ST JOSEPH'S UNIVERSITY

BENGALURU-27

DEPARTMENT OF BIOTECHNOLOGY

SYLLABUS FOR UNDERGRADUATE PROGRAMME

SJU SYLLABUS

For Batch 2022 -2025

Part A			
1	Title of the Academic Program	B.Sc. Biotechnology (Major)	
2	Program Code	**CBT, Bc-BT, Bi-BT(Biotechnology with Chemistry, Biochemistry and Biology)**	
3	Name of the University	St Joseph's University	
4	Objectives of the University	1. Academic Excellence 2. Character Formation 3. Social Concern	
5	Vision of the University	"Striving for a just, secular, democratic and economically sound society, which cares for the poor, the oppressed and the marginalized"	
6	Mission of the University	M1	St Joseph's University seeks to form men and women who will be agents of change, committed to the creation of a society that is just, secular and democratic.
		M2	The education offered is oriented towards enabling students to strive for both academic and human excellence.
		M3	The college pursues academic excellence by providing a learning environment that constantly challenges the students and supports the ethical pursuit of intellectual curiosity and ceaseless enquiry.
		M4	Human excellence is promoted through courses and activities that help students achieve personal integrity and conscientize them to the injustice prevalent in society.
7	Name of the Degree	Bachelor of Science (B.Sc.)	
8	Name of the Department offering the program	Biotechnology	
9	Vision of the Department offering the program	The Department of Biotechnology strives to introduce students to the joys of learning science, to inspire them to enquire, imagine and excel, and equip them to integrate this learning into living.	
10	Mission of the department offering the Program	● The Department of Biotechnology, through its curricular and research based pedagogical approaches, aims to engage students in conversations about basic concepts and advances in the field of Biotechnology. ● The Department strives to provide students with authentic learning experiences that encompass a spirit of enquiry, research, problem-solving and entrepreneurship.	

		● The Department is also invested in creating among its students a strong awareness of social and environmental problems at both local and global scales, mentoring them to identify meaningful academic and career opportunities, whilst inculcating them a strong sense of academic and personal integrity.	
11	Duration of the Program	3 years (Six semesters)	
12	Total No. of Credits	TO BE ANNOUNCED	
13	Program Educational Objectives (PEOs)	PEO 1	The two major program of Biotechnology with a combination of Chemistry, Biochemistry and Biology gives students insights into basic and applied aspects of these disciplines, besides equipping them with hands-on laboratory skills and the ability to analyze information based on scientific evidence, while also instilling an awareness of scientific engagement in addressing relevant social and environmental issues that affect humankind.
		PEO 2	
		PEO 3	
14	Graduation Attributes		The Following graduate attributes reflect the particular quality and feature or characteristics of an individual, that are expected to be acquired by a graduate through studies at St. Joseph's College. ● **Disciplinary knowledge** ● **Analytical reasoning** ● **Critical thinking** ● **Problem solving** ● **Communication Skills** ● **Research skills** ● **Cooperation/Teamwork** ● **Reflective thinking** ● **Information/digital literacy** ● **Self-directed learning** ● **Multicultural competence** ● **Moral and ethical awareness/reasoning** ● **Leadership readiness/qualities** ● **Global Outlook**
15	Program Outcomes (POs)	PO1	
		PO2	
		PO3	
		PO4	

16	Program Specific Outcomes (PSOs)	PSO1	Students graduating from the Biotechnology program will gain an understanding of the cellular, genetic, biochemical, and molecular foundations of life, besides attaining domain knowledge of biostatistics, bioinformatics, and immunology as well as applied aspects of biotechnology including genetic engineering, medical, environmental, plant and animal biotechnology, and entrepreneurship.
		PSO2	Students will achieve competency in a variety of laboratory skills including techniques in cell and molecular biology, microbiology, genetic engineering and applied biotechnological aspects, through hands on practical experience and practice, while consistently observing good laboratory practice.
		PSO3	Students will gain exposure to the basics of research, and have an appreciation of research methodology, through faculty supervised term papers and research projects.
		PSO4	The program will enable students to hone their skills of analytical thinking and problem solving, through a series of curricular and research-based pedagogical interventions.
		PSO5	Students will also learn and build on proficiencies in science communication, teamwork and collaboration, enabled by regular innovative assignments and activities.
		PSO6	The program will foster an appreciation of environmental, health associated and sustainability related issues at local and global scales, and the role of scientific acumen and evidence-based engagement in understanding and addressing these problems.

Part B

Sl.No	Course details	Credits

1.	Biotechnology	6
2.	Biology /Biochemistry/Chemistry	6
3.	Open Elective	3
4.	Language 1	3
5.	Language 2	3
6.	Skill based crédits	2
7.	Value based crédits	2

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	BT121	Cell biology and Genetics	56	4	4	40	60	100
Practical	BTP121	Cell biology and Genetics	44	4	2	15	35	50
Open elective	BT OE 1	Biotechnology for human welfare	42	3	3	40	60	100
Total Number of credits:					**9**			
Semester 2	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	BT221	Microbiological methods	56	4	4	40	60	100
Practical	BTP221	Microbiological methods and techniques	44	4	2	15	35	50
Open elective	BTOE2	Sustainable Agriculture and food security	42	3	3	40	60	100
Total Number of credits:					**9**			
Semester 3	Code Number	Title	No. of Hours of Instructions	Number of teaching hrs /week	Number of credits	Continuous Internal Assessment (CIA) marks	EndSemester Marks	Total marks
Theory	BT322	Biomolecules and Biostatistics	56	4	4	40	60	100
Practical	BTP322	Biomolecules and Biostatistics	44	4	2	15	35	50
Open elective	BTOE3	Biotechnology perspectives on sustainability and clean energy	42	3	3	40	60	100
Total Number of credits:					**9**			

