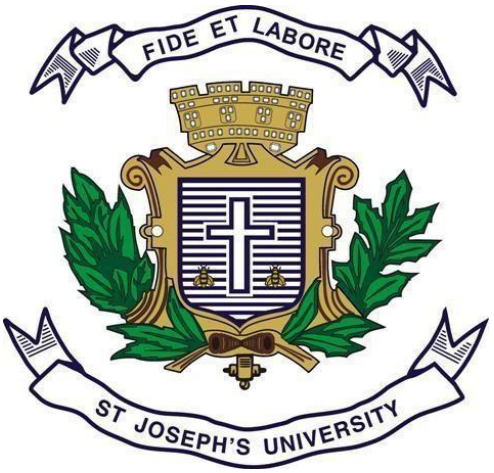
ST JOSEPH'S UNIVERSITY, BENGALURU-27.



DEPARTMENT OF BIOTECHNOLOGY

SYLLABUS FOR UNDERGRADUATE PROGRAMME

For Batch 2024-2027

(STATE EDUCATION POLICY)

The papers BT126 and BT1P 26 are for the Chemistry-Microbiology-Biotechnology Course only. All other courses are for Chemistry-Botany-Biotechnology, Chemistry-Zoology-Biotechnology. Chemistry-Biotechnology-Biology, Biochemistry-Biology-Biotechnology and Biochemistry-Biotechnology-Zoology courses.

SUMMARY OF CREDITS IN BIOTECHNOLOGY

DEPARTMENT OF BIOTECHNOLOGY (UG) (2024-2027)								
Semester 1	**Code Number**	**Title**	**No. of Hours of Instructions**	**Number of Hours of teaching per week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**
Theory	BT124	Introduction to Biomolecules and Microorganisms	45	03	03	40	60	100
Practical	BT 1P24	Techniques in Biochemistry and Microbiology	33	03	02	25	25	50
Theory	BT126	Biochemistry	45	03	03	40	60	100
Practical	BT 1P26	Techniques in Biochemistry	33	03	02	25	25	50
Total Number of credits:			**05**					
Semester2	**Code Number**	**Title**	**No. of Hours of Instructions**	**Number of teaching Hrs /week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**
Theory	BT224	Fundamentals of Cell Biology and Analytical Techniques	45	03	03	40	60	100
Practical	BT 2P24	Techniques in Cell Biology	33	03	02	25	25	50
Total Number of credits:			**05**					
Semester 3	**Code Number**	**Title**	**No. of Hours of Instructions**	**Number of Hours of teaching per week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**
Theory	BT325	Fundamentals of Genetics and Biostatistics	45	03	03	40	60	100
Practical	BT 3P25	Techniques in Genetics	33	03	02	25	25	50

		and Biostatistics						
Total Number of credits:			**05**					
Semester4	**Code Number**	**Title**	**No. of Hours of Instructions**	**Number of teaching Hrs /week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**
Theory	BT425	Molecular Biology	45	03	03	40	60	100
Practical	BT 4P25	Molecular Biology	33	03	02	25	25	50
Total Number of credits:			**05**					
Semester5	**Code Number**	**Title**	**No. of Hours of Instructions**	**Number of teaching Hrs /week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**
Theory	BT5126	Genetic Engineering and Synthetic Biology	45	03	03	40	60	100
Practical	BT 5P126	Techniques in Genetic Engineering and Synthetic Biology	33	03	02	25	25	50
Theory	BT5226	Immunology	45	03	03	40	60	100
Practical	BT 5P226	Immunology	33	03	02	25	25	50
Theory	BT5326	Bioinformatics and Omics	45	03	03	40	60	100
Practical	BT 5P326	Techniques in Bioinformatics and Omics	33	03	02	25	25	50
Theory	BT 5RM26	Research Methodology	30	2	02	20	30	50
Practical	BT 5S 26	Plant Tissue Culture	33	03	02	25	25	50
Total Number of credits:			**19**					
Semester6	**Code Number**	**Title**	**No. of Hours of Instructions**	**Number of teaching Hrs/week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**
Theory	BT6126	Industrial Biotechnology, Entrepreneurship and Bioethics	45	03	03	40	60	100
Practical	BT 6P126	Bioprocess Technology	33	03	02	25	25	50

Theory	BT6226	Plant, Environmental and Nanobiotechnology	45	03	03	40	60	100
Practical	BT 6P226	Methodologies in Plant, Environmental and Nanobioechnology	33	03	02	25	25	50
Theory	BT6326	Applied Medical Biotechnology	45	03	03	40	60	100
Practical	BT 6P326	Techniques in Applied Biotechnology	33	03	02	25	25	50
Practical	BT6S 26	Graduate Research Seminars	33	03	02	25	25	50
Project	BT6PR26	Project Work	66	03+03	04	50	50	100
Total Number of credits:			**21**					

BIOTECHNOLOGY UG SYLLABUS-SEP-2024 -27

Semester	**I**
Paper Code	**BT124**
Paper Title	**Introduction to Biomolecules and Microorganisms**
Number of Teaching Hours per week	**03 hours Theory and 03 hours Practical**
Number of Teaching hours per semester	**45**
Number of Credits	**3 + 2**

Objective of the Paper: This paper has two course subjects. The syllabus covers Biochemistry in both practical and theoretical aspects. It introduces biomolecules that are vital for understanding cell systems and thus providing the foundations of employing them in the industry. This paper also aims to introduce students to basic concepts in Microbiology, with key emphasis on instrumentation and analytical techniques used in microbial laboratories. The course also covers key concepts in antimicrobial agents and assessment of antimicrobial activity, besides providing opportunities for hands-on experiments involving isolation, culturing, control and study of microorganisms.

Content of Course: BT124: Introduction to Biomolecules and Microorganisms	
Biomolecules	**30Hrs**
Unit 1: Introduction	**2 hrs**
Introduction to Biochemical evolution, Prebiotic reactions and molecules, Urey Miller Experiment. Biochemical composition of living organisms, Role of matter in biological systems, Chemical bonds in biological systems.	1 hr 1 hr
Unit 2: Carbohydrates	**4 hrs**
Classification, structure of monosaccharides (trioses-PGA, DHAP, pentoses-Ribose, Deoxy-Ribose and hexoses-Glucose, Galactose, Fructose), Disaccharides-Sucrose, Maltose, Lactose and Polysaccharides-Starch, Glycogen, Occurrence and functions. **Active Learning**: Blood glucose control-Role of insulin and glucagon, Glucose Uptake, Types of GLUT with functions	3 hrs (1 hr)
Unit 3: Proteins	**7 hrs**
Classification and Structure of Amino acids and proteins, Zwitter ion concept, Isoelectric pH, Concept of pKa and Buffers Levels of organization of proteins- Peptide Bond, Primary and secondary structure, Tertiary and quaternary structures, Denaturation. **Active Learning**- Analysis of Stable Structures of Proteins	4 hrs 2 hrs (1 hr)
Unit 4: Enzymes	**6 hrs**

Classification – types and functions, enzyme units. Factors affecting Enzyme Action. Cofactors – types, examples (NAD, FAD) with functions. Active site, Role of tertiary structure. Mechanisms of enzyme catalysis-Models: Lock and Key and Induced fit. Concepts of Km and Vmax. Enzyme inhibition – competitive, uncompetitive and Non-competitive	2 hr 2hrs 2hrs
Unit 5: Lipids	**5 hrs**
Classification, functions and biological role of lipids Classification and Structure of fatty acids Properties of phospholipids, sphingolipids, glycolipids, steroids, amphipathic lipids, cholesterol **Active Learning**: Properties of triacylglycerols and test for purity of lipids.	2 hrs 1 hr 1 hr (1 hr)
Unit 6: Nucleic Acid	**6 hrs**
Chemical composition, structures; nucleosides, nucleotides; Watson & Crick model, Types of DNA – A, B and Z Types of RNA (mRNA, tRNA) with structure and functions **Active Learning**: Discussion on the original paper of Watson and Crick	3 hrs 2hr (1 hr)
Introduction to Microorganisms	**15 hrs**
Unit 1: History of Microbiology	**1 Hr**
The past and present of Microbiology, Case study on HIV's evolutionary past	
UNIT 2-Prokaryotic microorganisms and Viruses	**5 Hrs**
Bacteria-Cell wall, Capsule, Flagella, Fimbriae, Pili, Plasmids, Endospore, Reserve food. Virus- General Characteristic, life cycle of bacteriophage -lytic and lysogeny Active Learning- Structure and lifecycle of viruses	2 hr 2 hr (1hr)
UNIT 3-Eukaryotic microorganisms	**2 Hrs**
General characteristics of Algae, Fungi and Protozoa	
Unit 4- Microbial growth and Control	**3 Hrs**
Microbial growth-Growth curve and kinetics Sterilization techniques- Definition of terms, Physical methods- Heat & radiation Chemical Methods- Alcohol, aldehydes, phenols, halogen, sterilizing gases as antimicrobial agents	1 hr 2 hrs
Unit 5- Antimicrobial agents and Microbial resistance	**4 hrs**
Mode of action of antimicrobial agents: Antifungal agents- Amphotericin B and Griseofulvin Antibacterial agents- Plazomicin and Imipenum Mechanism of multi-drug resistance **Active Learning:** Antiviral agents- Amantadine and Acyclovir	2 hrs 1 hr (1 hr)

Practical II: BT 1P24: Techniques in Biochemistry and Microbiology

1. Introduction to molarity, molality and normality, Calculations for solution preparations, Instruments: Handling of pipettes, burettes, colorimeter and

spectrophotometer.

