ST. JOSEPH'S UNIVERSITY

BENGALURU 560027

DEPARTMENT OF BIOTECHNOLOGY

SYLLABUS FOR POSTGRADUATE PROGRAMME

2024-2026

M.Sc. BIOTECHNOLOGY, 2024-25 onwards
COURSE OVERVIEW

	PAPER CODE AND TITLE	Teaching Hours	No. of Credits	Total marks
SEMESTER I				
Paper I	BT7124: Biochemistry and Analytical techniques	60	04	100
Paper II	BT7224: Microbiology and Microbial Physiology	60	04	100
Paper III	BT7324: Molecular Genetics	60	04	100
Paper IV	BT7424: Research Methodology and Scientific Writing	60	04	100
PRACTICALS				
Paper I	BT7P1: Biochemistry and Physiology	88	04	50
Paper II	BT7P2: Microbiology and Molecular Genetics	88	04	50
		TOTAL	**24**	**500**
SEMESTER II				
Paper I	BT8124: Advanced Cell Biology	60	04	100
Paper II	BT8224: Molecular Biology	60	04	100
Paper III	BT8324: Genetic Engineering	60	04	100
Paper IV	BT8424: Biostatistics	60	04	100
Paper V-A **(DE)**	BTDE8524: Multiomics Technologies	60	04	100
Paper V-B **(DE)**	BTDE8624: Nanobiotechnology	60		
PRACTICALS				
Paper I	BT8P1: Cell and Molecular Biology	88	04	50
Paper II	BT8P2: Genetic engineering	88	04	50
		TOTAL	**28**	**600**

SEMESTER III				
Paper I	BT9125: Bioinformatics and Computational biology	60	04	100
Paper II	BT9225: Immunology	60	04	100
Paper III	BT9325: Industrial Biotechnology, Entrepreneurship and Bioethics	60	04	100
Paper IV	BT9425: Applied Biotechnology	60	04	100
PRACTICALS				
Paper I	BT9P1: Bioinformatics and Immunology	88	04	50
Paper II	BT9P2: Applied Biotechnology	88	04	50
Paper III	BT9P3: Research and Career development seminars	30	02	S/U
		TOTAL	**26**	**500**
SEMESTER IV				
	BT0125: Research Project	360	12	350
	Ignitors/Outreach		04	
		TOTAL	**16**	**350**
	Total No. of Credits:		**94**	

Course Curriculum for M.Sc. Biotechnology, 2024-25 onwards

Semester	**I**
Paper Code	**BT7124**
Paper Title	**Biochemistry and Analytical Techniques**
Number of teaching hours per week	**04**
Total number of teaching hours per semester	**60**
Number of credits	**04**

Objective of the Paper:

This course has been designed to introduce the students to concepts in biochemistry. It further emphasizes on the regulation and applications of biomolecules in health. The analytical techniques component of the course facilitates a detailed insight into biophysical techniques involved in biological research. It enables the student to choose and employ appropriate analytical techniques required for the analysis of specific biological samples. In addition, fosters critical thinking required for the interpretation of analytical data.

Syllabus: BT7124: Biochemistry and Analytical Techniques (60 hours)

Unit	Content	Teaching Hours
BIOCHEMISTRY		**30 Hrs**
Unit 1: Carbohydrates	Classification of carbohydrates, glycosaminoglycans, proteoglycans, sialic acid, lectins, gluconeogenesis, glycogen metabolism & their regulation; TCA cycle, ETC; Glycans in health and disease, glycomimetics, Applications of glycoconjugates.	6 hrs
Unit 2: Amino Acids and Proteins	Classification of amino acids and titration curves; biologically important peptides; Ramachandran Plot, Proteins- levels of organization; Ramachandran's plot; Structure and function of Mb, Hb and collagen. Overview of amino acid biosynthesis & urea cycle. Protein folding-molecular chaperones, models of protein folding,	8 hrs

	misfolding diseases.	
Unit 3: Lipids and Membrane Transport	Classification of lipids; Fatty acid biosynthesis and oxidation, Biologically important lipids: cholesterol, bile salts, eicosanoids- leukotrienes, prostaglandins and thromboxanes. Lipid bilayers, micelles, liposomes, membrane structure and assembly, transport of molecules across membrane-channels and pumps, model membrane systems and their applications.	3 hrs
Unit 4: Nucleic Acids	Structure and properties- Bases, Nucleosides, Nucleotides, Polynucleotides. Nucleic acid metabolism: Biosynthesis of purines and pyrimidines, De novo and Salvage pathways, biodegradation of purines and pyrimidines. (atypical nucleotides)	2 hrs
Unit 5: Enzyme Kinetics, Catalysis and Regulation	Properties of enzymes, classification, MichaelisMenten equation, kinetic parameters, Lineweaver -Burk plot, factors affecting enzyme activity, enzyme inhibition, multisubstrate reactions, enzyme units. Different catalytic strategies, Mechanism of RNase, chymotrypsin, carbonic anhydrase and lysozyme; Regulation of enzymes by- allosteric control, covalent modification, proteolytic cleavage and isoenzymes	8 hrs
Unit 6: Bioenergetics and Regulation Of Metabolic Pathways	Bioenergetics-basic principles; Equilibria and concept of free energy; Coupled processes; Logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; Principles of metabolic regulation; Signals and second messengers.	3 hrs
ANALYTICAL TECHNIQUES		**30 hrs**
Unit 1: Basics Of pH	Measurement of pH, concepts of normality and molarity, Biochemical buffers, Selection of biochemical buffers, Concepts of biosensors.	4 hrs
Unit 2: Chromatography	General principles, definitions and applications of Chromatography. Paper chromatography, Gel filtration, Ion-exchange, Affinity chromatography, High-performance liquid chromatography, Gas chromatography.	4 hrs

Unit 3: Centrifugation	Basic principles; Mathematics & theory (RCF, Sedimentation coefficient); centrifugation techniques, Applications	3 hrs
Unit 4: Spectroscopy I	Basics principles of Spectroscopy, Beers-Lambert law; extinction coefficient; light sources; monochromators; types of detectors; working principle and applications of UV-visible, FTIR, NMR, Raman, ICP-OES.	7 hrs
Unit 5: Spectroscopy II	Mass Spectrophotometry: Ionization modes - EI, ESI, MALDI; Detectors used in MS. Concept of GC-MS, LC-MS.	2 hrs
Unit 6: Electrophoretic and Blotting Techniques	Electrophoresis: Introduction and Principles; types of electrophoresis. Polyacrylamide and Agarose gel electrophoresis; Isoelectric, 2D. Blotting: Northern, Southern, Western	3 hrs
Unit 7: Microscopy	Light Microscopy, optical and phase contrast, Fluorescence microscopy, Electron microscopy: Sample preparation - Sputtering, Freeze etch and Freeze fracture techniques, Electron microscopy types – SEM, TEM and Cryo-electron Microscopy.	3 hrs
Unit 8: Radioactivity	Radioactive & stable isotopes; Units of radioactivity; Measurement of radioactivity - Geiger-Muller counter; Solid & Liquid scintillation counters (Basic principle, instrumentation & technique); Autoradiography; Applications of isotopes in biology	2 hrs

REFERENCE TEXTBOOKS:

BIOCHEMISTRY

1. V.Voet and J.G.Voet, Biochemistry, 3rd edition, John Wiley, New York, 2004.
2. A.L. Lehninger, Principles of Biochemistry, 4th edition, W.H Freeman and Company, 2004.
3. L. Stryer, Biochemistry, 5th edition, W.H. Freeman and Company, 2002.
4. Reginald H. Garrett, Charles M. Grisham. Biochemistry. Brooks Cole 5th Edition (2012). David Bender, Kathleen M. Botham, Robert Murray. Harpers Illustrated Biochemistry. 29th Edition, McGraw-Hill Medical Publishing (2012).
5. Thomas M. Devlin, Textbook of Biochemistry with Clinical Correlations. 7th Edition, John Wiley & Sons (2010).

ANALYTICAL TECHNIQUES

1. Freifelder D., Physical Biochemistry, Application to Biochemistry and Molecular Biology, 2nd Edition, W.H. Freeman & Company, San Fransisco, 1982.

2. Keith Wilson and John Walker, Principles and Techniques of Practical Biochemistry, 8th Edition, Cambridge University Press, 2018.
3. Modern Experimental Biochemistry. 2000. 3rd ed. by R.F. Boyer. The Benjamin Cummings Publ. Company.
4. Xinkun Wang, X. Next-generation sequencing data analysis. 1st edition, CRC Press, 2016.
5. Magdeldin, S. ed., 2015. Recent Advances in Proteomics Research. Intech Open.
6. Ghosh, P.K., 2015. Introduction to protein mass spectrometry. Academic Press.
7. Lottspeich, F. and Engels, J.W. eds., 2018. Bioanalytics: Analytical Methods and Concepts

COURSE OUTCOMES FOR BT7124: BIOCHEMISTRY AND ANALYTICAL TECHNIQUES

After successful completion of the course, students will:

CO1	Gain understanding on various biomolecules and their applications in biotechnology.
CO2	Develop insight into central energy metabolic pathways and their regulation.
CO3	Gain hands on skills in isolation, purification, quantification of biomolecules especially enzymes and estimation of Michaelis Menten constants
CO4	Learn the concepts of pH, selection of buffers & concentration gradients for separation, and analytical analysis of biomolecules through chromatography, centrifugation, spectroscopy and electrophoresis.
CO5	Understand various types and applications of advanced microscopic techniques and apply these concepts to select the suitable method based on biological samples. Gain insights on fundamentals and safety of radioisotopes for biological applications.
CO6	Perform practical sessions to learn various types of chromatographic separation of biological compounds and learn concepts of quantitative imaging.

Semester	**I**
Paper Code	**BT7224**
Paper Title	**Microbiology and Microbial Physiology**
Number of teaching hours per week	**04**
Total number of teaching hours per semester	**60**
Number of credits	**04**

Objective of the Paper:

This paper is intended as a basic primer into microbiology as well as a bridging course for students not previously exposed to these concepts. This course introduces microbial diversity and discusses the use of various techniques employed in molecular taxonomy of microbes. It further imparts knowledge about bacterial growth requirements and kinetics, control and epidemiology of infectious disease It introduces the theories of evolution and the origin of life. It then follows a broad arc covering various aspects of bacterial physiology including reproduction, communication, coordination and homeostasis. A molecular understanding of these events and their association with human disease will be the underlying theme.