Semester 4	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	BT422	Molecular Biology	56	4	4	40	60	100
Practical	BTP422	Molecular Biology	44	4	2	15	35	50
Open Elective	BTOE4	Evolution and origin of life	42	3	3	40	60	100
Open elective	BTOE5	Viruses-Friends or Foes	42	3	3	40	60	100
Total Number of credits:					**9**			
Semester 5	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	BT5123	Genetic Engineering and Bioinformatics	42	3	3	40	60	100
Theory	BT5223	Immunology and Medical Biotechnology	42	3	3	40	60	100
Practical	BTP5123	Techniques in Genetic Engineering and Bioinformatics	44	4	2	15	35	50
Practical	BTP5223	Immunology	44	4	2	15	35	50
Total Number of credits:					**10**			
Semester 6	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	BT6123	Bioprocess Technology and Entrepreneurship	42	3	3	40	60	100
Theory	BT6223	Plant, Environmental and Animal Biotechnology	42	3	3	40	60	100

Practical	BTP6123	Bioprocess Technology	44	4	2	15	35	50
Practical	BTP6223	Project work	44	4	2	15	35	50
Total Number of credits:					**10**			

COURSE OUTCOMES AND COURSE CONTENT

Semester	**I**
Paper Code	**BT121**
Paper Title	**Cell Biology and Genetics**
Number of teaching hours per week	**04T + 04P**
Total number of teaching hours per semester	**56**
Number of credits	**04 + 2 (T+P)**

Objective of the Paper: This course introduces students to the structural and functional foundations of prokaryotic and eukaryotic cells and teaches the basics of Mendelian and Population Genetics. The Cell Biology section deals with cellular and organellar structure and function, besides dealing with the molecular events in cell communication and the cell cycle. The Genetics section of the course deals exhaustively with Mendelian genetics and provides an introduction to human genetics.

Unit 1: Cell as a Basic unit of Living Systems and Cellular Organelles	14Hrs
Historical perspectives. Discovery of cell, the cell Theory, Ultra structure of a eukaryotic cell (Both plant and animal cells), Structural organization and functions of cell wall and plasma membrane. Structure and functions of cell organelles – Cytosol, Endoplasmic reticulum, Golgi complex, Mitochondria, Chloroplast, Ribosomes, Lysosomes, Peroxisomes, Nucleus, Nucleolus, vacuole, Cytosol and Cytoskeleton structures (Microtubules, Microfilaments and Intermediate filaments).	
Unit 2. Chromosomes and Cell Division	14Hrs
General Introduction, Discovery, Morphology and structural organization – centromere, secondary constriction, telomere, chromonema, euchromatin and heterochromatin, chemical composition and karyotype. Single-stranded and multi-stranded hypothesis, folded- fibre and nucleosome models. **Special type of chromosomes:** Salivary gland chromosome and Lamp-brush chromosomes. Cell cycle, phases of cell division, mitosis and meiosis, cell cycle check points, enzymes involved in regulation, cell signaling, cell communications, significance of cell cycle, achromatic apparatus, synaptonemal complex, cell Senescence and programmed cell death.	
Unit 3. Genetics:	14Hrs

History of genetics: Mendelian theory; Laws of inheritance- dominance, segregation, incomplete dominance, codominance with an example. Law of independent assortment, test cross, back cross and non-Mendelian inheritance. **Maternal Inheritance:** Plastid inheritance in Mirabilis, Kappa particles in paramecium and Petite characters in yeast, Sex-linked inheritance, Chromosome theory of inheritance. **Gene interaction:** Supplementary factors: comb pattern in fowls, Complementary genes- Flower colour in sweet peas, Multiple factors–Skin colour in human beings, Epistasis– Plumage colour in poultry, Multiple allelism: Blood groups in Human beings.	
Unit 4. Linkage And Mutation	14Hrs
Introduction, Coupling and repulsion hypothesis, Linkage in maize and Drosophila, Mechanism of crossing over and its importance, chromosome mapping-linkage map in maize. **Self learning- Mutations:** Types of mutations, Spontaneous and induced mutagens: Physical and chemical, Mutation at the molecular level, Mutations in plants, animals and microbes and its merits and demerits. Structural and numerical chromosomal aberrations. **Sex Determination in Plants and animals:** Concept of allosomes and autosomes, XX- XY, XX-XO, ZW-ZZ, ZO-ZZ types. Allosomal (Klinefelter syndrome and Turner's syndrome), Autosomal (Down syndrome and Cri-Du-Chat Syndrome) conditions.	

Practical I BTP121: Cell Biology and Genetics

1) Operation and working principle of simple and compound microscope
2) Use of Micrometer, measurement of onion epidermal cells and yeast
3) Study of mitosis from onion root tips
4) Study of meiosis in grasshopper testes/onion or Rhoeo flower buds.
5) Mounting of polytene chromosomes
6) Buccal smear - Barr bodies
7) Karyotype analysis - Human (Normal and Abnormal) and Onion
8) Isolation and staining of Mitochondria/ Chloroplast
9) Enumeration of RBC using Haemocytometer
10) Simple genetic problems based on theory
11) Blood typing

Text Books / References

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.

COURSE OUTCOMES FOR BT121: CELL BIOLOGY AND GENETICS

After successful completion of the course, students will:

CO1	Gain a nuanced understanding of cellular architecture and diversity of prokaryotic and eukaryotic cells, as well as insights into the ultrastructure, and roles of cellular organelles in various cellular functions.
CO2	Develop a deeper appreciation for the complexity and intricacy of cellular structure and function, and be able to form cross disciplinary connections relevant to cell structure and function.
CO3	Have a profound understanding of concepts in classical genetics and its exceptions, as well as a basic knowledge of population genetics and applications of linkage in quantitative genetics.
CO4	Be able to perform a variety of laboratory techniques routinely used for counting, staining and visualizing cells, be able to prepare and identify stages in mitotic and meiotic slides and answer questions pertaining to karyotypes and model organisms.
CO5	Achieve competence in undergraduate level problem solving skills relevant to the disciplines of cell biology and genetics.