2. Estimation of Reducing Sugars by DNS method.
3. Estimation of protein by Biuret method.
4. Enzyme Analysis, Kinetics.

5. Handling and applications of important instruments (biological safety cabinets, autoclave, incubator, hot air oven, light microscope, pH meter) used in the microbiology and Biotechnology laboratory.
6. Preparation of culture media for bacterial and fungal isolations, plate preparations and open air culture.
7. Colony characteristics study of bacteria and fungi from air exposure plate.
8. Bacteria– Gram staining Staining techniques, Fungi – Lacto-phenol cotton blue staining
9. Pure culturing techniques: Plating techniques and maintenance of individual cultures.
10. Biochemical Tests – IMViC, Starch hydrolysis, Catalase test, Gelatin hydrolysis, TSI agar and amylase production.

Text Books / References

1. Atlas RM. (1997). Principles of Microbiology. 2nd edition. WM.T. Brown Publishers.
2. Black JG. (2008). Microbiology: Principles and Explorations. 7th edition. Prentice Hall
3. Madigan MT, and Martinko JM. (2014). Brock Biology of Micro-organisms. 14th edition. Parker J. Prentice Hall International, Inc.
4. Pelczar Jr MJ, Chan ECS, and Krieg NR. (2004). Microbiology. 5th edition Tata McGraw Hill.
5. Srivastava S and Srivastava PS. (2003). Understanding Bacteria. Kluwer Academic Publishers, Dordrecht
6. Stanier RY, Ingraham JL, Wheelis ML and Painter PR. (2005). General Microbiology. 5th edition McMillan.
7. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9th edition Pearson Education.
8. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.
9. Cappucino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited
10. Microbiology- Concepts and applications by Paul A. Ketchum, Wiley Publications
11. Fundamentals of Microbiology –Frobisher, Saunders & Toppan Publications
12. Introductory Biotechnology-R.B Singh C.B.D. India (1990)
13. Fundamentals of Bacteriology - Salley
14. Frontiers in Microbial technology-P.S. Bison, CBS Publishers.
15. Biotechnology, International Trends of perspectives A. T. Bull, G.
16. General Microbiology –C.B. Powar
17. Principles of Biochemistry by Lehninger
18. Biochemistry by Stryer
19. Brooker, Wiemaier G, Stiling, Principles of Biology

ST. JOSEPH'S UNIVERSITY, BENGALURU

Semester	**I**
Paper Code	**BT126**
Paper Title:	**BIOCHEMISTRY**
Credits:	**3**
Teaching Hours per Week	**3**
Total Teaching Hours	**45**

Objective of the paper: The course aims to provide a strong foundation in the chemical basis of life and the structure and function of major biomolecules such as carbohydrates, proteins, lipids, and nucleic acids. It develops understanding of enzymes, enzyme kinetics, and metabolic processes with emphasis on their biological significance. The course also builds practical laboratory skills in biochemical techniques, biomolecule estimation, and data analysis. Overall, it prepares students to apply biochemical concepts to physiological systems and experimental

research.

Content of Course: Biochemistry	45hrs
Unit 1: Introduction	**2 hrs**
Introduction to Biochemical evolution, Prebiotic reactions and molecules, Urey Miller Experiment. Biochemical composition of living organisms, Role of matter in biological systems, Chemical bonds in biological systems.	**1 hr** **1 hr**
Unit 2: Carbohydrates	**6 hrs**
Classification, structure of monosaccharides (trioses-PGA, DHAP, pentoses-Ribose, Deoxy-Ribose and hexoses-Glucose, Galactose, Fructose), Disaccharides-Sucrose, Maltose, Lactose and Polysaccharides- Starch, Glycogen, Cellulose. Occurrence and functions. Derived sugars- amino sugars, polyols. **Active Learning:** Blood glucose control-Role of insulin and glucagon, Glucose Uptake, Types of GLUT with functions	**2 hrs** **3 hrs** **1 hr**
Unit 3: Proteins	**9 hrs**
Classification and Structure of Amino acids, Zwitter ion concept, Isoelectric pH. Concept of pKa and Buffers Levels of organization of proteins- Peptide Bond, Primary and secondary structure, Tertiary and quaternary structures, Denaturation and renaturation Principles of extraction and purification of proteins – salt and solvent precipitation, Dialysis for protein purification Active Learning- Analysis of Stable Structures of Proteins	**2 hrs** **2 hrs** **2 hrs** **1 hr** **1 hr** **1 hr**
Unit 4: Enzymes	**6 hrs**
Classification – naming and classification of enzymes, Enzyme-activity units. Cofactors – types, examples (NAD, FAD) with functions. Active site, Role of tertiary structure. Specificity – absolute, stereo, group. Mechanisms of enzyme catalysis-Models: Lock and Key and Induced fit.	**2 hrs** **2 hrs** **2 hrs**
Unit 5: Enzyme kinetics	**7 hrs**
Factors affecting enzyme reactions, Michaelis Menton equation, Concepts of Km and Vmax. Line Weaver Burke Plot, Significance and uses. Enzyme inhibition – competitive, uncompetitive and Non-competitive Allosteric regulation	**3 hrs** **2 hrs** **2 hrs**
Unit 6: Lipids	**6 hrs**
Classification, functions and biological role of lipids Classification and Structure of fatty acids (C16 to C20), saturated and unsaturated Properties of phospholipids, sphingolipids, glycolipids, steroids, amphipathic lipids, cholesterol Active Learning: Properties of triacylglycerols and test for purity of lipids.	**2 hrs** **1 hr** **2 hrs** **1 hr**
Unit 7: Lipid metabolism	**5 hrs**

Beta oxidation of fatty acids Biosynthesis of fatty acids Active Learning: Statins and hypolipedemia	**2 hr** **2 hrs** **1 hr**
Unit 8: Nucleic Acid	**4 hrs**
Chemical composition, structures; nucleosides, nucleotides; Watson & Crick model, Types of DNA – A, B and Z Types of RNA (mRNA, tRNA) with structure and functions	**2 hrs** **2 hrs**

BT1P26: Techniques in Biochemistry

1. Introduction to molarity, molality and normality, Calculations for solution preparations.
2. Instruments: Handling of colorimeter and spectrophotometer.
3. Preparation of buffers, optimizing a pH meter and measuring pH.
4. Estimation of Reducing Sugars by DNS method.
5. Estimation of DNA by Diphenylamine method.
6. Estimation of Protein by Biuret method.
7. Determination of acetyl value/saponification number of lipids.
8. Extraction of enzymes.
9. Enzyme kinetics I: Factors affecting
10. Enzyme kinetics II: Calculation of Km and Vmax.

Course Outcomes

CO No.	Course Outcome	Bloom's Level
1.	Explain fundamental biochemical concepts including biomolecular structure, function, enzyme mechanisms, and metabolic pathways.	Understand
2.	Analyze enzyme kinetics and biochemical reactions using scientific principles and interpret experimental data.	Analyze
3.	Demonstrate laboratory skills such as preparation of solutions and buffers, operation of basic instruments, and estimation of biomolecules.	Apply
4.	Apply biochemical knowledge to understand physiological processes like glucose regulation, lipid metabolism, and molecular interactions in living systems.	Apply

Reference Textbooks

Principles of Biochemistry by Lehninger
Biochemistry by Stryer
Principles of biology by Brooker, Wiemaier Graham and Stiling

Semester	**II**
Paper Code	**BT224**
Paper Title	**Fundamentals of Cell Biology and Analytical Techniques**
Number of Teaching Hours per week	**03 hours Theory and 03 hours Practical**
Number of Teaching hours per semester	**45**
Number of Credits	**3 + 2**

Objective of the Paper: This paper has been designed to expose students to a broad range of cell biological themes. The topics will be covered in depth, with references to the relevant techniques and disease implications. These will provide the students a firm handle of cell biological principles and the ability to understand and analyze diverse biological phenomenon.