Syllabus: BT7224: Microbiology and Microbial Physiology (60 hours)

Unit	Content	Teaching Hours
Microbiology		**30 h**
Unit 1: Bacterial diversity	General characteristics of bacteria & archaea. Morphology & structure of bacteria, cell membrane, organelles, genetic material, plasmid, spore, inclusion bodies; culture characteristics.	**4 h**
Unit 2: Eukaryotic microbes	General characteristics of fungi and algae- morphology, nutrition and reproduction.	**4 h**
Unit 3: Viruses	General properties of viruses, morphology and structure of viruses, Baltimore classification, lifecycle- lambda virus and SARS- CoV, diagnosis of viruses.	**3 h**
Unit 4: Molecular taxonomy	Criteria for microbial classification-Biochemical methods, serological techniques, phage typing, fatty acid profiles, DNA fingerprinting, rRNA sequence, Nucleic acid hybridization,	**4 h**

	Chemotaxonomy, signature sequences, and protein sequences.	
Unit 5: Microbial growth and Nutrition	Nutritional requirements and nutritional groupings of bacteria. Growth curve & factors affecting growth and growth rates. Primary and secondary metabolites.	**3 h**
Unit 6: Microbial control	Various methods of control of microorganisms: physical, chemical and biological. Antimicrobials- antibiotics, antivirals and antifungals. Decontamination and containment.	**6 h**
Unit 7: Epidemiology of diseases	Epidemiology approach to a disease & terminologies involved in the study, epidemiological markers and tools, approach to descriptive & analytical epidemiology (case studies).	**6 h**
Microbial Physiology		**30 h**
Unit 1: Origin of life	Chemical evolution, primordial soup and the primitive cell, theories of the origin of life, continental drift.	**4 h**
Unit 2: Evolution	Natural selection and survival of the fittest, genetic drift, sexual selection, co-evolution of human diseases, kin-selection and altruism.	**5 h**
Unit 3: Reproduction	Asexual reproduction in bacteria, multi-cellularity and evolution of sex.	**4 h**
Unit 4: Cell communication and responses	Principles of metabolic regulation; feedback regulation, quorum sensing in bacteria and biofilms, chemotaxis, vision, stochastic responses.	**5 h**
Unit 5: Microbiome	Host-microbe interactions, cooperative and competitive microbe-microbe interaction.	**4 h**
Unit 6: Pathogenesis	Bacterial virulence, transporters and secretion systems, toxins.	**5 h**
Unit 7: Antimicrobial resistance	Strategies of resistance, emergence of multidrug resistance and epidemiology, novel antimicrobials.	**3 h**

REFERENCE TEXTS:

1. Microbiology: concepts and applications- Pelczar MJ, Chan ECS, & Krieg NR; Pub: Tata Mcgraw-Hill Publishing Co
2. Microbiology- Prescott LM, Harley JP, & Klein DA; McGraw-Hill.
3. Brock Biology of Microorganisms- Madigan, Bender, Buckley, Sattley & Stahl; Pearson
4. Life: The Science of Biology by David E. Sadava (12thedition)

COURSE OUTCOMES FOR BT7224: MICROBIOLOGY AND MICROBIAL PHYSIOLOGY

After successful completion of the course, students will:

CO 1	Appreciate diversity among various microorganisms and assess the same using various microbiological and molecular techniques.
CO 2	Understand the nutritional requirements and growth kinetics of bacteria.
CO 3	Understand the importance of sterilization and disinfection and other allied methods used in microbiology.
CO4	Gain insights into how organisms originated and evolved complexity.
CO5	Understand and critically evaluate bacterial reproduction, homeostasis and communication.
CO6	Have a holistic grasp of microbial pathogenesis and how we aim to tackle it using biotechnology.
CO7	Be able to safely culture diverse bacterial species, design assays and analyse microbiological data.

PRACTICAL I: BT7P1: Biochemistry and Microbial Physiology (88 hrs)

ANALYTICAL TECHNIQUES

1. Preparation of buffers in biology and calculation of molarity, normality etc., Optimizing a pH meter and measuring the pH.
2. Absorption spectrum of coloured solution.
3. Column chromatography of plant pigments
4. Paper chromatography of amino acids.
5. Thin Layer Chromatographic technique for separation of compounds
6. Measurement of Cell Size and numbers

BIOCHEMISTRY

1. To prepare an Acetic-NaAcetate Buffer system and validate the Henderson-Hasselbach equation.
2. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law.

3. Estimation of amino acid by Ninhydrin method
4. Estimation of glucose by Hagedorn and Jenson method
5. Estimation of inorganic phosphate by Fiske-Subbarow method
6. An Enzyme Purification Theme (such as E. coli Alkaline phosphatase or any enzyme)
    (a) Preparation of cell-free lysates
    (b) Ammonium Sulfate precipitation
    (c) Ion-exchange Chromatography
    (d) Affinity Chromatography
    (e) Generating a Purification Table
    (f) Assessing purity by SDS-PAGE Gel Electrophoresis
    (g) Enzyme Kinetic Parameters: Km, Vmax and Kcat.

Microbial Physiology

1. Evolution of antibiotic resistance in bacteria (in vitro evolution).
2. Coacervation and phase-separation. (2 labs)
3. Complex life cycle of *Myxococcus xanthus* with distinct life-history stages, and the role of quorum sensing.
4. Bacterial growth curve

Semester	**I**
Paper Code	**BT7324**
Paper Title	**Molecular Genetics**
Number of teaching hours per week	**04**
Total number of teaching hours per semester	**60**
Number of credits	**04**

Objective of the Paper:
As part of Molecular Genetics, the course introduces concepts in Classical, Quantitative, Human, Bacterial and Viral Genetics. The course also explores epigenetics and use of genetic screens and genome wide association studies to understand the genomes of organisms.

Syllabus for BT7324: Molecular Genetics **(60 hours)**

Unit	Content	Teaching Hours
Unit 1: Classical Genetics	Mendelian laws, concept of dominance, segregation, independent assortment, chromosome theory of inheritance. Allelic and non-allelic interactions, lethal, multiple alleles, test of allelism, complementation.	6 h
Unit 2: Extension of Mendelian Genetics	Epistasis, Sex-linked inheritance, Sex determination, extranuclear inheritance, pleiotropy, penetrance and expressivity, linkage, crossing over.	10h
Unit 3: Genetic Material	Chromosomes and genes; Split genes, pseudogenes, non-coding genes, overlapping genes and gene families. Properties and evolution of genetic material, flow of genetic information.	4h
Unit 4: Genetic Models	Model systems for genetic analysis; Bacteriophage, *E. coli, Neurospora crassa*, yeast, *Arabidopsis*, *Drosophila, C. elegans*, Zebra fish, *Homo sapiens* - General outline of life cycle, importance in genetic analysis.	4h
Unit 5:	Use of genetic screens for discovery and characterisation of genes, understanding the biology of complex systems, types of genetic screens, effective design of a genetic screen,	7h

Mutations and Genetic screens	interpretation and analysis of screening data, complementation. Forward Genetics and Reverse Genetics, Mutagens, mechanism of mutagenesis, induction and isolation and selection of mutants and their role in genetic studies, Suppressors and types. Mutation: types of mutation, Loss of function mutation, Gain of function mutation, Frameshift mutations. Amorph, hypomorph and hypermorph.	
Unit 6: Quantitative Genetics	Multiple factor hypothesis and analysis of polygenes. Genotype-Environment Interaction and models for their measurement, estimation of Heritability Index. Human genetic diversity- Methods of study – Biochemical/molecular genetic markers.	4h
Unit 7: Human Genetics	Pedigree analysis- Mendelian inheritance and exceptions; Techniques of Chromosomal analysis: physical mapping, mapping markers, G/Q banding, FISH, comparative genome hybridization, long range restriction mapping, high resolution mapping STS/EST/MS/SNP/sequencing; Genetic mapping: Linkage analysis (RFLP/MS/SNP). Chromosomal disorders: Structural and numerical; Autosomal/sex chromosomal/sex reversal; Mechanisms– mitotic/meiotic non-disjunction / chromosomal rearrangements; some examples. Ethical, legal and social issues in Human genetics: Prenatal/adult (individual/family/population) screening of mutation/risk factor for genetic diseases	8h
Unit 8: Bacterial and Viral Genetics	Genome organization of viruses, and bacteria, Recombination in bacteria. Mechanism of recombination, transposable genetic elements. Transformation and conjugation in bacteria. Linkage map of bacterial chromosomes. Lytic cycle and lysogeny and its regulation. Transduction; specialized, generalized and abortive. Fine structure analysis of T phages; Benzers work, concept of cistrons.	4h
Unit 9: Population Genetics	Gene pools, allele frequencies, Hardy Weinberg equation, non-random breeding, genetic drift, gene flow, selection, speciation.	4h
Unit 10: Epigenetics	Non-genomic inheritance, Role of Heterochromatin and its interactions with histones, histone code, antagonistic repressors and activators, global changes on X-	4h

	chromosomes, effect of condensins, imprinting.	
Unit 11: Genome-wide association studies (GWAS)	Basic genetic concepts that drive GWAS, including the architecture of common and rare diseases, the structure of common human genetic variations, technologies for capturing genetic information, study designs, and the statistical methods used for data analysis. Future beyond GWAS	5h

REFERENCE TEXTS

Molecular Genetics

1. David Freifelder. (2004). Microbial genetics. 10th edition, Norosa publisher, New Delhi.
2. Lodish, H.D., Baltimore, A., Berk, B.L., Zipursky, P., Mastsydairs and Darnell, J. (2004). Molecular cell biology. Scientific American Books Inc., NY.
3. Gardner/Simmons/Snustad. (2006). Principal of Genetics. 8th Edn. John Wiley & sons.
4. Klug, W.S.,Cummings. (2003). Concepts of genetics, 7th Edn. Pearson Education.
5. Dale, J.W. (1994). Molecular Genetics of bacteria, John Wiley & Sons.
6. Streips and Yasbin. (2001). Modern microbial Genetics. Niley Ltd. 7. John Ringo (2004). Fundamental Genetics. Cambridge University Press
7. Benjamin Lewin, Gene IX, 9th Edition, Jones and Barlett Publishers, 2007.

COURSE OUTCOMES FOR BT7324: MOLECULAR GENETICS

After successful completion of the course, students will:

CO1	Be able to understand and apply concepts in Classical, Quantitative, Human Genetics, Bacterial and Viral Genetics.
CO2	Gain insight into the various types of mutations, mutagenic agents and subsequent alterations in inheritance.
CO3	Be able to use model organisms to validate genetic principles governing inheritance as well study of various mutants.
CO4	Apply various techniques to study either entire genomes or specific regions that govern traits of interest.

PRACTICAL BT7P2: Microbiology and Molecular Genetics

Molecular Genetics

1. Induced mutagenesis (random (PCR based, vectors) / site directed (PCR based)
2. Screening of Drosophila P mutants for environmental stresses
3. Study of Drosophila mutant types/ mapping using P
4. Drosophila: Mendelian Genetics, Sex linked inheritance
5. Complementation using Drosophila
6. Yeast mutant analysis AD1 and 2
7. Genetic mapping by P1 transduction
8. Genetic mapping by conjugation
9. Measurement of growth rate/ one step growth curve using T even phage

Microbiology

1. Obtaining strains, preparation of media for culturing and maintenance.
2. Preparation and culturing of pure cultures of strains.
3. Antibiotic susceptibility test and evaluation of dosage.
4. Molecular characterization using 16S rRNA part a
5. Molecular characterization using 16S rRNA part b
6. Molecular characterization using 16S rRNA part c
7. Cultivation and isolation of viruses from embryonated eggs.
8. Isolation of bacteriophages from sewage samples
9. Assessment of Genetic diversity using Molecular markers (RAPD/ AFLP)

Semester	**I**
Paper Code	**BT7424**
Paper Title	**Research Methodology and Scientific Writing**
Number of teaching hours per week	**04**
Total number of teaching hours per semester	**60**
Number of credits	**04**

Objective of the Paper:
This class introduces students to the basics of how scientific research is performed, and focuses on in-classroom activities that give students the experience and practice of reading and analyzing scientific literature, through to writing a research proposal.

