Therapeutic applications – Parkinson disease - Neurological disorder – limb amputation – heart disease - spinal cord injuries – diabetes –burns - HLA typing- Alzheimer's disease –tissue engineering application – production of complete organ - kidney – eyes - heart – brain.

**Unit V: Medical Microbiology** **5 lectures**

**Pathogenesis**: Lab diagnosis, prevention and control of important microbial diseases. Pathogenic bacterial diseases, Fungal diseases, Viral Diseases and Protozoan diseases. **Diagnostic Microbiology:** Sample collection and processing, Microscopy techniques (light, fluorescence, electron microscopy), Culture methods and identification of pathogens, Molecular diagnostics (PCR, qPCR, next-generation sequencing), Serological methods (ELISA, Western blot).

**Practicals** **15 lectures**

1. ELISA (Enzyme-Linked Immunosorbent Assay)/PCR for Disease Diagnosis
2. Cell Culture Techniques and Cytotoxicity Assay
3. DNA Fingerprinting Using Restriction Fragment Length Polymorphism (RFLP)
4. Western Blotting for Disease Diagnosis
5. Molecular docking study to predict the binding modes of ligands to target proteins and identify potential lead compounds for drug design.
6. Derivation of Embryonic stem cells from IVF derived embryos in goat.
7. Counting of viable spermatozoa by eosin, necrosin stain.
8. Establishment of primary fibroblast culture.
9. Extraction of DNA/RNA from clinical samples.
10. Conduction of PCR and for pathogen detection.

**Suggested Readings:**


1. Ruddon.R.W., Cancer Biology, Oxford University Press, Oxford, 1995.
2. King R.J.B., Cancer Biology, Addision Wesley Longmann Ltd, U.K., 1996.
3. Maly B.W.J., Virology a practical approach, IRL press, Oxford, 1987.
4. Dunmock.N.J and Primrose S.B., Introduction to modern Virology, Blackwell Scientific Publications, Oxford, 1988.
5. Leon Lachman et al Theory and Practice of Industrial Pharmacy, 3 Edition,
6. Lea and Febiger, 1986 2. Remington's Pharmaceutical Science, Mark Publishing and Co.
7. A.R Leach, Molecular Modeling Principles and Applications, Longman, 1996
8. J.M. Haile , Molecular Dynamics Simulation Elementary methods, , John Wiley and Sons ,1997
9. Patrick R. Murray, Ken S. Rosenthal, and Michael A. Pfaller. Medical Microbiology, 8th edition, 2016.

| Paper Name: BIOPROCESS ENGINEERING AND TECHNOLOGY | |
|---|---|
| Paper Code BITSPL25034 | Credit: 4 (2L++1T+1P) |
| Total Classes: 60= 45+15 (L+P) | Total Marks: 100 (T50+P20+IA30) |

**COURSE OBJECTIVE:**

The objectives of this course are to educate students about the fundamental concepts of bioprocess technology and its related applications, thus preparing them to meet the challenges of the new and emerging areas of biotechnology industry.

**COURSE OUTCOME:**

**CO1:** Understand the relevance of microorganisms from industrial context;

**CO2:** Carry out stoichiometric calculations and specify models of their growth;

**CO3:** Give an account of design and operations of various fermenters;

**CO4:** Present unit operations together with the fundamental principles for basic methods in production technique for bio-based products;

**CO5:** Calculate yield and production rates in a biological production process, and also interpret data;

**CO6:** Calculate the need for oxygen and oxygen transfer;

**CO7:** Critically analyze any bioprocess from market point of view;

**CO8:** Give an account of important microbial/enzymatic industrial processes in food and fuel industry

**COURSE CONTENT:**

**Unit I: Basic principles of biochemical engineering 5 lectures**

Isolation, screening and maintenance of industrially important microbes; microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); strain improvement for increased yield and other desirable characteristics.

**Unit II: Stoichiometry and models ofmicrobial growth Yeast genetics 5 lectures**

Elemental balance equations; metabolic coupling – ATP and NAD+; yield coefficients; unstructured models of microbial growth; structured models of microbial growth.

