

COURSES OF STUDY
M.Sc Biotechnology (Self Financing)
(2018-2020)



DEPARTMENT OF BIOTECHNOLOGY & BIOINFORMATICS
SAMBALPUR UNIVERSITY, JYOTI VIHAR
BURLA- 768019, ODISHA

OUTLINE OF COURSE STRUCTURE
M.Sc. BIOTECHNOLOGY (Session: 2018-20)

SEMESTER-I

Course Code	Course Name	Credits hours	Marks
BT-411	(A) Physical Sciences (B) Fundamental Biology	3	50
BT-412	Chemistry of Biomolecules	3	50
BT-413	Genetics	3	50
BT-414	Microbiology	3	50
BT-415	Molecular Biology- I	3	50
BT-416	Instrumentation and Techniques	3	50
BT-417	Practical (Genetics and Microbiology)	2	50
BT-418	Practical (Chemistry of Biomolecules)	2	50
Optional (Any One)	Add on non-credit course: A. Communication Skill B. Leadership & Personality Development		

SEMESTER-II

Course Code	Course Name	Credit hours	Marks
BT-421	Probability and Biostatistics	3	50
BT-422	Bioenergetics and Metabolism	3	50
BT-423	Immunology	3	50
BT-424	Molecular Biology- II	3	50
BT-425	Cell and Developmental Biology	3	50
BT-426	Industrial Biotechnology	3	50
BT-427	Practical (Immunology & Molecular Biology)	2	50
BT-428	Practical (Cell Biology & Industrial Biotechnology)	2	50

SEMESTER-III

Course Code	Course Name	Credit hours	Marks
BT-531	Recombinant DNA Technology	3	50
BT-532	Bioinformatics	3	50
BT-533	Bioprocess Engineering & Technology	3	50
BT-534	Cell Culture Techniques	3	50
BT-535	Plant Biotechnology	3	50
BT-536	Animal Biotechnology	3	50
BT-537	Practical (Cell Culture Tech. & Bioinformatics)	2	50
BT-538	Practical (Plant & Animal Biotechnology)	2	50
Optional (Any One)	Add on non-credit course: A. Entrepreneurship Development B. Soft Skill & IT Skill		

IV SEMESTER

Course Code	Course Name	Credit hours	Marks
BT-541	Genomics, Proteomics and Metabolomics	3	50
BT-542	IPRs, Biosafety and Bioethics	3	50
BT-543	(A) Agricultural Biotechnology (B) Clinical Pathology & Diagnostics (C) Environmental Biotechnology (D) Pharmaceutical Biotechnology	3	50
Elective Paper (Any one)			
BT-544	Seminar	3	50
BT-545	Project work and Viva Voce	(9+3)	200
Total Course Credit		90 CH	1600

Programme Outcome

PO-1	Critical Thinking: Take informed actions after identifying the assumptions that frame our thinking and actions
PO-2	Effective Communication: Will be able to speak, read, write and listen clearly in person and through electronic media in English and in one Indian Language
PO-3	Social Interaction (Interpersonal Relation): Elicit views of others, mediate disagreements and prepared to work in team
PO-4	Entrepreneurship Capability: Demonstrate qualities to be prepared to become an entrepreneurship
PO-5	Ethics: Recognize different value systems including your own, understand the moral dimensions and accept responsibility for them
PO-6	Environment and Sustainability: Understand the issues of environmental contexts and sustainable development
PO-7	Life-Long Learning: Acquire the ability to engage in independent and life-long learning in the context of socio-technological changes

FIRST SEMESTER

BT-411(A)

PHYSICAL SCIENCES

3 CH

50 MARKS

Objective: To bridge the gap between biology and physical sciences needed for the understanding and designing of biological problems for the students of biology background.

CO-1	Remember and understand the basic concepts/Principles of Physical Sciences
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit-I

Basic Mathematics: Logarithms, exponential series, factorials, graphs, coordinate geometry – straight line and non-linear relationships. Differentiation– Rates and limits, Differential coefficients, differentiation of a function, integration – basic concepts of integration, integration by substitution, integration by parts. Matrix algebra – linear transformation between vector spaces, representation of linear transformation by matrices, algebra of matrices, Eigen values and Eigen vectors of linear transformation.

Unit-II

Basic Physics and Computer Fundamentals: Surface tension, viscosity, photoelectric effect, basic characteristics of electricity and magnetism, charge, current, voltage, resistance, capacitor, electric field and impedance diodes, photoresistors, Semiconductors, transistors, integrated circuits and chips.

Computers: types, basic organization of computers, computer languages, software and hardware, operating systems, bit, byte, word, computer memory – types, data processing and storage.

Unit-III

Basic chemistry:atomic structure – waves and wave functions, quantum numbers, atomic orbitals, electronic configuration of atoms and periodic properties of elements, ionic radii's, ionization potential, electronic configuration of molecules. Bond lengths, bond angles, bond order and bond energies, types of chemical bond (weak and strong), intermolecular forces, structure of simple ionic and covalent bonds, carboxylic acids, aldehydes and ketones, amines (overview).