Syllabus for BT7424: Research Methodology and Scientific Writing (60 hours)

Unit	Content	Teaching Hours
SECTION A: RESEARCH METHODOLOGY		**40 hours**
UNIT 1: Fundamentals of Research	Science vs. Pseudoscience; Hypothesis, Theory, Law; Causation vs. Correlation; How to read a scientific paper; Critiquing research papers; The scientific method; An overview of the research process, criteria of good research; Basic vs. Applied research, qualitative vs. quantitative research. *Active learning:* Identifying elements of science and non/pseudoscience using an example. Identifying and critiquing elements of research, including the hypothesis and methodology.	10 hrs

UNIT 2: Defining a Research Problem	Identifying a research area of interest, importance of originality and impact, exploratory versus incremental research; Literature reviews: types of literature reviews, identifying research gaps, information literacy, methods and techniques of literature survey, scientific search engines, reference management systems and referencing styles; narrowing and defining the research problem, finding research protocols, establishing a framework for scientific research. *Active learning*: Using Mendeley to sort and tag reference papers relevant to assigned topics, do a systematic review of literature and identify gaps, and define specific research questions and objectives.	8 hrs
UNIT 3: Research Design and Experimentation	Overview of research design, formal and informal experimental designs. Hypothesis testing: an overview of statistical tests for data analysis, Parametric and non-parametric tests, Errors, Significance levels, p values and power. Experimental controls: Negative and positive controls, Reagent and Method controls, Replicates: Biological Replicates, Technical Replicates, Experimental Repeats, Time Courses, and Dose Responses. Repeatability, Reproducibility, Reliability, Specificity and sensitivity of instruments and techniques.	4 hrs 8 hrs
UNIT 4: Methods of Data Collection, Data Analysis and Documentation	Overview of the types of data, primary and secondary data collection methods, Big data in biology, data curation, physical and e-lab notebooks, numerical and graphical data. *Active learning*: Analysis of data in selected papers and interpretation of results. A close look at some papers with possibly flawed data interpretation.	6 hrs

UNIT 5: Ethics and Scientific Conduct	Introduction to Ethics, Scientific conduct and misconduct, responsibility and accountability of the researchers, Ethics in human and animal studies, Forms of misconduct: Data fabrication, plagiarism, authorship issues, Image manipulation, duplicate publications, investigation and consequences of scientific misconduct. *Active learning*: Identifying known examples of scientific misconduct and discussion. Case study on image manipulation.	6 hrs
SECTION B: SCIENTIFIC WRITING		**20 hrs**
UNIT 6- Introduction to Science Communication	Types of Scientific communication: Research papers, Research proposals, Posters, Project report; Publishing, H-index, Impact factors in publishing. Elements of effective scientific communication, scientific illustrations, Graphical abstracts.	4 hrs
UNIT 7- Writing an effective Review of Literature	Studying the lay of the land in your research area of interest, identifying work relevant to the study, categorizing and concisely describing this work, accurate referencing. *Active learning*: Students will work on writing a review of literature based on work done in Unit 2.	4 hrs
UNIT 8- Writing a Research Proposal	Basic elements of a research proposal, budget considerations, timelines, deliverables and the importance of plan B, funding agencies and research grants. Constructive criticism, how to do peer review, Mind maps, Effective powerpoint presentations. *Active learning*: Students work on writing their research proposals. Specific formats will be supplied.	4 hrs
UNIT 9: Presentation of Student Research Proposals	Instructor and Peer Feedback	8 hrs

REFERENCE TEXTS:

1. Research in Medical and Biological Sciences, Petter Laake, Benestad & Olson, 2015, Elsevier
2. Research Methodology, 2nd Ed, CR Kothari, 2004, New Age India Publications
3. Experimental design for Biologists, 2nd Ed, David J. Glass, 2014, CSHL Press
4. Research Methodology: The Aims, Practice & Ethics of Science, Peter Purzan, 2016, Springer

COURSE OUTCOMES FOR BT7424: RESEARCH METHODOLOGY AND SCIENTIFIC WRITING

After successful completion of the course, students will:

CO1	Have a grasp of the fundamentals of scientific research and the basic framework of the scientific process, while also gaining a clear understanding of the ethical dimensions in research.
CO2	Be able to search, sort, select and critically analyze scientific literature, and prepare a literature review.
CO3	Develop skills in formulating and evaluating research questions, and develop a Research Proposal.
CO4	Be able to formulate a research framework around their research question/s.
CO5	Be able to appreciate and evaluate components of scholarly writing and will demonstrate enhanced writing skills.
CO6	Develop the skills needed for effective science communication and demonstrate augmented presentation skills.

Semester	**II**
Paper Code	**BT8124**
Paper Title	**Advanced Cell Biology**
Number of teaching hours per week	**04**
Total number of teaching hours per semester	**60**
Number of credits	**04**

Objective of the Paper:

This course has been designed to expose students to a broad range of advanced cell biological themes. The topics will be covered in depth, with references to the relevant techniques and disease implications. These will provide students a firm handle on cell biological principles and the ability to understand and analyze a research problem.

Syllabus for BT8124: Advanced Cell Biology **(60 hours)**

Unit	Content	Teaching Hours
Unit 1: Cell biology basics	Cellular organization, compartmentalisation, homeostasis, cells to tissues.	2 h
Unit 2: Post-translational modifications	Phosphorylation: kinases, adaptors and phosphatases, glycosylation and the cell surface, ubiquitin and proteostasis, methylation and acetylation of histones, writers, readers and erasers, irreversible proteolysis and lipidation.	5 h
Unit 3: Cell division	Discovery of yeast cell cycle mutants, cell cycle and its regulation, cell cycle checkpoints, recent theories of cell division, meiosis, synapsis and crossing over, non-disjunction.	6 h
Unit 4: Development	Fertilization, principles of embryonic development, development in *Drosophila,* genes and patterning, development of asymmetry.	4 h

Unit 5: Stem cell and differentiation	Embryonic and adult stem cells, asymmetric division, stem cell niche, totipotent, pluripotent and multipotent stem cells, iPSC and the stem cell revolution, molecular determinants of pluripotency and self-renewal, organoids and 3D culture.	6 h
Unit 6: Cellular Signalling	Signalling modules and characteristics, GPCR signalling and cAMP pathway, tyrosine kinase signalling and MAPK pathways, Wnt signalling in development and cancer, signalling crosstalk.	7 h
Unit 7: Endo-lysosomal system	Overview of cargo trafficking and the endocytic system, clathrin-coated pits and receptor-mediated endocytosis, autophagy and cell survival, exocytosis and the secretory pathway, role of trafficking in host-pathogen interaction.	6 h
Unit 8: Cell and tissue polarity	Cellular asymmetry, polarity in epithelial and non-epithelial tissues, apico-basal polarity, signalling pathways that regulate polarity.	5 h
Unit 9: Cell adhesion and motility	Cell-cell and cell-matrix adhesion, gap junctions, desmosomes and tight junctions, composition and ultrastructure, extracellular matrix and integrin signalling, cell movement and its regulation, collective cell migration.	6 h
Unit 10: Cell Death	Necrotic cell death, Apoptosis, regulation and its detection, non-canonical modes of cell death, senescence and aging.	5 h
Unit 11: Molecular basis of cancer	Immortalization and transformation, oncogenes, tumor suppressor genes, driver and passenger mutations, hallmarks of cancer, dysregulation of the cell cycle, principles of metastasis, angiogenesis, apoptosis and cancer, cancer stem cell hypothesis.	8 h

REFERENCE TEXTS:

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

Additional reading material will be provided in class in the form of presentations, handouts and journal articles.

COURSE OUTCOMES FOR BT8124: Advanced Cell Biology

After successful completion of the course, students will:

CO1	Have an in depth understanding of the inner workings of cells and how they form tissues.
CO2	Learn fundamental concepts of cellular reproduction and stem cells including their applications.
CO3	Appreciate essential cellular processes including endocytosis, signaling, interactions and cell death, and how they are deregulated in cancer.
CO4	Read and interpret historical and current scientific data, and critique published articles.
CO5	Be able to work with various models, using in vitro and in vivo assays, including Drosophila, yeasts and novel model systems.
CO6	Design questions around cell biological phenomenon and then collect, analyze and synthesize cell biological data.

Semester	**II**
Paper Code	**BT8224**
Paper Title	**Molecular Biology**
Number of teaching hours per week	**04**
Total number of teaching hours per semester	**60**
Number of credits	**04**

Objective of the Paper:
This paper is designed to give students an in-depth understanding of the core, foundational principles of Molecular Biology, while also allowing them to appreciate the scientific experimentation that led to many of the seminal advances in molecular biology.

Syllabus for BT8224: Molecular Biology **(60 hours)**

Unit	Content	Teaching Hours
SECTION A: THE BIOCHEMISTRY OF LIFE		**12 hours**
UNIT 1- Chemical Bonds determine Macromolecular Structure	Characteristics of chemical bonds, the concept of free energy, the importance of weak bonds and high-energy bonds in biological systems	2 hrs
UNIT 2- Nucleic acids convey Genetic Information	An overview of classical experiments that led to discovery of DNA structure, the mechanism of DNA replication, and the central dogma.	6 hrs
UNIT 3- DNA, Genes and Genomes: Structure and Organization	DNA structure and topology, Genes and Genomes (viral, prokaryotic, eukaryotic, organellar); Nucleosomes, Chromatin and Chromosomes, Features of Prokaryotic and Eukaryotic genomes, RNA, Protein structures and Protein: nucleotide interactions	4 hrs
SECTION B: MAINTENANCE OF THE GENOME		**18 hrs**

UNIT 4- DNA Replication	DNA Polymerase: Structure and mechanism of catalysis, Other proteins involved in DNA replication and a replication overview, DNA synthesis at the Replication Fork in prokaryotes and eukaryotes, Replication origins and Initiation of DNA replication in prokaryotes and eukaryotes, Replication termination and the end replication problem in eukaryotes, Reverse transcription.	7 hrs
UNIT 5- Mutations and DNA Repair	Causes and types of DNA Damage, types of mutagens, Replication errors and Mismatch repair, DNA Repair by Direct reversal of DNA damage, Excision repair	5 hrs
UNIT 6- Homologous recombination and DNA Transposition	The Holliday model of Homologous recombination, The double strand DNA break repair model, Molecular mechanisms of RecBCD and RuvABC mediated homologous recombination, Mechanisms of DNA transposition, Examples of transposable elements and their regulation	6 hrs
SECTION C: GENE EXPRESSION		**18 hrs**
UNIT 7- Transcription	RNA Polymerase structure and the sigma factor, Prokaryotic and eukaryotic promoters, Transcription in prokaryotes, transcription in eukaryotes, Processing of eukaryotic mRNA, Error correction	9 hrs
UNIT 8- Translation	Ribosomes, tRNA and the Genetic Code, Initiation, Elongation and termination of prokaryotic translation, Initiation, Elongation and termination of eukaryotic translation, Post translational processing of proteins	9 hrs
SECTION D: REGULATION OF GENE EXPRESSION		**12 hrs**
UNIT 9- Prokaryotic Gene Expression Regulation	Principles of Gene expression regulation, Gene regulation at transcription initiation: Constitutive and Regulatory control, Regulation of bacterial mRNA elongation by attenuation, CRISPR	6 hrs