**Unit III: Bioreactor design and analysis 9 lectures**

Batch and continuous fermenters; modifying batch and continuous reactors: chemostat with recycle, multistage chemostat systems, fed-batch operations; conventional fermentation v/s biotransformation; immobilized cell systems; large scale animal and plant cell cultivation; fermentation economics; upstream processing: media formulation and optimization; sterilization; aeration, agitation and heat transfer in bioprocess; scale up and scale down; measurement and control of bioprocess parameters.

**Unit IV: Downstream processing and product recovery 6 lectures**

Separation of insoluble products - filtration, centrifugation, sedimentation, flocculation; Cell disruption; separation of soluble products: liquid-liquid extraction, precipitation, chromatographic

techniques, reverse osmosis, ultra and micro filtration, electrophoresis; final purification: drying; crystallization; storage and packaging.

**Unit V: Fermentation economics** **6 lectures**

Isolation of micro-organisms of potential industrial interest; strain improvement; market analysis; equipment and plant costs; media; sterilization, heating and cooling; aeration and agitation; bath-process cycle times and continuous cultures; recovery costs; water usage and recycling; effluent treatment and disposal.

**Unit VI: Applications of enzyme technology in food processing** **6 lectures**

Mechanism of enzyme function and reactions in process techniques; enzymatic bioconversions *e.g.* starch and sugar conversion processes; high-fructose corn syrup; interesterified fat; hydrolyzed protein *etc.* and their downstream processing; baking by amylases, deoxygenation and desugaring by glucoses oxidase, beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing.

**Unit VII: Applications of microbial technology in food process operations and production, biofuels and biorefinery** **8 lectures**

Fermented foods and beverages; food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; microbes and their use in pickling, producing colours and flavours, alcoholic beverages and other products; process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; bacteriocins from lactic acid bacteria – production and applications in food preservation; biofuels and biorefinery.

**Practicals:** **15 lectures**

1. Basic Microbiology techniques
    a) Scale up from frozen vial to agar plate to shake flask culture.
    b) Instrumentation: Microplate reader, spectrophotometer, microscopy.
    c) Isolation of microorganisms from soil samples.
2. Experimental set-up
    a) Assembly of bioreactor and sterilization.
    b) Growth kinetics.
    c) Substrate and product inhibitions.
    d) Measurement of residual substrates.
3. Data Analysis
    a) Introduction to Metabolic Flux Analysis (MFA).
4. Fermentation

a) Batch.

b) Fed-batch.

c) Continuous.

5. Unit operations

   a) Microfiltrations: Separation of cells from broth.

   b) Bioseparations: Various chromatographic techniques and extractions.

6. Bioanalytics

   Analytical techniques like HPLC, FPLC, GC, GC-MS *etc.* for measurement of amounts of products/substrates.

**Suggested readings:**


1. Shuler, M. L., & Kargi, F. (2002). *Bioprocess Engineering: Basic Concepts.* Upper Saddle River, NJ: Prentice Hall.
2. Stanbury, P. F., & Whitaker, A. (2010). *Principles of FermentationTechnology*. Oxford: Pergamon Press.
3. Blanch, H. W., & Clark, D. S. (1997). *Biochemical Engineering.* New York: M. Dekker.
4. Bailey, J. E., & Ollis, D. F. (1986). *Biochemical Engineering Fundamentals*. New York: McGraw-Hill.

| Paper Name: VACCINE BIOLOGY | |
|---|---|
| **Paper Code BITSPL25044** | **Credit: 4 (2L++1T+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**COURSE OBJECTIVE:**

This course will provide students with an overview of current developments in different areas of vaccines.

