**National College (Autonomous)**

**(For the students admitted from the Academic Year 2022-2023 onwards)**

**Syllabus for B.Sc., BIOTECHNOLOGY**



**PG & Research Department of Biotechnology & Microbiology**

**National College (Autonomous)**

**Tiruchirappalli – 620 001.**

Syllabus for B.Sc., Biotechnology

(From the Academic Year 2022-23 onwards)



Department of Biotechnology and Microbiology

National College

(Autonomous)

Tiruchirappalli – 620 001.

**NATIONAL COLLEGE (AUTONOMOUS)**

**TIRUCHIRAPPALLI – 620 001.**

**(College with Potential for Excellence)**

**(Nationally Reaccredited at ‘A+’ Level by NAAC)**

**DEPARTMENT OF BIOTECHNOLOGY AND MICROBIOLOGY**

**Vision:**

To create potential and competent professionals through career oriented training aided with advanced technical skills and equipping them with professional ethics, environmental and societal apprehension.

**Mission:**

* Dissemination of global demand based knowledge through teaching with technical professionalism.
* Creation of individuals with social and environmental concern.
* Training the students to create economically and environmentally viable solutions.

**Programme Educational Objectives (PEOs):**

**PEO 1: Cognitive Objective**

**PEO 1a:** Developing the potential for vertical career growth in biotech-oriented industries, service sectors and related avenues.

**PEO 1b:** Inculcating technical and managerial skills crucial for real time scenarios through the enhancement of problem solving skills and advanced technical documentation ability.

**PEO 2: Affectionate Objective**

Grooming the students with technical proficiency to equip them for the emergence of sustainable technology and solutions for prevailing environmental, societal and cultural concerns.

**PEO 3: Behavioral Objective**

Instilling knowledge and awareness on professional ethics, bioethical and health issues, intellectual property rights and life-long learning through career oriented courses such as IPR, biosafety and bioethics.

**PROGRAM OUTCOMES**

On completion of B.Sc., Biotechnology Program, the students are expected to

|  |  |
| --- | --- |
| **No.** | **Description** |
| **PO1** | Proficient knowledge in the lead domains of Biotechnology |
| **PO2** | Enriched written and verbal communication for the dissemination of knowledge and ideas. |
| **PO3** | Efficiency to solve complex problems, critically relate, analyse existing situations and proficiency for the selection of appropriate tools/instrument |
| **PO4** | Knowledge that imparts leadership and teamwork qualities for applications in various fields of Microbiology and research |
| **PO5** | Moral, ethical, public and environmental awareness associated with sustainability issues. |
| **PO6** | Multi-cultural competency, self-instrospected attitudes and thirst for life-long learning |

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**B.Sc. BIOTECHNOLOGY**

**COURSE STRUCTURE UNDER C.B.C.S.**

**(Applicable to Candidates admitted from the Academic Year 2022-23 onwards)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sem** | | **Part** | | **Course** | | | **Course Title** | **Hrs/ Wk** | **Credit** | | **Exam Hrs.** | | **Marks** | | | | | | **Total** | |
| **CIA** | | **External** | | | |
|  | | **W** | | **O** | |  | |
| I | | I | | - | | | Tamil – I/ Hindi – I/ Sanskrit – I | 6 | 3 | | 3 | | 25 | | 75 | | - | | 100 | |
| II | | - | | | English – I | 6 | 3 | | 3 | | 25 | | 75 | | - | | 100 | |
| III | | Core Course I  U22BT1 | | | Cell Biology and Genetics | 5 | 5 | | 3 | | 25 | | 75 | | - | | 100 | |
| Core Course II U22BT2P | | | Lab in Cell Biology, Genetics | 3 | 2 | | 3 | | 25 | | 75 | | - | | 100 | |
| Allied Course I U22ABT1 | | | Biochemistry – I: Biomolecules | 5 | 4 | | 3 | | 25 | | 75 | | - | | 100 | |
| Allied Course II U22ABT2P | | | Lab in Biochemistry | 3 | 2 | | 3 | | 25 | | 75 | | - | | 100 | |
| IV | | - | | | Environmental Studies | 2 | 2 | | 3 | | 25 | | 75 | | - | | 100 | |
| **Total** | | | | | | | | **30** | **21** | |  | |  | |  | |  | | **700** | |
| II | | I | | - | | | Tamil – II/Hindi – II/ Sanskrit – II | 6 | 3 | | 3 | | 25 | | 75 | | - | | 100 | |
| II | | - | | | English – II | 4 | 2 | | 3 | | 25 | | 75 | | - | | 100 | |
| - | | | Communicative English – 1 | 2 | 1 | | 3 | | 25 | | 70 | | 05 | | 100 | |
| III | | U22BT2P | | | Lab in Molecular Biology | 3 | 2 | | 3 | | 25 | | 75 | | - | | 100 | |
| Core Course III  U22BT3 | | | Molecular Biology | 5 | 5 | | 3 | | 25 | | 75 | | - | | 100 | |
| U22ABT2P | | | Lab in Biochemical Techniques | 3 | 2 | | 3 | | 25 | | 75 | | - | | 100 | |
| Allied Course III U22ABT3 | | | Biochemistry – II: Intermediary Metabolism | 5 | 4 | | 3 | | 25 | | 75 | | - | | 100 | |
| IV | | Skilled Based Elective I  U22SBE1 | | | Introduction to Bioentrepreneurship Skills | 2 | 2 | | 3 | | 25 | | 75 | | - | | 100 | |
| **Total** | | | | | | | | **30** | **21** | |  | |  | |  | |  | | **800** | |
|  | | | | | | | |  |  | |  | |  | |  | |  | |  | |
| III | | I | - | | Tamil – III/Hindi – III/ Sanskrit – III | | | 6 | | 3 | | 3 | | 25 | | 75 | | - | | 100 |
| II | - | | English – III | | | 6 | | 3 | | 3 | | 25 | | 75 | | - | | 100 |
| III | Core Course IV  U22BT4 | | Immunology | | | 4 | | 4 | | 3 | | 25 | | 75 | | - | | 100 |
| Core Course V U22BT5P | | Lab in Immunology | | | 3 | | 2 | | 3 | | 25 | | 75 | | - | | 100 |
| Allied Course IV  U22ABT4 | | General Microbiology | | | 4 | | 4 | | 3 | | 25 | | 75 | | - | | 100 |
| Allied Course V U22ABT5P | | Lab in General Microbiology | | | 3 | | 2 | | 3 | | 25 | | 75 | | - | | 100 |
| IV | Skilled Based Elective II  U22SBE2 | | Bioentrepreneurship  Skills I/II | | | 2 | | 2 | | 3 | | 25 | | 75 | | - | | 100 |
| Skilled Based Elective III  U22SBE3P | | Lab in Bioentrepreneurship  Skills I/II | | | 2 | | 2 | | 3 | | 25 | | 70 | | 05 | | 100 |
| **Total** | | | | | | | | **30** | | **22** | |  | |  | |  | |  | | **800** |
| IV | I | | | - | | Tamil – IV/Hindi – IV/ Sanskrit – IV | | 6 | | 3 | | 3 | | 25 | | 75 | | - | | 100 |
| II | | | - | | English – IV | | 4 | | 2 | | 3 | | 25 | | 75 | | - | | 100 |
| - | | Communicative English – II | | 2 | | 1 | | 3 | | 25 | | 70 | | 05 | | 100 |
| III | | | U22BT5P | | Lab in rDNA Technology | | 3 | | 2 | | 3 | | 25 | | 75 | | - | | 100 |
| Core Course VI  U22BT6 | | rDNA Technology | | 4 | | 4 | | 3 | | 25 | | 75 | | - | | 100 |
| U22ABT5P | | Lab in Applied Microbiology | | 3 | | 2 | | 3 | | 25 | | 75 | | - | | 100 |
| Allied Course VI  U22ABT6 | | Applied Microbiology | | 4 | | 4 | | 3 | | 25 | | 75 | | - | | 100 |
| IV | | | Non-Major Elective I  U22NMBT1 | | Animal Cell Culture Techniques | | 2 | | 2 | | 3 | | 25 | | 75 | | - | | 100 |
| - | | Value Education | | 2 | | 2 | | 3 | | 25 | | 75 | | - | | 100 |
| **Total** | | | | | | | | **30** | | **22** | |  | |  | |  | |  | | **900** |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| V | III | Core Course VII  U22BT7 | Bioinstrumentation | 5 | 5 | 3 | 25 | 75 | - | 100 |
| Core Course VIII  U22BT8 | Bioprocess and Enzyme Technology | 5 | 5 | 3 | 25 | 75 | - | 100 |
| Core Course IX  U22BT9P | Lab in Bioinstrumentation and Bioprocess and Enzyme Technology | 6 | 4 | 3 | 25 | 70 | 05 | 100 |
| Elective Course I  U22BT10E | Environmental Biotechnology | 5 | 4 | 3 | 25 | 75 | - | 100 |
| Elective Course II  U22BT11E | IPR, Biosafety and Bioethics | 5 | 4 | 3 | 25 | 75 | - | 100 |
| IV | Non-Major Elective II  U22NMBT2 | Bioprocess Technology | 2 | 2 | 3 | 25 | 75 | - | 100 |
| - | Soft Skills | 2 | 2 | 3 | 25 | 75 | - | 100 |
| **Total** | | | | **30** | **26** |  |  |  |  | **700** |
| VI | III | Core Course X  U22BT12 | Plant Biotechnology | 6 | 6 | 3 | 25 | 75 | - | 100 |
| Core Course XI  U22BT13 | Animal Biotechnology | 6 | 6 | 3 | 25 | 75 | - | 100 |
| Core Course XII  U22BT14 | Bioinformatics | 6 | 6 | 3 | 25 | 75 | - | 100 |
| Core Course XIII  U22BT15P | Lab in Plant Biotechnology, Animal Biotechnology and Environmental Biotechnology | 6 | 4 | 3 | 25 | 70 | 05 | 100 |
|  | Elective Course III  U22BT16E | Biostatistics | 5 | 4 | 3 | 25 | 75 | - | 100 |
| V | - | Gender Studies | 1 | 1 | 3 | 25 | 75 | - | 100 |
| - | Extension Activities | - | 1 | - | - | - | - | - |
| **Total** | | | | **30** | **28** |  |  |  |  | **600** |
| **Grand Total** | | | | **180** | **140** |  |  |  |  | **4500** |

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| **SEMESTER - I** |  | **CODE - U22BT1** |
| **Core Course I: CELL BIOLOGY AND GENETICS** | | |
| **CREDITS - 5** |  | **HOURS – 5** |

**Objectives:**

* To describe the structural organization of cells.
* To interpret the diversified functions of every organelles in the cell.
* To understand cell cycle.
* To discuss the laws of Mendelian genetics.
* To understand the patterns of inheritance.

**Course Outcomes:**

At the completion of the course, the student would be able to:

|  |  |  |
| --- | --- | --- |
| **Cognitive level** | **Course outcome** | **Knowledge Level** |
| CO1 | * Define the cell structure and its functions | K1 |
| CO2 | * Describe the structural and functional aspects of cellular organelles | K2 |
| CO3 | * Discuss the significance of cytoskeletal elements in cell division | K3 |
| CO4 | * Interpret the concepts of Mendelian genetics | K4 |
| CO5 | * Define the mechanisms of linkage and crossing over | K5 |

**C1 – Remember C2 – Understand**

**Unit I**

Cell as a basic unit: Discovery of cells, Development of cell theory, Prokaryotic and Eukaryotic cell organization, Structure of plant and animal cell; Cell Membrane: Architecture, Models, Membrane Transport.

**Unit II**

Ultra structure and Function of Organelles: Nucleus, Mitochondria, Chloroplast, Endoplasmic Reticulum, Golgi apparatus, Ribosomes, Lysosomes, Vacuoles, Peroxisomes and Glyoxisomes.

**Unit III**

Cytoskeletal elements: Intermediary filaments, actin filaments and microtubules; Cellular interactions: Cell-Cell (Junctions and Cell signalling), Cell-ECM; Cell cycle: Mitosis and Meiosis.

**Unit IV**

Mendelian Genetics: Introduction to Mendelian inheritance; Mendel’s laws: Monohybrid cross, Dihybrid cross, Test cross, Back cross, Incomplete dominance and Codominance.