COURSE OUTCOMES AND COURSE CONTENT

Semester	**II**

Paper Code	**BT221**
Paper Title	**Microbiological methods**
Number of teaching hours per week	**04T + 04P**
Total number of teaching hours per semester	**56**
Number of credits	**04 + 2 (T+P)**

Objective of the Paper:

This paper 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: DSC-2T, Microbiological Methods	**56 Hrs**
Unit 1:Instrumentation	**14Hrs**
Microscopy: Principles of Microscopy- resolving power, numerical aperture, working principle and applications of light, Compound microscope, Dark field microscope, Phase contrast microscope, Fluorescence Microscope, confocal microscope, Electron Microscopes- TEM and SEM. **Analytical techniques:** Working principles and applications: Centrifuge, Ultracentrifuge, Spectrophotometer, Chromatography: Paper and TLC.	
Unit 2: Sterilization techniques	**14Hrs**
Definition of terms; **Physical methods of control:** Principle, construction and applications of moist heat sterilization, Boiling, Pasteurization, Fractional sterilization-Tyndallization and autoclave. Dry heat sterilization-Incineration and hot air oven. Filtration – Diatomaceous earth filter, seitz filter, membrane filter and HEPA ; Radiation : Ionizing radiation-γ rays and non ionizing radiation- UVrays **Chemical methods:** Alcohol, aldehydes, phenols, halogen, metallic salts, Quaternary ammonium compounds and sterilizing gases as antimicrobial agents.	
Unit 3: Microbiological techniques	**14Hrs**

Culture Media: Components of media, natural and synthetic media, chemically defined media, complex media, selective, differential, indicator, enriched and enrichment media **Pure culture methods**: Serial dilution and plating methods (pour, spread, streak); cultivation, maintenance and preservation/stocking of pure cultures; cultivation of anaerobic bacteria **Stains and staining techniques:** Principles of staining, Types of stains-simple stains, structural stains and differential stains.	
Unit 4: Antimicrobial agents and assessment of antimicrobial activity	**14Hrs**
Mode of action of antimicrobial agents: Antifungal agents: Amphotericin B, Griseofulvin Antiviral agents: Amantadine, Acyclovir, Azidothymidine Antibacterial agents: Plazomicin, Ervacycline, Omadacyclin and Imipenum. Challenges in antimicrobial therapy; Emergence of antibiotic resistance (MDR, XDR) **Assessment of antimicrobial activity:** Antibacterial-Disc and agar well diffusion techniques, Microdilution method, Zone of inhibition, MCB, Determination of IC 50. Antifungal-Determination of MFC, Time kill kinetics assay, sorbitol assay. Antiviral-CPE, virus yield reduction assay, TCID, Neutralization ASSAY, Hemagglutination inhibition.	

Practical II: BTP221: Microbiological Methods and techniques

1. To study the principle and applications of important instruments (biological safety cabinets, autoclave, incubator, BOD incubator, hot air oven, light microscope, pH meter) used in the microbiology and Biotechnology laboratory.
2. Sterilization of medium using Autoclave and assessment for sterility
3. Sterilization of glassware using Hot Air Oven and assessment for sterility
4. Sterilization of heat sensitive material by membrane filtration and assessment for sterility
5. Preparation of culture media for bacteria, fungi and their cultivation.
6. Plating techniques: Spread plate, pour plate and streak plate.
7. Isolation of bacteria and fungi from soil, water and air
8. Study of Rhizopus, Penicillium, Aspergillus using temporary mounts
9. Colony characteristics study of bacteria from air exposure plate
10. Staining techniques: Bacteria– Gram, Negative, Capsule, Endospore staining
    Fungi – Lactophenol cotton blue staining
11. Water analysis - MPN test
12. Biochemical Tests – IMViC, Starch hydrolysis, Catalase test, Gelatin hydrolysis

13. Bacterial cell motility – hanging drop technique.

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.
5. 5th edition Tata McGraw Hill.
6. Srivastava S and Srivastava PS. (2003). Understanding Bacteria. Kluwer Academic Publishers, Dordrecht
7. Stanier RY, Ingraham JL, Wheelis ML and Painter PR. (2005). General Microbiology. 5th edition McMillan.
8. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9th edition Pearson Education.
9. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.
10. Cappucino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited
11. Microbiology- Concepts and applications by Paul A. Ketchum, Wiley Publications
12. Fundamentals of Microbiology –Frobisher, Saunders & Toppan Publications
13. Introductory Biotechnology-R.B Singh C.B.D. India (1990)
14. Fundamentals of Bacteriology - Salley
15. Frontiers in Microbial technology-P.S. Bison, CBS Publishers.
16. Biotechnology, International Trends of perspectives A. T. Bull, G.
17. General Microbiology –C.B. Powar

COURSE OUTCOMES for BT 221: Microbiological Methods

After successful completion of the course, students will:

CO1	Develop an appreciation of the diversity of the microbial world and understand the basic instrumentations used in microbiological laboratories.
CO2	Be able to determine growth parameters in bacteria, understand the basis of molecular interactions and build on them, besides selecting and implementing microbial control methodologies for basic laboratory purposes.
CO3	Acquire competence to design and prepare different culture media, design methodology to isolate and culture microorganisms and have a good grasp of various techniques for identification of bacteria and fungi.
CO4	Have an understanding on how to use antimicrobial agents and perform assessment of antimicrobial activity

COURSE OUTCOMES AND COURSE CONTENT

Semester	**III**
Paper Code	**BT322**

Paper Title	**Biomolecules and Biostatistics**
Number of teaching hours per week	**04T + 04P**
Total number of teaching hours per semester	**56**
Number of credits	**04 + 2 (T+P)**

Objective of the Paper: This paper has two course subjects. The syllabus covers Biochemistry in both practical and theoretical aspects. The other portion covers an intermediate biostatistics knowledge that is of use in biological research.