**COURSE OUTCOME:**

**CO1:** Understand fundamental concepts of human immune system and basic immunology;

**CO2:** Differentiate and understand immune responses in relation to infection and vaccination;

**CO3:** Understand requirement and designing of different types of vaccines;

**CO4:** Understand importance of conventional and new emerging vaccine technologies.

**COURSE CONTENT:**

**Unit I: Fundamentals of immunesystem** **9 lectures**

Overview of Immune system; Human Immune system: Effectors of immune system; Innate & Adaptive Immunity; Activation of the Innate Immunity; Adaptive Immunity; T and B cells in adaptive immunity; Immune response in infection; Correlates of protection.

**Unit II: Immune response to infection** **9 lectures**

Protective immune response in bacterial; viral and parasitic infections; Primary and Secondary immune responses during infection; Antigen presentation and Role of Antigen presenting cells: Dendritic cells in immune response; Innate immune response; Humoral (antibody mediated) responses; Cell mediated responses: role of CD4+ and CD8+ T cells; Memory responses: Memory and effector T and B cells, Generation and Maintenance of memory T and B cells.

**Unit III: Immune response to vaccination** **9 lectures**

Vaccination and immune response; Adjuvants in Vaccination; Modulation of immune responses: Induction of Th1 and Th2 responses by using appropriate adjuvants and antigen delivery systems - Microbial adjuvants, Liposomal and Microparticles as delivery systems; Chemokines and cytokines; Role of soluble mediators in vaccination; Oral immunization and Mucosal Immunity.

**Unit IV: Vaccinetypes & design** **9 lectures**

History of vaccines, Conventional vaccines; Bacterial vaccines; Viral Vaccines; Vaccines based on routes of administration: parenteral, oral, mucosal; Live attenuated and inactivated vaccine; Subunit Vaccines and Toxoids; Peptide Vaccine.

**Unit V: Vaccine technologies** **9 lectures**

Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers.

**Practicals** **15 lectures**

1. Preparation of Bacterial Cultures for Vaccine Development
2. Demonstration of immunization for generating antibodies
3. ELISA (Enzyme-Linked Immunosorbent Assay) for Vaccine Efficacy
4. Use of Adjuvant and its effect on Immune Response
5. DNA Vaccine Plasmid Preparation
6. Demonstration of cell culture technique for virus propagation for vaccine development

**Suggested Books:**


**1.** Janeway, C. A., Travers, P., Walport, M., & Shlomchik, M. J. (2005). *Immuno Biology: the Immune System in Health and Disease*. USA: Garland Science Pub.

**2.** Kindt, T. J., Osborne, B. A., Goldsby, R. A., & Kuby, J. (2013). *Kuby Immunology*. New York: W.H. Freeman.

**3.** Kaufmann, S. H. (2004). *Novel Vaccination Strategies*. Weinheim: Wiley-VCH.

**4.** Journal Articles (relevant issues) from: Annual Review of Immunology, Annual Review of Microbiology, Current Opinion in Immunology, Nature Immunology, Expert review of vaccines.

| Paper Name: MOLECULAR DIAGNOSTICS/MOOCs | |
|---|---|
| **Paper Code BITSPL25054** | **Credit: 4 (2L++1T+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**COURSE OBJECTIVE:**

The objectives of this course are to sensitize students about recent advances in molecular biology and various facets of molecular medicine which has potential to profoundly alter many aspects of modern medicine including pre- or post-natal analysis of genetic diseases and identification of individuals predisposed to disease ranging from common cold to cancer.

**COURSE OUTCOME:**

**CO1:** This course will equip the students with the basics of life's building blocks - DNA, RNA, and proteins - exploring their structure, function, and how DNA variations influence health, individuality, and medication responses.

**CO2:** It will navigate students to the world of molecular analysis techniques, from differentiating PCR methods for research and diagnostics to understanding FISH, ISH, microarrays, next-generation sequencing, and bioinformatics tools for data analysis.

**CO3:** Students will be able to explain the concept of metabolomics and its role in biomarker discovery for various diseases.

**CO4:** Students will be able to analyze case studies demonstrating the impact of molecular diagnosis on improving healthcare for specific diseases.