**Unit V**

Interaction of factors: Complementary, lethal and epistatic; Linkage and crossing over in *Zea mays*; Polygenic inheritance; Genic balance theory in Drosophila and human being; Brief outline of allosomal (Klinefelter syndrome), autosomal (Down syndrome) disorders; Population Genetics: Hardy – Weinberg law.

**TEXT BOOKS**

1. Karp G. (2009). Cell and molecular biology: concepts and experiments, John Wiley & Sons.
2. De Robertis, E.D.P and De Robertis E.M.F. (2001). Cell and Molecular Biology, 8th edition, Lippincott Williams and Wilkins, New York.
3. [William S Klug](https://www.worldcat.org/search?q=au%3AKlug%2C+William+S.%2C&qt=hot_author); [Michael R Cummings](https://www.worldcat.org/search?q=au%3ACummings%2C+Michael+R.%2C&qt=hot_author); [Charlotte A Spencer](https://www.worldcat.org/search?q=au%3ASpencer%2C+Charlotte+A.%2C&qt=hot_author); [Michael Angelo Palladino](https://www.worldcat.org/search?q=au%3APalladino%2C+Michael+Angelo%2C&qt=hot_author); [Darrell Killian](https://www.worldcat.org/search?q=au%3AKillian%2C+Darrell%2C&qt=hot_author) (2019). Concepts of genetics. 12th Edition, New York: Pearson.

**REFERENCE BOOKS**

1. Lewin B. (2008). Genes IX, Jones and Bartlett, Burlington.
2. Rastogi S.C. (2004), Cell Biology, 2nd Edition, New Age International Publishers, New Delhi.
3. Gardner, E. J., Simmons, M. J., & Snustad, D. P. (1991). *Principles of genetics*. 8th Edition, NewYork:J.Wiley.

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| --- | --- | --- | --- | --- | --- | --- |
| **Co/Po** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
| **CO1** | 9 | 3 | 1 | 3 | 3 | 9 |
| **CO2** | 3 | 3 | 3 | 9 | 3 | 9 |
| **CO3** | 9 | 1 | 3 | 3 | 9 | 9 |
| **CO4** | 9 | 3 | 1 | 3 | 3 | 9 |
| **CO5** | 9 | 3 | 3 | 9 | 9 | 9 |
| **CO6** | 3 | 3 | 1 | 3 | 9 | 9 |
| **Weightage** | 42 | 16 | 12 | 30 | 36 | 54 |

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| **SEMESTER - I** |  | **CODE – U22ABT1** |
| **Allied Course I: BIOCHEMISTRY – I: BIOMOLECULES** | | |
| **CREDITS -  4** |  | **HOURS - 5** |

**Objectives:**

⮚ To understand the atomic, molecular structures and molecular bonding.

⮚ To understand the structural diversity of carbohydrates.

⮚ To learn the structural and functional characteristics of amino acids & proteins.

⮚ To describe the classes and forms of lipids.

⮚ To comprehend the basic characteristics of nucleic acids and vitamins.

**Course Outcomes:**

At the completion of the course, the student would be able to:

|  |  |  |
| --- | --- | --- |
| **CO**  **Level** | **Course outcome** | **K**  **Level** |
| CO1 | Define basic concepts, definitions and properties ofbiomolecules | K1 |
| CO2 | Classify,  compare  and  cite  structural  aspects  ofbiomolecules | K2 |
| CO3 | Apply  structural  aspects  of  biomolecules  withfunctional  relevance  to  proteins,  vitamins  and nucleic acid | K3 |
| CO4 | Compare, contrast and distinguish proteins, lipids,carbohydrates and nucleic acid | K4 |
| CO5 | Summarize sequencing methodologies of proteinsand validate | K5 |
| CO6 | Prepare buffers, estimation of protein ,carbohydrate,compare summarize DNA denaturation and renaturation. | K6 |

**Unit: 1**

Atoms and molecules; Types of Bonds; Water: properties; Acids, bases and buffers; Chemistry of Carbohydrates: Definition and Classification; Occurrence and structure of monosaccharides, disaccharides and polysaccharides; Linear and ring forms for glucose, fructose, sucrose and lactose; Properties of carbohydrates: isomerism, mutarotation, oxidation, reduction; Functions of carbohydrates.

**Unit: II**

Amino Acids - General structure of amino acids; Amino acids codes; Classification of amino acids based on the nature of the R group (polar, non-polar, acidic, basic, neutral); Modified amino acids in protein, non-protein amino acids; Levels of organization of protein structure – primary structure – composition, Secondary structure – α helix (egg albumin), β - pleated sheath (keratin), triple helix (collagen); Tertiary structure with reference to myoglobin; Quaternary structure with reference to hemoglobin; Biological functions of proteins.

**Unit:III**

Lipids: Chemical nature, classification and biological functions; Fatty acids: definition, classification – saturated, unsaturated, hydroxy and cyclic fatty acids; structure and properties of fatty acids; Simple and mixed triglycerides – structure and general properties; Characterization of fats – Iodine value, Saponification value, Acid number, Reichert-Meissl number.

**Unit:IV**

Structure of purine and pyrimidine bases, nucleosides and nucleotides and their biological importance; Types of DNA : A, B, Z DNA, structure and biological significance, superhelicity; Properties of DNA – hypochromic and hyperchromic effect, melting temperature- denaturation and renaturation, Cot curve, viscosity.

**Unit:V** Vitamins: Definition, classification; water soluble (vitamin B1, B2, B3, B6, B12 and C) and fat soluble vitamins (A, D, E and K): occurrence, biochemical roles and deficiency diseases.

**Textbooks:**

1.   Fundamentals of Biochemistry - J.L. Jain, Sunjay Jain, Nitin Jain, S. Chand &Company.

2.   Harper’s Biochemistry- Rober K. Murray, Daryl K. Grammer, McGraw Hill, Lange Medical

Books. 25th edition.

3.   Biochemistry – Voet and Voet, 4th Edition, Wiley Publication.

**Referencce Books:**

1.   Biochemistry- Dr. Amit Krishna De, S. Chand & Co. Ltd.

2.   Biochemistry – J. M. Berg, J. L. Tymochzo, L. Stryer (7th Edition) W. H. Freeman Publisher.

3.   Lehninger Principles of Biochemistry- David L. Nelson, Michael M. Cox, Macmillan Worth Publishers

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| --- | --- | --- | --- | --- | --- | --- |
| **CO/PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
| **CO1** | 9 | 1 | 1 | 9 | 1 | 3 |
| **CO2** | 9 | 1 | 3 | 9 | 9 | 3 |
| **CO3** | 9 | 1 | 3 | 9 | 1 | 3 |
| **CO4** | 9 | 3 | 9 | 9 | 1 | 9 |
| **CO5** | 9 | 3 | 9 | 9 | 3 | 9 |
| **CO6** | 9 | 9 | 9 | 9 | 9 | 3 |
| **Weightage** | **54** | **18** | **34** | **54** | **25** | **30** |

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| **SEMESTER – II** |  | **CODE - U22BT3** |
| **Core Course III: Molecular Biology** | | |
| **CREDITS - 5** |  | **HOURS - 5** |

**Objectives**

⮚ To understand the scientific evidences on the genetic material and its organization.

⮚ To describe the events and processes involved in the duplication and expression of the genetic material.

* To analyze the mechanisms of mutations and DNA repair.
* To understand the process involved in gene expression,

⮚ To correlate the development and causes of cancer to mutagenesis and gene expression.

**Course Outcomes (CO)**

On successful completion of the course, students will be able to

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| --- | --- | --- |
| **Cognitive level** | **COURSE OUTCOMES** | **K**  **Level** |
| CO1 | List out the properties, structure and function of genes in living organisms at the molecular level | K1 |
| CO2 | Summarize the basic concepts in genetic material and its replication | K2 |
| CO3 | Apply knowledge about the chromosomal aberrations and oncogenesis | K3 |
| CO4 | Analyze about causes and types of mutations, detection of mutations and DNA damage and repair | K4 |
| CO5 | Evaluate the molecular mechanisms involved in transcription and translation | K5 |
| CO6 | Discuss the various methods of gene regulatory mechanisms | K6 |

**UNIT I**

Experiments on Genetic Material: Griffith, Hershey and Chase Experiment, Avery and McCarty Experiment, Chargaff’s Rule, Watson and Crick Model; Prokaryotic and Eukaryotic Genome Organization; Chromosome: Structure and Function.

**UNIT II**

Central Dogma of Life: Replication (Prokaryotic and Eukaryotic); Transcription (Prokaryotic and Eukaryotic), Post Transcriptional Modifications (Polyadenylation,Cappingand Splicing); Translation: Genetic Code; Mechanism of Translation (Prokaryotic and Eukaryotic), Post Translational Modifications (Phosphorylation, Methylation, Glycosylation, Acetylation, Ubiquitination and Lipidation).

**UNIT III**

DNA Repair Mechanisms; Mutations: Mutagenesis, Types of Mutations,Mutational Hot Spots, Reversion; Transposable Elements (Insertion Sequence and Integrons).

**UNIT IV**

Gene Regulation Mechanisms: General aspects of Prokaryotic and Eukaryotic Gene Regulation; The Lactose System and Operon Model:*Gal* Operon,*trp* Operon; Concept of Feedback Inhibition; RNAi.

**UNIT V**

Chromosomal Aberrations (Number & Structure): Ploidy and Structural Aberrations; Position Effect; Chromosome Mapping.Oncogenesis: Development, Causes and Types of cancer; Oncogenes and Tumor Suppressor Genes.

**TEXT BOOKS**

1. Lodish H. (2016). Molecular Cell Biology, 8thedition, W. H Freeman and company, New York.
2. De Robertis, E.D.P and De Robertis E.M.F. (2001). Cell and Molecular Biology, 8th edition, Lippincott Williams and Wilkins, New York.
3. Friefelder D. (2009). Molecular Biology, 2nd Edition, Narosa Publishing House, New Delhi.

**REFERENCE BOOKS**

1. Lewin B. (2008). Genes IX, Jones and Bartlett, Burlington.
2. Rastogi, S.C. (2004). Cell Biology, 2nd Edition, New Age International Publishers, New Delhi.
3. Molecular biology of the gene (2004). Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. M.

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| --- | --- | --- | --- | --- | --- | --- |
| **CO/PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
| **CO1** | 9 | 9 | 9 | 9 | 3 | 9 |
| **CO2** | 9 | 3 | 9 | 3 | 9 | 9 |
| **CO3** | 9 | 9 | 3 | 9 | 3 | 9 |
| **CO4** | 3 | 9 | 1 | 3 | 9 | 9 |
| **CO5** | 9 | 3 | 9 | 1 | 3 | 3 |
| **CO6** | 9 | 3 | 9 | 9 | 9 | 9 |
| **Weightage** | 48 | 36 | 40 | 34 | 36 | 48 |

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| --- | --- | --- |
| **SEMESTER – I & II** |  | **CODE – U22BT2P** |
| **Core Course Lab II:**  **LAB IN CELL BIOLOGY, GENETICS & MOLECULAR BIOLOGY** | | |
| **CREDITS - 4** |  | **HOURS - 3** |

**Lab in Cell Biology, Genetics & Molecular Biology**

**(Group & Individual practical – under STAR College Scheme)**

**CELL BIOLOGY**

1. Equipment used in laboratory, general practice and maintenances
2. Identification of various stages of cell division (mitosis and meiosis).
3. Mitosis and Meiosis – onion root tip and grasshopper testis squash methods

**MOLECULAR BIOLOGY** (Individual Experiment under STAR College Scheme)

1. Isolation of genomic DNA from bacterial culture
2. Isolation of genomic DNA from plant tissue.
3. Quantification of DNA using UV spectrophotometer.
4. Agarose gel electrophoresis of genomic DNA.