Fundamentals of Cell Biology	**30 Hrs**
Unit 1: Cell biology basics	**2 hours**
Cell theory, cell size and volume, cellular organization Eukaryotes vs prokaryotes, compartmentalization.	1 hr 1 hr
Unit 2: Cell structure and function	**4 hours**
Introduction to eukaryotic cells, basics of cell organelles Nucleus, ER and Golgi complex, endomembrane system, mitochondria and chloroplast **Active Learning**: Endosymbiotic theory.	1 hr 2 hrs (1 hr)
Unit 3: Plasma membrane and transport	**4 hours**
Structure of the plasma membrane and associated proteins, membrane permeability Active and passive transport, facilitated diffusion and transport proteins, tonicity and osmoregulation	2 hrs 2 hrs
Unit 4: Cellular energetics	**4 hours**
Introduction to metabolism (anabolism and catabolism), ATP and reaction coupling, C3 and C4 cycles, overview of cellular respiration Oxidative phosphorylation and the electron transport chain, fermentation and anaerobic respiration **Active Learning**: Evolution of photosynthesis	2 hrs 1 hr (1 hr)

Unit 5: Cell communication	**5 hours**
Introduction to cell signaling and general principles Ligands and receptors, GPCR signaling (yeast mating type signaling), feedback and homeostasis Endocrine pathways and long- distance communication, HPA axis.	2 hrs 2 hrs 1 hr
Unit 6: Cell cycle and regulation	**5 hours**
Cell cycle overview, interphase and mitotic phases Cell cycle checkpoints and tumor suppressors Introduction to meiosis, synapsis and crossing-over **Active Learning**: Cell cycle dysregulation in cancer	1 hr 1 hr 2 hr (1 hr)
Unit 7: Cell cytoskeleton and tissue formation	**4 hours**
Filaments and tubules Organization of cytoskeletal elements Cell movement Plant cell wall **Active Learning**: Role of the extracellular matrix in tissue formation.	1 hr 1 hr 1 hr (1 hr)
Unit 8: Cell death	**3 hours**
Definition of life and death, accidental and programmed cell death Apoptosis: brief introduction and physiological importance Cell viability and tests for cell death.	1 hr 1 hr 1 hr
Analytical Techniques	**15 hours**
Unit 9: Basic principles	**2 hours**
Units of measurement, electrolytes and pH, quantitative biological measurements.	2 hrs
Unit 10: Cell disruption and centrifugation	**3 hours**
Methods of cell lysis: physical and chemical, Basic principle of sedimentation, types of centrifugation, preparative versus analytical centrifugation.	1 hr 2 hrs
Unit 11: Microscopy	**3 hours**
Light microscopy, magnification, numerical aperture, resolution Fluorescent proteins and live cell imaging, fluorescence microscopy Electron Microscopy	1 hr 1 hr 1 hr

Unit 12: Chromatography	**3 hours**
Principles of chromatography and performance parameters, adsorption and partition chromatography, size-exclusion chromatography, affinity chromatography **Active Learning**: High-performance liquid chromatography.	2 hrs (1 hr)
Unit 13: Electrophoresis	**2 hours**
Discussion on matrices, agarose electrophoresis, SDS and native PAGE	
Unit 14: Basics of spectroscopy	**2 hours**
Ultraviolet and visible light spectroscopy **Active Learning**: Fluorescence spectroscopy.	1 hr (1 hr)

Practical: BT 2P24: Techniques in Cell Biology

1) Calculation of cell number using a hemocytometer
2) Effect of cell size on diffusion using agarose gel.

3) Sedimentation: isolation of chloroplasts
4) Staining of mitochondria (Janus Green) in cheek cells.
5) Mitosis: Onion root tip
6) Meiosis: Anthers
7) Osmosis: RBC/yeast
8) Chromatography: TLC of amino acids
9) Micrometry
10) Electrophoresis: agarose gel electrophoresis of dyes

Reference text

Molecular Cell Biology, Eighth Edition, 2016, Harvey Lodish; Arnold Berk; Chris A. Kaiser; Monty Krieger; Anthony Bretscher; Hidde Ploegh; Angelika Amon; Kelsey C. Martin

Principles and techniques of Biochemistry and Molecular Biology, Seventh Edition, 2010 Keith Wilson and John Walker.

Semester	**III**
Paper Code	**BT325**
Paper Title	**Fundamentals of Genetics and Biostatistics**
Number of Teaching Hours per week	**03 hours Theory and 03 hours Practical**
Number of Teaching hours per semester	**45 Theory + 33 Practical**
Number of Credits	**3 +2**

Objective of the Paper: This paper has two course subjects. The syllabus covers Genetics and Biostatistics in both practical and theoretical aspects. As part of Genetics, it introduces the fundamental principles of Mendelian Genetics exhaustively. This paper also aims to introduce students to basic concepts in Biostatistics and its applications in the field of biological sciences.

Content of Course: BT325: Fundamentals of Genetics and Biostatistics	
Genetics	**30Hrs**
Unit 1: Mendelian Genetics	**4 hrs**
Mendel's study of heredity-Mendel's experiments, Genotype, phenotype, zygosity, Alleles: dominant and recessive; Principle of segregation, Monohybrid cross, Principles of Independent assortment - Dihybrid cross, Trihybrid ratio, Application of Mendel's Principles-The Punnett square method, the probability method and	1 hr 1 hr 1 hrs
the chi-square test; **Active Learning**: Problems.	1 hr
Unit 2: Non Mendelian Inheritance	**6 hrs**
Allelic variation, incomplete dominance and co-dominance; Multiple alleles: ABO blood type alleles in humans, Rh factor alleles in humans; Genotypic interaction- Epistasis (dominant and recessive) , Pleiotropy **Active Learning**: Problems, Extra nuclear inheritance-inheritance of plastid and kappa particles	1 hr 1 hr 1 hr 1 hr 2 hrs

Unit 3: Linkage and Crossing Over	**3 Hrs**
Introduction, detection of linkage, factors affecting recombination frequency, cytological basis of crossing over, crossing over in four strand stage, relation between chiasma and crossing over; Two-point test cross and three-point test cross, Recombination frequency.	1 hr 1 hr 1 hr
Unit 4: Sex Determination, Sex Linkage, Pedigree Analysis	**8 hrs**
Sex determination-Pattern and sex chromosomes, Sex determination in human beings, flowering plants; Dosage compensation-Proof of the Lyon hypothesis, dosage compensation for Drosophila; Sex linkage, Sex linked genes in human beings-Haemophilia; Genes on X and Y chromosomes; Pedigree analysis-Penetrance and expressivity, Inheritance patterns: Autosomal and Sex- linked (dominant, recessive) **Active Learning**: Problems.	2 hrs 1 hr 2hrs 2hr 1 hr
Unit 5: Population Genetics	**3 hrs**
Concept of Gene pool and Allele Frequencies (Gene and genotypic frequencies) The Hardy-Weinberg principle, Application of the Hardy – Weinberg principle and factors affecting H-W equilibrium-Natural selection, Genetic drift; Speciation-Definition of species and mode of speciation (allopatric, sympatric)	1 hr 1 hr 1 hr
Unit 6: Chromosomal Aberrations	**6 hrs**
Numerical chromosomal aberrations– Euploidy, polyploidy- Auto and Allopolyploids; Aneuploidy- Trisomy, monosomy, nullisomy; Examples of aneuploid humans. **Structural chromosomal aberrations**-Deletions and Duplication of chromosome segments; Rearrangement of chromosome structure - inversion, translocation	3 hrs 3hrs
BIOSTATISTICS	15 Hrs
UNIT 1-Introduction	2Hrs
Definition of selected terms Scale of measurements, Methods of collecting data, Presentation of data, statistical tables, Need for reduction of data.	
UNIT 2-Population and Sampling Techniques	2Hrs
Concepts of statistical population and sample, need for sampling studies; Simple procedures of random sampling; Methods of sampling.	2 Hrs
UNIT 3- Measures of Central Tendencies	3 Hrs
Mean, Median, Mode	3 hrs
Unit 4- Measures of Dispersion	3 Hrs

Range, quartile deviation Mean deviation, Variance & Standard deviation, Coefficient of Variance	1Hr 2 Hrs
Unit 5- Probability	2hrs
Basic concepts; Basic theorems of probability addition and multiplication theorems; Conditional probability Introduction to Probability distributions, Binomial, Poisson and Normal Distribution	1 hr 1hrs
Unit 6- Correlation and Regression	3hrs
Correlation concept and applications; Regression concept and applications	

Practical III: BT 3P25: Techniques in Genetics and Biostatistics

1. Fly husbandry I
2. Fly husbandry II
3. Crossing: Monohybrid crosses
4. Isolation of salivary gland chromosomes.
5. Identification of Biomarkers.
6. Barr body identification.
7. Blood typing and probability testing.
8. Karyotyping
9. Data Analysis I.
10. Data Analysis II.
11. DNA fingerprinting

Text Books / References

Genetics:

1. Molecular Biology of Cell - Bruce Alberts et al, Garland publications.
2. Animal Cytology and Evolution- MJD, White Cambridge University Publications
3. Molecular Cell Biology-Daniel, Scientific American Books
4. Cell Biology - Jack d Bruke, The William Twilkins Company
5. Principles of Gene Manipulations- Old & Primrose, Black Well Scientific Publications
6. Cell Biology-Ambrose &Dorothy M Easty, ELBS Publications
7. Fundamentals of Cytology- L. W. Sharp, McGraw Hill Company
8. Cytology-Willson&Marrison, Reinform Publications
9. Molecular Biology- Christopher Smith, Faber & Faber Publications
10. Cell Biology & Molecular Biology – EDP De Robertis& EMF Robertis, Saunder College.
11. Cell Biology- C.B Powar, Himalaya Publications
12. Basic Genetics- Daniel L. Hartl, Jones &Barlett Publishers USA
13. Human Genetics and Medicine lark Edward Arnold P London
14. Genetics – Monroe W Strickberger, Macmillain Publishers, New York
15. Genes V - Benjamin Lewin, Oxford University Press.
16. Genes I - Benjamin Lewin, Wiley Eastern Ltd., Delhi
17. Genes II - Benjamin Lewin, Wiley & Sons Publications
18. Genes III- Benjamin Lewin, Wiley & Sons Publications
19. Principles of Genetics- Sinnott, L.C. Dunn, Dobzhansky, McGraw-Hill.
20. Genetics – Edgar Altenburg Oxford & IBH publications
21. Principles of Genetics – E.J. Gardener, M.J. Simmons and D.P. Snustad, John Wiley & Son Publications
22. Genetics- P.K.Gupta, Rastogi Publication, Meert, India.