**CO5:** Students will be able to identify common genetic alterations associated with various cancers.

**CO6:** Students will understand the importance of quality control measures in diagnostic testing and become familiar with relevant regulations and approvals for genetic testing.

**COURSE CONTENT:**

**Unit I: Genome Biology in health and disease** **5 lectures**

DNA, RNA, Protein: An overview; chromosomal structure & mutations; DNA polymor- phism: human identity; clinical variability and genetically determined adverse reactions to drugs.

**Unit II: Genome: resolution, detection and analysis** **8 lectures**

PCR: Real-time; ARMS; Multiplex; ISH; FISH; ISA; RFLP; DHPLC; DGGE; CSCE; SSCP; Nucleic acid sequencing: new generations of automated sequencers; Microarray chips; EST; SAGE; microarray data normalization & analysis; molecular markers: 16S rRNA typing; Diagnostic proteomics: SELDI-TOF-MS; Bioinformatics data acquisition & analysis.

**Unit III: Diagnostics metabolomics** **5 lectures**

Metabolite profile for biomarker detection the body fluids/tissues in various metabolic disorders by making using LCMS & NMR technological platforms.

**Unit IV: Detection and identity of microbial diseases** **8 lectures**

Exemplified by two inherited diseases for which molecular diagnosis has provided a dramatic improvement of quality of medical care: Fragile X Syndrome: Paradigm of new mutational mechanism of unstable triplet repeats, von-Hippel Lindau disease: recent acquisition in growing number of familial cancer syndromes.

**Unit V: Detection of inherited diseases** **7 lectures**

Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers.

**Unit VI: Molecular oncology** **8 lectures**

Detection of recognized genetic aberrations in clinical samples from cancer patients; types of cancer-causing alterations revealed by next-generation sequencing of clinical isolates; predictive biomarkers for personalized onco-therapy of human diseases such as chronic myeloid leukemia, colon, breast, lung cancer and melanoma as well as matching targeted therapies with patients and preventing toxicity of standard systemic therapies.

**Unit VII: Quality assurance and control** **4 lectures**

Quality oversight; regulations and approved testing.

**Practicals:** **15 lectures**

1. DNA/Protein Extraction from Biological Samples
2. Agarose Gel Electrophoresis
3. Immunoblotting
4. Polymerase Chain Reaction (PCR) Amplification
5. Demonstrate the role of PCR/ELISA/Western blotting in disease diagnosis

**Suggested Books:**


1. Campbell, A. M., & Heyer, L. J. (2006). Discovering Genomics, Proteomics, and Bioinformatics. San Francisco: Benjamin Cummings.
2. Brooker, R. J. (2009). Genetics: Analysis & Principles. New York, NY: McGraw-Hill.
3. Glick, B. R., Pasternak, J. J., & Patten, C. L. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, DC: ASM Press
4. Coleman, W. B., & Tsongalis, G. J. (2010). Molecular Diagnostics: for the Clinical Laboratorian. Totowa, NJ: Humana Press

**SEMESTER X**

| Paper Name: BIOENTREPRENEURSHIP | |
|---|---|
| **Paper Code: BITSPL25064** | **Credit: 4 (2L++1T+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**COURSE OBJECTIVE:**

Research and business belong together and both are needed. In a rapidly developing life science industry, there is an urgent need for people who combine business knowledge with the understanding of science & technology. Bio-entrepreneurship, an interdisciplinary course, revolves around the central theme of how to manage and develop life science companies and projects. The objectives of this course are to teach students about concepts of entrepreneurship including identifying a winning business opportunity, gathering funding and launching a business, growing and nurturing the organization and harvesting the rewards.

**COURSE OUTCOME:**

**CO1:** Students should be able to gain entrepreneurial skills

**CO2:** The students should be able to understand the various operations involved in venture creation, identify scope for entrepreneurship in biosciences and utilize the schemes promoted through knowledge centres and various agencies.

**CO3:** The knowledge pertaining to management should also help students to be able to build up a strong network within the industry.