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| --- | --- | --- | --- | --- | --- | --- |
| **Co/Po** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
| **CO1** | 9 | 3 | 1 | 3 | 3 | 9 |
| **CO2** | 3 | 3 | 3 | 9 | 3 | 9 |
| **CO3** | 9 | 9 | 3 | 3 | 9 | 9 |
| **CO4** | 9 | 3 | 9 | 3 | 3 | 9 |
| **CO5** | 9 | 3 | 3 | 9 | 9 | 9 |
| **CO6** | 3 | 3 | 9 | 3 | 9 | 9 |
| **Weightage** | 42 | 24 | 28 | 30 | 36 | 54 |

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| --- | --- | --- |
| **SEMESTER – II** |  | **CODE – U22ABT3** |
| **Allied Course III: Biochemistry - II: Intermediary Metabolism** | | |
| **CREDITS - 4** |  | **HOURS - 5** |

**Objectives:**

⮚To understand the thermodynamics of biological systems.

⮚To interpret the metabolic pathways of carbohydrates and their significance in energy production.

⮚To understand the anabolic and catabolic mechanisms relative to proteins.

⮚To describe the synthesis of lipids and oxidation of fatty acids.

⮚To learn the biosynthesis and degradation of nucleic acids.

**Course Outcomes:**

At the completion of the course, the student would be able to:

|  |  |  |
| --- | --- | --- |
| **CO Level** | **Course outcome** | **K Level** |
| CO1 | Define metabolic concepts and pathways | K1 |
| CO2 | List and describe various metabolic pathways | K2 |
| CO3 | Apply bioenergetics concepts of carbohydrates, Proteins, Lipid and nucleic acids | K3 |
| CO4 | Compare, contrast and distinguish proteins, lipids, carbohydrates and nucleic acid metabolism | K4 |
| CO5 | Summarize physiological and functional relevance of metabolic pathways. | K5 |
| CO6 | Integrate anabolic, catabolic pathways of carbohydrates, proteins, lipids and nucleic acids. | K6 |

**Unit:I**

Bioenergetics: Molecular basis for evolution; Principles of thermodynamics: free energy functions, ATP as the energy metabolite; Carbohydrates: Glycolysis, Citric acid cycle, Electron transport chain, Pentose phosphate pathway, Gluconeogenesis, glycogenesis, glycogenolysis, Cori cycle, anaplerotic reactions, Entner-Doudoroff pathway, glucuronate pathway; Hormonal regulation of carbohydrate metabolism.

**Unit:II**

Amino Acids: Amino acids as precursors for proteins; General reactions of amino acid, breakdown and synthesis; Transamination, decarboxylation, oxidative & non-oxidative deamination of amino acids; Urea cycle and its regulation.

**Unit:III**

Lipids: Introduction, Lipid biosynthesis; Hydrolysis of triacylglycerols; Fatty acid biosynthesis, Oxidation of fatty acids; Acetyl CoA carboxylase, fatty acid synthase; Metabolism of cholesterol and its regulation.

**Unit:IV**

Nucleotides: (*de novo*) Biosynthesis and degradation of purine and pyrimidine nucleotides and its regulation; salvage pathway; Biosynthesis of deoxyribonucleotides and polynucleotides including inhibitors of nucleic acid biosynthesis; Porphyrins: Biosynthesis and degradation; Production of bile pigments.

**Unit:V**

Vitamins & minerals as Coenzymes and Cofactors: Role and mechanism of action of NAD+/NADP+, FAD, lipoic acid, thiamine pyrophosphate, tetrahydrofolate, biotin, pyridoxal phosphate, B12 coenzymes and metal ions with specific examples.

## TEXTBOOKS

1. Harper's Illustrated Biochemistry (2018)- McGraw-Hill Education 31st Edition
2. Lehninger Principles of Biochemistry- David L. Nelson, Michael M. Cox, Macmillan Worth Publishers.
3. Fundamentals of Biochemistry - J.L. Jain, Sunjay Jain, Nitin Jain, S. Chand &Company.

## REFERENCE BOOKS

1. Biochemistry – Voet and Voet, 4th Edition, WileyPublication
2. Biochemistry- Dr. Amit Krishna De, S. Chand & Co.,Ltd.
3. Biochemistry – J. M. Berg, J. L. Tymochzo, L. Stryer (7th Edition) W. H. Freeman Publisher.

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| --- | --- | --- | --- | --- | --- | --- |
| **CO/PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
| **CO1** | 9 | 1 | 1 | 9 | 1 | 3 |
| **CO2** | 9 | 1 | 3 | 9 | 1 | 3 |
| **CO3** | 9 | 1 | 3 | 9 | 1 | 3 |
| **CO4** | 9 | 3 | 9 | 9 | 1 | 9 |
| **CO5** | 9 | 3 | 9 | 9 | 3 | 9 |
| **CO6** | 9 | 9 | 9 | 9 | 3 | 9 |
| **Weightage** | 54 | 18 | 34 | 54 | 10 | 36 |

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| **SEMESTER – I & II** |  | **CODE – U22ABT2P** |
| **Allied Course Lab II: LAB IN BIOCHEMISTRY** | | |
| **CREDITS - 3** |  | **HOURS - 3** |

**Lab in Biochemsitry**

**(Group & Individual practical – under STAR College Scheme)**

1. Basic calculations in Biochemistry - Normality, Molarity, Molality percent solutions (v/v, w/v).
2. Calibration of pH meter
3. Preparation of biological buffer - phosphate buffer
4. Extraction of Proteins from biological materials
5. Protein separation methods: -Ammonium sulphate Precipitation
6. SDS PAGE – Group Experiment
7. Estimation of Proteins by Lowry’s method
8. Estimation of Proteins by Biuret method
9. Purity check of DNA & RNA by UV Spectrophotometry - A260/280
10. Separation of amino acids by Paper Chromatography
11. Separation of sugars by Paper Chromatography
12. Separation of amino acids by Thin layer chromatography
13. Separation of sugars by Thin layer chromatography

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| **Co/Po** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
| **CO1** | 9 | 3 | 9 | 3 | 3 | 9 |
| **CO2** | 3 | 9 | 3 | 9 | 3 | 9 |
| **CO3** | 9 | 1 | 3 | 3 | 9 | 9 |
| **CO4** | 9 | 3 | 9 | 3 | 3 | 9 |
| **CO5** | 9 | 9 | 3 | 9 | 9 | 9 |
| **CO6** | 3 | 9 | 9 | 3 | 9 | 9 |
| **Weightage** | 42 | 34 | 34 | 30 | 36 | 54 |

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| **SEMESTER - II** |  | **CODE - U22SBE1** |
| **Skill Based Elective 1: Introduction to Bioentrepreneurship** | | |
| **CREDITS - 2** |  | **HOURS - 2** |

**Objectives:**

* To teach students about concepts of entrepreneurship
* To help student in identifying a winning business opportunity, gathering funding and
* To educate the student about launching a business, growing and nurturing the organization and harvesting the rewards.

**Course Outcomes:**

At the completion of the course, the student would be able to:

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| --- | --- | --- |
| **Cognitive level** | **Course outcome** | **Knowledge Level** |
| CO1 | Define, basic concepts, theories and definitions of Bio-entreprenurship andaccountingpractices | K1 |
| CO2 | Classify and contrast the different governmental, nongovernmental organizations and financial organization | K2 |
| CO3 | Apply, relate and discover the knowledge center, information technology and regulatory compliances in entrepreneurship | K3 |
| CO4 | Compare, connect, contrast and differentiate bioindustries, applications and the management | K4 |
| CO5 | Judge, value and validate marketing strategies | K5 |
| CO6 | Design, develop, or modify bioentrepreneurship role in future needs | K6 |

**C1 – Remember C2 – Understand C3 – Apply**

**UNIT I- Basics of Bioentrepreneurship**

Introduction to bioentrepreneurship – Biotechnology in a global scale, Scope in Bioentrepreneurship, Importance of entrepreneurship. Meaning of entrepreneur, function of an entrepreneur, types of entrepreneur, advantages of being entrepreneur.

**UNIT II- Innovation** – types, out of box thinking, opportunities for Bioentrepreneurship. Entreprenuership development programs of public and private agencies (MSME, DBT, BIRAC, Startup and Make in India). Patent landscape, IP protection and commercialization strategies.

**Management, Accounting and Finance**

Business plan preparation: business feasibility analysis by SWOT, Sources of financial assistance – making a business proposal, approaching loan from bank and other financial institutions, budget planning and cash flow management, basics in accounting practices - balance sheet, P&L account, and estimation of income, expenditure and Income tax.

**UNIT III- Knowledge Centre and Information Technology**

Knowledge centers - Universities, innovation centre, research institutions and business incubators. R&D - technology development and upgradation, assessment of technology development, managing technology transfer, industry visits to successful bio-enterprises, Understanding of regulatory compliances and procedures (CDSCO, NBA, GLP, GCP & GMP). Use of IT in improving business performance; E-business setup, Digital marketing management.

**UNIT IV -Marketing and Human Resource Development**

Assessment of market demand for potential product(s) of interest, Market conditions, segments, prediction of market changes, identifying needs of customers including gaps in the market. Branding issues, developing distribution channels – franchising policies, promotion, advertising, branding and market linkages. Marketing of agro products. Recruitment and selection process, leadership skills, managerial skills, organization structure, training, team building and teamwork.

**UNIT V - Bioindustries**

Definition, characteristics, need and rationale, objectives, scope and advantages of small scale  
industries. Types of bioindustries – Pharma, Agri and Industry. Biofertilizers production -  
Azospirillium, Azolla, Cyanobacteria and its applications. Biopecticides production - Bacterial,  
fungal, viral and plant insecticides. Sericulture. Apiculture. Dairy farming. Single Cell Protein Production and applications. Vermicomposting and its applications. Mushroom cultivation and its application. Ancillary and tiny industries

**TEXT BOOKS**

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.

**REFERENCE BOOKS**

1. Tripati, P.C and Reddy, P.N (2017). Principles of Management, 6th Edition, Tata Mc Graw Hill.
2. Vasant Desai (2011). Dynamics of Entrepreneurial Development & Management. Himalaya Publishing House Pvt Ltd, India.
3. Charantimath Poornima M. (2005). Entrepreneurship Development – Small Business Enterprises” Pearson Education, India.

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| **CO/PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
| **CO1** | 9 | 1 | 1 | 9 | 1 | 3 |
| **CO2** | 9 | 1 | 3 | 9 | 1 | 3 |
| **CO3** | 9 | 1 | 3 | 9 | 1 | 3 |
| **CO4** | 9 | 3 | 9 | 9 | 3 | 9 |
| **CO5** | 9 | 3 | 9 | 9 | 3 | 9 |
| **CO6** | 9 | 9 | 9 | 9 | 3 | 9 |
| **Weightage** | 54 | 18 | 34 | 54 | 12 | 39 |

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| **SEMESTER - III** |  | **CODE - U22BT4** |
| **Core Course IV : IMMUNOLOGY** | | |
| **CREDITS - 4** |  | **HOURS - 4** |

**Objectives**

* To learn the immune system and its functions.
* To understand the significance of antigen-antibody interactions in clinical diagnosis.
* To understand the concepts of cell mediated immunity.
* To acquire knowledge on immune responses in transplantation and cancers.
* To discuss defence mechanisms in microbial systems.

# Course Outcomes:

On successful completion of the course, students will be able to

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| **CO LEVEL** | **COURSE OUTCOMES** | **KNOWLEDGE LEVEL** |
| CO1 | Define various types and basic components of the immune system in eukaryotes and prokaryotes | KI |
| CO2 | Explain the inter-relationship between the immune systems, various pathogens and disease conditions | K2 |
| CO3 | Utilize the concepts of immune reaction in diagnosis, monoclonal antibodies and vaccine production | K3 |
| CO4 | Examine the immune responses under specific disease conditions and immune rejection | K4 |
| CO5 | Validate the disease prevention measures such as suitable vaccines and transplantation criteria | K5 |
| CO6 | Modify the protocols for effective diagnostics and improvise the therapeutic strategies | K6 |

**UNIT I**

Basics of Immune System: Overview of immune system – Immunity – Classification- Innate, Acquired. Haematopoiesis – Cells, tissues and organs of the immune system – their structure and functions – Interrelationship between innate and adaptive immunity. Antigens Definition and types – Antigenicity – immunogen and immunogenicity – properties - epitope – hapten – adjuvants – Immune response and its types – Antibodies - structure – types – function

**UNIT II**

Antigen-Antibody- Invitro testing agglutination, precipitation, ABO Blood grouping and Rh typing - ELISA – RIA – IF – Flowcytometry – HA & HI – CFT – *in vivo* testing – Skin tests - immune complex tissue demonstrations. Clonal selection theory – Monoclonal Antibodies and its applications - Hybridoma Technology for MAb production- Complement – structure -properties – functions of complement components and pathways.