UNIT 10- Eukaryotic Gene Expression Regulation	Transcription factors and combinatorial control of eukaryotic gene regulation, Epigenetic regulation of eukaryotic gene expression, Role of RNAs in eukaryotic gene expression regulation, Gene expression regulation in developmental stages	6 hrs

REFERENCE TEXTS

1. Molecular Biology of the Gene, Watson et al, 7th ed, 2014, Pearson EDUCATION
2. Genomes 4.0, T.A Brown, 2017, Garland Science
3. Lewin's GENES XII, Krebs, Goldstein, Kilpatrick, 2017, Jones and Bartlett
4. Molecular Cell Biology, Harvey Lodish et al, 2016, WH Freeman
5. Molecular biology, Robert F. Weaver (5th ed), 2012, McGraw Hill

COURSE OUTCOMES FOR BT8224: MOLECULAR BIOLOGY

After successful completion of the course, students will:

CO1	Gain an in-depth understanding of the macromolecular structure, function and organization that form the biochemical basis of life, how genomes are maintained, genes are expressed and regulated, through an investigation of the underlying molecular mechanisms.
CO2	Be able to read, understand and analyze primary scientific literature and appreciate both classical and recent experimentation that has advanced the field of molecular biology.
CO3	Develop analytical and problem-solving skills by routine quantitative and qualitative analysis to interpret molecular biological data.
CO4	Be able to apply cross disciplinary concepts to understand biological phenomena.
CO5	Exhibit competence in performing basic experiments involving isolation and analysis of DNA, RNA and Protein and some assays for transcription, translation and regulation.
CO6	Be able to independently work safely and effectively in the laboratory and execute a variety of experiments using the standard methods and techniques in molecular biology, and record, analyze and interpret results.

PRACTICAL II: BT8P1: Cell and Molecular Biology (88 hrs)

1. Overview and plan of work for the labs
2. Planaria as a model for regeneration and stem cells (1)
3. Planaria as a model for regeneration and stem cells (2)
4. Drosophila developmental assay
5. Chemical induction of aneuploidy
6. Analysis of apoptosis and necrosis in WBCs/yeast (laddering/morphology)
7. Histology: H&E staining and analysis
8. Effect of starvation-induced autophagy on cell viability
9. Nucleotide composition of RNA samples.
10. Isolation of genomic DNA from bacteria/yeast/blood
11. Estimation of bacterial genomic DNA and purity check of isolated DNA
12. PCR amplification of histone/ribosomal RNA genes
13. Analysis of PCR products and troubleshooting
14. Drosophila labs (1)
15. Drosophila labs (2)
16. Drosophila labs (3)
17. Induction of protein expression, solubility of proteins
18. SDS PAGE and coomassie staining (1)
19. SDS PAGE and coomassie staining (2)
20. Data Analysis and reporting/Revision/Repeat of failed experiments

Semester	**II**
Paper Code	**BT8324**
Paper Title	**Genetic Engineering**
Number of teaching hours per week	**04**
Total number of teaching hours per semester	**60**
Number of credits	**04**

Objective of the Paper:

This paper introduces students to various milestones in aspects of Genetic engineering and assisted technologies with emphasis on the latest developments. Many advanced techniques involved in genome editing, cloning and NGS are covered in the paper.

Syllabus for BT8324: Genetic Engineering **(60 hours)**

Unit	Content	Teaching Hours
Genetic Engineering		
Unit 1 – Introduction and DNA Modification	Introduction to genetic engineering and recombinant DNA technology, Concept of cloning and its applications. DNA structure – modifications using various enzymatic reactions, hydrolysis and formation of phosphodiester bonds, removal of phosphate groups and its effects. Enzymatic cleavage of DNA. Restriction and modification enzymes, Restriction mapping, DNA ligases, Polynucleotide kinase, Alkaline phosphatases, exonucleases, S1 nucleases, terminal nucleotide transferase	8 hrs
Unit 2- Nucleic acid sources & Amplification of DNA	Genomic DNA, cDNA, Adapters, linkers, homopolymer tails, modified oligos (labeled oligos), Concepts of degenerate oligos, Concepts of Polymerase chain reaction - principle, types – RT-PCR, Nested PCR, Multiplex PCR, IC-PCR, and applications of PCR	7 hrs

Unit 3 – Vectors and Gene Libraries	Vectors used for cloning – Plasmids, Bacteriophage vectors, Phagemids, Cosmids, BACs, YACs, Shuttle vectors, Animal vectors, Ri, Ti plasmids, Binary vectors, Expression vectors, Concept of genomic libraries, Construction and Detection, Genome coverage	12 Hrs
Unit 4- Methods of DNA Transfer	Direct, Indirect methods of gene transfer, Agrobacterium mediated gene transfer, Electroporation, Lipofection, Microinjection and Biolistics	8 Hrs
Unit 5 – Screening of Transformants	Antibiotic Resistance, Replica Plating, Insertional inactivation, Marker Rescue, Nucleic acid blotting and hybridization - Preparation of DNA and RNA probes, Applications of hybridization-based tests, Labeling methods (Radioactive and Non-radioactive).	8 Hrs
Unit 6- Gene Expression Analysis and Regulation - 1	Microarrays – Types, Data analysis – Normalization, Aspects of DGE. Concepts of SSH-PCR, Realtime PCR/Q-PCR, Digital Droplet PCR. DNAse Footprinting Assay, Chip Assays.	3 Hrs
Unit 7- Control of Gene Expression	Construction of transcriptomics libraries, Gene silencing strategies - Antisense RNA technology, RNAi technology and functional genomics Applications, CRISPR-Cas9 for genome editing and CRISPR – Cas 13 technologies.	5 Hrs
Unit-8 OMICS	Sangers sequencing, Automated method of DNA sequencing, Shotgun approach for Genomes, Data assembly. NGS aspects - Illumina Technology, NGS for Epigenomics – Bisulphite Sequencing. Introduction to OMICS.	4 Hrs
Unit- 9 Synthetic Genetic Engineering	Gateway approaches for multigene constructs, Reverse Genetics, Infectious clones, RACE and its application to sequence novel genomes/genes, Construction of custom expression vector systems – Promoter, Reporters, Markers, Fusion Protein Tags, Terminators. Choice of expression hosts, case studies.	5 Hrs

REFERENCE TEXTS

1. Lottspeich, F. and Engels, J.W. eds., 2018. Bioanalytics: Analytical Methods and Concepts in Biochemistry and Molecular Biology. John Wiley & Sons.
2. Brown, T.A., 2020. Gene cloning and DNA analysis: an introduction. John Wiley & Sons.
3. Primrose, S.B. and Twyman, R., 2013. Principles of gene manipulation and genomics. John Wiley & Sons.
4. Clark, D.P. and Pazdernik, N.J., 2011. Biotechnology: Academic Cell Update Edition. Academic Press.
5. Lu, Y., 2017. Cell-free synthetic biology: Engineering in an open world. Synthetic and systems biotechnology, 2(1), pp.23-27.
6. Zhao, H., 2018. Synthetic Biology–Metabolic Engineering. Springer.
7. García-Cañas, V., Cifuentes, A. and Simó, C., 2014. *Applications of advanced omics technologies: From genes to metabolites*. Elsevier.
8. Arivaradarajan, P., Misra, G, 2018. *Omics approaches, technologies & applications*. Springer.
9. Barh, D. and Azevedo, V. eds., 2019. *Single-Cell Omics: Volume 1 & 2: Technological Advances and Applications*. Academic Press.
10. Simionato, C., 2021. *Separation Techniques Applied to Omics Sciences*. Springer International Publishing.

COURSE OUTCOMES FOR BT8324: GENETIC ENGINEERING

After successful completion of the course, students will:

CO1	Gain knowledge about sources and purification methods of nucleic acids, modifying, amplifying and cloning them into various types of vectors, DNA transfer technologies.
CO2	Understand advanced cloning techniques, various types of heterologous expression hosts and screening, selection methods of positive clones, aspects of sequencing and strategies for controlling the gene expression.
CO3	Understand Sequencing technologies and their applications in the various areas of biology
CO4	Gain hands-on experience in isolation, amplification of nuclei acids, its modification and cloning and designing of a customized vector for expression of specific proteins
CO5	Well versed with the methods of selection, screening of positive clones and concept of reporter genes.

BT8P2: Genetic Engineering and Omics

Genetic engineering

1. Isolation of mRNA from tissues and purity analysis (2 labs)
2. Synthesis of cDNA from mRNA.
3. PCR primer design and customized vector design.
4. PCR amplification/RT-PCR amplification of gene of interest
5. Isolation of plasmid DNA by Alkaline lysis and Restriction digestion of plasmid DNA
6. Ligation of gene of interest into a vector and prep of competent cells
7. Bacterial transformation
8. Blue-white screening and Colony PCR based screening.
9. Sequencing of the gene, assembly, analysis.
10. Southern blotting transfer and detection (3 labs)
11. Agroinfiltration of Binary vector with GFP into *N. benthamiana* and Reporter gene assay (2 labs)
12. Cloning and expression of GFP in *E.coli*
13. qPCR analysis of Gene expression in plant/Animal cell samples (2 Labs)
14. In vitro transcription/Translation of a gene (using cell free lysates)
15. Analysis of Transcription/translation products through Agarose gel or SDS PAGE.
16. RAPD and PCR - RFLP analysis of the bacterial/plant samples for study of molecular diversity

Semester	**II**
Paper Code	**BT8424**
Paper Title	**Biostatistics**
Number of teaching hours per week	**04**
Total number of teaching hours per semester	**60**
Number of credits	**04**

Objective of the Paper:
This course is designed to introduce students to the basics of biostatistical analyses and R programming. It provides students a platform into deriving, consolidating, presenting and analyzing data using various statistical procedures and tests. The course also introduces principles of hypothesis testing and design of biological experiments.