Biostatistics:

Principles of Biostatistics, Rosner

Biostatistics by Khan and Khanum
Biostatical Analysis, Jerrold H. Peasron

Course Outcomes for BT325

After successful completion of the course, the students will:

CO1	Comprehend Fundamental Genetic Principles
CO2	Analyze Genetic Interactions and Variability
CO3	Apply Genetic Concepts in Population Studies
CO4	Understand and Apply Statistical Concepts
CO5	Analyze Data Using Descriptive Statistics
CO6	Apply Statistical Methods for Data Interpretation

Semester	**IV**
Paper Code	**BT425**
Paper Title	**Molecular Biology**
Number of Teaching Hours per week	**03 hours Theory and 03 hours Practical**
Number of Teaching hours per semester	**45 Theory + 33 Practicals**
Number of Credits	**3 + 2**

Objective of the Paper: This course deals with the fundamentals of Molecular Biology: DNA structure, replication, gene expression and regulation. The practical sessions train the student in selected basic techniques in DNA isolation and analysis.

Content of Course: BT425: Molecular Biology	**45h**
Molecular Biology	**45h**
Unit 1: DNA structure and function	**6h**
Classical experiments: Griffith's, Avery, and Hershey - Chase experiments The race to enumerate the structure of DNA, Watson and Crick's model of the DNA double helix DNA Compaction and Structure of eukaryotic chromosomes/eukaryotic gene Active learning exercise: Analysis of data from classical experiments that led to the discovery of DNA structure	1h 2h 2h 1h
Unit 2: DNA Replication	**7h**
Semiconservative model of replication (Meselson & Stahl experiment) Bidirectionality and semi-discontinuous nature of Replication, Replication fork and the main scheme of DNA replication Replication in Prokaryotes: Initiation, elongation and termination Replication in Eukaryotes: Initiation, elongation and termination, telomeres, telomerase	1h 1h 1h 2h 2h
Unit 3: DNA Damage and Repair	**8h**
Radiation Damage, DNA instability, Oxidative damage, Alkylation Damage Introduction to mutagens, types of mutagens (chemical, physical and biological) Active learning exercise: Mutations Repair mechanisms: Photoreactivation, Excision Repair, Mismatch repair and SOS response Non homologous end joining and Homologous recombination to repair Double stranded DNA breaks	2h 1h 1h 2h 2h
Unit 4: Gene expression: Transcription	**8h**
Promoters, General Transcription factors, DNA binding domains Bacterial Transcription Initiation, Elongation and Termination	2h 2h 2h

Active learning: Eukaryotic RNA Polymerases, Promoters, Eukaryotic Transcription Initiation, Elongation and Termination Processing of eukaryotic mRNAs-Capping, Splicing and Polyadenylation.	2h
UNIT 5: Gene expression: Translation	**8h**
Structure of Ribosomes, Transfer RNA, Aminoacylation, mRNA and the Genetic Code Molecular events of Translation initiation, elongation and termination in prokaryotes Overview of the molecular events of Translation Initiation, Elongation and Termination in eukaryotes Active learning: Post translational modifications of proteins	2h 2h 3h 1h
Unit 6: Gene expression regulation	**8h**
Concept of regulation, overview of gene regulation Prokaryotic Gene Regulation-Lac and Trp operons Eukaryotic Gene Regulation- Regulatory promoter elements, epigenetic changes in chromatin structure and DNA methylation Active learning - RNAi	1h 4h 2h 1h

Practical IV: BT 4P25: Molecular Biology

1. Introduction to DNA Isolation and Discussion of Cheek cell DNA isolation
2. Preparation of buffers and Cheek cell DNA Isolation
3. Agarose Gel electrophoresis of cheek cell DNA
4. DNA isolation from *E.coli*, *S. cerevisiae*, and plant leaf samples (Part A)
5. DNA isolation from *E.coli*, *S. cerevisiae*, and plant leaf samples (Part B)
6. DNA isolation from *E.coli*, *S. cerevisiae*, and plant leaf samples (Part C)
7. Analysis/Comparison of DNA quality and concentration, Agarose gel electrophoresis
8. Understanding Protein Structure and SDS PAGE set up
9. Extraction of total protein from dal / lentil samples
10. Electrophoresis of extracted protein through SDS PAGE

Text Books / References

1. Genomes 3.0, T.A Brown
2. Genes to Proteins, Burton E Tropp, Fourth Edition
3. Principles of Biology, Brooker, Widmaier, Graham and Stiling
4. Molecular Biology of the Gene, James D. Watson

COURSE OUTCOMES for BT425:

After successful completion of the course, students will:

CO1	Critically Evaluate DNA Structure and Chromatin Organization
CO2	Integrate DNA Replication and Repair Mechanisms
CO3	Examine the Complexity of Transcription and Translation
CO4	Investigate Post-Transcriptional and Post-Translational Modifications
CO5	Analyze Gene Regulation and Epigenetic Modifications

Semester	**V**
Paper Code	**BT5126**
Paper Title	**GENETIC ENGINEERING AND SYNTHETIC BIOLOGY**
Number of teaching hours per week	**03T + 03P**
Total number of teaching hours per semester	**45 (30+15)**
Number of credits	**03 + 2 (T+P)**

Objective of the Paper:

This course introduces the principles and tools of genetic engineering, including cloning, transformation, and genome analysis. It familiarizes students with advanced genomic technologies like CRISPR and NGS. The course also explores synthetic biology approaches for designing gene constructs and therapeutic applications. Ethical concerns, case studies, and real-world applications are integrated through active learning. The paper covers a detailed conceptual module supported by a strong practical session on these concepts.

GENETIC ENGINEERING	**30 Hrs**
Unit 1: Introduction	**2 hrs**
Principles of Recombinant DNA Technology & Genetic Engineering techniques (in brief), applications, goals, and ethical issues.	
Unit 2: Tools in Genetic Engineering	**4Hrs**
Restriction Endonucleases and Restriction Mapping DNA ligase, Alkaline Phosphatase, Polynucleotide kinase, Terminal transferases, S1 nuclease, Linkers and Adapters, Polymerases-Klenow fragment, Pol I, *Taq* polymerase,	3 hrs 1 hr
Unit 3: Vectors	**13 hrs**
Natural plasmids, Artificial plasmids - pBR322 and pUC19: Design and Advantages. Viral Vectors - Lambda Bacteriophages- Insertional vectors and Replacement vectors- features and design, Phage display Cosmids and Phagemids - definition, features, design with examples Characteristics of Eukaryotic Vectors: Design and Advantages	4 hrs 4 hrs 2 hr 3 hr
Unit 4: Methods of Gene Transfer and Screening	**3hrs**
Methodology, Advantages and Disadvantages of the following methods of transformation: Chemical Competence-Induction, Biolistics, Lipofection, Electroporation, Microinjection, *Agrobacterium-mediated*, Selection, screening, and analysis of transformants and recombinants – Blue white	
Unit 5: Techniques in cloning and gene expression analysis	**4 hrs**
PCR – Reverse transcription PCR, qPCR, Genomic libraries, and cDNA libraries **Active learning**- Southern blotting	
Unit 6: Genomic Technologies and Applications	**4 hrs**
Techniques of genome sequencing- Sanger, Genome editing by CRISPR-Cas	2 hr 1 hr

Active learning- Case studies of CRISPR-Cas	1 hr
SYNTHETIC BIOLOGY	**15hrs**
Unit 7: Design of gene constructs for synthetic biology	**5hrs**
Introduction to Synthetic Biology – Expression, purification and characterization of recombinant proteins. Design of expression strategies – promoters, fusion protein tags, reporter genes, Marker genes Gibson assembly- Artificial Genes	1 hr 3hrs 1hr
Unit 8: Advanced Vectors	**5hrs**
Cloning vectors: BAC, YAC, Expression vectors: Bacterial- pRSET, Yeast- pYES, Animal- pcDNA, Plant- pCAMBIA	1hrs 4hrs
Unit 9: Expression systems and applications	**2hrs**
Heterologous expression systems – *E. coli* inducible expression system (BL-21 DE3 pLysS)	2hrs
Unit 10: Synthetic Biology and Pathway Engineering	**3hrs**
Pathway engineering – Biofuels, edible vaccines **Active Learning:** Synthetic Biology Products	2hrs 1hr

Practical V:

BT5P 126: Techniques in Genetic Engineering and Synthetic Biology (30hrs)

1. Isolation of plasmid DNA from *E. coli* Lab - 1 (3hrs)
2. Isolation of pkasmid DNA from *E.coli* Lab - 2 (3hrs)
3. Single and double restriction digestion of the plasmid DNA (EcoR1, Hind III, BamHI) and its analysis by electrophoresis (3hrs)
4. Amplification by PCR Lab- 1 (3hrs)
5. Amplification by PCR Lab- 2 (3hrs)
6. Purification of an isolated fragment. (3hrs)
7. Cloning of an insert into vector (3hrs)
8. Preparation of competent cells (3hrs)
9. Transformation of ligated DNA (3hrs)
10. Screening of transformants (Colony PCR/RE Mapping) (3hrs)

Text Books / References

Genetic Engineering:

1. Watson, J.D., Tooze, J. and Kurtz, D.T., Recombinant DNA: A short Course, Scientific American Books, New York.
2. T. A. Brown, Essential Molecular Biology a Practical Approach -Oxford University Press
3. Brown, T. A. Gene cloning and DNA analysis: an introduction. John Wiley & Sons.
4. S.B Primrose and R. W. Twyman. Principles of Gene Manipulation and Genomics. 7th Edition.
5. Purohit,S.S., Biotechnology Fundamentals and Application- Himalaya Publications.