**UNIT III**

Cell Mediated Immunity: T-cells and types - Antigen processing and presentation – Major histocompatability complex – Class 1 & 2. Cytokines: Interleukins and interferons. Hypersensitivity – Definition - Gell and Coombs classification – Antibody mediated: Anaphylaxis, Cytotoxic, Immune complex mediated - Delayed type hypersensitivity - Autoimmune diseases - Immune tolerance.

**UNIT IV**

Transplantation immunology – Blood Transfusion reactions – Tissue and Organ transplantation - Graft rejection – Graft vs Host reaction – Tumor immunology – tumor associated antigens. Immune response to tumor - Vaccines –Immunization types – Vaccine types – live attenuated vaccines, killed vaccines, purified polysaccharide vaccines – toxoid vaccines – recombinant vaccines and DNA vaccines.

**UNIT V**

Diversity of defence systems in prokaryotes: Responses against viral DNA - restriction enzymes, CRISPR; CRISPR associated proteins (Cas); CRISPR loci in archaea; Innate immune responses of fungi – Fungal Nucleotide Oligomerization Domain (NOD)-like receptors (NLRs); Role of fungal NLRs controlling VI in bacterial–fungal interactions.

**TEXT BOOKS**

1. Punt J, Sharon Stranford, Patricia Jones and Judith A Owen. J. Kuby Immunology (2018) 8th ed. WH Freeman.
2. Roitt, I.M., M.David Roth, Jonathan Brostoff and David Male (Editors). Immunology (2012) 8th Edn, Elsevier Saunders, London, UK.
3. Weir M. D. and J. Stewart, Immunology (1997), 8th Ed., Churchill Livingston, USA.

**REFERENCE BOOKS**

1. Richard Coico and Geoffrey Sunshine. Immunology: A Short Course, (2015) 7th Edn,Wiley Blackwell, NY,
2. Gabrial Virella (Editor) Medical Immunology (2001) 5th Edition, Marcel Dekkar, NY.
3. Weir M. D. and J. Stewart, Immunology (1997), 8th Ed., Churchill Livingston, USA.
4. Roitt, I.M., Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Roitt's Essential Immunology (2017) 13th Edition, Wiley-Blackwell Publishers, UK
5. Hyde R. M., Microbiology and Immunology (2012), 3rd Edition. Springer Science & Business Media.

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| **CO/PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
| **CO1** | **9** | **3** | **3** | **3** | **1** | **3** |
| **CO2** | **9** | **3** | **9** | **3** | **9** | **9** |
| **CO3** | **9** | **3** | **3** | **3** | **1** | **3** |
| **CO4** | **9** | **9** | **3** | **3** | **9** | **3** |
| **CO5** | **9** | **3** | **9** | **3** | **9** | **3** |
| **CO6** | **9** | **3** | **3** | **9** | **3** | **9** |
| **Weightage** | **54** | **24** | **40** | **24** | **32** | **40** |

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| **SEMESTER - III** |  | **CODE - U22SBE2** |
| **Skill Based Elective II: Bio Entrepreneurship-I** | | |
| **CREDITS -  2** |  | **HOURS - 2** |

**Objectives:**

* To understand the concepts of macropropagation, vermicomposting, mushroom cultivation, apiculture and cuniculture
* To interpret the market analysis data for planning for entrepreneurship projects.
* To understand the workings of management, institutions and governing bodies with regards to running a business.

**Course Outcomes:**

At the completion of the course, the student would be able to:

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| **Cognitive level** | **Course outcome** | **Knowledge Level** |
| CO1 | Define, concept, production and management bioindustries | K1 |
| CO2 | Describe the structural and production aspects of the mushroom cultivation, vermicompost, Apiculture and cuniculture | K2 |
| CO3 | Apply the concepts of bioindustries to start and run a production facility | K3 |
| CO4 | Compare, connect, contrast and different bioindustries, applications and the management | K4 |
| CO5 | Judge, value and validate marketing strategies | K5 |
| CO6 | Design, develop, or modify bioentrepreneurship role in future needs | K6 |

**C1 – Remember C2 – Understand C3 – Apply**

**Unit I- Mushroom cultivation**

Introduction to mushroom culture; Historical background; Present status of mushroom culture in India. Cultivation methods – infrastructure substrates; Preparation of spawns; Formulation and preparation of composts; Spawn running and cropping; Control of pathogens and pests. Cultivation of *Volvariella* sp. *Pleurotus* sp. and *Agaricus bisporus*. Nutritional values, Recipes from Mushroom.

**Unit II- Macropropagation**

Introduction to Macropropagation and their different types - *In-situ*, detach and split advantages and disadvantages. Selection of mother plants-different substrate for propagation- developmental stages of plants - primary, secondary and tertiary. Application of Macropropagation.

**Unit III- Vermiculture**

Introduction-Compost development, Quantification and characterization of solid waste, factors responsible for composting. Earthworm- rearing, role of earthworms in vermicompost, vermispecies, earthworms and microorganisms- vermicompost- methods and steps, nutrition enrichment- applications of vermiculture.

**Unit IV- Apiculture**

Introduction to Bees and Beekeeping-Overview of Beekeeping; History- Species of honey bees- life history- bee colony, castes, developmental significance of social life- natural colonies and their yield. Bee Flora and Pollination. Bee Health Management-Bee Enemies and their Management, Bee-Diseases and their Management, Protection from Poisoning. Seasonal and Specific Management. Products Collected and Modified by Bees (Honey, Propolis and Pollen). Products Synthesized by Bees (Bee's Wax-Royal Jelly-Bee Venom). Marketing, Economics and Development Programmes.

**Unit V -Cuniculture**

Introduction to rabbit and breeds- Advantages and disadvantages; handling methods; types of feeds; rearing methods; disease managements; commercial applications.

**TEXT BOOKS**

1. Bahl Neeta. 1984. Handbook on mushrooms. Oxford and IBH Publishing Co., New Delhi. 123 p
2. Emmanuel Njukwe, Abdou Tenkouano, Delphine Amah, Kassim Sadik, Perez Muchunguzi, Moses Nyine and Thomas Dubois Macro-Propagation Propagation Propagation Of Banana And Plantain (2016).International Institute of Tropical Agriculture, Cameroon or Uganda.
3. Glenn Munroe (2006),Manual of On-Farm Vermicomposting and Vermiculture. Organic Agriculture Centre of Canada.
4. Gupta, J.K., Sharma, H K and Thakur, R K. 2009. Practical Manual on Beekeeping.Department of Entomology and Apiculture, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, p 83.
5. Lebas,F. (1997). The rabbit - Husbandry, health and production, FAO Animal Production and Health Series No. 21.

**REFERENCE BOOKS**

1. Chang, S.T. and Miles, P.G. 2004. Mushroom cultivation: nutritional value, medicinal effect and environmental impact. CRC Press, Boca Raton. 451p
2. Njukwe, Emmanuel & Ouma, Emily & Van Asten, Piet J.A. & Muchunguzi, Perez & Amah, Delphine. (2013). Challenges and Opportunities for Macropropagation Technology for *Musa* spp. among Smallholder Farmers and Small and Medium-scale Enterprises. 10.1079/9781780642314.0066**.**
3. Handbook of Vermicomposting Technology (1999).Sreenivasan,E.The Western India Plywoods Ltd
4. Mishra R.C. (1995) Honey bees and their management in India. ICAR Publication, New Delhi.

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| **CO/PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
| **CO1** | 9 | 1 | 1 | 9 | 1 | 3 |
| **CO2** | 9 | 1 | 3 | 9 | 1 | 3 |
| **CO3** | 9 | 1 | 3 | 9 | 1 | 3 |
| **CO4** | 9 | 3 | 9 | 9 | 3 | 9 |
| **CO5** | 9 | 3 | 9 | 9 | 3 | 9 |
| **CO6** | 9 | 9 | 9 | 9 | 3 | 9 |
| **Weightage** | 54 | 18 | 34 | 54 | 12 | 36 |

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| **SEMESTER - III** |  | **CODE - U22SBE3** |
| **Skill Based Elective – Bio Entrepreneurship-II** | | |
| **CREDITS - 2** |  | **HOURS – 2** |

**Objectives:**

* To understand the concepts of biofuels, wine productions, molecular diagnostics and food testing & analysis.
* To learn how to find and equip themselves for a technical position in a corporation dealing with the above businesses.
* To understand the workings of management, institutions and governing bodies with regards to running a business.

**Course Outcomes:**

At the completion of the course, the student would be able to:

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| --- | --- | --- |
| **Cognitive level** | **COURSE OUTCOMES** | **Knowledge level** |
| CO1 | Understand the concepts of biofuel production | K1 |
| CO2 | Learn about the types of molecular diagnostics and food testing analyses that can be applied in real world | K2 |
| CO3 | Utilize the concepts of fermentation in the production of wine | K3 |
| CO4 | Understand and apply the mechanisms of plant-microbe interactions for development of inoculums to be used as biofertilizers | K4 |

**C1 – Remember C2 – Understand C3 – Apply**

**Unit I- Biofuel production**

Biomass as energy source, opportunities and challenges, form of Biomass-Solid, liquid, gas, Different generation of biomass- first, second and third, Introduction to biofuel: oleaginous microbes-Microalgae, yeast and bacteria, Low-cost feedstock and microbes used for advance biofuel production-Bioethanol and biobutanol. Transesterification and fatty acid analysis, Biodiesel quality standard and economics. Biofuel and biorefinery.

**Unit II - Molecular Diagnostics**

Genetic abnormalities and inherited diseases; Cytogenetic techniques in the detection of Inherited disorders-karyotyping, FISH.

An introduction to single nucleotide polymorphisms, haplotypes and linkage analysis. Utilization of PCR in molecular diagnosis, designing of primers, diagnostic methods for Inherited diseases including Congenital Adrenal hyperplasia, Type I Diabetes, Maturity onset diabetes of the young (MODY); sequencing of PCR products, whole Exon sequencing for the diagnosis of Inherited diseases.

**Unit III- Food testing and Analysis**

Basic testing: physiochemical parameters, nutritional analysis, Microbial analysis, Heavy metals, stability testing. Introduction about FSSAI license, ISO 22000/ISO22002 for unit, AYUSH certificates.

**Unit IV - Wine production**

Viticulture: Introduction to viticulture, definition and terminologies. Classification of wine: Generic classification, varietal classification. Raw materials and equipment use in wine production: crusher, press fermenter, filtration and additives used in wines. White wine-production and recommended varieties.  Red wine-production and recommended varieties.  Fortified wine-production and recommended varieties.  Production of wine from fruits other than grapes.

**Unit V- Biofertilizers:**

Microbial biofertilizers, types. Customization strategies for field/soil condition, Targeted isolation and selection, Mass production methods, Preparation and storage, Delivery strategies to crops. Traditional biofertilizers, preparation methods and advantages. Vemicompost - production, storage and logistics.

**TEXT BOOKS**

1. Ozcan Konur. 2017. Bioenergy and Biofuels. CRC Press, Taylor & Francis Group. ISBN 9781351228138.
2. Lela Buckingham and Maribeth L Flaws. (2007). A review of molecular diagnostics: Fundamentals, methods and Clinical Applications. F. A. Davis Company, Philadelphia.
3. Molecular Diagnostics, 3rd Edition; George Patrinos Wilhelm Ansorge Phillip B. Danielson, (2017) Academic Press.
4. Manual of Methods of Analysis of Foods (2016). Food Safety and Standards Authority of India Ministry of Health and Family Welfare Government of India, New Delhi.
5. [Grainger, K. and](https://onlinelibrary.wiley.com/action/doSearch?ContribAuthorRaw=Grainger%2C+Keith) [Tattersall](https://onlinelibrary.wiley.com/action/doSearch?ContribAuthorRaw=Tattersall%2C+Hazel),[H](https://onlinelibrary.wiley.com/action/doSearch?ContribAuthorRaw=Tattersall%2C+Hazel).(2016) Wine Production and Quality, Print ISBN:9781118934555 |Online ISBN:9781118934562 |DOI:10.1002/9781118934562.
6. Mahendra K. Rai (2005). Hand book of Microbial biofertilizers, The Haworth Press, Inc. New York.