Syllabus for BT8424: Biostatistics **(60 hours)**

Unit	Content	Teaching Hours
Unit 1: Descriptive Statistics	Frequency Distribution, Characteristics of a Frequency Distribution, Measures of central tendency: mean, median, mode; Measures of spread: range, percentile, standard deviation, kurtosis, skewness; Tabular and Graphical Presentation of Data.	8h
Unit 2: Probability Theory and Random Variables	Probability Definition, Rules for Calculating Probabilities, Discrete random variables: Bernoulli, Binomial, Poisson, Continuous random variables: Normal, Standard normal distribution.	10h
Unit 3: Correlation and Regression	Correlation, Karl Pearson Correlation Coefficient, Regression analysis, Simple linear regression, Significance testing of correlation and regression coefficients	5h
Unit 4: Inferential statistics and one sample hypothesis testing	Samples and populations: Random, stratified and cluster sampling. Single- and Double-blind experiments. Point and interval estimates, Sampling distributions: t, chi-square, F distributions, Hypothesis testing: null and alternative hypotheses, decision criteria, critical values, type I and type II errors, the meaning of statistical significance, power of a test, One sample hypothesis testing: Normally distributed data: z,	15h

	t and chi-square tests. Binomial proportion testing.	
Unit 5: Multi-sample and nonparametric hypothesis testing	Two sample hypothesis testing; Nonparametric methods: signed rank test, rank sum test, Kruskal-Wallis test, Analysis of variance: One-way ANOVA. Two- way ANOVA. Post ANOVA tests: Tukey's test, Dunnett's Test.	8h
Unit 6: Design of Experiments	Designed Experiments, Principles of experimental design, Randomization, Blocking, Replication & Extraneous Variables. Completely Randomized Design, Randomized block design, Latin Square Design, Factorial Design, Split- Block Design	10h
Unit 7: Data curation and management	Introduction to Data Science, Missing data, Data cleanup, data organization.	4h

REFERENCE TEXTS

1. Wayne W. Daniel, Chad L. Cross,2012, 10th edition, Biostatistics: A Foundation for Analysis in the Health Sciences, Wiley Sciences Publishers
2. Gupta S.P., 2010, 5th Edition, Statistical Methods, Sultan chand & Sons
3. Siegel, S., Johan, N., Casellan, Jr. 1956. Non-parametric Tests for Behavior Sciences.
4. Learning Statistics: http://freestatistics.altervista.org/en/learning.php.
5. Electronic Statistics Text Book: http://www.statsoft.com/textbook/stathome.html

COURSE OUTCOMES FOR BT8424: BIOSTATISTICS

After successful completion of the course, students will:

CO1	Be able to consolidate, present data in tables, graphs and describe any distribution using the standard population parameters.
CO2	Understand and derive theoretical probability distributions and use them in assigning probabilities to desirable events.
CO3	Gain in-depth understanding of concepts in bivariate analysis such as correlation and regression and linear regression analysis
CO4	Develop insight into hypothesis testing using various testing procedures and be able to draw statistically valid inferences from data.
CO5	Be able to efficiently design and analyze biological experiments.
CO6	Gain expertise in the use of R programming in biostatistical analyses and gain insights into basics of data science.

Semester	**II**
Paper Code	**BTDE8524**
Paper Title	**Omics Technologies, Synthetic and Systems Biology**
Number of teaching hours per week	**04**
Total no. of teaching hours per semester	**60**
Number of credits	**04**

Objectives of the Paper:

This course provides insights into Multi-OMICS technologies with emphasis on the aspects of research-oriented applications and translational research. Concepts related to OMICS and their applications in the fields of biology, plant protection, translational medicine, toxicology and environmental research are covered in this course.

Syllabus: BTDE8524: Omics Technologies, Synthetic and Systems Biology (60 hours)

Unit	Content	Teaching Hours
Omics Technologies		**45 Hrs**
Unit 1:	**Genomics technologies**	
	Introduction to NGS Sequencing – Illumina Technology, *De novo* sequencing or Resequencing; Exome sequencing; RNA sequencing; Small RNA sequencing; Metagenomics; NGS workflow: DNA/RNA isolation and quantitation; Fragmentation (different methods – Physical / Enzymatic/ Chemical); Library preparation-blunt end and adapter ligation, amplification, index addition; single end and paired end reads; Exome/ gene panel capture; Ribosomal RNA depletion (RNA-Seq) and small RNA enrichment; 16S rRNA based sequencing for metagenomics; Data format, Quality control-Phred score; FastQC, data analysis tools and pipeline, Read length, read depth, sequence coverage. Annotation, Variant Calling etc., Cancer Gene Panels.	9 hrs
Unit 2:	**Epigenomics approaches and Transcriptomics**	

	ATAC-Sequencing, MNase sequencing, Chip-Sequencing, Bisulfite sequencing, MIRA, BisChip Sequencing, PAT Chip, ChIRP Sequencing approaches. Library preparation, and analysis pipeline, Choice of sequencing methods and tools for read mapping, assembly, identification of splicing variants and differential expression analysis. Biogenesis, characteristics and analysis of small RNA like microRNAs and phasiRNAs. Applications of transcriptomics - case studies. Microarrays and Data mining, GEO Dataset analysis.	9 hrs
Unit 3:	**Proteomics**	
	2D-Gel based Proteomics, DIGE, Topdown and Bottom up approaches, Mass spectrometry – ionization methods (MALDI, electrospray), mass analysers, fragmentation modes (CID, HCD and ETD), intact protein analysis, protease digestion, peptide mass fingerprinting, tandem mass spectrometry, introduction to Data Independent Analysis (DIA); Protein sequence and spectral databases/ libraries, de-novo sequencing. Introduction to quantitative proteomics- Differential proteomics, post-translational modifications, Targeted proteomics- Parallel reaction monitoring, Multiple reaction monitoring.	8 hrs
Unit 4:	**Metabolites and Metabolomics**	
	Metabolomics-an overview, basic sample preparation strategies-extraction, derivatization, Workflow for lipidomics (MS based Lipidomics); Targeted Vs Untargeted metabolomics; Peak detection, retention time alignment; identification of molecular features and metabolites; structural confirmation of metabolites. Applications of metabolomics in Alzheimers, CVD, Food Science and Nutrition, Plant improvement, Microbial bioremediation etc.,	8 hrs
Unit 5:	**Single Cell Omics**	
	Methods of Single Cell Isolation – Micromanipulation, Immunopanning, FACS, Magnet activated cell sorting, Method of single-cell type nuclei, Single Cell Analysis – Genomics, Epigenomics, Transcriptomics, Proteomics, Metabolomics – Applications. Data analysis in single cell sequencing, single cell omics for circulating tumour cells, single cell omics in breast cancer, CVD, metabolic disorders, autoimmune disorders, drug discovery, cell based medicine and therapy and in plants.	7 hrs

Unit 6:	**Applications of Omics**	
	Omics applications in Toxicology, Nutrition, Health and medicine, Environment, Microbiome analysis, Agriculture, Marine systems, Biomarker discovery, Personalized medicine, soil science.	4 hrs
Synthetic & Systems Biology		**15 hrs**
Unit 7	**Synthetic Biology**	
	Introduction, Genetic circuits and logic gates, bacterial photography, genetic elements for new control systems, pathway engineering, biofuels, metabolic engineering, pathway engineering- Artemisinin; de novo design of pathways, engineering in algae, plants, gene design – BioBricks, gene assembly, gene design – synthetic genomes, artificial cells – vaccines, structured devices – DNA, Engineering of Riboswitches, Cell free Biosynthesis – protein expression etc., Structured devices – protein, Ethical, Legal and Social aspects of Synthetic Biology – Biowarfare.	6 hrs
Unit 8:	**Introduction to Systems Biology**	
	Systems Biology Networks- basics of computer networks, Biological uses and Integration. Networks and Pathways – Types and methods. Metabolic networks. Cellular models. Introduction- databases KEGG, EMP, MetaCyc, AraCyc, TCGA etc., Expression databases and various databases related to systems biology, Tools – Cytoscape, DAVID etc.,	9 hrs

REFERENCE TEXTS:

1. Simó, C., Cifuentes, A. and García-Cañas, V., 2014. *Fundamentals of advanced omics technologies: from genes to metabolites*. Elsevier.
2. García-Cañas, V., Cifuentes, A. and Simó, C., 2014. *Applications of advanced omics technologies: From genes to metabolites*. Elsevier.
3. Banerjee, R., Kumar, G.V. and Kumar, S.J. eds., 2019. *Omics-based approaches in plant biotechnology*. John Wiley & Sons.
4. Barh, D., Zambare, V. and Azevedo, V. eds., 2013. *Omics: applications in biomedical, agricultural, and environmental sciences*. CRC Press.
5. Arivaradarajan, P. and Misra, G., 2018. *Omics Approaches, Technologies And Applications*. Springer, Singapore.
6. Barh, D. and Azevedo, V. eds., 2019. *Single-Cell Omics: Volume 1: Technological Advances and Applications*. Academic Press.

7. Barh, D. and Azevedo, V. eds., 2019. *Single-Cell Omics: Volume 2: Technological Advances and Applications*. Academic Press.
8. Simionato, C., 2021. *Separation Techniques Applied to Omics Sciences*. Springer International Publishing.

COURSE OUTCOMES FOR BTDE8524: OMICS TECHNOLOGIES, SYNTHETIC AND SYSTEMS BIOLOGY

After successful completion of the course, students will:

CO1	Understand the techniques, concepts behind Omics technologies
CO2	Learn aspects of Genomics, transcriptomics, metabolomics and their applications
CO3	Gain an understanding of Single cell omics, applications of the technology in improving quality of human life
CO4	Become familiar with multiple applications of omics in various fields of biology
CO5	Understand the concepts of systems biology, modeling of pathways
CO6	Learn about the synthetic biology concepts involved in designing systems and their pros and cons.

Semester	**II**
Paper Code	**BTDE8624**
Paper Title	**Nanobiotechnology**
Number of teaching hours per week	**04**
Total number of teaching hours per semester	**60**
Number of credits	**04**

Objective of the Paper:
This elective paper provides a deep insight into the subject of nanobiotechnology with emphasis on the aspects of research-oriented applications of nanotechnology in biotechnology. Students will learn fundamental concepts pertaining to physics, chemistry and biology to gain deep understanding on the behavior and functioning of nanomaterials and their relevant bio-based applications. Later, students will be able to apply nanotechnology concepts in the fields of therapeutics, diagnostics, translational medicine, plant growth promotion and protection, toxicology and environmental protection.

Syllabus for BTDE8624 Nanobiotechnology **(60 hours)**

Unit	Content	Teaching Hours
NANOBIOTECHNOLOGY		60 hrs
Unit 1: Introduction & History	Definitions and concepts of Nanobiotechnology, Historical background and landmarks. Broad areas of Nanobiotechnology, Applications of Nanobiotechnology. Cell-nanostructure interactions	3 hrs
Unit 2: Fundamental concepts to understand nanotechnology	Coulomb potential, potential energy and intermolecular distance curve, charge-dipole interactions, induced dipoles, polarizability; dispersion; steric repulsion; hydrogen bonding; hydrophobic and hydration interactions. Types of chemical bonds in molecules. Concepts on molecular orbitals. Brownian movement, diffusion, Fick's Law, transport properties of biomolecules. DNA, RNA, protein, lipid bilayer and cell wall structure.	3 hrs

Unit 3: Nanomaterial types, their synthesis and characterization	Types and characteristics of nanomaterials used in nanobiotechnological applications. Approaches for synthesis of nanomaterials – Physical, Chemical and Biological methods (Microbial and plant based). Synthesis of gold, silver, zinc, copper nanoparticles from microbes and plant sources. Synthesis of nanomaterials from plants (cellulose). Techniques used in characterization of nanomaterials - Spectroscopic, morphological and other techniques. *Active learning*: Synthesis and characterization of nanoparticles and its cytotoxicity analysis.	8 hrs
Unit 4: Properties of Nanomaterials	Nanomaterial properties – Optical, electronic, magnetic, mechanical and catalytic properties. Quenching of nanosystems. Case studies on Nanoparticles, quantum dots, nanotubes and nanowires.	7 hrs
Unit 5: Protein/Lipid - based Nanostructures, Nanobiomachines and Signaling	Overview, chemistry and structure, Genetics & Secondary cell-wall polymers. Self-assembly in suspension, Recrystallization at solid supports, Formation of regularly arranged Nanoparticles. Cell as nanobio-machine, link between the signaling pathways & molecular movements as well as neuron function. Concepts in nanobio-machines for information processing and communications.	6 hrs
Unit 6: Functionalization of nanosystems and natural systems producing nanoparticles	DNA/RNA/Protein/Peptide based functionalization of nanoparticle systems, Detection of proteins (Bio Barcodes), virus as nanoparticle systems, Magnetosomes, Bacteriorhodopsin and its potential applications (overview, structure, photoelectric applications, photochromic applications, applications in energy).	7 hrs
Unit 7: Applications of Nanotechnology In Biology	Chip-based Assays, Drug targeting, Gene/Drug delivery, DNA computing, Nanobiosensors, Biomedicine, Quantum dots for biological labeling, Nanobarcodes, Nanoparticles as Non-Viral Transfection Agents, Block copolymers, liposome systems, 3-D Nanostructured Mineralized Biomaterials, Surface modification for enhanced cell-nanomaterial interaction.	9 hrs