**COURSE CONTENT:**

**Unit I: Innovation and entrepreneurship in bio-business 12 lectures**

Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (*e.g.* pharmaceuticals *vs.* Industrial biotech), Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities, Alternatives faced by emerging bio-firms and the relevant tools for strategic decision, Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies.

**Unit II: Bio markets - business strategy and marketing 12 lectures**

Negotiating the road from lab to the market (strategies and processes of negotiation with financiers, government and regulatory authorities), Pricing strategy, Challenges in marketing in bio business (market conditions & segments; developing distribution channels, the nature, analysis and management of customer needs), Basic contract principles, different types of agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills.

**Unit III: Finance and accounting 12 lectures**

Business plan preparation including statutory and legal requirements, Business feasibility study, financial management issues of procurement of capital and management of costs, Collaborations & partnership, Information technology.

**Unit IV: Technology management** **9 lectures**

Technology – assessment, development & upgradation, Managing technology transfer, Quality control & transfer of foreign technologies, Knowledge centres and Technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP).

**Practical:**

1. Market Research and Analysis for a Biotechnology Product:
2. Business Plan Development for a Biotech Startup
3. Regulatory Pathway Analysis for a Biotechnology Product
4. Intellectual Property (IP) Management and Patent Search
5. Pitch Presentation for a Biotechnology Venture

**Suggested Readings:**


1. Adams, D. J., & Sparrow, J. C. (2008). *Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences*. Bloxham: Scion.
2. Shimasaki, C. D. (2014). *Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies*. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.
3. Onetti, A., & Zucchella, A. *Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge*. Routledge.
4. Jordan, J. F. (2014). *Innovation, Commercialization, and Start-Ups in Life Sciences*. London: CRC Press.
5. Desai, V. (2009). *The Dynamics of Entrepreneurial Development and Management*. New Delhi: Himalaya Pub. House.

| Paper Name: ENZYME TECHNOLOGY | |
|---|---|
| **Paper Code: BITSPL25074** | **Credit: 4 (2L++1T+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**COURSE OBJECTIVE:**

To introduce the theory as well as applications of enzyme technology in food, medical, and household industries.

**COURSE OUTCOMES:**

**CO1:** To familiarize students to nomenclature and properties of enzymes

**CO2:** To acquaint students with the fundamentals of enzyme properties, nomenclatures, characteristics and mechanisms and apply biochemical calculation for enzyme kinetics.

**CO3:** Students will compare methods for production, purification, characterization and immobilization of enzymes that can benefit human life and plot graphs based on kinetics data.

**CO4:** To discuss various application of enzymes that can benefit human life.

**CO5:** Discover the current and future trends of applying enzyme technology for the commercialization purpose of biotechnological products.

**CO6:** Students will gain practical knowledge on enzyme kinetics and hands on skills in enzyme immobilization techniques.

**COURSE CONTENT:**

**Unit 1: Enzyme preparation** **12 lectures**

General properties of enzymes like effect of pH, temperature ions, etc. Potential Sources and Screening for novel Enzymes, Media used for enzyme production. Extraction, assay and large-scale purification of Enzymes-Extraction of soluble and membrane-bound enzymes. Preliminary and Advanced purification procedures, Criteria of purity. Determination of molecular weights of enzymes

**Unit 2: Immobilized Enzymes** **10 lectures**

Preparation and properties of immobilized enzymes. Application of Immobilized enzymes: General principles. Genetic immobilization of enzymes on yeast cell surface

**Unit 3: Industrial Use of Enzymes** **13 lectures**

Use of enzymes in detergents. Enzymes in the fruit juices, wine, brewing and distillation industries. Use of proteases in the leather and wool industry. Applications of glucose oxidase and catalase in the food industry.Use of enzymes in cellulose and starch hydrolysis. Use of lactases in the dairy industry. Medical applications of enzymes

**Unit 4: Advances and future prospects in Enzyme Technology** **10 lectures**

Enzymes and recombinant DNA technology. Synthesis of artificial enzymes: Enzyme engineering. Use of 'unnatural' substrates. Coenzyme-regenerating systems. Enzymes and Bioinformatics.