**REFERENCE BOOKS**

1. Luque,R. and Campelo,J.M. and Clark, J.H. (2011). Hand Book of Biofuel production,Woodhead Publishing Limited,
2. Diagnostic Molecular Pathology: A Guide to Applied Molecular Testing, 1st Edition. William Coleman Gregory Tsongalis (2016) Academic Press.
3. Nielsen,S.S.(2017). Food Analysis, Food Science Texts Series, ISBN : 978-3-319-44125-2.
4. Kannaiyan, S. (2003). Biotechnology of Biofertilizers, CHIPS, Texas.

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| **CO/PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
| **CO1** | 3 | 1 | 1 | 9 | 1 | 3 |
| **CO2** | 3 | 1 | 3 | 9 | 1 | 3 |
| **CO3** | 3 | 9 | 3 | 9 | 9 | 9 |
| **CO4** | 9 | 3 | 9 | 9 | 9 | 9 |
| **CO5** | 9 | 3 | 9 | 9 | 3 | 9 |
| **CO6** | 9 | 9 | 9 | 9 | 3 | 9 |
| **Weightage** | 36 | 27 | 34 | 54 | 26 | 42 |

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| **SEMESTER - IV** |  | **CODE – U22BT6** |
| **Core Course VI: rDNA TECHNOLOGY** | | |
| **CREDITS - 4** |  | **HOURS - 4** |

**Objectives:**

* To understand the types and significance of restriction enzymes.
* To learn about the different types of vectors and their specific applications.
* To understand gene transfer techniques and selection of recombinants.
* To understand PCR based gene amplification and its applications.
* To learn the applications of rDNA technology.

**Course Outcomes:**

At the completion of the course, the student would be able to:

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| --- | --- | --- |
| **CO LEVEL** | **COURSE OUTCOMES** | **KNOWLEDGE LEVEL** |
| CO1 | Define the concepts and components of genetic engineering and gene transfer | KI |
| CO2 | Outline the mechanisms of restriction enzymes and other molecular techniques involved | K2 |
| CO3 | Examine gene transfer and gene amplifications methods in eukaryote and prokaryotes | K3 |
| CO4 | Analyze the suitable genetic vectors for the gene transfer process | K4 |
| CO5 | Scrutinize the selection and screening of the recombinant products | K5 |
| CO6 | Design the strategies to improve the quality of recombinant products and enhance the production volume | K6 |

**UNIT I**

Overview of genetic engineering and recombinant DNA technology; Concept of restriction and modification - DNA modifying enzymes, Restriction endonucleases, Ligases, Inter-and intra-molecular associations, Linkers and Adaptors.

**UNIT II**

Vectors:Different Kinds of Vectors - Plasmids, Cosmids, Phagemids, Viral vectors, Shuttle vectors, expression vectors, YAC and BAC.

**UNIT III**

Gene Transfer Techniques: Transformation, Electroporation, Microinjection and *Agrobacterium* mediated gene transfer; Recombinant Selection and Screening: Marker/Reporter genes, Antibiotic Resistance, Blue-White selection, GFP – GUS; Blotting and Hybridization.

**UNIT IV**

Gene amplification techniques and applications: PCR- Principle, Types, PCR based cloning: cDNA synthesis, cloning and genomic library, Site directed mutagenesis, Applications: RAPD, RFLP, SNPs and DNA fingerprinting; Sequencing: Conventional and NGS.

**UNIT V**

Applications of rDNA technology: Strategies for the production of recombinant proteins: insulin, human growth hormone; Transgenic plants with reference to virus and pest resistances, herbicide tolerance and stress tolerance (cold, heat and salt); Bio-pharmaceuticals and secondary metabolite production.

**TEXT BOOKS**

1. Brown T. A. (2001). Gene Cloning, Blackwell Science Publishers.
2. Primrose S. B. (2001). Molecular Biotechnology, Panima Publishing House, New Delhi.

**REFERENCE BOOKS**

1. Bernard R, Glick and Jack J. Pasternak. (2002). Molecular Biotechnology, Panima Publishing House, New Delhi.
2. Ernst L and Winnacker. (2003). Genes to Clones, Panima Publishing House, New

Delhi.

1. Watson J.D, Gilman M, Witkowski and Zoller M. (1992). Recombinant DNA, Scientific

American books.

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| **CO/PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
| **CO1** | 9 | 3 | 9 | 9 | 9 | 3 |
| **CO2** | 9 | 3 | 9 | 1 | 9 | 3 |
| **CO3** | 9 | 3 | 3 | 9 | 9 | 3 |
| **CO4** | 9 | 3 | 9 | 9 | 3 | 3 |
| **CO5** | 9 | 3 | 3 | 3 | 9 | 9 |
| **CO6** | 9 | 3 | 9 | 9 | 9 | 9 |
| **Weightage** | **54** | **18** | **38** | **36** | **58** | **40** |

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| **SEMESTER - IV** |  | **CODE - U22ABT6** |
| **Allied Course IV : APPLIED MICROBIOLOGY** | | |
| **CREDITS -  4** |  | **HOURS - 4** |

* To understand the basic role of Microorganisms in the food industry and methods to preserve food.
* To analyze the role of microorganisms in the soil environment
* To understand the role of microorganisms in aquatic ecosystem and discuss their interaction in the environment
* To explain the role of microorganisms in bioremediation
* To discuss the beneficial Microbial Interactions with Human and their harmful effects.

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| **Cognitive level** | **Course outcome** | **Knowledge Level** |
| CO1 | List the basic role of Microorganisms in the various microbiological industries | K1 |
| CO2 | Explain the microbial balance and interactions in soil, water | K2 |
| CO3 | Apply knowledge in food, industrial and environmental bioremediation | K3 |
| CO4 | Analyze the role of microorganisms in human microbial flora and its virulence | K4 |
| CO5 | Determine the harmful effects of microorganisms in the environment and industries | K5 |
| CO6 | Discuss the various methods of preservation of food and collection, transport of clinical samples | K6 |

**UNIT I**

Food as a substrate for microorganisms – Principles of Food Preservation- General principles and application methods – asepsis, removal of microorganisms, anaerobic conditions, high temperature, low temperature, drying and food additives; Factors  affecting the growth of microorganisms in food, feed and fodder- Extrinsic and Intrinsic factors, chemical preservatives and food additives; Heat processing- D, Z, and F values and working out treatment parameters for canned foods; Spoilage of food: milk and milk products, meat and meat products, fish, sea foods and canned foods.

**UNIT II**

Soil as a habitat for microorganisms; Microbial balance in soil. Factors affecting microbial community in soil-soil moisture, organic and inorganic chemicals; Microbial interactions- negative interactions- Ammensalism, competition, parasitism and predation (mycoparasitism, mycophagy, namatophagy – predaceous fungi), commensalism positive interactions – mutualism, synergism, associative symbiosis- cyanobacteria (Rhizobium legume symbiosis).

**UNIT III**

Water ecosystem and its type; Marine microorganisms and their importance; Eutrophication; Brief account of major water borne diseases and their control measures; Water treatment –waste types, solid and liquid wastes characterization; Primary secondary, tertiary solid waste treatment; Bioaccumulation, Bioremediation, Bioleaching of copper and uranium.

**UNIT IV**

Microbiology of xenobiotics - emerging pollutants, persistence and biomagnifications; Petroleum hydrocarbons - their microbial degradation; Bioremediation of soil and water; Corrosion of metals due to microbial growth and biofilms.

**UNIT V**

Beneficial Microbial Interactions with Human: Normal microbial population of healthy human body -Entry of pathogens into the host, types of bacterial pathogens; Mechanism of bacterial pathogenicity- colonization and growth, Virulence, Virulence factors – exotoxins, enterotoxins, endotoxins, neurotoxin; Host defense mechanisms; Factors for infection and innate resistance to infection; Collection, transport and culturing of clinical samples.

**TEXT BOOKS**

1. Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott’s Microbiology. 11th Edition. McGraw Hill International.
2. Pelczar Jr, M.J. Chan, E.C.S. and Kreig, N.R.  (2006). Microbiology, Mc. Graw Hill. Inc, New York.
3. Allen I. Lasakin, Geoffery M. Gadd. (2001) Advances in Applied Microbiology. Academic Press.

**REFERENCE BOOKS**

1. Greenwood, D., Slack, R.B. and Peutherer, J.F. (2002) Medical Microbiology, 16th Edn. Churchill Livingstone, London.
2. Adams MR & MO Moss (2005). Food Microbiology, New Age International (P) Limited. Publishers; 1st Edition, New Delhi.
3. Robert, L Tate (1995). Soil Microbiology. First edition, John Wiley and Sons, Inc. New York.

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| **Co/Po** | **PO1** | **PO2** | | **PO3** | **PO4** | | **PO5** | **PO6** |
| **CO1** | 9 | 3 | | 1 | 3 | | 3 | 9 |
| **CO2** | 3 | 3 | | 3 | 9 | | 3 | 9 |
| **CO3** | 9 | 1 | | 3 | 3 | | 9 | 9 |
| **CO4** | 9 | 3 | | 1 | 3 | | 3 | 9 |
| **CO5** | 9 | 3 | | 3 | 9 | | 9 | 9 |
| **CO6** | 3 | 3 | | 1 | 3 | | 9 | 9 |
| **Weightage** | 42 | 16 | | 12 | 30 | | 36 | 54 |
| **SEMESTER -IV** | | |  | | | **CODE – U22BT5P** | | |
| **Core Course Lab V**  **LAB IN IMMUNOLOGY AND rDNA TECHNOLOGY** | | | | | | | | |
| **CREDITS - 4** | | |  | | | **HOURS - 3** | | |

**Lab in rDNA Technology and Immunology**

**(Group & Individual practical)**

1. Blood Grouping
2. Total WBC and RBC
3. Estimation of Haemoglobin
4. Preparation of Serum components
5. Radial Immunodiffusion test
6. Double Immunodiffusion test
7. Restriction Digestion of plasmid DNA
8. Ligation of restricted fragments

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| **Co/Po** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
| **CO1** | 9 | 3 | 9 | 3 | 3 | 9 |
| **CO2** | 3 | 3 | 3 | 9 | 3 | 9 |
| **CO3** | 9 | 9 | 3 | 3 | 9 | 9 |
| **CO4** | 9 | 3 | 9 | 3 | 3 | 9 |
| **CO5** | 9 | 3 | 3 | 9 | 9 | 9 |
| **CO6** | 3 | 9 | 9 | 3 | 9 | 9 |
| **Weightage** | 42 | 30 | 36 | 30 | 36 | 54 |

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| **SEMESTER -IV** |  | **CODE – U22ABT5P** |
| **Allied Course Lab V: LAB IN MICROBIOLOGY** | | |
| **CREDITS - 3** |  | **HOURS - 3** |

**Lab in Microbiology**

**(Group & Individual practical)**

1. Microbiology laboratory: general practices and maintenances.
2. Microscopes – Basic Parts and Handling
3. Sterilization Principles and Techniques
4. Hanging Drop Experiment
5. Staining Techniques: Simple, Gram, Acid Fast, Spore
6. Media preparation: liquid, solid and agar slants, basal, enriched, enrichment, differential and selective
7. Inoculation techniques – pour plate – spread plate –dilution techniques
8. Pure culture and subculture techniques.

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| **Co/Po** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
| **CO1** | 9 | 3 | 3 | 9 | 9 | 9 |
| **CO2** | 3 | 9 | 3 | 3 | 3 | 9 |
| **CO3** | 9 | 3 | 9 | 9 | 9 | 9 |
| **CO4** | 9 | 3 | 3 | 9 | 9 | 9 |
| **CO5** | 9 | 9 | 9 | 9 | 9 | 9 |
| **CO6** | 3 | 3 | 9 | 3 | 9 | 9 |
| **Weightage** | 42 | 30 | 36 | 42 | 48 | 54 |

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| **SEMESTER - V** |  | **CODE – U22BT7** |
| **Core Course VII : BIOINSTRUMENTATION** | | |
| **CREDITS - 5** |  | **HOURS - 5** |

**Objectives:**

* To understand the rationale behind the selection of analytical methods for various biological applications.
* To understand the real-time applications of spectroscopic and microscopic techniques.
* To understand the working and applications of structural elucidation techniques.
* To learn the principle and working of chromatographic techniques.
* To understand the working and applications of electrophoretic techniques.