Unit 8: Applications of Nanoparticles promoting plant growth	Application of nanoparticles as nanopesticides, nanoinsecticides, nanofungicides, nanofertilizers. Bioengineered nanomaterials for Plant growth promotion – Fullerene, Single walled Carbon nanotubes and Multiwalled Carbon nanotubes and metal nanoparticles (ZnO, TiO2, CeO2, Silver, Gold and Iron oxide nanoparticles).	4 hrs
Unit 9: Nanobiotechnology In Therapeutics And Diagnosis	Nanoparticles as contrast agents, nanoparticles for imaging (CT, MRI, Nanodentistry), Surface Modified Nanoparticles for Cancer therapy, MEMS/NEMS based devices for therapy, Anisotropic and Magnetic Particles (Hyperthermia), Nanorobots and Nanodevices in medicine, concepts of Pharmacogenomics and Nanotechnology in Personalized Medicine, nano-mechanobiology concepts for the assessment of cellular environment, Wearable nanobiosensors.	7 hrs
Unit 10: Nanobiotechnology for Sustainable Environment	Challenges to sustainability in the environment. Nano biocatalysis in bioenergy production and remediation. Application of nanotechnology in production of biofuels, bioremediation, nanotoxicity testing in environmental samples.	4 hrs
Unit 11: IPR and Regulatory Issues in Nanobiotechnology	Ethical, Legal and Social Issues related to applications of Nanobiotechnology. Patenting of Nano based products, Biopiracy, Biosafety levels involved in Nanobiotechnology experiments, Regulatory steps involved in approval of Nanobiotechnology products.	2 hrs

REFERENCE TEXTS:

1. Abd-Elsalam, K.A. and Prasad, R. eds., 2018. Nanobiotechnology applications in plant protection. Springer.
2. Mirkin, C.A. and Niemeyer, C.M. eds., 2007. Nanobiotechnology volume I & II: more concepts and applications. John Wiley & Sons.
3. Logothetidis, S. ed., 2012. Nanomedicine and nanobiotechnology. Springer Science & Business Media.
4. Rajesh Singh Tomar, Anurag Jyoti, Shuchi Kaushik. 2020. Nanobiotechnology Concepts and Applications in Health, Agriculture, and Environment. Apple Academic Press.
5. Verma, M.L. ed., 2020. Nanobiotechnology for Sustainable Bioenergy and Biofuel Production. CRC Press.
6. Kaushik, A. K., & Dixit, C. K. (Eds.). (2016). Nanobiotechnology for sensing applications: from lab to field. CRC Press.

7. Omran, B.A., 2020. Nanobiotechnology: A Multidisciplinary Field of Science. Springer.
8. Rai, M., Abyaneh, M.R. and Ingle, A.P. eds., 2020. Nanobiotechnology in Diagnosis, Drug Delivery and Treatment. Wiley-Blackwell.
9. "Biological Physics: Energy, Information, Life" by P. Nelson, Freeman, 2008
10. "Physical Biology of the Cell" by R. Phillips et al., Garland (2012).
11. Other required study materials to be provided by the course instructor.

COURSE OUTCOMES FOR BTDE8624: NANOBIOTECHNOLOGY
After successful completion of the course, students will:

CO1	Learn fundamentals of Nanotechnology, types and properties of nanomaterial and its synthesis.
CO2	Understand how biological molecules such as proteins and DNA could be organized or integrated with nanostructures or nanoparticles.
CO3	Gain knowledge of the applications of nanomaterials in translational medicine, diagnostics and therapy, plant protection and environmental applications.
CO4	Gain appreciation of biosafety and IPR issues involved in commercialization of nano biotechnological products.

Semester	**III**
Paper Code	**BT9125**
Paper Title	**Bioinformatics and Computational Biology**
Number of teaching hours per week	**04**
Total number of teaching hours per semester	**60**
Number of credits	**04**

Objective of the Paper:
This course covers key concepts in bioinformatics and computational biology including programming concepts, tools- Big data analytics, sequence analysis and molecular modeling. Emphasis is laid on the research aspects of the above.

Syllabus for BT9125: Bioinformatics and Computational Biology (60 hours)

Unit	Content	Teaching Hours
Bioinformatics and Computational Biology		**60 hrs**
Unit -1: Basics of Computation	Operating systems - CUI, GUI. Basics commands of Linux operating system. R-programming for Bioinformatics.	**4 hrs**
UNIT 2- Introduction to Bioinformatics	Disciplines – Genomics, Proteomics, Computational Biology, Transcriptomics, Pharmacogenomics, Metabolomics. Concepts. Sequence assembly. Type of databases - Nucleotide sequence databases, Primary nucleotide sequence databases - ENA, Genbank, DDBJ; Specialized genome databases – GOLD, TAIR, SGD. Literature Databases – PUBMED. Human Genome Project – OMIM database.	**6 hrs**
UNIT 3- Proteins and Databases	Protein sequence databases- UniprotKB, Sequence motif databases/Secondary Protein sequence databases - PROSITE, Interpro. Protein structure databases, Protein Data Bank - SCOP, CATH, KEGG, PubChem databases, Interactome databases. Methods of Protein Secondary Structure Prediction – GOR, Chou Fasman and Neural Networks.	**7 hrs**

UNIT 4- Sequence alignment, Sequence analysis and Algorithms	Pairwise Sequence Comparison - Pairwise sequence alignment (global, local), gap penalties - Linear and Affine gap penalty, similarity vs. distance. Identity Scoring Matrix, Scoring matrices for amino acid sequence alignment, PAM BLOSUM Matrix; Smith –Waterman algorithm for local alignment, Needleman-Wunsch algorithm, Statistics of Sequence alignment score: E- value; BLAST and variants. Multiple sequence alignment: Clustal Algorithm. Concepts of Sequence analysis. RNA secondary structure prediction – RNA secondary structure, features: stems, loops, bulges, Pseudoknots, Nussinov algorithm, mFold tool. Sequence analysis.	**9 hrs**
UNIT 5- Molecular Phylogenetics	Concept of Phylogenetic tree, Rooted, unrooted, Molecular Clock Hypothesis, Distance based data - UPGMA and Neighbor Joining Methods. Character based data: Maximum Parsimony and Maximum likelihood method. Methods of tree evaluation - Bootstrapping.	**4 hrs**
UNIT 6- Big data /NGS Analysis concepts	Introduction to Next Generation Sequencing (NGS) data - Biases and sequencing errors of Illumina technology, FastQ file format, Quality reads assessment (FastQC software), Reads pre-processing. Genome assembly assessment – Variant analysis – VCF. SAM/BAM formats - Genome annotation formats – GFF3. Visualization of Genome - Circos	**8 hrs**
UNIT 7- Transcriptomic analysis and RNA-seq	RNA-seq assembly, Transcripts reconstruction, quantification - Identification of differentially expressed genes, Gene enrichment analysis. SRA database.	**6 hrs**
UNIT 8- Molecular modeling	Concept of Protein modeling, Ab-initio based protein modeling, Protein homology modeling, Energy minimization, Molecular dynamics.	**5 hrs**
UNIT 9- Ligand-protein interactions	Concept of Docking. Protein-protein docking algorithms and programs, Ligand-Protein docking.	**4 hrs**
UNIT 10- Drug	Pharmacophore based drug design - 2D and 3D structures of chemical compounds, molecular descriptors and Lipinski rules,	**5 hrs**

Designing	QSAR. Identification of Drug targets, Active site prediction, Molecular modeling, ADMET studies.	
UNIT 11- Biological networks	Gene interaction and regulation Networks, Protein-protein interaction networks, Visualization of networks – Cytoscape.	**2 hrs**

REFERENCE TEXTS

1. Baxevanis, A.D., Bader, G.D. and Wishart, D.S. eds., 2020. Bioinformatics. John Wiley & Sons.
2. Xinkun Wang, X. Next-generation sequencing data analysis. 1st edition, CRC Press, 2016.
3. Keith, J.M., Volume I: Data, Sequence Analysis, and Evolution Second Edition.
4. Keith, J.M., Volume II: Structure, Function, and Applications Second Edition.
5. Yao, Y. ed., 2018. Applied Computational Genomics (Vol. 13). Springer.
6. Shaik, N.A., Hakeem, K.R., Banaganapalli, B. and Elango, R., 2019. Essentials of Bioinformatics.
7. Larson, R.S. and Oprea, T.I. eds., 2006. Bioinformatics and drug discovery: Humana Press.
8. Mount, David W., and David W. Mount. *Bioinformatics: sequence and genome analysis*. Vol. 1. Cold Spring Harbor, NY: Cold spring harbor laboratory press, 2001.

COURSE OUTCOMES FOR BT9125: BIOINFORMATICS AND COMPUTATIONAL BIOLOGY

After successful completion of the course, students will:

CO1	Learn the basic concepts of Operating systems and able to write codes for DGE data analysis in R.
CO2	Assimilate aspects of Databases, Datamining, Sequence alignment, Sequence analysis, Phylogenetics and be able interpret the results.
CO3	Learn about methods of NGS sequence assembly, variant analysis, DGE analysis of RNASeq data, visualize the biological networks.
CO4	Understand and apply methods of Biomolecular modeling, Docking, Drug Designing.
CO5	Mine data from various databases and be able to analyze and present complex biological data.
CO6	Able to predict the 3D models of biomolecules, design ligand molecules and analyze their ADMET properties.

Semester	**III**
Paper Code	**BT9225**
Paper Title	**Immunology**
Number of teaching hours per week	**04**
Total number of teaching hours per semester	**60**
Number of credits	**04**

Objectives of the Paper:
This course offers advanced understanding of mechanisms of immunity and the various cross talks that happen within each of the immune components within our body. Students will also be introduced to concepts of tolerance, autoimmunity, host-pathogen interactions and applications of various immunotherapies in treatment of cancer.