Suggested readings:

1. Basic Mathematics, Serge A. Lang, Springer publisher (1988).ISBN-13: 978-0387967875.
2. Higher Engineering Mathematics, B.S. Grewal and J.S.Grewal, Khanna Publishers, New Delhi (2007).ISBN-13: 978-8900120905.
3. Calculus and analytical geometry, G. B Thomas, R. L. Finney, 9th Ed., Pearson Education Asia (Adisson Wesley), New Delhi (2000). ISBN-13: 978-0201531749.
4. Trigonometry, Algebra and Calculus, T.Veerarajan, Tata McGraw Hill Publishing Co. Ltd, New Delhi (2003). ISBN: 978-0070535077.
5. Fundamentals of Physics, D. Halliday, R. Resnick, J. Walker. John Wiley and Sons (2010).ISBN-13: 978-9971513306.
6. Chemistry: An Introduction to General, Organic, and Biological Chemistry, Karen C. Timberlake. Pearson (2015). ISBN-13: 978-1292061320.
7. Fundamental Principles of Inorganic Chemistry, D Banerjea. Sultan Chand and Sons(2001). ISBN-13: 978-8170148159
8. Fundamentals of Computers, Reema Thareja. Oxford University Press (2015). ISBN-13: 978-0199452729.

Objective: To provide basic knowledge of biology for the understanding of the advance courses of Bioinformatics & Biotechnology for the students from non-biology background.

CO-1	Remember and understand the basic concepts/Principles of Foundation Biology
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit I

Chemistry of living organisms: biomolecules, origin of life, cell- unit of living organisms and multicellular organisms, structure of animal, plant and bacterial cell, sub-cellular organelles (cytoskeleton, mitochondria, golgi complex, endoplasmic reticulum, chloroplast, ribosome, lysosome, nucleus).

Unit II

Classification and nomenclature of living organisms (plant and animal): survey of microbial world, diversity in animal and plant kingdom, phylogeny, organic evolution, evidences in support of evolution (morphological, embryological, taxonomy, genetic, biochemical and molecular), origin of species and speciation; environmental and anthropogenic impact on living organisms.

Unit III

Genetics- science of heredity: chromosome number and structure, cell division- meiosis and mitosis, mendelian principle of heredity; monohybrid and dihybrid cross (examples); physiological basis of life (locomotion, respiration, digestion, circulation, excretion); reproduction in plants and animals; hormonal integration of physiological processes.

Suggested readings:

1. Life: The Science of Biology: Volume III: Plants and Animals. David Sadava, David M. Hillis, H. Craig Heller, May Berenbaum. 10th Ed., W. H. Freeman(2003).ISBN-13: 978-1464141249.
2. Biology, Peter H. Raven, George B Johnson, Kenneth A. Mason, 10thEd., Tata McGraw Hill (2013). ISBN-13: 978-9351341802.
3. Life Sciences Fundamentals and Practice (Part I&II), Pranav Kumar, Usha Mina. Pathfinder Academy Pvt. Ltd (2017). ISBN-13: 978-8190642705.
4. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology, P.S. Verma,V.K. Agarwal V.K, S. Chand and Company Limited (2016). ISBN-13: 978-8121924429.
5. Cell Biology for Biotechnologists, Shaleesha A Stanley. Narosa Publishing House (2008). ISBN-13: 978-8173198083.
6. Concepts of Genetics, William S Klug, Michael R Cummings, Charlotte A Spencer,10thEd., Pearson Education Limited (2016). ISBN-13: 978-9332577466.
7. Principles of genetics, Eldon John Gardner, Michael J Simmons, D Peter Snustad, 8th Ed., Wiley India Pvt.Ltd (2014). ISBN-13: 978-8126510436.

Objective: To offer extensive coverage of important biomolecules (carbohydrates, lipids, nucleic acids, proteins) that are involved in the maintenance and metabolic processes of all living organisms.

CO-1	Remember and understand the basic concepts/Principles of Chemistry of Biomolecules
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit I

Biomolecules: carbohydrates (monosaccharides, disaccharides, formations of polysaccharides and structural diversity), lipids (types of fatty acids and lipids), sphingolipids, conjugated and complex lipids; DNA structures: Nucleotides and nucleosides, DNA double helix, DNA structure (Z-DNA, B-DNA, A-DNA), triple helix DNA, tetraplex DNA, DNA binding proteins, Sequence specific Protein – DNA interactions, RNA secondary and tertiary structures.

Unit II

Protein structure: chemical building blocks, Peptide bond, torsion angles and rotatable bonds, Ramachandran map, protein structures (primary, secondary, super-secondary, tertiary, different classes and sub-classes of protein structures, quaternary), protein folding, protein motifs, and domains; protein structure determination; purification of proteins, crystallization of proteins, X-ray crystallography, NMR and its limitations.

Unit III

Engineering & design of protein structure, Homologous protein, Protein sequencing, Site-directed mutagenesis, Protein flexibility and stability, Engineering of protein structure and applications (case studies). Membrane proteins and its function, Metalloproteins, Carbohydrate binding proteins, Metalloenzymes: Structure and Function.