6. Glick & Pasternack, Molecular Biotechnology.

Text Books / References

Synthetic Biology:

1. Freemont, P. S., & Kitney, R. I. Synthetic Biology-a Primer. World Scientific.
2. **Brunsveld, L., & Suga, H. Synthetic Biology: Royal Society of Chemistry.**
3. Zhao, H. Synthetic biology: tools and applications. Academic Press.
4. J. Sambrook, EF Fritsch and T. Maniatis, Molecular Cloning: A Laboratory Manual.
5. Hames, B. D., & Higgins, S. J. Protein Expression: A practical approach
6. **Wittmann, C., & Lee, S. Y. (Eds.). Systems metabolic engineering. Springer Science & Business Media.**
7. Liljeruhm, J., Gullberg, E., & Forster, A. C. Synthetic biology: a lab manual. World Scientific.

COURSE OUTSOMES FOR BT5126

After successful completion of the course, students will

CO1	Explain the principles, tools, vectors, and ethical aspects of genetic engineering and synthetic biology.
CO2	Demonstrate knowledge of enzymes, cloning strategies, and gene transfer methods used in recombinant DNA technology.
CO3	Apply molecular techniques such as PCR, sequencing, CRISPR-Cas, and cloning for gene analysis and manipulation.
CO4	Design and evaluate gene constructs, vectors, and expression systems for applications in synthetic biology.
CO5	Perform core laboratory techniques in molecular cloning and critically assess real-world applications of synthetic biology in healthcare, agriculture, and industry.

Semester	**V**
Paper Code	**BT5226**
Paper Title	**IMMUNOLOGY**
Number of teaching hours per week	**03 (T) + 03 (P)**
Total number of teaching hours per semester	**45**
Number of credits	**(3T+2P)**

Objective of the Paper: This course introduces the fundamentals of immunology, focusing on the structure and function of the immune system, and the mechanisms of humoral and cell-mediated responses. It integrates theoretical concepts with clinical case studies. with practical sessions offering hands-on experience in core immunological techniques.

IMMUNOLOGY	
Unit 1: Fundamentals of Immunology	2 hrs
Types of immune responses Innate Immunity: Physiological barriers and mechanisms of inflammation Adaptive immune system**:** Introduction Case Study of Infection: Highlighting innate vs acquired response	
Unit 2: Cells of the Immune System	4 hrs
Haematopoiesis and lineage commitment	

Cells of the Immune System: Granulocytes, Monocytes, Macrophages, Dendritic Cells, Natural Killer (NK) Cells, B cells, and T cells.	
Unit 3: Organs of the Immune System	5 hrs
Lymphoid Organs: Primary: Bone Marrow, Thymus Secondary: Spleen, Lymph nodes Lymphocytes: T cells and B cell development Positive and Negative Selection Case study: *Developmental disorders associated with the immune system*	
Unit 4: Antigens	2 hrs
Epitopes and Paratopes Factors influencing Immunogenicity **Active Learning:** Adjuvants and Haptens	1 hr 1 hr
Unit 5: Antibodies	7 hrs
History of antibody discovery and Porter's experiments Structure and properties of Immunoglobulins Antigen-Antibody interaction (avidity and affinity) Effector functions of Immunoglobulins Immunogenes: structure and overview of VDJ recombination Hybridoma technology and monoclonal antibody generation **Active Learning:** Examples of mAbs	1 hr 1 hr 1 hr 2 hrs 1 hr 1 hr
Unit 6: Humoral Immune Response	7 hrs
Theories of Antibody Production: Instructive Theory, Clonal Selection Theory B cell activation and clonal expansions Primary vs Secondary response Allelic exclusion and class switching Case study: *Memory B cells in Vaccination*	
Unit 7: Major Histocompatibility Complex and Antigen Presentation	5 hrs
MHC I and MHC II**:** Structure and peptide binding Antigen presentation Antigen Processing Pathways**:** Endogenous pathway (MHC I) Exogenous pathway (MHC II)	
Unit 8: Cell-Mediated Immune Response	8 hrs
T-cell activation, differentiation Role of Cytotoxic T lymphocytes (CTLs) and Helper T cells Effector functions - Perforin and Granzyme Pathway Fas-FasL (Death Receptor) Pathway CTL-mediated immunity in viral infections Case study*: HIV escape from CTL killing*	
Unit 9: Immunotolerance and autoimmunity	5 hrs
Central Tolerance: Thymic deletion and B cell tolerance in bone marrow Peripheral Tolerance: Deletion, Anergy, Regulatory T cells Introduction to autoimmunity and failure of tolerance: Graves' disease and Multiple Sclerosis **Active Learning:** Case study: autoimmune disorders	4 hrs 1 hr

Practical: BT5P226 IMMUNOLOGY

1. Introduction to blood cells and preparation of blood smear-differential staining.
2. Immunodiffusion- SRID
3. ODD titration
4. ODD pattern
5. Agglutination test - VDRL test
6. Agglutination tests - WIDAL test
7. Dot Enzyme-linked immunosorbent assay (Dot ELISA)
8. Isolation of amylase/IgY
9. Amylase assay/ Protein estimation
10. SDS PAGE

Text Books / References

Immunology by Richard A. Goldsby, Thomas J. Kindt, Barbara A. Osborne & Janis Kuby
Immunology: Essential and Fundamental by Sulabha Pathak & Urmi Palan.

COURSE OUTSOMES FOR BT5226

After successful completion of the course, students will

CO1	Explain the fundamental mechanisms of innate and adaptive immunity and their interplay in host defense, using case studies of infections as examples.
CO2	Differentiate between the origin, structure, and functional roles of immune cells and organs, and analyze their relevance in immune system disorders.
CO3	Apply knowledge of antigen and antibody structure to interpret antigen-antibody interactions, and evaluate their applications in diagnostics and therapeutics such as monoclonal antibodies.
CO4	Construct immunological pathways of humoral and cell-mediated immune responses, and predict outcomes in scenarios such as vaccination, viral infections, and immune evasion strategies.
CO5	Assess the mechanisms of immune tolerance, and propose strategies to prevent or manage autoimmune diseases using knowledge of central and peripheral tolerance.

Semester	**V**
Paper Code	**BT5326**
Paper Title	**Bioinformatics and Omics**
Number of teaching hours per week	**03T + 03P**
Total number of teaching hours per semester	**45 (30+15)**
Number of credits	**03 + 02 (T+P)**

Course Objectives

This course introduces the fundamental concepts of bioinformatics, including biological databases, sequence analysis, and computational tools. Students will learn key algorithms and software used in genomics and proteomics. The Omics section explores the principles of genomics, transcriptomics, proteomics, and metabolomics. Emphasis is placed on data interpretation, tools, and applications in health and disease.

BIOINFORMATICS	30 Hrs
Unit 1: Introduction and applications	**1 hr**
Introduction to bioinformatics, Branches of Bioinformatics, connections to genes and genomes, applications in genomics, gene expression,	
Unit 2: Databases	**6 hrs**
Concept and structure of a database, Examples- DNA Databases - Genbank, ENA, DDBJ, Protein Databases - Uniprot, PROSITE, Interpro, PDB Literature Database - Pubmed	
Unit 3: Analysis of sequences	**5 hrs**
Types of alignments - global and local alignments, Pairwise, multiple; Similarity searching – BLAST- concept, types and applications, output and interpretation (E-value) Multiple Sequence Alignment (MSA)- concept and applications, CLUSTAL method, output and interpretation, scoring matrices, penalties.	
Unit 4: Phylogenetic analysis	**4 hrs**
Concept of phylogenetics, Tree building methods -Neighbour Joining method, Maximum-Likelihood, Tree evaluation	
Unit 5: Molecular Modelling	**5 hrs**
Basic principles of protein modelling – homology modelling. Concepts of drug designing - principles of docking, QSAR, ADMET, Lipinski Rule of five	
Unit 6: Concepts of Next Generation Sequencing	**4 hrs**
Short read, Long read NGS – Illumina Sequencing Approach QC, Construction of libraries, output formats – FASTQ Active Learning - Nanopore Sequencing Technology	3 hrs 1 hr
Unit 7: Concepts of AI and ML in Bioinformatics	**5 hrs**
Protein structure prediction methods – GOR, Artificial Neural Networks, Construction of Datasets (Trained and Test), Fitting of model, Evaluation of prediction accuracy. **Active Learning** - Application of AI in Bioinformatics - Alpha fold	**4 hrs** **1hr**
OMICS	**15 hrs**
Unit 8: Introduction to Omics and Big Data	**2 hrs**
Disciplines – Genomics, Epigenomics, Transcriptomics, Proteomics, Metabolomics, Pharmacogenomics, Interactomics and Applications	
Unit 9: Genomics	**3 hrs**
Whole Genome Sequencing (WGS) – Paired End, Single End Data, *Denovo* and Reference assembly, tools, annotation, Phylogenomics, Genome circular plots - CIRCOS	
Unit 10 Transcriptomics	**4 hrs**
Concept of transcriptomics, Microarrays and RNA-seq, GEO database, Transcriptome assembly and Differential Gene expression analysis (DGE)	
Unit 11 Proteomics and Metabolomics	**6 hrs**
Tools of proteomics - 2D-Gel electrophoresis, High Resolution Mass spectrometry (ESI/MALDI – MS/MS) Metabolome analysis – Case study (LC-MS, GC-MS approaches) **Active Learning** - Protein-Protein Interaction (PPI) Database – STRING **Active Learning -** Applications and Case Studies in Omics: Biomedical, Agricultural, Pharmaceutical, Marine applications	**4 hrs** **1 hr** **1 hr**