Syllabus for BT9225: Immunology **(60 hours)**

Unit	Content	Teaching Hours
Unit 1: General Introduction	Innate and adaptive immune responses, haematopoiesis, cells of the immune system, primary and secondary lymphoid organs.	4 h
Unit 2: Mechanism of Innate Immunity	Innate immune recognition, pattern recognition receptors, Toll-like receptor signalling, barriers of immunity, complement system - characteristics and components, complement activation - classical, alternative and lectin pathways, outcome of complement activation and deficiencies.	7 h
Unit 3: Inflammation and Inflammatory Responses	Cytokines - Role in inflammatory response, cytokine receptors, role of cell adhesive molecules - selectins, mucins, integrins, ICAMS, mechanism of leukocyte extravasation, role of neutrophils in inflammation, inflammatory response - localized, acute and chronic responses, anti-inflammatory agents, allergic reactions.	7 h

Unit 4: Antigens	Types of antigens, antigen-antibody interactions, tools to detect antigens,	3 h
Unit 5: Antibody structure and diversity	Structure of antibodies, classes and function of antibodies, theories of antibody diversity, organization of immunogenes, rearrangement of variable regions in immunoglobulin, somatic recombination and genetic diversity, allelic exclusion.	5 h
Unit 6: Humoral immunity	B cell receptor and signalling, maturation of B cells, positive and negative selection, activation and proliferation of B cells, thymus-dependent and independent antigens, differentiation of B cells - affinity maturation, class switching, generation of plasma and memory cells, features and phases of adaptive response.	5 h
Unit 7: Major histocompatibility complex	Self vs non-self, HLA structure and diversity, pathways of antigen processing and presentation - endogenous and exogenous pathways,	4 h
Unit 8: Cell-mediated Immunity	Cell Mediated Response - types, development and function of effector T cells, TCR signalling, immunological synapse, role of NK cells and TREGs in cell mediated immunity, T cell-mediated cytotoxicity	5 h
Unit 9: Tolerance	Types of tolerance, mechanisms - clonal deletion, clonal anergy, receptor editing, clonal ignorance, antigen blockage, immune privilege, examples of autoimmune diseases	5 h
Unit 10: Transplantation	Different types of transplants, allorecognition, mechanism and stages of allograft rejection, overview of organ transplantation, skin transplantation and artificial skin, concept of xenotransplantation	4 h

Unit 11: Immuno-oncology and Immunotherapy	Basic principles of immunotherapy, immunosuppression in cancer and immune checkpoint inhibitors, adoptive cell therapies: tumour infiltrating lymphocytes, CAR-T cells and NK cells, antibody-based therapy - naked, conjugated and bispecific.	5 h
Unit 12: Vaccines	Active and passive immunisation, types of vaccines, adjuvants, responses to vaccination, vaccine booster and memory, cancer vaccines.	4 h

REFERENCE TEXTS:

Immunology by Richard A. Goldsby, Thomas J. Kindt, Barbara A. Osborne & Janis Kuby
Immunology a comprehensive review: Darla J. Wise & Gordon R. Carter-Anebooks
Lecture notes in Immunology: Ian Todd & Gavin Spicket

COURSE OUTCOMES FOR BT9225: IMMUNOLOGY

After successful completion of the course, students will:

CO1	Get an insight into in-depth concepts of Immunology
CO2	Understand the architecture of the innate and adaptive immune system and their interaction
CO3	Appreciate how our immune system is tightly regulated to prevent unwanted reactions in the form of autoimmune and hypersensitivity
CO4	Understand processes that responds to an infection, including humoral and cell mediated responses
CO5	Analyze assay data, arrive at meaningful conclusions in the context of diagnostic and immunotechniques
CO6	Understand concepts and application of immunotherapy in cancer

PRACTICAL I: BT9P1: Bioinformatics and Immunology (88 hrs)

1. Information retrieval from Databases – Genbank, Uniprot kb, KEGG, SRA, GEO, Database homology search using BLAST.
2. Sequence analysis using BioEdit package & Phylogenetic analysis using MEGA.
3. WGS- QC, Assembly and Annotation.
4. RNAseq-DGE
5. Protein modeling using *Ab initio* servers, Homology modeling tools.
6. Energy Minimisation, Protein structure evaluation using Procheck.
7. QSAR dataset and pharmacophore modeling with molecular modeling tools
8. Prediction of ADMET properties.
9. Rigid body docking, Flexi docking using Autodock and Hex.

Immunology

1. Blood smear and DLC
2. Diagnostic tests (WIDAL and VDRL)
3. Extraction of IgY antibodies from chicken eggs
4. Estimation of IgY concentration by Bradford method
5. Papain and pepsin fragmentation of IgY and SDS PAGE
6. ELISA (TSH/T3/T4)
7. SRID and ODD-titration
8. Isolation of leukocytes and sample preparation
9. SDS PAGE and Western blotting (1)
10. SDS PAGE and Western blotting (2)

Semester	**III**
Paper Code	**BT9325**
Paper Title	**Industrial Biotechnology, Entrepreneurship and Bioethics**
Number of teaching hours per week	**04**
Total number of teaching hours per semester	**60**
Number of credits	**04**

Objectives of the Paper:

This course is designed to cover the industrial aspects involving bioreactors and its processes for production of bio-based products. A brief introduction to the course pertaining to general requirements in industrial bioprocesses and significance of strain improvement will enable students to realize the critical parameters impacting bioprocesses. The course also covers aspects of entrepreneurship, bioethics and biosafety.

Syllabus: BT9325: Industrial Biotechnology, Entrepreneurship and Bioethics (60 hours)

Unit	Content	Teaching Hours
INDUSTRIAL BIOTECHNOLOGY		40 hrs
Unit 1: Introduction	Commercial potential of Industrial Biotechnology in India. Historical overview of industrial fermentation process microorganisms, mode of operation, General requirements of fermentation processes.	2 hrs
Unit 2: Strain Improvement	Target for improvement, Optimisation, methods of strain improvement, screening and detection, preservation, Understanding cultures ATCC, GRAS. Targets and examples for Yeast strain improvement	4 hrs
Unit 3: Bioreactors	Design and operation of bioreactors, Types: CSTR, airlift, bubble column, packed bed, fluidized bed and membrane-based reactors. Stability analysis of bioreactors.	6 hrs
Unit 4: Upstream processing	Fundamentals of upstream processing. Bioprocess considerations for bacterial cells, animal cells and plant cells. Media used in fermentation - an overview, industrial scale sterilization technique (batch, continuous and membrane based), Microbial growth kinetics in batch, fed-batch and continuous modes of operation. Enzyme immobilization:	8 hrs

	Physical and chemical techniques for enzyme immobilization – adsorption, matrix entrapment, encapsulation, cross-linking, covalent binding	
Unit 5: Heat and Mass transfers	Introduction to differential equations (first order and second order, rate constants and stoichiometry). Heat transfer: Modes of heat transfer: Conduction, Convection and radiation. Laws of thermodynamics. Overall heat-transfer coefficient. Heat capacity at constant pressure and at constant volume. Heat exchange equipment - heat exchangers, heat transfer in agitated vessels and packed bed reactors. Mass transfer: Oxygen mass transfer in bioreactors, microbial oxygen demands, Mass transfer coefficients (K_LA and K_GA), mass transfer correlations. Scale up criteria for bioreactors based on oxygen transfer, power consumption and impeller tip speed and agitation; agitation of liquids; gas-liquid systems; gas-solid suspensions; agitator scale up	9 hrs
Unit 6: Downstream Processing	Introduction to downstream processing principles, characteristics of biomolecules and bioprocesses. Cell disruption strategies. Isolation: Adsorption, liquid-liquid extraction, aqueous two-phase extraction, membrane separation: ultrafiltration and reverse osmosis, dialysis, precipitation of proteins Separation: Unit operations for solid-liquid separation, filtration and centrifugation, flocculation, precipitation and supercritical extraction. Product finishing: Crystallization principles, equipment used; Drying principles and equipment for drying and Lyophilization. Use of chromatography in purification at the industrial level. Waste treatment in industrial biotechnology.	7 hrs
Unit 7: Industrial scale production	Alcohol, Antibiotics, Citric acid, Single cell protein, Monoclonal antibodies, Vitamin, Vaccine, Polyphenols.	4 hrs
ENTREPRENEURSHIP		15 hrs
Unit 1: Introduction and Start-up Opportunities	The New Industrial Revolution: The Big Idea,Business Start-up; Ideation; Venture Choices ; The Rise of The Startup Economy ; The Six Forces of Change; The Start-up Equation; The Entrepreneurial Ecosystem; Entrepreneurship in India;	8 hrs

	Government Initiatives.	
Unit 2: Startup Capital Requirements and Legal Environment	Identifying Startup capital Resource requirements; estimating Startup cash requirements; Develop financial assumptions; Constructing a Process Map; Positioning the venture in the value chain; Launch strategy to reduce risks; Startup financing metrics; The Legal Environment; Approval for New Ventures; Taxes or duties payable for new ventures.	7 Hrs
BIOETHICS		5 hrs
Unit 1: Bioethics and Biosafety	Introduction to Bioethics and Biosafety: definition and needs of Bioethics, Social and Ethical issues in biotechnology. Application of bioethics: the expanding scope of ethics from biomedical practice to biotechnology. Introduction to Biosafety: definition and needs of biosafety, levels of biosafety, applications of biosafety at workplace, Biosafety during development of biotech products. Examples and case studies.	3 hrs
Unit 2: Ethical Issues	Ethical issues regarding genetically modified organisms (foods and crops); bioethics in biodiversity and resource management. Animal cloning and human cloning and their ethical aspects.	2 hrs

REFERENCE TEXTS:

Unit operations in Chemical Engineering by McCabe W.L. and Smith J.C. McGraw Hill

A Textbook of Chemical Engineering Thermodynamics by Narayanan K. V., Ed 1. PHI publishers (1st Ed.), 2001.

Prescott & Dunn (2002) Industrial Microbiology, Agrobios (India) Publisher

Lee, S.Y., Nielsen, J. and Stephanopoulos, G., "Industrial Biotechnology: Products and Processes", John Wiley & Sons, 2016.

Waites, M.J., Morgan,N.L., Rockey,J.S., Higton, G., "Industrial Microbiology: An Introduction"Blackwell, 2001.

Cruger, W., Cruger, A., "A Textbook of Industrial Microbiology", Panima PublishingCorporation, 2nd Edition, 2005

Treybal R.E, "Mass Transfer Operations", McGraw-Hill, 3rd edition. 1981.

Stanbury P.F, Whitaker H, Hall S.J (1997) Principles of Fermentation Technology, Aditya Books

Sateesh M.K (2008) Bioethics & Biosafety, IK Publishers.

COURSE OUTCOMES FOR BT9325: INDUSTRIAL BIOTECHNOLOGY, ENTREPRENEURSHIP AND BIOETHICS

After successful completion of the course, students will:

CO1	Understand concepts of fermentation process and production stages pertaining to upstream, downstream and heat and mass transfer mechanisms for the production of specific products.
CO2	Model data on industrially relevant microbial strains using differential calculus.
CO3	Perform practical sessions to identify parameters that impact bioprocesses. Also gain hands on experience in employing certain upstream and downstream techniques.
CO4	Generate ideas needed for startup, construct business model canvas, cost structures, value propositions, key activities and pitch ideas for startup
CO5	Use case studies to debate and understand ethical issues and gain insight into industrial regulations.

Semester	**III**
Paper Code	**BT9425**
Paper Title	**Applied Biotechnology**
Number of teaching hours per week	**04**
Total number of teaching hours per semester	**60**
Number of credits	**04**

Objectives of the Paper:

The course introduces students to biotechnological tools that have advanced modern agriculture. The course discusses generation of transgenic crops and the current GM crop landscape, the basics of animal cell culture and its applications, recent biotechnological applications in medicine, and also gives students an understanding of the role of biotechnology in managing various environmental issues that plague our planet.