**Practical**: **15 lectures**

1. Enzyme preparation- purification procedures
2. Determination of Enzyme Activity Using a Simple Substrate**:**
3. Analysis of Effect of pH/Temperature on Enzyme Activity
4. Analysis of Substrate Specificity of Enzymes
5. Enzyme Immobilization and Activity Assay
6. Enzyme production by microbes/plants/animals.
7. Detection of isozymes on gel by staining
8. Assay of Glutamate dehydrogenase/Urease/Alkaline phosphatase
9. Immobilization of whole cells (Yeast/Bacteria) by calcium alginate method

**Suggested Readings:**


- Enzymes: Biochemistry, Biotechnology and Clinical Chemistry- Palmer T, Horwood Publishing Chichester, England.
- Method of Enzymatic Analysis- Bergmeyer HU. Academic Press, NY R.A. Copland Enzymes, Wiley VCH
- Enzymes and Immobilized Cells in Biotechnology. Laskin AI. The Benjamin/Cummings Publishing Company, INC., California.
- Fermentation Microbiology and Biotechnology. Mansi ME & Bryce C, Taylor & Francis Ltd, London.
- Industrial Biotechnology. Jogdand SN, Himalaya Publishing House, Mumbai.
- Fundamentals of Enzymology: Price NC and Stevens L, Oxford Univ. Press. Demonstration of the principles of enzyme-catalysed reactions using alkaline phosphatase – Pricea N and Newman L. Biochemistry and Molecular Biology Education.

| Paper Name: IPR, Biosafety and Bioethics | |
|---|---|
| **Paper Code: BITSPL25084** | **Credit: 4 (2L++1T+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**COURSE OBJECTIVE:**

To provide basic knowledge on intellectual property rights and their implications in biological research and product development. To become familiar with India's IPR Policy. To learn biosafety and risk assessment of products derived from biotechnology and regulation of such products. To become familiar with ethical issues in biological research. This course will focus on consequences of biomedical research technologies such as cloning of whole organisms, genetic modifications, DNA testing.

**COURSE OUTCOME:**

**CO1:** Understand the rationale for and against IPR and especially patents;

**CO2:** Understand why India has adopted an IPR Policy and be familiar with broad outline of patent regulations;

**CO3:** Understand different types of intellectual property rights in general and protection of products derived from biotechnology research and issues related to application and obtaining patents;

**CO4:** Gain knowledge of biosafety and risk assessment of products derived from recombinant DNA research and environmental release of genetically modified organisms, national and international regulations;

**CO5:** Understand ethical aspects related to biological, biomedical, health care and biotechnology research.

**COURSE CONTENT:**

**Unit I: Introduction to IPR** **10 Lectures**

Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; introduction to history of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; concept of 'prior art': invention in context of "prior art"; patent databases - country-wise patent searches (USPTO, EPO, India); analysis and report formation.

**Unit II: Patenting** **10 Lectures**

Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application; role of a Country Patent Office; filing of a patent application; precautions before patenting-disclosure/non-disclosure - patent application- forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types

of patent applications: provisional and complete specifications; PCT and conventional patent applications; international patenting-requirement, procedures and costs; financial assistance for patenting- introduction to existing schemes; publication of patents-gazette of India, status in Europe and US; patent infringement- meaning, scope, litigation, case studies and examples; commercialization of patented innovations; licensing – outright sale, licensing, royalty; patenting by research students and scientists-university/organizational rules in India and abroad, collaborative research - backward and forward IP; benefit/credit sharing among parties/community, commercial (financial) and non-commercial incentives.

**Unit III: Biosafety** **9 Lectures**

Biosafety and Biosecurity - introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs; principles of safety assessment of transgenic plants – sequential steps in risk assessment; concepts of familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation – protection goals, compilation of relevant information, risk characterization and development of analysis plan; risk assessment of transgenic crops *vs* cisgenic plants or products derived from RNAi, genome editing tools.