Practical V: BT 5P 326: Techniques in Bioinformatics and Omics (30hrs)

1. Bioinformatics- Genome Data Viewer, PubMed
2. Sequence analysis- BLAST and phylogenetic analysis using MEGA
3. Structure analysis tool- Rasmol, Swiss PDB Viewer
4. Protein Structure prediction through Phyre2 server and Ramachandran plot analysis of the predicted structure Lab - 1
5. Protein Structure prediction through Phyre2 server and Ramachandran plot analysis of the predicted structure Lab - 2
6. Rigid body docking through Autodock tool
7. Prediction of ADMET properties
8. Bacterial WG assembly and annotations using Galaxy cloud computing Lab- 1
9. Bacterial WG assembly and annotations using Galaxy cloud computing Lab- 2
10. Phylogenomics, Circular plot, and Secondary metabolite analysis of Bacterial genome

Text Books / References

1. Introduction to bioinformatics by Sundararajan and Balaji
2. Bioinformatics by Murthy
3. Developing Bioinformatics computer skills by Cynthia Gibas and Per JambeckO'reilly
4. Bioinformatics- concepts, skills, and applications, By S.C Rastogi, Namita Mendiratta and Parag Rastogi. CBS publisher
5. Introduction to Bioinformatics by Arthur M. Lesk. Oxford University Press
6. Bioinformatics-sequence and genome analysis by David W. Mount. CSH Lab Press

Text Books / References

1. Introduction to Proteomics -Tools for the New Biology by Daniel C. Liebler, Humana Press.
2. Mass Spectrometry for Biotechnology by Gary Siuzdak, Academic Press.
3. Proteomics for Biological Discovery by Timothy Veenstra and John Yates, Wiley.
4. Metabolomics- Methods and Protocols by Wolfram Weckwerth, Humana Press.
5. Lipidomics- Technologies and Applications by Kim Ekroos, Wiley-VCH.
6. Transcriptomics: Expression Pattern Analysis, Virendra Gomase, Somnath Tagore; VDM Publishing.

COURSE OUTSOMES FOR BT5326

After successful completion of the course, students will

CO1	Explain the fundamental concepts, branches, and applications of bioinformatics and omics.
CO2	Retrieve and interpret biological information from DNA, protein, structural, and literature databases.
CO3	Apply and analyze sequence alignment, similarity search, phylogenetic methods, and molecular modelling tools for biological data analysis.
CO4	Evaluate next-generation sequencing (NGS) data and assess the role of AI/ML approaches in protein structure prediction and bioinformatics.
CO5	Integrate and critically assess genomic, transcriptomic, proteomic, and metabolomic datasets for applications in biomedical, agricultural, and industrial fields.

Semester	**V**
Paper Code	**BT 5S 26**
Paper Title	**Plant Tissue Culture**
Number of teaching hours per week	**02T**
Total number of teaching hours per semester	**30**
Number of credits	**2**

Objectives: To equip students with hands-on skills in establishing and maintaining plant tissue cultures through mastery of aseptic techniques, media preparation, explant handling, culture initiation, regeneration, and specialized cell culture methods, thereby enabling them to apply plant tissue culture for research and commercial applications.

1. Setup of a PTC Lab
2. Media preparation for Tissue Culture
3. Explant Selection, Sterilization and Inoculation
4. Media optimization for Direct Organogenesis
5. Shoot regeneration
6. Root regeneration
7. Callus induction
8. Callus suspension cultures-I
9. Callus suspension cultures-II
10. Isolation of protoplast and viability

COURSE OUTSOMES FOR BT5S 26

After successful completion of the course, students will

CO1	Set up and operate a plant tissue culture laboratory, including sterile workspace preparation and safe handling of instruments
CO2	Prepare and optimize culture media with appropriate nutrient and hormone compositions for various tissue culture objectives.
CO3	Select, sterilize, and inoculate explants aseptically to initiate cultures for direct organogenesis, shoot, and root regeneration.
CO4	Establish and maintain callus and suspension cultures, including monitoring growth parameters and subculturing techniques.
CO5	Isolate and assess viability of protoplasts using enzymatic methods and appropriate microscopic evaluation techniques.

Semester	**V**
Paper Code	**BT5RM26**
Paper Title	**Research Methodology in Life Sciences**
Number of teaching hours per week	**2**
Total number of teaching hours per semester	**30**
Number of credits	**2**

Objective of the Paper:

This course aims to equip undergraduate students with a clear, working understanding of how scientific research is conceived, designed, executed, analysed, and communicated. By the end

of the course, students should be able to identify researchable problems, critically engage with scientific literature, formulate testable hypotheses, and choose appropriate study designs while adhering to ethical standards. The course aims to develop foundational competence in data collection and basic statistical analysis, enabling students to interpret results rather than merely compute them. Emphasis is placed on practical skills—using standard databases, designing simple instruments, analysing data with commonly used software, and reporting findings in accepted scientific formats-so that students are prepared to undertake independent projects and critically evaluate research across the life sciences.

Course Syllabus:

Unit 1: Research Foundations (6 hours)

Meaning, types (exploratory, experimental), and process of scientific research. Problem identification, literature review using databases like PubMed/Google Scholar, and hypothesis formulation. The Scientific method.

Unit 2: Research Design (6 hours)

Designs for science: experimental, quasi-experimental, observational. Sample selection, variables, controls, and pilot testing. Ethics and feasibility assessment.

Unit 3: Data Collection Methods (6 hours)

Primary methods (lab experiments, surveys, sensors) and secondary sources. Sampling (random, purposive), instruments (questionnaires, scales), and ensuring reliability/validity. Practical: Design a simple data collection tool.

Unit 4: Data Analysis Basics (6 hours)

Descriptive stats (mean, SD, graphs) and inferential basics (t-test, correlation). Hypothesis testing steps and errors (Type I/II). Hands-on with Excel/SPSS for science datasets.

Unit 5: Reporting and Interpretation (6 hours)

Report structure (IMRaD format) and visualization (charts, tables). Interpretation, APA/Vancouver citations, and avoiding plagiarism. Mini-project presentation.

Course Outcomes

CO	Course Outcome Statement	Bloom's Level	Category
CO1	Explain the principles of scientific research and differentiate between major research types, including exploratory, experimental, and observational studies.	L2	Understanding
CO2	Identify researchable problems and formulate testable hypotheses through systematic literature review using scientific databases.	L3 & L4	Application & Analysis
CO3	Design an ethically sound and feasible research study by selecting appropriate variables, sampling strategies, controls, and data collection methods.	L5	Evaluation
CO4	Apply basic statistical tools to analyse scientific data and interpret results in the context of hypothesis testing and experimental error.	L3 & L4	Application & Analysis
CO5	Prepare and present a structured scientific report following standard formats, using proper citation practices and data visualization techniques.	L6	Creation

Semester	**VI**
Paper Code	**BT6126**
Paper Title:	**INDUSTRIAL BIOTECHNOLOGY, ENTREPRENEURSHIP AND BIOETHICS**
Credits:	**3**
Teaching Hours per Week	**3**
Total Teaching Hours	**45**

OBJECTIVES OF THE COURSE

- Provide comprehensive understanding of industrial biotechnology and fermentation processes.
- Familiarize students with strain improvement, bioprocess development and downstream processing.
- Introduce entrepreneurial approaches in biotechnology-based industries.
- Develop skills in business model development and startup planning.
- Sensitize students to ethical, regulatory and biosafety issues in biotechnology.

INDUSTRIAL BIOTECHNOLOGY (30 Hours)	
Unit 1: Introduction to Industrial Biotechnology Scope and importance of industrial biotechnology, Historical developments, Basic principles of fermentation technology, Overview of bioprocess industries in India.	**3hrs**
Unit 2: Strain Improvement and Maintenance Classical Methods – Random mutagenesis, Recombinant DNA Approaches, Protoplast Fusion, and Modern Methods - Adaptive Laboratory Evolution, Metabolic Engineering, CRISPR-Cas system	**4 hrs**
Unit 3: Fermentation Media and Sterilization Types of media, Media formulation strategies, Sterilization techniques: heat, radiation and filtration	**3 hrs**
Unit 4: Fermenters and Process Parameters: Design and components of fermenters, Types of fermenters, Aeration and agitation, Oxygen and mass transfer, Temperature and pH regulation, Filtration systems	**4 hrs**
Unit 5: Types of Fermentation and Bioreactors Solid-state fermentation, Submerged fermentation, Batch, fed-batch and continuous fermentation, Immobilized enzyme and cell bioreactors	**4 hrs**
Unit 6: Downstream Processing Cell disruption methods, Separation and extraction, Concentration and purification strategies, Industrial recovery challenges	**4 hrs**
Unit 7: Industrial Products: Beer, Citric acid, Penicillin, Glutamic acid, Vitamin B12, Yoghurt and cheese Single Cell Proteins (SCP) Active Learning: Single Cell Oils (SCO)	**5 hrs**
ENTREPRENEURSHIP and BIOETHICS (15 Hours)	
Unit 8: Entrepreneurial Foundations: Biotechnology entrepreneurship, Traits and skills of entrepreneurs, Creative and design thinking, Role of incubators, mentors and funding agencies.	**4 hrs**
Unit 9: From Idea to Business Model: Idea generation, Business plan preparation, Business Model Canvas, Funding sources (Angel investors, Venture capital, CSR, Government grants), Active Learning: Develop a biotechnology startup idea and prepare a Business Model Canvas and executive pitch	**5 hrs**
Unit 10: Regulatory Framework and IPR Biosafety guidelines (national and international overview), Good Manufacturing Practices (GMP), Intellectual Property Rights in biotechnology, Patents, licensing and technology transfer Active Learning: Case study analysis on GMO ethics / CRISPR controversy/biotechnology patent disputes	**3 hrs**
Unit 11: Introduction to Bioethics: Meaning and scope of bioethics, Ethical principles: autonomy, beneficence, non-maleficence, justice; Ethics in biotechnology research	**3 hrs**
Unit 12: Industrial and Environmental Ethics: GMOs and biosafety, Environmental impact of bioprocess industries Waste management and sustainability.	**3 hrs**