Content of Course: DSC-3T,	**56 Hrs**
Biomolecules	**28Hrs**
Unit 1: Introduction	**2 hrs**
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, 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. Principles of extraction and purification of proteins – salt and solvent precipitation, Dialysis for protein purification. **Active Learning**-Classification of proteins based on structure, function and composition	3 hrs 2 hrs 1 hr 1 hr
Unit 4: Enzymes	**5 hrs**

Classification – types and functions, enzyme 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. Concepts of Km and Vmax. Enzyme inhibition – competitive, uncompetitive and Non-competitive	1 hr 2hrs 2hrs
Unit 5:Lipids	**5 hrs**
Classification, functions and biological role of lipids Classification and Structure of fatty acids Properties of triacylglycerols and test for purity of lipids. Properties of phospholipids, sphingolipids, glycolipids, steroids and amphipathic lipids	2 hrs 1 hr 1 hr 1 hr
Unit 6: Nucleic Acid	**5 hrs**
Chemical composition, structures; nucleosides, nucleotides; Watson & Crick model, Types of DNA – A, B and Z Types of RNA with structure and functions	3 hrs 2hrs
Biostatistics	**28 Hrs**
Unit 1: Introduction	**1 hrs**
Definition of selected terms Scale of measurements, Methods of collecting data, Presentation of data statistical tables, Need for reduction of data.	
Unit 2: Measures of Central Tendencies	**4 hrs**
Measures of averages and location: Mean, Median, Mode	
Unit 3: Measures of Dispersion	**5 hrs**
Range, quartile deviation, Mean deviation, Variance & Standard deviation, Coefficient of Variance	
Unit 4: Population and Sampling Techniques Concepts of statistical population and sample need for sampling studies; Simple procedures of random sampling; Methods of sampling.	**3 hr**
Unit 5: Probability	**6 hrs**
Basic concepts; Basic theorems of probability addition and multiplication theorems; Conditional probability, Bayes Theorems; Probability distribution definition & applications; Binominal distribution and its application; Poisson distribution and its application; Normal distribution and its application.	

Unit 6: Correlation and Regression	**3 hrs**
Correlation concept and applications; Regression concept and applications	
Unit 7: Hypothesis Testing	**6 hrs**
Logic of statistical standard error estimation testing of hypothesis; Tests of significance: Normal deviate tests (Z test); Student's "t" test; Chi-Squared test; F. test and analysis of variance; Statistics in Genetics	

Practical II: BTP322: Biomolecules and Biostatistics

1. Introduction to R software
2. Central tendencies and measures of dispersion
3. Basics of probability
4. Distributions I – Normal distribution
5. Distributions II– Binomial and Poisson distribution
6. Correlation and Regression
7. Hypothesis testing, Student's t-test, Chi-squared test and ANOVA.
8. Introduction to molarity, molality and normality, Calculations for solution preparations. Instruments: Handling of colorimeter and spectrophotometer.
9. Estimation of Reducing Sugars by DNS method.
10. Estimation of DNA by Diphenylamine method.
11. Estimation of protein by Biuret method.

Text Books / References

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

BIOMOLECULES:

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

COURSE OUTCOMES for BT 322:

After successful completion of the course, students will:

CO1	Understand structures, functions and importance of biomolecules
CO2	Be able to design experiments, conduct and analyze experiments and carry out estimations of important biomolecules
CO3	Be able to consolidate, present data in tables, graphs and describe any distribution using the standard population parameters.

CO4	Gain expertise in the use of R programming in biostatistical analyses.

COURSE OUTCOMES AND COURSE CONTENT

Semester	**IV**
Paper Code	**BT422**
Paper Title	**MOLECULAR BIOLOGY**
Number of teaching hours per week	**04T + 04P**
Total number of teaching hours per semester	**56**
Number of credits	**04 + 2 (T+P)**

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: DSC-4T	**56 hrs**
Molecular Biology	**56 hrs**
Unit 1:DNA Structure and function	**8 hrs**
Classical experiments: Griffith's, Avery and Hershey - Chase experiments	2 hrs
The race to enumerate the structure of DNA, Watson and Crick's model of the DNA double helix	2 hrs
DNA Compaction and Structure of eukaryotic chromosomes/eukaryotic gene	2 hrs
Active learning exercise: Analysis of data from classical experiments that led to the discovery of DNA structure	2 hrs
Unit 2: DNA Replication	**10 hrs**
Semiconservative model of replication (Meselson & Stahl experiment)	1 hr
Bidirectionality and semi-discontinuous nature of replication	2hrs
Replication fork and the main scheme of DNA replication	1 hrs
Replication in Prokaryotes: Initiation, elongation and termination	3 hrs
Replication in Eukaryotes: Initiation, elongation and termination, telomeres, telomerase	3 hrs
Unit 3: DNA Damage and repair	**9 hrs**
Radiation Damage, DNA instability, Oxidative damage, Alkylation Damage	2 hrs
Introduction to mutagens, types of mutagens (chemical, physical and biological)	1 hr
Active learning exercise*:* Mutations and Cancer	1 hr
Photoreactivation, Excision Repair, Mismatch repair and SOS response	3 hrs
Non homologous end joining and Homologous recombination to repair double stranded DNA breaks	2 hrs