**Course Outcomes:**

## At the completion of the course, the student would be able to:

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| --- | --- | --- |
| **CO Level** | **Course outcome** | **K Level** |
| CO1 | Define basic concepts, theories and definitions of analytical methods | K1 |
| CO2 | Classify and contrast the techniques in structural elucidation of biomolecules | K2 |
| CO3 | Apply, relate and discover the techniques used in imaging and analytical methods | K3 |
| CO4 | Compare, contrast and differentiate techniques to separate and quantify biomolecules | K4 |
| CO5 | Summarize separation methodologies of proteins, nucleic acid and validate | K5 |
| CO6 | Design or modify methods for separation of proteins, carbohydrates and nucleic acids | K6 |

## **C1–Remember C2-Understand C3 –Apply**

**UNIT I**

Selection of analytical methods; Performance Indicators: Accuracy, Precision, Detection Limit, Sensitivity and Analytical Range; Types of errors: Random and Systematic; Calibration methods: Standard curve and Internal standard addition.

**UNIT II**

Spectroscopic Techniques:Principle, Instrumentation, Working and Applications of UV-Visible, IR and Fluorescence spectroscopy.

Microscopic Techniques: Principle, Instrumentation, Working and Applications of Scanning Electron Microscopy, Transmission Electron Microscopy, Confocal Microscopy and Flow Cytometry.

**UNIT III**

Structure Elucidation Techniques: NMR, MS–Ionization (MALDI, ESI), Analyzer (TOF and Quadrupole) and Detector.

Centrifugation: Principle, Types (Differential, Ultra and industrial centrifugation) and Applications.

**UNIT IV**

Chromatographic Techniques: Theories on chromatography - Rate and Plate theory, Van Deemter equation, Resolution of chromatography; Principle, Instrumentation, Working and Applications of Thin Layer, Adsorption, Gel Exclusion, Ion exchange, Affinity, Liquid (HPLC, FPLC) and Gas chromatography.

**UNIT V**

Electrophoretic Techniques: Principle, Instrumentation, Working and Applications of Gel (Agarose, PAGE and SDS-PAGE), Capillary and Pulse Field Electrophoresis; Isoelectric focusing: Theory, Instrumentation and Applications.

**TEXT BOOKS**

* 1. Wilson, K., and J. Walker. (2010). Principles and Techniques of Practical Biochemistry and Molecular Biology, 7th Edition, Cambridge University Press, U.K.
  2. Skoog, D. A., Holler, F. J., and S. R. Crough. (2007). Instrumental Analysis, 6th Edition, Brooks Cole Publishing Company, USA.

**REFERENCE BOOKS**

1. Chatwal, G.R., and Anand, S.K. (2019). Instrumental Methods of Chemical Analysis, 5th Edition, Himalaya Publishing House, India.
2. Sharma, B.K. (2014). Instrumental Methods of Chemical Analysis, 24th Edition, GOEL Publishing House, India.

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| **CO/PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
| **CO1** | 9 | 1 | 1 | 9 | 1 | 3 |
| **CO2** | 9 | 1 | 3 | 9 | 1 | 3 |
| **CO3** | 9 | 1 | 3 | 9 | 1 | 9 |
| **CO4** | 9 | 3 | 9 | 9 | 1 | 9 |
| **CO5** | 9 | 3 | 9 | 9 | 3 | 9 |
| **CO6** | 9 | 9 | 9 | 9 | 3 | 9 |
| **Weightage** | 54 | 18 | 34 | 54 | 10 | 42 |

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| **SEMESTER - V** |  | **CODE - U22BT8** |
| **Core Course VIII : BIOPROCESS AND ENZYME TECHNOLOGY** | | |
| **CREDITS -  5** |  | **HOURS - 5** |

**Objectives:**

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| --- | --- |
| ⮚ | To understand the basic principles of bioprocess technology. |
| ⮚ | To discuss the types of bioreactors and processes. |
| ⮚ | To understand downstream processing for product recovery and purification. |
| ⮚ | To learn protocols for industrial production of primary and secondary metabolites. |
| ⮚ | To understand enzymes and its industrial applications. |

**Course Outcomes**

At the completion of the course, the student would be able to:

|  |  |  |
| --- | --- | --- |
| **CO level** | **Course outcome** | **K level** |
| CO1 | Describe the history and concepts of bioprocess technology | K1 |
| CO2 | Classify the types of fermentation and enzymes | K2 |
| CO3 | Prepare & formulate the media and modify the strains | K3 |
| CO4 | Compare and contrast the modes of fermentation | K4 |
| CO5 | Evaluate Growth kinetics and Enzyme kinetics | K5 |
| CO6 | Design and develop Downstream processing, Production of enzymes, antibiotics etc. | K6 |

**Unit:I**

Introduction to bioprocess technology: Brief history and concepts; Screening and selection of industrially important microbes; Strain improvement; Media/substrates for industrial fermentation: typical media, media formulation and optimization; Preservation of industrially important microorganisms (long term and short term).

**Unit:II**

Fermentation and its types: Solid state and submerged fermentation; Concepts of basic modes of fermentation: Batch, Fed batch and Continuous; Growth kinetics; Bioreactor design and operations: basic function, design, components and body construction; Sterilization of Bioreactor: air and media sterilization; Bioprocess control and monitoring: online measurement - on / off control, Control systems -PID & Fuzzy logic; Types of fermentor: Stirred tank reactor (STR), Airlift reactor (ALR) and Photo-bioreactor.

**Unit:III**

Downstream Processing: Objectives and criteria; Intra and extracellular products; Primary separation- Cell disruption [Physical, chemical and enzymatic methods]; Foam separation, flocculation, precipitation, filtration and centrifugation; Secondary separation: Liquid - liquid extraction, two-phase aqueous extraction, solvent recovery; Membrane based separation (micro& ultra-filtration); Purification: Chromatography; Drying devices, crystallization and whole brothprocessing.

**Unit:IV**

Bioprocess and Industrial Production: Production of enzymes-amylases; Acetone – Butanol - Ethanol (ABE) fermentation; Antibiotic production - penicillin; Amino acid production- proline and glutamic acid; Vitamin production - vitamin B12; Organic acid production – acetic acid and citric acid.

**Unit:V**

Enzymes: Occurrence, cellular localization, Nomenclature and classification; Enzyme properties and kinetics; Immobilized Enzymes – Methods, Principle and application; Industrial applications of Enzymes – Amylase, Lipase; Clinical importance of Enzymes – LDH, Creatine kinase, Aspartate transaminase, Alanine transaminase, Alkaline and acid phosphatase.

**Textboos**

1.   Stainer R.Y, Ingrtham J.L, Wheels M.L and Painter P.R. (1987). General Microbiology, MacMillan.

2.   Stanbury P.F, Whitaker A and Hall S.J. (1997). Principles of ferme ntation technology, Oxford University Press.

3.   Pauline M. Doran, Bioprocess Engineering Principles, 2nd Ed., Academic Press, 2012.

**Referencce boos**

1.   Prescott L. M, Harley J. P and Klein D. A. (1999). Microbiology, 4th edition, Mc Graw Hill.

2.   Michael L. Shuler, FikretKargi, Bioprocess Engineering – Basic Concepts, 2nd Ed., PearsonEducation India, 2015.

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| **CO/PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
| **CO1** | 9 | 1 | 1 | 9 | 1 | 3 |
| **CO2** | 9 | 1 | 3 | 9 | 1 | 3 |
| **CO3** | 9 | 1 | 3 | 9 | 1 | 3 |
| **CO4** | 9 | 3 | 9 | 9 | 1 | 9 |
| **CO5** | 9 | 3 | 9 | 9 | 3 | 9 |
| **CO6** | 9 | 9 | 9 | 9 | 3 | 9 |
| **Weightage** | 54 | 18 | 34 | 54 | 10 | 36 |

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| **SEMESTER – V** |  | **CODE - U22BT10E** |
| **Elective Course I: ENVIRONMENTAL BIOTECHNOLOGY** | | |
| **CREDITS -  5** |  | **HOURS - 5** |

## Objectives:

* + Tounderstandthe fundamentalconceptsofecology.
  + Tolearn thedifferenttypes of pollution.
  + Tounderstandindustrialeffluenttreatment.
  + Tounderstand remotesensinganditsapplications.
  + Tounderstandenvironmentalpolicies.

## CourseOutcomes:

At the completion of the course,the student would be ableto:

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| --- | --- | --- |
| **Cognitive level** | **Course outcome** | **Knowledge Level** |
| CO1 | Define basic concepts and principles of ecology | K1 |
| CO2 | Explain different types of pollution and its causes | K2 |
| CO3 | Classify different types of aerobic and anaerobic processes in waste water treatment | K3 |
| CO4 | Distinguish various kinds of bioremediation processes | K4 |
| CO5 | Determine biosensors and remote sensing in environmental monitoring. | K5 |
| CO6 | Elaborate environmentalpolicies | K6 |

**C1–Remember C2-Understand C3 –Apply**

## **UNIT-I**

EcologicalConceptsandPrinciples;GeologicalconsiderationandHomeostasis;Biologicalcontrolof chemical environment; Energy transfer in an ecosystem: Food chain & food web; Energybudget; Production and decomposition in a system; Ecological efficiencies; Trophic structure andenergypyramids;Ecologicalenergetics;Principlespertainingtolimitingfactors;Biogeochemicalcycles (N, C, P cycles); Carbon trade & foot print; Ecosystem types: freshwater, marine, estuarine& terrestrial.

## **UNIT-II**

Environmental Pollution:Water pollution - oil spills; Soil Pollution- Waste land formation,deforestation, shifting cultivation, loss of soil fertility; Air pollution; Industrial pollution; Noisepollution; Radiation Pollution: Types and possible hazards of radioactive substances; Globalenvironmentalchanges:Greenhouse effect.

## **UNIT-III**

Wastewatertreatment;Aerobicprocess–activatedsludge,oxidation ponds,tricklingfilter,towers, rotating discs, rotating drums, oxidation ditch; Anaerobic process - Anaerobic digestion,anaerobic filters, up-flow anaerobic sludge blanket reactors; Biotechnological applications inindustrialeffluenttreatment:pharmaceutical, tannery,dairy,distillery,textile,pulpandpaper.

## **UNIT-IV**

Remote sensing and its applications in resource management and pollution monitoring - IRSsatellites & their sensors; Biosensors; Bioremediation; Pollution abatement; Biotechnologicalapplications for hydrocarbon and pesticide degradation; Bioleaching and recycling of metallicwaste;Nanobioremediationandphytoremediation.

## **UNIT-V**

Qualityofenvironmentforlifeonearth;Deteriorationofenvironmentalqualitywithreferencetoanthropogenicimpact;Methodsofassessmentofenvironmentalquality:Shorttermstudies/surveys;EnvironmentalImpactAssessment(EIA):Environmentalpolicies- TheEnvironmentalProtectionAct,1986.

## **TEXT BOOKS**

1. Evans,G.M.andFurlong,J.C.(2003),EnvironmentalBiotechnology:TheoryandApplications,Wiley Publishers.
2. Ritmann,B.andMcCarty,P.L.(2000),EnvironmentalBiotechnology:Principle&Applications,2ndEd.,McGrawHillScience.

## **REFERENCE BOOKS**

1. HarvinderSohal&AKSrivastava(1982)EnvironmentandBiotechnology,BlackWellpublishers.NewDelhi.
2. Jogdand,S.N.(1995)EnvironmentalBiotechnology,HimalayaPublishingHouse
3. EnvironmentalBiotechnologyandCleanairBioprocessbyE.J.Olguin,G.SanchezandE.Hernandez(2003) Taylor& Francis.