Practical VI: BT6P126: BIOPROCESS TECHNOLOGY

1. Preparation of media, strain selection, culture and maintenance of algal and fungal cultures I
2. Preparation of media, strain selection, culture and maintenance of algal and fungal cultures II
3. Principle and handling of a bioreactor
4. Production of Wine and Estimation of alcohol by specific gravity method.
5. Isolation and culturing of microbes for antibiotic sensitivity test
6. Immobilization of yeast
7. Estimation of citric acid from *Aspergillus niger*
8. Estimation of Lactic acid and Lactose
9. Isolation and estimation of proteins from industrially important sources.
10. Mushroom cultivation
11. Revision lab

REFERENCES

1 Stanbury, P.F., Whitaker, A., & Hall, S.J. (2017). Principles of Fermentation Technology (3rd ed.). Butterworth-Heinemann.
2 Crueger, W., & Crueger, A. (2017). Biotechnology: A Textbook of Industrial Microbiology (2nd ed.). Panima Publishing Corporation.
3 Prescott, S.C., & Dunn, C.G. (2002). Industrial Microbiology. Agrobios (India).
4 Glazer, A.N., & Nikaido, H. (2007). Microbial Biotechnology: Fundamentals of Applied Microbiology. Cambridge University Press.
5 Hisrich, R.D., Peters, M.P., & Shepherd, D.A. (2017). Entrepreneurship. McGraw Hill Education.
6 Osterwalder, A., & Pigneur, Y. (2010). Business Model Generation. Wiley Publications.
7 Desai, V. (2019). Entrepreneurial Development. Himalaya Publishing House.
8 Sateesh, M.K. (2008). Bioethics and Biosafety. I.K. International Publishing House.
9 Beauchamp, T.L., & Childress, J.F. (2019). Principles of Biomedical Ethics. Oxford University Press.
10 Government of India, Department of Biotechnology. Biosafety Guidelines and Regulations (latest edition).
11 World Health Organization. Laboratory Biosafety Manual (latest edition).

CO #	Course Outcome Statement	Bloom's Level	Category
CO1	**Explain** the fundamental principles of fermentation, media formulation, and the historical evolution of bioprocess industries.	L2	Understanding
CO2	**Apply** strain-improvement techniques (CRISPR, metabolic engineering) and	L3	Applying

CO #	Course Outcome Statement	Bloom's Level	Category
	sterilization methods to optimize industrial microbial yield.		
CO3	**Analyze** the design and operational parameters of various bioreactors and downstream processing steps for efficient product recovery.	L4	Analyzing
CO4	**Evaluate** the ethical, biosafety, and regulatory implications of GMOs and biotechnological research in a global and national context.	L5	Evaluating
CO5	**Develop** a comprehensive biotechnology business plan and Business Model Canvas (BMC) integrating innovation and funding strategies.	L6	Creating
CO6	**Execute** laboratory protocols for the production, estimation, and purification of industrial products like alcohol, organic acids, and enzymes.	L3	Applying

Semester	**VI**
Paper Code	**BT6226**
Paper Title:	**PLANT, ENVIRONMENTAL AND NANOBIOTECHNOLOGY**
Credits:	**3**
Teaching Hours per Week	**3**
Total Teaching Hours	**45**

Objective of the Paper: This course aims (i) to provide students with a foundational and applied understanding of plant biotechnology, covering transgenic and gene-edited crops, molecular pharming, and plant specialized metabolism, while highlighting their roles in food security, sustainable agriculture, and industrial and pharmaceutical applications, (ii) to equip students with a comprehensive understanding of environmental biotechnology principles and applications, focusing on sustainability, environmental genomics, bioremediation, wastewater treatment, biocontrol strategies, and clean energy technologies, with an emphasis on real-world case studies and regional environmental initiatives, and (iii) to introduce the fundamentals and multidisciplinary nature of nanobiotechnology, provide knowledge on different classes of nanomaterials, and help students understand the key design factors involved in the synthesis and fabrication of nanostructures. It also explores current and future applications of

nanostructured materials.

Scope: The course aims to introduce and familiarize concepts, principles, and practices in plant, environmental, and nano biotechnology. The practical sessions provide hands-on experience on relevant aspects of the aforementioned fields.

BT6226: PLANT, ENVIRONMENTAL, AND NANOBIOTECHNOLOGY	**45 Hrs**
PLANT BIOTECHNOLOGY	**15 Hrs**
Unit 1: Introduction to plant biotechnology	**2 hrs**
Statistics on population and food security, Concept of regenerative agriculture Impact of biotechnology on global agriculture and sustainability	1 hr 1 hr
Unit 2: Generation of transgenic plants	**6 hrs**
Plant transformation vectors A transgenic construct: promoters, terminators, selectable markers, reporter genes Plant transformation techniques- Particle gun method (Rice), *Agrobacterium*-mediated transformation (Tobacco) Case study: BT plants and Golden rice	1 hr 2 hr 2 hr 1 hr
Unit 3: Gene-edited plants	**3 Hrs**
Difference between gene-editing and genetic modification (GMOs), principle of CRISPR-mediated plant gene-editing. Case study: DRR Dhan 100 (Kamala) and Pusa DST Rice 1 Regulatory framework	2 hrs 1 hr
Unit 4: Molecular pharming	**2 hrs**
Plants as host systems for molecular pharming of industrial proteins/enzymes, therapeutic/pharmaceutical proteins, edible vaccines.	2 hrs
Unit 5: Plant specialized metabolites	**2 hrs**
Classification and roles of plant secondary/specialized metabolites: terpenoids, alkaloids, flavonoids, glycosides, phenolics **Active learning**- Applications of specialized metabolites, metabolic engineering	1 hr 1 hr
ENVIRONMENTAL BIOTECHNOLOGY	**15 hrs**
Unit 1: Environment and sustainability	**2 hrs**
Introduction: Global environmental issues, concepts of cleaner bioprocesses, eco-efficiency, and 5-R policy, case studies from Bangalore (Waste-to-Value Park at Kannahalli, wastewater treatment using soil biotechnology approaches at Herohalli lake).	2 hrs
Unit 2: Environmental genomics and biodiversity assessment	**2 hrs**
Methods (eDNA extraction, basic workflow of metabarcoding, metagenomics, sequencing from environmental samples), Microbiome assessment of sewage water, assessment of biodiversity, indicator species	2 hrs
Unit 3: Bioremediation	**3 hrs**

Introduction, types (*In situ, Ex situ*), techniques- bioaugmentation, biofilters, bioreactors, biostimulation, bioventing, composting. Examples of organisms used in bioremediation	3 hrs
Unit 4: Sewage and wastewater treatment	**2 hrs**
Overview of sewage treatment processes, levels of sewage treatment, anoxic and aerobic secondary treatment processes. Case studies: strain Improvement for enhanced sewage treatment	2 hrs
Unit 5: Biocontrol (Biological insecticides)	**1 hrs**
Concept of biocontrol and stewardship, viral insecticide (NPV), bacterial insecticide (*B. sphaericus*)	1 hrs
Unit 6: Clean energy	**3 hrs**
Biofuels: bioethanol, biogas, Microbial Fuel Cells (MFCs) **Active learning:** clean energy initiatives in Karnataka.	3 hrs
Unit 7: Biosensors	**2 hrs**
Introduction to environmental biosensors: biosensors used in detection of heavy metals, nitrogen compounds, pesticides, and herbicides	2 hrs
NANO-BIOTECHNOLOGY	**15 hrs**
Unit 1: Introduction to nanotechnology	**3 hrs**
Concept and definitions of Nanobiotechnology & historical background, classification of nanomaterials, raw qmaterials for nanotechnology: quantum dot, carbon-based nanostructures – buckyballs, graphene, nanotubes; metal-based nanostructures – gold and silver. Active learning: biological nanomaterials (chitosan).	3 hrs
Unit 2: Synthesis and characterization of nanoparticles	**3 hrs**
Physical methods: milling and laser pyrolysis method; chemical methods: sol-gel and co-precipitation method and biological methods (plants and microbes).	3 hrs
Unit 3: Techniques used in characterization of nanomaterials	**3 hrs**
Basic principles and applications of UV-visible spectroscopy, Fourier Transform Infrared Spectroscopy (FTIR), X-ray diffraction (XRD), Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Analysis (EDX), Transmission Electron Microscope (TEM).	3 hrs
Unit 4: Properties of nanomaterial	**4 hrs**
Optical, electronic, magnetic, and catalytic properties.	4 hrs
Unit 5: Application of nanotechnology	**2 hrs**
Agricultural (Nanopesticides), biomedical (Nano-bandages), and military (Nano-metamaterials).	2 hrs