Unit 4: Gene expression: Transcription	**10 hrs**
Promoters, General Transcription factors, DNA binding domains	1 hr
Bacterial Transcription Initiation, Elongation and Termination	3 hrs
Eukaryotic RNA Polymerases, Promoters, Eukaryotic Transcription Initiation, Elongation and Termination	3 hrs
Processing of eukaryotic mRNAs-Capping, Splicing and Polyadenylation	3 hrs
Unit 5: Gene expression: Translation	**10 hrs**
Structure of Ribosomes, Transfer RNA, Aminoacylation, mRNA and the Genetic Code.	3 hrs
Molecular events of Translation initiation, elongation and termination in prokaryotes	3 hrs
Molecular events of Translation Initiation, Elongation and Termination in eukaryotes	3 hrs
Post translational processing of proteins	1 hr
Unit 6: Gene expression regulation	**9 hrs**
Concept of regulation, overview of gene regulation	1 hr
Prokaryotic Gene Regulation-Lac and Trp operons	4 hrs
Eukaryotic Gene Regulation- Regulatory promoter elements, changes in chromatin structure and DNA methylation	4 hrs

Practical IV: BTP422: Molecular Biology

1. Introduction to DNA Isolation and Discussion of Cheek cell DNA isolation (Protocol A)
2. Preparation of buffers and Cheek cell DNA Isolation
3. Agarose Gel electrophoresis
4. Presentation of DNA isolation protocol B by students groups and calculations
5. Calculations and preparation of buffers for protocol B
6. DNA isolation by student groups using Protocol B
7. Analysis/Comparison of DNA quality and concentration, Agarose gel electrophoresis
8. Understanding Protein Structure and SDS PAGE
9. Extraction of total protein from dal / lentil samples
10. 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

COURSE OUTCOMES for BT422:

After successful completion of the course, students will:

CO1	Gain an understanding of how genomes are maintained, genes are expressed and regulated
CO2	Have the ability to read and understand primary scientific literature and appreciate both classical experimentation in the field of molecular biology.

CO3	Exhibit competence in performing basic experiments involving isolation and analysis of DNA and Protein

COURSE OUTCOMES AND COURSE CONTENT

Semester	**V**
Paper Code	**BT5123**
Paper Title	**GENETIC ENGINEERING AND BIOINFORMATICS**
Number of teaching hours per week	**03T + 04P**
Total number of teaching hours per semester	**42**
Number of credits	**03 + 2 (T+P)**

Objective of the Paper: The course introduces the students to details in cloning and Bioinformatics. Both the concepts are futuristic and interesting. The paper covers a detailed conceptual module supported by a strong practical session on these concepts.

Content of Course: DSC-5T1,	**42 Hrs**
GENETIC ENGINEERING	**28 Hrs**
Unit 1: Introduction	**2 hrs**
Principles of Recombinant DNA Technology & Genetic Engineering techniques (in brief), applications, goals, and ethical issues.	
Unit 2: General Methods of Transformation	**3hrs**
Methodology, Advantages and Disadvantages of the following methods of transformation: Competence-Induction, Biolistics, Lipofection, Electroporation, Microinjection, Macroinjection, DNA co-precipitation, Sonication, *Agrobacterium* mediated.	

Unit 3: 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 hrs
Unit 4: Vectors for cloning	**11 hrs**
Natural plasmids, PBR322 and PuC19: Design and Advantages. Cloning Vectors based on bacterial plasmids Scheme of cloning-restriction, ligation, Lambda Bacteriophages- Insertional vectors and Replacement vectors- features and design. M13 Bacteriophage- features and designs Cosmids and Phagemids - definition, features, design with examples List of vectors for cloning in Yeasts (*S. cerevesiae, P. pastoris)*- features with examples YAC- features and designs	2 hrs 3 hrs 2 hrs 1 hr 1 hr 1 hr 1 hr
Unit 5:Techniques in cloning and gene analysis	**4 hrs**
PCR, Genomic libraries and cDNA libraries, Introduction to molecular markers. **Active learning**- Southern blotting	
Unit 6: Techniques related to Genomes	**4 hrs**
Techniques of genome sequencing- Sanger, NGS, Nanopore Applications of genomics **Active learning**- Genome editing by Crispr-Cas	2 hr 1 hr 1 hr
BIOINFORMATICS	**14 Hrs**
Unit 1:Introduction and applications	**1 hr**
Introduction to bioinformatics, connections to genes and genomes, applications in genomics, gene expression, protein structure, history of Bioinformatics	
Unit 2: Databases	**2 hrs**
Gateway sites (NCBI, EMBL, DDBJ), concept and structure of a database, Examples- Genbank, Uniprot, NCBI Genomes, PDB	
Unit 3: Analysis of sequences	**5 Hrs**
Similarity searching, global and local alignments; BLAST- concept and applications, algorithm (scoring matrices, penalties etc.), output and interpretation (E-value); Multiple Sequence Alignment (MSA)- concept and applications, CLUSTAL, output and interpretation	
Unit 4: Phylogenetic analysis	**3 hrs**
Concept of a phylogeny, connection between MSA and phylogenies (neighbor joining method), **Active learning**-basics of ancestral sequence/trait mapping	
Unit 5:Structure databases	**2 hrs**
Protein structure database (PDB)- data format, major features of protein structure, basic principles of docking, principles of homology modeling	
Unit 6:Literature search and Pubmed	**1 hrs**

Citations, references, and literature search, Pubmed	

Practical V: BTP5121: Techniques in Genetic engineering and bioinformatics

1. Isolation of plasmid from an assigned organism
2. Single and double restriction digestion of the plasmid DNA (EcoR1, Hind III, BamHI) and its analysis by electrophoresis
3. Purification of an isolated fragment.
4. Amplification by PCR
5. Ligation of a fragment to a restricted vector
6. Preparation of competent cells
7. Transformation of ligated DNA
8. Bioinformatics- Genome Data Viewer, PubMed
9. Sequence analysis- BLAST and CLUSTALX
10. Structure analysis tool- Rasmol, Swiss PDB Viewer

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. Bruce Alberts, Molecular Cell Biology Ernst L. Winnacker,
4. From Genes to Clones: Introduction to Gene technology Principles of Gene Manipulation and Introduction to Genetic Engineering, 3rd Ed
5. Purohit,S.S., Biotechnology Fundamentals and Application- Himalaya Publications.
6. Glick & Pasternack, Molecular Biotechnology.