**Unit IV: National and International Regulations** **9 Lectures**

International regulations – Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; Draft bill of Biotechnology Regulatory authority of India - containments – biosafety levels and category of rDNA experiments; field trails – biosafety research trials – standard operating procedures - guidelines of state governments; GM labelling – Food Safety and Standards Authority of India (FSSAI).

**Unit V: Bioethics** **7 Lectures**

Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. Bioethics in research – cloning and stem cell research, Human and animal experimentation, animal rights/welfare, Agricultural biotechnology - Genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations - Protection of environment and biodiversity – biopiracy.

**Practical:** **15 Lectures**

1. Understanding and Conducting a Patent Search
2. Case Study Analysis of Biosafety Regulations
3. Developing an Informed Consent Form for a Biotech Study
4. Ethical Analysis of a Biotechnology Case Study

5. Patent infringement-Case Studies (Basmati rice, Turmeric, Neem)
6. Proxy filing of Indian Product patent
7. Proxy filing of Indian Process patent
8. Exploring patent database

**Suggested readings:**


1. *National IPR Policy*, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI
2. *Complete Reference to Intellectual Property Rights Laws*. (2007). Snow White Publication Oct. Kuhse, H. (2010). *Bioethics: an Anthology*. Malden, MA: Blackwell.
3. Recombinant DNA Safety Guidelines, 1990 Department of Biotechnology, Ministry of Science and Technology, Govt. of India. Retrieved from http://www.envfor.nic.in/ divisions/csurv/geac/annex-5.pdf
4. Craig, W., Tepfer, M., Degrassi, G., & Ripandelli, D. (2008). *An Overview of General Features of Risk Assessments of Genetically Modified Crops*. Euphytica, 164(3), 853-880. doi:10.1007/s10681-007-9643-8.

| Paper Name: PROTEIN ENGINEERING | |
|---|---|
| **Paper Code: BITSPL25094** | **Credit: 4 (2L++1T+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**COURSE OBJECTIVE:**

The aim of this course is to introduce methods and strategies commonly used in protein engineering.

**COURSE OUTCOME:**

**CO1:** Analyse structure and construction of proteins by computer-based methods;

**CO2:** Describe structure and classification of proteins;

**CO3:** Analyse purity and stability of proteins and explain how to store them in best way;

**CO4:** Explain how proteins can be used for different industrial and academic purposes such as structure determination, organic synthesis and drug design.

**COURSE CONTENT:**

**Unit I: Introduction to protein Engineering 11 Lectures**

Protein engineering – definition, applications; Features or characteristics of proteins that can be engineered (definition and methods of study) – affinity and specificity; Spectroscopic properties; Stability to changes in parameters as pH, temperature and amino acid sequence, aggregation propensities, *etc.* Protein engineering with unnatural amino acids and its applications

**Unit II: Stability of Protein structure 11 Lectures**

Methods of measuring stability of a protein; Spectroscopic methods to study physicochemical properties of proteins: far-UV and near-UV CD; Fluorescence; UV absorbance; ORD; Hydrodynamic properties–viscosity, hydrogen-deuterium exchange; Brief introduction to NMR spectroscopy – emphasis on parameters that can be measured/obtained from NMR and their interpretation.

**Unit III: Applications 13 Lectures**

Forces stabilizing proteins – Van der waals, electrostatic, hydrogen bonding and weakly polar interactions, hydrophobic effects; Entropy – enthalpy compensation; Experimental methods of protein engineering: directed evolution like gene site saturation mutagenesis; Module shuffling; Guided protein recombination, *etc.*, Optimization and high throughput screening methodologies like GigaMetrix, High throughput microplate screens *etc.*, Application to devices with bacteriorhodopsin as an example; Engineering antibody affinity by yeast surface display; Applications to vaccines, Peptidomimetics and its use in drug discovery.