BT6P226: Methodologies in Plant, Environment, and Nano Biotechnology

Plant Biotechnology

1. Biochemical tests for analyzing the secondary metabolites of medicinal plant samples.

2. Preparation of artificial seeds.
3. In-vitro plant cultivation (seed sterilization and maintenance of plants)

Environment Biotechnology

1. Determination of the DO, BOD, and COD in water samples-Part 1
2. Determination of the DO, BOD, and COD in water samples-Part 1
3. Analysis of the hardness of water sample
4. Isolation and growth response of petroleum-degrading bacteria from oil-contaminated soil/Isolation and screening of dye-degrading bacteria from textile effluent

Nano-Biotechnology

1. Green synthesis of silver nanoparticles
2. Chemical synthesis of Magnetic nanoparticles
3. Application of NPs for water purification/antimicrobial activity

Text Books/References:

Plant Biotechnology:

Adrian Slater, Nigel Scott and Mark Fowler, Oxford University Press, Metabolic engineering of plant secondary metabolism, Verpoorte and Alferman, 2000

Environmental biotechnology:

Textbook of Environmental Biotechnology – P K Mohapatra Environmental Biotechnology – Vallero Daniel

Environmental Biotechnology-New Approaches and Prospective Applications- Marian Petre

Bionanotechnology:

Ljiljana Fruk and Antonina Kerbs. Bionanotechnology: Concepts and Applications, Cambridge University Press, 2021

Madhuri Sharon, Maheshwar Sharon, Sunil Pandey and Goldie Oza. Bionanotechnology concepts and applications, CRC Press, 2012.

Pradeep T. A textbook of nanoscience and nanotechnology. Tata McGraw Hill Education,2012. Siddhartha Shrivastava. Introductory nanobiotechnology. New Central Book Agency, 2013

Arunava Goswami and Samrat Roy Choudhury. Nanobiotechnology, basic and applied Aspects. Anthem Press, 2017.

Semester	**VI**
Paper Code	**BT6326**
Paper Title	**Applied Medical Biotechnology**
Number of teaching hours per week	**3+2**
Total number of teaching hours per semester	**45**
Number of credits	**(T+P)**

Objective of the Paper:

This course aims to develop a strong conceptual and applied understanding of key biomedical biotechnology approaches used in disease diagnosis, therapeutic development, and clinical

research. It emphasizes experimental techniques, model systems, and clinical applications, along with ethical, biosafety, and regulatory considerations, to enable students to critically interpret biomedical data and appreciate the translational impact of biotechnology in modern medicine.

Unit 1: Introduction to Cell Culture	**5 hrs**
Cell culture laboratory set-up and biosafety, Types of cell culture and cell lines, Cell culture Media, Cryopreservation and Thawing, Applications in diagnostics, Active Learning - HeLa cells: scientific impact & ethics	
Unit 2: Quantitative assays	**5 hrs**
Principles and methodology of ELISA, Immunohistochemistry, Western blot, qPCR, Cell viability assays, Apoptosis assays, Flow cytometer	
Unit 3: Generation of transgenic model organisms	**4 hrs**
Methodology of production of Dolly, GloFish, SCID mouse, Mutant *Drosophila,* metabolic mouse models	
Unit 4: Immunotherapy	**5 hrs**
Hybridoma technology, Antibody conjugates, Therapeutic antibodies and Biologics. Active Learning - Case Studies: Trastuzumab (HER2 + breast cancer), Rituximab (B-cell lymphomas)	
Unit 5: Gene and Cell Therapy	**5 hrs**
Ex vivo and in vivo approaches, Gene editing tools, Stem cells: embryonic, adult, iPSCs, Clinical applications and limitations	
Unit 6: Regenerative Medicine	**4 hrs**
Tissue engineering basics, Biomaterials and scaffolds, Organoids and 3D cell culture models	
Unit 7: Cancer Biology	**6 hrs**
Concepts of carcinogenesis, concepts of protooncogenes, oncogenes, TSG, Cancer progression, types of carcinogens, Receptor Tyrosine Kinase pathway	
Unit 8: Cancer diagnostics and therapeutics	**4 hrs**
Stages of cancer and TNM system, Cancer biomarkers, Liquid biopsy, FNAC, CAR-T therapy	
Unit 9: Vaccines	**4 hrs**
Vaccine types with examples, COVID-19 vaccine (mRNA vaccine) as case study	
Unit 10: Clinical Trials	**3 hrs**

Phases I–IV, Ethical considerations, Regulatory approvals (DCGI, FDA, EMA – overview Case study- Covid 19 vaccine clinical trials	

Practical: BT6P26 - Techniques in Applied Medical Biotechnology

1. Trypan Blue assay
2. MTT assay and Cell culture demo
3. Western blotting I
4. Western blotting II
5. H&E staining
6. Enzyme extraction I
7. Enzyme extraction II
8. Analysis of chromosomal aberrations
9. Virtual lab/plate based ELISA
10. Collagen gel preparation
11. Revision Lab

Text Books / References

1.**Ian R. Freshney**, *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications*, 7th Edition, Wiley-Blackwell.
2. **Landecker, Hannah**, "*Immortality, In Vitro: A History of the HeLa Cell Line*," **BioSocieties**.
3. **Kuby Immunology**, Owen J.A., Punt J., Stranford S.A., Jones P.P., *8th Edition*, W.H. Freeman & Company.
`4. **Fundamentals of Clinical Trials**, Lawrence M. Friedman et al., *5th Edition*, Springer. *(Classic reference for Phases I–IV and trial evaluation)*
5.Hanahan, D., & Weinberg, R. A. (2000). The hallmarks of cancer. Cell, 100(1), 57–70. https://doi.org/10.1016/S0092-8674(00)81683-9

CO No.	Course Outcome	Bloom's Level	Category
CO1	Explain the basic concepts and scope of biomedical biotechnology and its role in health and disease.	Remember, Understand	Knowledge, Comprehension
CO2	Describe fundamental animal cell culture techniques, laboratory safety, and ethical practices used in biomedical research.	Understand	Comprehension
CO3	Explain the principles of common diagnostic and analytical techniques used in biomedical and clinical laboratories.	Understand, Apply	Comprehension, Application
CO4	Outline the basic concepts of vaccines, monoclonal antibodies, gene therapy, and their biomedical applications.	Understand	Comprehension

CO5	Describe the basic molecular basis of human diseases, including cancer, and relate laboratory studies to clinical applications.	Understand, Analyze	Comprehension, Analysis

Semester	**VI**
Paper Code	**BT6S26**
Paper Title	**Graduate research seminars**
Number of teaching hours per week	3
Total number of teaching hours per semester	30+3
Number of credits	**2**

Objective of the Paper: The goal of this paper is to improve students' skills in scientific communication and their ability to evaluate and discuss biotechnology research. Students will be required to deliver a presentation of relevant scientific literature to a diverse audience, attend presentations of other students' work, and participate in discussions of the presented research. All 6th-semester biotechnology students are mandated to participate in these seminars.

Through this course, students will:

- read research papers
- ask relevant questions
- present science clearly and concisely
- design research ideas
- understand ethics and innovation

Course structure:

Session 1: Introduction to Research Seminars	
● What is graduate-level research? ● Seminar expectations and format ● How to read scientific papers efficiently	3 hrs
Session 2: Cell Biology	3 hrs
Session 3: Cell Biology	3 hrs
Session 4: Molecular biology	3 hrs
Session 5: Molecular biology	3 hrs
Session 6: Methods	3 hrs
Session 7: Methods	3 hrs

Session 8: Medical biotechnology	3 hrs
Session 9: Medical biotechnology	3 hrs
Session 10: Genetic engineering	3 hrs
Session 11: Genetic engineering	3 hrs

Students will be given 2-3 relevant research papers every week, which they will discuss within their peer groups and present to the class. These seminars will be student-led and faculty-moderated discussions. Students will also perform a review of the literature and prepare a draft of a review article.

Evaluation:

- Class presentation: 25 M (7M: oral presentation, 5M: design and clarity, 8M: understanding, 5M: response to questions)
- Summary of class presentations: 15M
- Attendance and class engagement: 10M

Course Outcomes:

CO	Course Objective Statement	Bloom's Level	Category
CO1	**Critically analyze** primary research articles to appreciate experimental designs and independently arrive at data-driven conclusions.	L4 & L5	Analysis & Evaluation
CO2	**Synthesize and present** complex biological data into clear, concise oral presentations using appropriate visual aids.	L6	Synthesis / Creation
CO3	**Construct** a technical literature review that organizes existing research.	L6	Creation
CO4	**Formulate** evidence-based questions during peer discussions to demonstrate active engagement in scientific discourse.	L4	Analysis

CO5	**Debate** innovative potential of emerging technologies in medical and genetic engineering.	L5	Evaluation

Semester	**VI**
Paper Code	**BT6PW26**
Paper Title	**Project Work**
Number of teaching hours per week	3+3
Total number of teaching hours per semester	60+6
Number of credits	**4**

The modalities of this have to be clarified by the Registrar's office.