Bioinformatics:

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

COURSE OUTCOMES for BT 5123:

After successful completion of the course, students will:

CO1	Understand concepts in cloning and construct strategies to minimize ethical concerns in recombinant DNA technology
CO2	Construct and perform experiments in cloning by handling enzymes and instruments like PCR that are used for genetic engineering.
CO3	Choose and execute Bioinformatics softwares that are relevant for specific outcomes.
CO4	Analyze the outcomes of basic bioinformatics programmes and present the same in specific formats.

COURSE OUTCOMES AND COURSE CONTENT

Semester	**V**
Paper Code	**BT5223**
Paper Title	**IMMUNOLOGY AND MEDICAL BIOTECHNOLOGY**
Number of teaching hours per week	**03T + 04P**
Total number of teaching hours per semester	**42**
Number of credits	**03 + 2 (T+P)**

Objective of the Paper: This course deals with the fundamentals of Immunology. It familiarizes the student with basics of the human immune system and immune response.It outlines the basics and builds into an in-depth understanding of both humoral and cellular immune responses. The practical sessions allow for hands-on training in immunological experiments. Medical biotechnology covers the epidemiological aspects of disease and the technological means to diagnose and treat them

Content of Course: DSC-5T2,	**42 Hrs**
IMMUNOLOGY	**28 Hrs**
Unit 1: Fundamentals of Immunology	**4 hrs**
Innate and Acquired Immunity Mechanisms of innate immunity - Inflammation, Phagocytosis Case study of infection Immune response	
Unit 2: Cells and Organs of The Immune System	**4 hrs**
Hematopoiesis, Cells of the immune system - Granulocytes, Macrophages, Dendritic Cells, NK Cells Lymphocytes - Development, Maturation, Activation and Selection of T cells and B cell Primary and Secondary Lymphoid Organs	
Unit 3: Antigens	**1 hr**
Concept of Epitopes and Paratopes, Types of antigens Factors affecting Immunogenicity Concept of Adjuvants and Haptens	
Unit 4: Antibodies	**3 Hrs**
History of Antibodies, General structure and properties of antibodies Structure and functions of Immunoglobulins - IgG, IgM, IgA, IgE, IgD Active Learning - novel antibody variants	

Unit 5: Immunogenes	**3 hrs**
Historical experiments in immunogene, Immunogene structure VDJ Recombination	
Unit 6: Antigen - Antibody Interactions	**2 hrs**
Primary interactions between antigen and antibody - electrostatic, hydrogen, hydrophobic and Van der Waal's interactions Secondary interactions - Agglutination and Precipitation, Concepts of Affinity and Avidity	
Unit 7: Major Histocompatibility Complex and Antigen Presentation	**3 hrs**
Structure of MHC I and MHC II Synthesis and assembly of MHC I and MHC II Exogenous and Endogenous antigen processing pathways	
Unit 8: Immunotolerance	**2 hrs**
Central tolerance Peripheral tolerance	
Unit 9: Humoral Response	**4 hrs**
Primary and secondary humoral response Theories of antibody production - instructive and selective theory Somatic hypermutation, Class switch recombination, Affinity maturation	
Unit 10: Cell Mediated Response	**2 hrs**
Perforin and granzyme pathways Death receptor ligand signaling	
MEDICAL BIOTECHNOLOGY	**14 Hrs**
Unit 1- Epidemiology:	**2 hrs**
Introduction to epidemiological studies (terminology) Methods of disease transmission and disease cycles Reservoirs of infections, Portals of entry and exit of Pathogens Epidemiology of Polio	
Unit 2- Pathology:	**2 hrs**
Normal human microbiota, Microbial colonization, Microbial virulence -Toxins, Hydrolytic enzymes, Capsule, Adherence factors, Invasiveness	
Unit 3- Immunotechnology and Diagnostics:	**2 hrs**
ELISA, Western Blotting, Immunofluorescence MTT, Cell Cytotoxicity Assays, Apoptosis Assays, Hybridoma and Production of Monoclonal Antibodies	
Unit 4-Vaccines:	**2 hrs**
Introduction to vaccines, Active and Passive Immunization Types of vaccines, Note on hybrid and conjugate vaccines	
Unit 5-Transplantation Biology:	**3 hrs**
Antigens involved in graft rejection, Allorecognition — Direct and indirect	

Graft rejection - Role of APCs, Effector cells, Graft Vs Host Disease (GVHD) Immunosuppressive therapies — Induction Therapy and Maintenance therapy	
Unit 6: Cancer Biology:	**3 hrs**
Introduction, factors of predisposition, tumour classification, diagnosis (IHC) Treatment {Monoclonal Antibodies, Non-specific Immunotherapies, Oncolytic Virus Therapy **Active learning**-T-cell therapy (CAR-T), and prevention (Cancer Vaccines)}	

Practical IV: BTP5221: IMMUNOLOGY

1. Introduction to blood cells and preparation of blood smear-differential staining.
2. Immunodiffusions- SRID and Rocket immunoelectrophoresis
3. ODD titration and pattern
4. Virtual lab- B cell maturation, Macrophage Infiltration Pathways
5. Immunohistochemistry/Enzyme based antioxidant assays
6. Agglutination tests- VDRL and WIDAL test
7. Enzyme linked immunosorbent assay (ELISA)
8. Isolation of IgG from eggs
9. Purification of IgG from eggs
10. SDS PAGE of IgG