**Unit IV: Computational approaches 10 Lectures**

Computational approaches to protein engineering: sequence and 3D structure analysis, Data mining, Ramachandran map, Mechanism of stabilization of proteins from psychrophiles and thermophiles *vis-à-vis* those from mesophiles; Protein design, Directed evolution for protein engineering and its potential.

**Practical:** **15 lectures**

1. Site-Directed Mutagenesis of a Protein Gene
2. Expression and Purification of a Recombinant Protein
3. Enzyme Kinetics of a Mutant Protein
4. Protein Stability Assay
5. Computational Modeling of Protein Mutations

**Suggested Readings:**


1. Edited by T E Creighton, (1997), *Protein Structure: a Practical Approach*, 2nd Edition, Oxford university press.
2. Cleland and Craik, (2006), *Protein Engineering, Principles and Practice*, Vol 7, Springer Netherlands.
3. Mueller and Arndt, *Protein Engineering Protocols*, 1st Edition, Humana Press.
4. Ed. Robertson DE, Noel JP, (2004), *Protein Engineering Methods in Enzymology*, 388, Elsevier Academic Press.
5. J Kyte; (2006), *Structure in Protein Chemistry*, 2nd Edition, Garland publishers

| Paper Name: NANOBIOTECHNOLOGY | |
|---|---|
| **Paper Code: BITSPL25104** | **Credit: 4 (2L++1T+1P)** |
| **Total Classes: 60= 45+15 (L+P)** | **Total Marks: 100 (T50+P20+IA30)** |

**COURSE OBJECTIVE:**

The course aims at providing a general and broad introduction to multi-disciplinary field of nanotechnology. It will familiarize students with the combination of the top-down approach of microelectronics and micromechanics with the bottom- up approach of chemistry/biochemistry; a development that is creating new and exciting cross-disciplinary research fields and technologies. The course will also give an insight into complete systems where nanotechnology can be used to improve our everyday life.

**COURSE OUTCOME:**

**CO1:** On successful completion of this course, students should be able to describe basic science behind the properties of materials at nanometre scale

**CO2:** They will know the principles behind advanced experimental and computational techniques for studying nanomaterials.

**COURSE CONTENT:**

**Unit I: Introduction to Nanobiotechnology** **5 Lectures**

Introduction to Nanobiotechnology; Concepts, historical perspective; Different formats of nanomaterials and applications with example for specific cases; Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures, Synthesis and characterization of different nanomaterials.

**Unit II: Nano-films** **7 Lectures**

Thin films; Colloidal nanostructures; Self Assembly, Nanovesicles; Nanospheres; Nanocapsules and their characterisation.

**Unit III: Nanoparticles** **10 Lectures**

Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers.

**Unit IV: Applications of Nanoparticles** **10 Lectures**

Nanoparticles for diagnostics and imaging (theranostics); concepts of smart stimuli responsive nanoparticles, implications in cancer therapy, nanodevices for biosensor development.

**Unit V: Nanomaterials** **8 Lectures**

Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers.

**Unit VI: Nanotoxicity** **5 Lectures**

Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment; Fate of nanomaterials in different stratas of environment; Ecotoxicity models and assays; Life Cycle Assessment, containment.

**Practical:** **15 lectures**

1. Basics of preparation and characterization of nanomaterials.
2. Preparation of DNA/Protein/Lipid coupled nanoparticles.
3. Demonstration of nanoparticle-mediated drug delivery.
4. *In vitro* and *in vivo* assessment of nanotoxicity

**Suggested Readings:**


1. GeroDecher, Joseph B. Schlenoff, (2003); *Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials*, Wiley-VCH Verlag GmbH & Co. KGaA
2. David S. Goodsell, (2004); *Bionanotechnology: Lessons from Nature*; Wiley-Liss
3. Neelina H. Malsch (2005), *Biomedical Nanotechnology*, CRC Press
4. Greg T. Hermanson, (2013); *Bioconjugate Techniques*, (3rd Edition); Elsevier
5. Recent review papers in the area of Nanomedicine.