Syllabus: BT9425: Applied Biotechnology **(60 hours)**

Unit	Content	Teaching Hours
Plant Biotechnology		**15 hrs**
Unit 1	**Food Security**	**1 hr**
	Statistics on Global hunger, and discussion about SDG 2.0-Zero hunger. Plants for food, feed, fiber and fuel. Challenges facing agriculture.	
Unit 2	**Transgenic Crops**	**5 hrs**
	The transgenic crop landscape, Plant transformation techniques, strategies for engineering stress tolerance, GMOs for pest and disease resistance, abiotic stress tolerance, herbicide tolerance, biofortification. Regulatory Frameworks.	
Unit 3	**Biotechnological tools in genetic improvement of crops**	**5 hrs**
	Molecular markers, Marker assisted selection, Genomics and Proteomics in crop improvement, RNAi, CRISPR/Cas9 gene editing	
Unit 4	**Conservation and Ecology**	**2 hrs**
	Diversity, hotspots, Invasive species, plant-animal interactions, *ex situ* and *in situ* approaches to conservation, DNA Barcoding, Gene banks	

Unit 5	**Plant Secondary Metabolites and Metabolic Engineering**	**2 hrs**
	Secondary metabolites, bioactive compounds. Strategies for metabolic engineering –over expression/ repression- gene, transcription factors, model plants for metabolite, plant-based vaccines, therapeutic proteins	
Animal Biotechnology		**15 hrs**
Unit 1	**Animal Cell Culture**	**7 hrs**
	Introduction and biology of cultured cells; Equipment, aseptic techniques and safety protocols; Requirements of animal cell culture: Types of cell culture media and supplements, Preparation and sterilization of media; Types of cell cultures and cell lines; Disaggregation of cell culture – Mechanical and Enzymatic methods; Maintenance of cell Lines- Cryopreservation and Germplasm storage; Cell counting and viability assays- MTT, LDH, Alamar assay; Growth phases of cells in culture.	
Unit 2	**Applications of Animal Cell Culture**	**4 hrs**
	3D cell and organ culture, artificial skin, blood and tissues; Extraction of biomolecules from cell culture; Production of bioactive compounds and growth hormones; Viral Propagation; Assisted Reproductive Technology (ART); In vitro fertilization; Histochemistry, metabolic and analytical assays using cell lines.	
Unit 3	**Experimental Animal Models**	**4 hrs**
	Basic components of an animal house and safety precautions; Ethical clearance for use of animal models in research; Maintenance and diet of different animal models; Knockout and transgenic models; Drug trials using animal models.	
Environmental Biotechnology		**15 hrs**
Unit 1	**Introduction to our Environment**	**2 hrs**
	Definitions on atmosphere, hydrosphere, lithosphere and biosphere. Concepts on Natural Resources: Food, Water, Energy.	
Unit 2	**Bioremediation and Biocontrol (Biological insecticides/pesticides)**	**4 hrs**
	Bioremediation: Introduction, Types (In situ, Ex situ), Bioremediation techniques: Bioaugmentation and Biostimulation. Organisms used in Bioremediation. Case studies of bioremediation.	

	Biocontrol: Biocontrol using organisms: Baculovirus (using NPV), *B. sphaericus*. Production of bioinsecticides and biopesticides.	
Unit 3	**Waste management**	**5 hrs**
	Emerging pollutants. Solid waste: Definitions, Characteristics, Types, Sources and Properties of solid waste. Liquid waste: Overview of wastewater treatment. Aerobic/anaerobic treatment process (Attached and suspended processes), Sludge treatment: Sources and characteristics of sludge, sludge thickening, sludge stabilization, conditioning of sludge, Disinfection of sludge, dewatering, heat drying, ultimate disposal of sludge. Case studies on industrial waste treatment: Biohazardous waste, Dairy, leather and Paper industry.	
Unit 4	**Concepts on Sustainability and Alternatives to conventional energy**	**4 hrs**
	Sustainable development goals (SDG). Environmental sustainability. Concepts of circular economy and case studies. Biofuels: Bioethanol, Biomethanol, Biodiesel. Solar energy: working principle, materials used, classification and properties. Fabrication of solar cells using biomaterials. Clean energy: Ocean based energy and Hydrogen based fuels.	
Medical Biotechnology		**15 hrs**
Unit 1	**Stem cell therapy and Tissue engineering**	**5 hrs**
	Production of stem cells (HSCs, mesenchymal and iPSCc), tools to study and isolate stem cells, applications in regenerative medicine. Types of engineered tissues, design considerations, biophysical characteristics, in situ regeneration, extracorporeal devices	
Unit 2	**Gene Therapy**	**3 hrs**
	Viral vectors, CRISPR-CAS, delivery systems, case studies	
Unit 3	**Therapeutics**	**4 hrs**
	Preclinical testing, PK/PD of a drug, novel small molecule drugs including PROTACS.	
Unit 4	**Diagnostics**	**3 hrs**
	Biomarkers, protein-based diagnostics, nucleic acid-based diagnostics, biosensors	

REFERENCE TEXTS:

Plant Biotechnology

1. Plant Biotechnology: The Genetic Manipulation of Plants, Adrian Slater, Nigel Scott, Mark Fowler, Oxford; Second edition (2008)
2. Plant Physiology by Lincoln Taiz and Eduardo Zeigler, Sinauer Associates, Fifth edition (2010)
3. Biotechnology of Natural Products. Wilfred Schwab, Bernd M. Lange, Matthias Wust (Edts.), Springer (2018)
4. Plant Biotechnology and Genetics: Principles, Techniques, and Applications; C. Neal Stewart Jr (Ed.), John Wiley & Sons, Inc. (2008)

Animal Biotechnology

1. Culture of animal cells: A manual of basic techniques, Freshney, R.I. 5th Edition, John Wiley and Sons.
2. Animal cell culture, John R W Masters. 3rd Edition, Oxford University Press

Environmental Biotechnology

1. Environmental Studies by R Geetha Balakrishna, KG Lakshminarayana Bhatta, Sunstar Publisher, 2016.
2. Environmental studies by – Dr. J.P.Sharma (Third edition)
3. Environmental Engineering by Howard S. Peavey, Donald R. Rowe, George Techobanolous, McGraw-Hill International Editions.
4. Wastewater Engineering – Treatment, Disposal and Reuse, Metcalf And Eddy, Inc. 3rd Edition Tata McGraw-Hill Publishing Company Limited.
5. Additional study material as provided by the instructor.

Medical Biotechnology

1. Medical Biotechnology, Pratibha Nallari & V. Venugopal Rao, 2010, Oxford University Press

PRACTICAL II: BT9P2: Applied Biology (88 hrs)

Plant Biotechnology

1. Plant Tissue Culture
2. Molecular Markers
3. DNA Barcoding
4. *in planta* transformation
5. Selection and regeneration of putative transgenics

Animal Biotechnology

1. Handling cell culture labware, media preparation and best practices to ensure aseptic conditions during cell culture
2. Primary cell culture technique
3. XTT and cell proliferation assays
4. Growth and maintenance of a cell line

Environmental Biotechnology

1. Isolation and Characterization of Bacterial colonies from Anthropogenic Contaminated Soil/water samples.
2. Bacterial growth kinetics in media enriched with anthropogenic material.
3. Estimation of Hardness (or) COD (or) BOD (or) DO of water samples.
4. Esterification of oil samples.
5. Bioindicator species.

Industrial biotechnology

1. Preparation of bioreactor, utilities for bioreactor operation with any strain.
2. Growth of bacteria/yeast – estimation of biomass, calculation of specific growth rate, yield coefficient using a biofermenter.
3. Enzyme immobilization – gel entrapment method
4. Extraction and estimation of Lycopene from Tomato varieties (or) Anthocyanin extraction and estimation from plant samples (or) extraction and estimation of any other products.
5. Isolation and enrichment of strains to produce industrially important compounds.

COURSE OUTCOMES FOR BT9425: APPLIED BIOTECHNOLOGY

After successful completion of the course, students will:

CO1	Have an understanding of various biotechnological tools that are important in food security, nutrition and conservation
CO2	Have an appreciation of the transgenic crop landscape, while also garnering lab skills in plant tissue culture, basic plant transformation and molecular techniques
CO3	Understand fundamental concepts and address global environmental issues using environmental biotechnology. Apply concepts of bioremediation and waste treatment for the production of alternate energy resources
CO4	Perform practical sessions to realize the complexity of environmental issues pertaining to pollutants
CO5	Have a thorough understanding of the basics and practical aspects of animal cell culture and its applications
CO6	Gain insights into advances in stem cell and gene therapy

Semester	**III**
Paper Code	**BT9P3**
Paper Title	**Research and Career Development Seminars**
Number of teaching hours per week	**02**
Total number of teaching hours per semester	**30**
Number of credits	**02**

Objective of the Paper:

This course has been designed to give students exposure to various advanced topics in Biotechnology, as both student presentations and invited, expert lectures. The course is structured to include presentation and discussion of recent and cutting edge research from peer reviewed scientific literature, as well as expert scientific lectures, workshops, site visits and career talks in collaboration with premier research institutes and labs in Bangalore. The program will also prepare students for successful student placements for their internships in the academia and industry.

The final student grade for this course will be based on their paper presentations, engagement in talks, reports submitted and attendance. A satisfactorily Completed/Incomplete (S/U grade) will be awarded to the student in the marks card.

Semester	**IV**
Paper Code	**BT0125**
Paper Title	**Research Project**
Number of teaching hours per week	**36**
Total number of teaching hours per semester	**360**
Number of credits	**12**

Students will dedicate the entire semester to doing research projects in-house or in accredited external labs of their choosing, subject to discussion and approval of projects by the SJC faculty supervisor and the co-supervisor at the external lab. Students wanting to do relevant industry internships in lieu of research projects will be permitted to do so, subject to approval of terms and conditions by a Board comprising the Dean, Head of the department and PG coordinator.

Evaluation Criteria:

Fortnightly discussion with the guide and
Monthly reports of work undertaken: **4 reports X 30 marks: 120 marks**
Interim presentation: **1X 30 marks : 30 marks**

Final project report: **100 marks**

(If a co-supervisor I an external lab or industry is involved, 50 marks will be awarded by this co-supervisor and 50 marks by the SJC faculty supervisor)

Final presentation: **80 marks (40, internal and 40 marks external)**

Viva voce: **20 marks**

Total marks: **350**

MSc BIOTECHNOLOGY, EVALUATION PATTERNS

MSc CIA and End Semester Exams = 50:50

ESE QP Pattern: Maximum 50 marks

Part A - Answer any SEVEN (out of 9) questions: 2 x 7 = 14 marks
Part B - Answer any FOUR (out of 6) questions: 5 x 4 = 20 marks
Part C - Answer any TWO (out of 3) questions: 8 x 2 = 16 marks

MSc Practical Exams: 15 PIA: 35 ESPE

50 marks QP pattern (Marks will be reduced to 35)

1. Performance based Q1-10 marks
2. Performance based Q2-10 marks
3. Spotters - 2X5 = 10 marks
4. Analytical questions- 2X5 = 10 marks
5. Viva – 10 marks