Text Books / References

Immunology by Richard A. Goldsby, Thomas J. Kindt, Barbara A. Osborne & Janis Kuby
Immunology by Ivan M. Roitt, Jonathan Brostoff& David K. Male
Immunology: Essential and Fundamental by Sulabha Pathak &UrmiPalan.
Immunology a comprehensive review: Darla J. Wise & Gordon R. Carter-Anebooks
Lecture notes in Immunology: Ian Todd & Gavin Spicket
Microbiology and Immunology: Monica Gandhi et.al. Blackwell publishing.
Schaum's Immunology: George R.Pinchuk
Essential Immunology: Viva books private Ltd
Patrick R Murray, Ken S Rosenthal and Michael A Pfaller (2016) Medical Microbiology. Elsevier
PrathibaNallari and V Venugopal Rao (2010) Medical Biotechnology. Oxford University Press.
Weinberg R A (2007) The Biology of Cancer. Garland Science

COURSE OUTCOMES for BT 5223:

After successful completion of the course, students will:

CO1	Understand basic concepts of immunology
CO2	Correlate to our body's response during an infection
CO3	Analyze assay data and construct meaningful conclusions
CO4	Understand progression pathways of malignancy

COURSE OUTCOMES AND COURSE CONTENT

Semester	**VI**
Paper Code	**BT6123**
Paper Title	**BIOPROCESS TECHNOLOGY AND ENTREPRENEURSHIP**
Number of teaching hours per week	**03T + 04P**
Total number of teaching hours per semester	**42**
Number of credits	**04 + 2 (T+P)**

Objective of the Paper: The paper will introduce students to industrial biotechnology and get them to understand entrepreneurial approach to start ups. The biprocess paper will give a detailed description of all components in an industry that uses strains for producing industrially important products.

Content of Course: DSC-6T1,	**42 Hrs**
BIOPROCESS TECHNOLOGY	**33 Hrs**
Unit 1: Introduction	**2 hrs**
Introduction to Industrial Biotechnology, Basic principles of fermentation technology	
Unit 2: Strain improvement	**3 hrs**
Screening and Isolation of Microorganisms, Maintenance of strains, Improvement (Mutant selection, Recombinant DNA methods)	
Unit 3: Fermentation media	**2 hrs**
Natural and Synthetic Media, Sterilization techniques – Heat, Radiation and Filtration methods	
Unit 4: Fermentors	**3 hrs**
Design of fermenters, Types of fermenters, Factors affecting fermentation-Aeration, Agitation, Temperature regulation, Mass transfer, Oxygen transfer and Filtration method.	
Unit 5:Types of fermentation	**3 hrs**
Solid State fermentation, submerged fermentation, batch fermentation, fed-batch fermentation, continuous fermentation, Immobilized enzyme and cell bioreactors.	
Unit 6: Process development	**4 hrs**
Down Stream Processing (DSP)- Disruption of cells, Separation, Extraction, Strategies for concentration and Purification of products	
Unit 7: Production	**8 hrs**
Brief account of the following products obtained by industrial productions Alcoholic Beverage–Beer	1 hr each

Organic acid–Citric acid Antibiotic –Penicillin Amino acids–Glutamic acid Vitamin–B12 Fermented Foods –Yoghurt and Cheese Microbial Foods – Single cell proteins (SCP), **Active learning**-single cell oils (SCO)	
Unit 8: Enzyme Biotechnology	**3 hrs**
Introduction to enzymes – examples of enzymes from animal, plant and microbial source Industrial uses of amylase enzyme Introduction to bulk and fine enzymes	
Unit 9: Plant tissue culture	**5 hrs**
Introduction-Totipotency, Phytohormones and its role in invitro propagation; basic lab requirements, Culture media Micropropagation - Collection, sterilization, preparation and inoculation of explants	
ENTREPRENEURSHIP	**9 hrs**
Unit 1: Introduction	
Why to become an entrepreneur, the skills/ traits required to be an entrepreneur, Creative and Design Thinking, the entrepreneurial decision process, skill gap analysis, and role models, mentors and support system, entrepreneurial success stories	**3 hrs**
Unit 2: Idea to development	
Idea generation, business plan, developing a business model canvas	**6 hrs**

Practical IV: BTP6123: BIOPROCESS TECHNOLOGY

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

Text Books / References

1.Sullia S. B &Shantharam S: (1998) General Microbiology, Oxford & IBH Publishing Ltd.
2. Bisen P.S (1994) Frontiers in Microbial Technology, 1st Edition, CBS Publishers
3. Glaser A.N &Nilaido. H (1995) Microbial Biotechnology, W.H Freeman & Co.
4. Prescott & Dunn (1987) Industrial Microbiology 4th Edition, CBS Publishers & Distributors
5. Prescott & Dunn (2002) Industrial Microbiology, Agrobios (India) Publishers
6. Crueger W. &Crueger A. (2000) A text of Industrial Microbiology, 2nd Edition, Panima Publishing Corp
7. Stanbury P.F, Whitaker H, Hall S.J (1997) Principles of Fermentation Technology, Aditya Books (P) Ltd

COURSE OUTCOMES for BT 6123:

After successful completion of the course, students will:

CO1	Design basic fermentors and suggest models for various examples
CO2	Understand strain improvement strategies and practically learn to culture and maintain strains
CO3	Identify manufacturing process steps in few product manufacturing industries
CO4	Generate ideas needed for startup, construct business model canvas, cost structures, value propositions, key activities and write executive summaries for startup ventures.