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| **Co/Po** | **PO1** | | **PO2** | **PO3** | **PO4** | **PO5** | | **PO6** |
| **CO1** | 9 | | 3 | 1 | 3 | 3 | | 9 |
| **CO2** | 3 | | 3 | 3 | 9 | 3 | | 9 |
| **CO3** | 9 | | 1 | 3 | 3 | 9 | | 9 |
| **CO4** | 9 | | 3 | 1 | 3 | 3 | | 9 |
| **CO5** | 9 | | 3 | 3 | 9 | 9 | | 9 |
| **CO6** | 3 | | 3 | 1 | 3 | 9 | | 9 |
| **Weightage** | 42 | | 16 | 12 | 30 | 36 | | 54 |
| **SEMESTER – V** | | |  | | | | | **CODE - U22BT11E** | | |
| **Elective Course III: IPR, BIOSAFETY AND BIOETHICS** | | | | | | | | | | |
| **CREDITS -  4** | | |  | | | | | **HOURS - 5** | | |

**Objectives:**

* To learn the significance and framework of Intellectual Property Rights.
* To learn the protocols of patenting.
* To understand and implement biosafety protocols.
* To understand biosafety levels and good laboratory practices.
* To understand ethical requisites in biological research.

**Course Outcomes:**

At the completion of the course, the student would be able to:

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| **Cognitive level** | **Course outcome** | **Knowledge Level** |
| CO1 | Understand the types of IP and its significance | K1 |
| CO2 | Learn patent filing and processes involved | K2 |
| CO3 | Understand and apply biosafety protocols when handling biological, chemical and equipment hazards | K3 |
| CO4 | Understand and implement the biosafety procedures that are required for BSL-1, 2, 3 and 4 | K4 |
| CO5 | To understand and differentiate between ethical concerns | K5 |

**C2 – Understand; C3 – Apply**

**UNIT I**

Intellectual Property Rights: Significance of IPR; Types of IP: patents, trademarks, copyright, industrial designs, trademark, trade secret and geographical Indications; Treaties on IPR, GATT, WTO, WIPO and TRIPS; Farmers rights.

**UNIT II**

Patents and Patenting System; Patent law: Principles – Need for patent law in biotechnology; Types of patents; Role of a Country Patent office; Patent applications: Forms and guidelines– Types of patent application; Patent specification: provisional and complete specification – Patent databases: India, USPTO, and EPO; Patent infringement: Case studies on Turmeric and Neem.

**UNIT III**

Biosafety: causes, classification, identification of hazards, issues in biosafety; Handling:types of accidents, first aid and precautionary measures; Clean room procedures: classification and specification; Basic methods for safe handling, transport, and storage of biological and chemical materials; Equipment related hazards.

**UNIT IV**

Levels of Biosafety: Biological safety cabinets-Horizontal and Vertical Laminar Air Flow Cabinet, fume hood; Primary and secondary containments – Biosafety levels of specific Microorganisms (food and water borne pathogens), infectious agents, chemicals and carcinogens; Material Safety Data Sheet; Guidelines: Biosafety Guidelines and regulations (National and International including Cartagena Protocol) of Government of India; GMOs and LMOs; Roles of Institutional Biosafety Committee.

**UNIT V**

Bioethics: Introduction to ethics and bioethics and its framework; Ethical, legal and socioeconomic aspects of gene therapy, germ line, somatic, embryonic and adult stem cell research; Ethical implications of GM crops, GMOs, human genome project and cloning, designer babies, biopiracy and biowarfare; Eugenics; Animal right activities and Ethical limits.

**TEXT BOOKS**

1. Erbisch, F.H, Maredia, K.M, Intellectual property rights in agricultural biotechnology, Universities Press (India) Ltd, 2000.
2. Deepa Goel and Shomini Parashar (2013). IPR, Biosafety and Bioethics, Pearson Education publisher,
3. Senthil Kumar Sadasivam and Mohammed Jaabir S. (2008). IPR, Biosafety and Biotechnology Management, Jasen Publications, India.

**REFERENCE BOOKS**

1. Singh. K.K, Intellectual Property Rights in Biotechnology, Springer India, 2015. ISBN 9788132220589.
2. Sasson A. Biotechnologies and Development, UNESCO Publications.
3. Rajmohan Joshi (Ed.). 2006. Biosafety and Bioethics. Isha Books, Delhi.

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| **Co/Po** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
| **CO1** | 9 | 3 | 1 | 3 | 3 | 9 |
| **CO2** | 3 | 3 | 3 | 9 | 3 | 9 |
| **CO3** | 9 | 1 | 3 | 3 | 9 | 9 |
| **CO4** | 9 | 3 | 1 | 3 | 3 | 9 |
| **CO5** | 9 | 3 | 3 | 9 | 9 | 9 |
| **CO6** | 3 | 3 | 1 | 3 | 9 | 9 |
| **Weightage** | 42 | 16 | 12 | 30 | 36 | 54 |

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| **SEMESTER -V** |  | **CODE – U22BT9P** |
| **Core Course Lab IX**  **LAB FOR COURSES IN SEMESTER V** | | |
| **CREDITS - 4** |  | **HOURS - 6** |

**LAB FOR COURSES IN SEMESTER V**

**(Group & Individual practical)**

1. Isolation of DNA
2. Agarose gel electrophoresis (Group)
3. Paper chromatography
4. Qualitative analysis of DNA
5. Parts and designs of bioreactors.
6. Production of biomass
7. Batch and continuous fed batch fermentation.
8. Recovery of products.
9. BLAST & MSA
10. Phylogenetic tree analysis
11. Databases handling & sequence retrieval
12. Protein structure prediction
13. Motif & Domain prediction
14. Comparative analysis of DNA & Proteins
15. Enzyme Assay – Qualitative
16. Effect of pH
17. Effect of Temperature
18. Effect of Substrate Concentration – Km value detection
19. Specific Activity of Enzymes

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| **Co/Po** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
| **CO1** | 9 | 9 | 9 | 3 | 9 | 9 |
| **CO2** | 3 | 3 | 3 | 9 | 3 | 9 |
| **CO3** | 9 | 9 | 3 | 3 | 9 | 9 |
| **CO4** | 9 | 3 | 9 | 3 | 3 | 9 |
| **CO5** | 9 | 9 | 9 | 9 | 9 | 9 |
| **CO6** | 3 | 3 | 9 | 3 | 9 | 9 |
| **Weightage** | 42 | 36 | 42 | 30 | 42 | 54 |

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| **SEMESTER - VI** |  | **CODE – U22BT13** |
| **Core Course X : PLANT BIOTECHNOLOGY** | | |
| **CREDITS -  6** |  | **HOURS - 6** |

**Objectives:**

⮚ To learn the basic concepts of plant tissue culture.

⮚ To study techniques for overcoming incompatibility barriers.

⮚ To acquire knowledge on different gene transfer methods.

⮚ To understand molecular markers for trait determination.

⮚ To understand plant-pathogen interactions for selection of traits.

**Course Outcomes:**

At the completion of the course, the student would be able to:

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| --- | --- | --- |
| **CO LEVEL** | **COURSE OUTCOMES** | **KNOWLEDGE LEVEL** |
| CO1 | Define the fundamentals of plant tissue culture techniques, gene transfer methods, molecular markers and plant-pathogen interactions | K1 |
| CO2 | Explain concepts of *In-Vitro* propagation methods and role of plant conservation, marker assisted selection of plant traits and breeder’s rights | K2 |
| CO3 | Apply the different plant tissue culture experiments to overcome the incompatibility barriers and conservation plants. | K3 |
| CO4 | Analyze the problem of contamination and difficulty in the plant tissue culture techniques | K4 |
| CO5 | Determine the suitable media for various plant tissue cell techniques and appropriate gene transfer methods. | K5 |
| CO6 | Maximize the applications of technology for plant conservation and its uses. | K6 |

**UNIT I**Plant breeding methods: conventional and non-conventional breeding methods; History of plant cell, tissue and organ culture; laboratory organization; Sterilization; Media preparation composition of media (Whites and MS); Callus culture; Organogenesis; Meristem culture; Micropropagation; Hardening and Green House Technology.

**UNIT II**

Overcoming incompatibility barriers: anther culture, embryo culture; Somatic embryogenesis & embryoids; Synthetic Seeds; Protoplast isolation and fusion; Cybrid Production; Cell suspension culture – Production of Secondary Metabolites; Cryopreservation and germplasm – applications and limitations.

**UNIT III**

Genetic Engineering in Plants: Molecular biology of Agrobacterium mediated DNA transfer; Ti plasmids - binary and co-integrated vectors; Gene transfer techniques in plants: Physical- electroporation, gene gun methods, vacuum and agroinfiltration; Chemical - PEG-mediated; Biological - *Agrobacterium tumefaciens* and *Agrobacterium rhizogenes*.

**UNIT IV**

Selectable markers, reporter genes and promoters; Mapping of genes/QTLs; Molecular Markers: PCR based markers (RFLP, RAPD, ISSR and SSR’s); marker-assisted selection; Plant DNA fingerprinting; Release of new varieties and plant breeder’s rights: UPOV and PPVFR.

**UNIT V**

Molecular biology of plant-pathogen interactions and application of gene transfer in the crop improvement - pest resistance (Bt cotton); herbicide resistance (Olyphosate tolerance) and delayed fruit ripening (FlavaSavr); molecular farming (edible vaccines); Strategies for gene selection for biotic and abiotic stress tolerance in the plant; Management of genetically engineered plants; Transgene escape and concern about GM crops.

**TEXT BOOKS**

1. Bhojwani S.S. and Razdan M.K. (2004). Plant Tissue culture: theory and practice, Elsevier science.

2. Slater, A., Scott, N. W., & Fowler, M. R. (2008). Plant Biotechnology: An Introduction to

Genetic Engineering. Oxford: Oxford University Press.

3. Lycett G.W. and Grierson D. (1990). Genetic Engineering of crop plants.

**REFERENCE BOOKS**

1. Bernard R. Glick and Jack J. Pasternak. (2001). Molecular Biotechnology- Principles and applications of recombinant DNA technology. ASM Press, Washington DC.

2. Dixon R.A and Gonzales R.A. (2004).Plant cell culture, IRL press.

3. Hammond J, McGarvey P and Yusibov V. (Eds). (1999). Plant Biotechnology – New

products and Applications, Springer Publication.

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| **CO/PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
| **CO1** | **9** | **3** | **3** | **3** | **9** | **3** |
| **CO2** | **9** | **9** | **9** | **9** | **3** | **3** |
| **CO3** | **9** | **3** | **9** | **9** | **9** | **9** |
| **CO4** | **9** | **3** | **1** | **3** | **9** | **3** |
| **CO5** | **9** | **3** | **9** | **9** | **1** | **9** |
| **CO6** | **9** | **3** | **3** | **9** | **9** | **9** |
| **Weightage** | **54** | **24** | **34** | **38** | **36** | **36** |

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| **SEMESTER - VI** |  | **CODE – U22BT13** |
| **Core Course XI : ANIMAL BIOTECHNOLOGY** | | |
| **CREDITS -  6** |  | **HOURS – 6** |

**Objectives:**

* To learn the molecular biology of fertilization and basics in ART.
* To explain and apply cell culture techniques.
* To learn the methods of introducing DNA into cell lines.
* To understand gene therapy and human genome mapping.
* To understand the principles and applications of transgenics.

**Course Outcomes:**

At the completion of the course, the student would be able to:

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| --- | --- | --- |
| **CO LEVEL** | **COURSE OUTCOMES** | **KNOWLEDGE LEVEL** |
| CO1 | Define the fundamentals of gametogenesis, concepts and components of animal cell culture and gene transfer methods | KI |
| CO2 | Specify the molecular events of fertilization, the biology of cultures cell and mechanisms of transgenesis | K2 |
| CO3 | Experiment with the primary cell culture establishment, scale-up, collection and preservation of embryos | K3 |
| CO4 | Analyze the problem of contamination in animal cell culture and the basis of apoptosis | K4 |
| CO5 | Determine the cell viability, cytotoxicity, IC50 and confirmation of DNA transfer in animal cells | K5 |
| CO6 | Maximize the applications of technology for human welfare in terms of diagnosis and treatment | K6 |

**Unit I**

Embryology; Gametogenesis and fertilization in animals; Molecular events during fertilization;Genetic regulations in embryonic development;*In vitro* fertilization and embryo transfer; Collection and preservation of embryo;Culture of embryos, embryonic stem cells and its applications.