COURSE OUTCOMES AND COURSE CONTENT

Semester	**VI**
Paper Code	**BT6223**
Paper Title	**PLANT, ENVIRONMENTAL AND ANIMAL BIOTECHNOLOGY**

Number of teaching hours per week	**03T + 04P**
Total number of teaching hours per semester	**42**
Number of credits	**03+ 2 (T+P)**

Objective of the Paper: This course deals with the application of biotechnology in utilizing plants and animals for bettering human life. The course also introduces the concept of green environment technologies and an insight into the techniques of reclaiming lost air, soil and water health.

Scope: It aims to introduce and familiarize concepts, principles and practices in plant, animal and environmental biotechnology. The practical sessions encompass a project that would answer pertinent questions in the above fields. The exercise provides hands-on experience to formulate research problems, design and conduct experiments as well as draw scientific inferences from the results.

Content of Course: DSC-6T2,	**42 Hrs**
Plant Biotechnology	**14 Hrs**
Unit 1:Plants for Food, Fuel, Feed and Fiber	**2 hrs**
Statistics on population, food security etc., Challenges for Agriculture Impact of Biotechnology on Global Agriculture and Sustainability	1 hr 1 hr
Unit 2: Generation of transgenic plants	**3 hrs**
Gene discovery and analysis, plant transformation vectors A transgenic construct: Promoters, terminators, selectable markers, reporter genes Plant transformation techniques- Particle gun method (Rice), *Agrobacterium* mediated Transformation (Tobacco)	1 hr 1 hr 1 hr
Unit 3: Transgenic plants	**5 Hrs**
Herbicide tolerant, Insect resistant and Abiotic stress tolerant transgenic crop plants: Strategies, Case studies The GM crop debate: Safety, ethics, social perception & acceptance of GM crops	3 hrs 2 hrs
Unit 4: Molecular Pharming	**2 hrs**
Plants as host systems for molecular pharming of industrial proteins/ enzymes, therapeutic/ pharmaceutical proteins, edible vaccines etc. Case studies.	
Unit 5: Plant secondary metabolites	**2 hrs**
Classification and roles of plant secondary metabolites: terpenoids, alkaloids, flavonoids, glycosides, phenolics **Active learning**- Applications of secondary metabolites, Metabolic engineering	1 hr 1 hr
ANIMAL BIOTECHNOLOGY	**14 Hrs**
Unit 1:Introduction to Cell Culture and Cell Lines	**3 Hrs**

Scope of animal tissue culture, Lab requirements for Aseptic conditions, Balanced Salt Solution, Culture Media-Natural media, Complex media, chemically defined media, Advantage and disadvantage of Serum in media, importance of media components, Explant isolation and culture, Primary culture, Secondary culture, Transformed cell lines, Continuous cell lines; Enzymatic and mechanical disaggregation of cells, Cryopreservation, Thawing.	3 hrs
Unit 2: Concept of Transgene and Transgenics	**5 hrs**
Concept of Transgene, Transgenic organism and clones Transfection: Examples involving microinjection and use of Retroviral vectors Clone and Nuclear transfer (Dolly) Animal models for studying diseases (Cancer as an example)	1 hr 2 hrs 1 hr 1 hr
Unit 3: Expression of mammalian genes	**5 hrs**
Scorable and Selectable markers for animal gene constructs Transgenic Mice –expression of foreign genes, Knockout Mice concept and their application in research Transgenic Cattle, Transgenic Fish **Active learning**-Prerequisites for setting up animal house and bioethics	1 hrs 2 hrs 1 hr 1 hr
Unit 4: Production of Pharmaceuticals	**1 hr**
Introduction, Strategies to optimize product yield, Downstream Processing, pharmacokinetics & pharmacodynamics, drug formulation, preclinical and clinical trials. (Take any one product as an example)	1 hr
ENVIRONMENTAL BIOTECHNOLOGY	**14 Hrs**
Unit 1:Air, Water and soil health	**2 hrs**
Introduction: Physical, Chemical and biological properties of air, water and soil, Concepts of cleaner bioprocesses, eco-efficiency. 5-R policy. Case studies from Bangalore	2 hrs
Unit 2: Environmental genomics	**2 hrs**
Methods (e-DNA, sequencing from environmental samples), 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	2 hrs
Unit 5: Biocontrol (Biological insecticides)	**1 hrs**
NPV, *B. sphaericus.*	1 hrs
Unit 6: Clean energy	**2 hrs**
Biofuels: Bioethanol, Biogas, **Active Learning**-Clean Energy Initiatives in Karnataka.	2 hrs
Unit 7: Biosensors	**2 hrs**

Introduction to environmental Biosensors: biosensors used in detection of heavy metals, nitrogen compounds, pesticides and herbicides	2 hrs

Practical IV: BTP6224: Project work

Students are divided into small groups and do hands-on projects under the supervision of faculty members. Students plan and execute experiments. Projects are assessed as following:

Practical Internal Assessment:	15 marks
Final exam	15 marks (3 questions x 5 marks)
Project presentation	10 marks
Project report	10 marks

Text Books / References

Plant biotechnology:

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

Animal biotechnology:

Short Protocols in Molecular Biology, 4th Edn, Ed: Ausubel, Kingston, and Moore, 1999.
Culture of Animal Cells: A Manual of Basic Technique, 4th Edn, by Ian Freshney, 2000.
Molecular Biotechnology: Primrose.
Animal Cell biotechnology: R.E. Spier and J.B. Griffiths (1988), Academic press.
Animal Biotechnology: Murray Moo-Young (1989), Pergamon Press, Oxford.

COURSE OUTCOMES for BT 6223:

After successful completion of the course, students will:

CO1	Understand basic concepts of Plant, Animal and Environmental Biotechnology
CO2	Be able to design and execute basic transgenic experiments in plants and assess data
CO3	Incorporate concepts learnt in Animal Biotechnology to gain expertise in cell culture techniques

CO4	Understand prevalent environmental conditions in Karnataka and other Indian states using concepts learnt in Environmental Biotechnology