**Unit II**

Animal cell culture: Fundamentals, Facilities and Applications; Media for Animal cells; Types of cell culture: Primary cell culture, secondary culture, cell transformation, cell lines, insect cell lines, stem cell cultures;Cell viability and cytotoxicity; Biology of cultured cells;Measurement of growth, cell synchronization, senescence and apoptosis; Organ culture; Cryopreservation; Scale-up.

**Unit III**

Genetic engineering in animals: methods of DNA transfer into animal cells - calcium phosphate co precipitation, micro-injection, electroporation, liposome encapsulation; Biological vectors; Hybridoma technology; Vaccine production.

**Unit IV**

Gene therapy;Mapping of human genome; RFLP and its applications; DNA fingerprinting in Forensic Science; Molecular diagnosis of Genetic disorders.

**Unit V**

Transgenics: Transgenic animals; Production and recovery of products from animal tissue cultures: cytokines, plasminogen activators, blood clotting factors, growth hormones; Transgenic animals – Merits and demerits;Ethical issues in animal biotechnology.

**TEXT BOOKS**

1. Freshney, E. D. 2000. Animal Cell Culture: A practical approach. John Wiley Pub.,New York.
2. Mather, J.P. and Barnes, D. (Eds.). 1998. Animal Cell Culture Methods (Methods in Cell Biology. VOL. 57). Academic Press, London.
3. Singer, M. and P. Berg. (Ed.). 1997. Exploring Genetic Mechanisms. University Science Books,

Sausilato, CA, USA.

**REFERENCE BOOKS**

1. Butler, M. (Ed.). 1990. Mammalian Cell Biotechnology- A Practical Approach. Oxford Univ. Press, Oxford.
2. E.J. Murray (Ed) .1991. Gene Transfer and Expression Protocols – Methods in Molecular Biology Vol.7. Humana Press,Totowa,
3. NJ. Watson, J.D., N.H.Hopkins, T.W.Roberts, J.A.Steitz and A.M. Weiner.1987. Molecular Biology of Gene. Benjamin Cummins, San Franscisco.

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| **CO/PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
| **CO1** | 9 | 3 | 3 | 3 | 9 | 3 |
| **CO2** | 9 | 9 | 9 | 9 | 3 | 3 |
| **CO3** | 9 | 3 | 9 | 9 | 9 | 9 |
| **CO4** | 9 | 3 | 1 | 3 | 9 | 3 |
| **CO5** | 9 | 3 | 9 | 9 | 1 | 9 |
| **CO6** | 9 | 3 | 3 | 9 | 9 | 9 |
| **Weightage** | **54** | **24** | **34** | **38** | **36** | **36** |

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| **SEMESTER - VI** |  | **CODE – U22BT14** |
| **Core Course XII: BIOINFORMATICS** | | |
| **CREDITS - 6** |  | **HOURS - 6** |

**Objectives:**

* To understand the scope of bioinformatics and its applications.
* To understand the tools for the evaluation of biological data and databases.
* To learn nucleotide and protein sequence analysis.
* To understand and apply phylogeny and phylogenetic analysis.
* To understand the resources available for metabolic pathway analysis.

**Course Outcomes:**

At the completion of the course, the student would be able to:

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| **Cognitive level** | **Course outcome** | **Knowledge Level** |
| CO1 | Understand and apply the basic concepts of bioinformatics | K1 |
| CO2 | Apply the tools available for biological sequence analysis | K2 |
| CO3 | Understand and perform biological sequence alignments | K3 |
| CO4 | Understand phylogeny and carry out phylogenetic analyses | K4 |
| CO5 | Understand and correlate genomic, metabolic pathway databases. | K5 |

**C2 – Understand C3 – Apply**

**Unit I**

History and scope of Bioinformatics; Emerging branches of Bioinformatics: genomics, proteomics, systems biology, and chemoinformatics; Accessing Bioinformatics resources/databases: NCBI, PubMed, EBI, EMBL and ExPASy; Applications and limitations of Bioinformatics.

**Unit II**

Genbank, FASTA and Swiss-Prot file formats; Sequence Databases: Nucleotide Sequence Databases - GenBank, EMBL, DDBJ, Protein Sequence Databases - SWISS-PROT, TrEMBL, UniProt PIR; ExPASy tools: ProtParam; Genome Databases: GOLD, TIGR; Derived Databases: Prosite, PRODOM, Pfam, PRINTS, CATH, SCOP, DALI; Structure databases: PDB, MMDB, MDL MOL; Protein Structure Visualization Tools: RasMol, Swiss PDB Viewer.

**Unit III**

Biological sequence analysis: models for sequence analysis and their biological motivation; Basic concepts of sequence similarity, identity and homology; Definitions of homologues: orthologues and paralogues; Sequence Alignment: Pairwise Sequence Alignments - Local and Global alignment, LALIGN, Dot matrix, scoring matrices - PAM and BLOSUM, substitution matrices, alignment scores and gap penalties; Database search tools & their versions: BLAST and FASTA.

**Unit IV**

Basic concepts and approaches for MSA: progressive, hierarchical; CLUSTALW and TCOFEE: applications; Phylogeny: concept of dendrograms and its interpretation; Phylogenetic analysis: maximum parsimony, UPGMA and NJ methods; Distance calculations: K2P; Phylogenetic trees: rooted and unrooted trees; Phylogeny programs: PHYLIP, PAUP, MEGA.

**Unit V**

Microbial Genome Databases: GOLD, GDB; Integrated Microbial Genomes & Microbiomes; NCBI’s Microbial Genome Databases; Mapviewer; Gene Finding Tools: prokaryotic and eukaryotic tools; Genescan, GLIMMER and MUMMER; Metabolic pathway databases: KEGG; Microarray databases; Informatics solutions for genomics, proteomics, metabolomics and interactomics.

# TEXT BOOKS

1. Arthur M. Lesk, (2003). Introduction to Bioinformatics, Oxford University Press, New Delhi, 2003.
2. David W. Mount, Bioinformatics – Sequence and Genome analysis, Cold Spring Harbor Laboratory Press, New York, 2001.
3. G. Gibson &S.V.Muse, A Primer of Genome Science, Sinauer Associates, Inc. Publishers, 2002.

**REFERENCE BOOKS**

1. A. Baxevanis and B.F. Ouellette. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Wiley- Interscience, Hoboken, NJ, 2005.
2. A. M.Campbell& L. J. Heyer, Discovering Genomics, Proteomics & Bioinformatics, CSHL Press, 2003.

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| **Co/Po** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
| **CO1** | 9 | 3 | 3 | 3 | 3 | 9 |
| **CO2** | 3 | 3 | 3 | 9 | 3 | 9 |
| **CO3** | 9 | 9 | 3 | 3 | 9 | 9 |
| **CO4** | 9 | 3 | 1 | 3 | 3 | 9 |
| **CO5** | 9 | 3 | 3 | 9 | 9 | 9 |
| **CO6** | 3 | 3 | 9 | 3 | 9 | 9 |
| **Weightage** | 42 | 24 | 22 | 30 | 36 | 54 |

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| **SEMESTER – VI** |  | **CODE – U22BT16E** |
| **Elective Course III: BIOSTATISTICS** | | |
| **CREDITS - 5** |  | **HOURS - 5** |

**Objectives:**

* To understand the significance of statistical analysis in biology.
* To discuss the significance of statistical measures in biology.
* To learn the application of regression analysis in practical applications.
* To understand the basics of hypothesis testing and statistical significance.
* To acquire knowledge on various statistical tools available for the analysis of biological data.

**Course Outcomes:**

On completion of the course, the student would be able to:

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| **CO LEVEL** | **COURSE OUTCOMES** | **KNOWLEDGE LEVEL** |
| CO1 | Define the elements of statistics including data collection methods, experimental designs and analysis methods | K1 |
| CO2 | Explain the data types and sampling methods with measures of errors | K2 |
| CO3 | Apply data representation methods, Measures of central tendency and deviation in correlation and significance analysis | K3 |
| CO4 | Examine data correlation and regression models for statistical analysis | K4 |
| CO5 | Assess statistical significance using parametric and non-parametric tests | K5 |
| CO6 | Develop experimental designs with statistical validation | K6 |

**UNIT I:**

Concepts of Statistics: Types – Descriptive and Inferential; Hypothesis and Statistical Errors; Data – Types of data based on source, characteristics and levels, Methods of data collection; Sampling – Essentials of sampling, sampling methods; Experimental designs; Data representation –Tabulation, Diagrammatic and Graphical.

**UNIT II:**

Measures of central tendency: Mean, Median and Mode; Measures of dispersion: Mean and Standard deviation.

**UNIT III:**

Correlation analysis: Karl Pearson’s and Spearman’s Rank Correlation; Regression: Types – Positive, Negative and Zero, Simple linear regression analysis.

**UNIT IV:**

Tests of significance:‘t’-test, Chi-square and Goodness of fit, ‘F’ test and Analysis of variance (ANOVA): One-way.

**UNIT V:**

Non – Parametric tests: Kruskal-Wallis test, Mann-Whitney U test, Rank test.Concepts of Experimental Designs:Characteristics – Replication, Randomization and Local Control; Types: Single factor experiments – Completely Randomized Design, Randomized Block Design and Latin Square Design; Factorial Design– Plackett Burmann Design and Response Surface Methodology; Introduction to Software Packages: SPSS and MATLAB.

**TEXT BOOKS**

1. Sokal, R.R. and F.J. Rohlf. (1981). Biometry, W.K. Freeman, San Francisco.
2. Zar, J.H. (2003). Biostatistical Analysis, Pearson Education (Singapore) Pvt. Ltd., Indian Branch, New Delhi.

**REFERENCE BOOKS**

1. Triola, M. M., Triola, M. F., & Roy, J. A. (2006). Biostatistics for the biological and health sciences, Boston: Pearson Addison-Wesley.
2. Gurumani, N. (2002). An introduction to Biostatistics, MJP publisher.

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| **CO/PO** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
| **CO1** | 9 | 3 | 9 | 9 | 9 | 3 |
| **CO2** | 9 | 3 | 9 | 9 | 9 | 3 |
| **CO3** | 9 | 3 | 9 | 9 | 9 | 9 |
| **CO4** | 9 | 3 | 9 | 9 | 9 | 9 |
| **CO5** | 9 | 3 | 9 | 9 | 9 | 9 |
| **CO6** | 9 | 3 | 9 | 9 | 9 | 9 |
| **Weightage** | **54** | **18** | **54** | **54** | **54** | **42** |

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| **SEMESTER -VI** |  | **CODE – U22BT15P** |
| **Core Course Lab XIII**  **LAB FOR COURSES IN SEMESTER VI** | | |
| **CREDITS - 4** |  | **HOURS - 6** |

**LAB FOR COURSES IN SEMESTER VI**

**(Group & Individual practical)**

1. Determination of BOD and COD of polluted and pond water.
2. Isolation, identification of microbe from extreme environment soil and water.
3. Assessment of water quality by MPN technique
4. Air quality test to determine CO2 by titration method.
5. Preparation of panchakavya.
6. Plant tissue culture- sterilization, media preparation, hormones.
7. Micropropagation, shoot induction and root induction.
8. Callus induction, anther culture, Ovule culture, Protoplast isolation, viability and culture
9. Synthetic seeds preparation
10. Agrobacterium-mediated transformation in plants (Demo).
11. Undertake plant genomic DNA isolation by CTAB method and its quantitation by visual as well as spectrophotometeric methods.
12. Primary Cell Cultures (Demo)
13. Trypsinization (Demo)
14. Cell Counting

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| **Co/Po** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
| **CO1** | 9 | 3 | 1 | 3 | 3 | 9 |
| **CO2** | 3 | 3 | 3 | 9 | 3 | 9 |
| **CO3** | 9 | 1 | 3 | 3 | 9 | 9 |
| **CO4** | 9 | 3 | 9 | 3 | 3 | 9 |
| **CO5** | 9 | 3 | 3 | 9 | 9 | 9 |
| **CO6** | 3 | 9 | 9 | 3 | 9 | 9 |
| **Weightage** | 42 | 24 | 28 | 30 | 36 | 54 |