Suggested reading:

1. DNA Structure and Function, Richard R Sinden. Academic Press(2012). ISBN-13: 978-0126457506.
2. Lehninger Principles of Biochemistry, David L. Nelson, Michael M. Cox, Freeman, W. H. & Company (2008). ISBN-13: 978-0716743392.
3. Fundamentals of Biochemistry: life at the molecular level, Donald Voet, Judith G. Voet, Charlotte W. Pratt, New York: Wiley (2016). ISBN-13: 978-1118129180.
4. Outlines of Biochemistry, Eric E Conn, Paul K Stumpf, George Bruening, Wiley India Pvt.Ltd (2011). ISBN-13: 978-8126509300.
5. Biochemistry, Jeremy M. Berg, John L. Tymoczko, Gregory J. Gatto, Lubert Stryer, 8th Ed., Freeman and company (2015). ISBN-13: 978-1464126109.
6. Harper's Illustrated Biochemistry, Victor W Rodwell, David A Bender, Kathleen M Botham, Victor W Rodwell, David A Bender, Kathleen M Botham, 29th Ed., Mcgraw-Hill Book Company (2015). ISBN-13: 9781259252860.

Objectives: To understand human, animal and plant genome, human genetic disorders and molecular genetics based therapies.

CO-1	Remember and understand the basic concepts/Principles of Genetics
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit-I

Mendelian principle: dominance, segregation and independent assortment; extensions of Mendelian principle: co-dominance, Incomplete dominance, gene interactions, supplementary genes, complementary genes, duplicate genes, epistasis, inborn error of metabolism, pleiotropy, genomic imprinting; sex determination: sex chromosome, sex determination in plants and animals, dosage compensation, sex linkage, sex limited and sex influenced characters; extra chromosomal inheritance; maternal inheritance, polygenic inheritance in human beings.

Unit-II

Concept of gene: allele, multiple alleles, pseudoallele, complementation tests; linkage and crossing over; linkage and mapping in eukaryotes: two-point cross, three-point cross, haploid mapping (tetrad analysis), human chromosomal maps: X linkage, autosomal linkage, Lod score for linkage testing, Pedigree analysis, penetrance and expressivity, family tree, dominance inheritance, recessive inheritance, sex-linked inheritance; Eukaryotic chromosome: types of chromosomes, DNA arrangement, nucleoprotein composition, chromosomal banding, centromeres and telomeres, C-value paradox.

Unit-III

Mutation: types, causes and detection; Mutant types – lethal, conditional, biochemical, loss of function, gain of function; germinal versus somatic mutants, insertional mutagenesis; structural and numerical alterations in chromosomes (deletion, duplication, inversion, translocation, ploidy and their genetic implications); population genetics: gene pool, gene frequency, Hardy Weinberg genetic equilibrium; gene flow and genetic drift.

Suggested reading:

1. Principles of genetics, Eldon John Gardner, Michael J Simmons, D Peter Snustad, 8th Ed., Wiley India Pvt. Ltd (2014). ISBN-13: 978-8126510436.
2. Genetics, Monroe W Strickberger. 3rd Edition. Prentice Hall India Learning Private Limited (2015). ISBN-13: 978-9332555105.
3. Genetics, B.D. Singh, Kalyani Publishers / LyallBk Depot (2016). ISBN-13: 978-8127248673.
4. Genetics: From Genes to Genomes, Leland H Hartwell, Leroy Hood, Michael L Goldberg, Tata McGraw Hill Publishing Co Ltd (2015). ISBN-13: 978-9339219888.
5. Principles of Population Genetics, Andrew G. Clark, Daniel L. Hartl, 4th Ed., Sunderland: Sinauer Associates (2007). ISBN-13: 978-0878933082.
6. Principles of Genetics, Robert H. Tamarin, 7th Edition, Tata McGraw-Hill Edition. ISBN-0-07-048667-0.

Objective: To familiarize the students with basic concepts of microbiology including classification, identification, culture techniques, growth kinetics, and physiology and preservation methods for microorganisms.

CO-1	Remember and understand the basic concepts/Principles of Microbiology
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit-I

An overview of the microbial world (bacteria, archea, eukaryote). Classification of archea and eubacteria as per Bergey's manual; microbial phylogeny. Structural organization of prokaryotic cell (bacterial wall, capsule, flagella, pilli, pronucleus, ribosomes, plasmid).

Unit-II

Bacterial nutrition and nutritional category, bacterial culture: synchronomous and asynchronous culture, continuous culture and chemostat. Bacterial growth, mathematical expression of growth, generation time, specific growth rate.

Bacterial metabolism: glucose dissimilation pathways, bacterial respiration with organic and inorganic reluctant, chemolithotrophy. General principle of bacterial conjugation, transduction and transformation. Bacterial pathogenecity and anti-microbial compounds.

Unit-III

Virus: generalproperties, structure, purification, cultivation;principle of viral taxonomy. Bacteriophage: structure, classification, one-step growth experiment. Production of DNA phage, RNA phage, lytic cycle, temperate phage and lysogeny. Animal virus and its reproduction, viral infection (presistent, latent and slow virus infection). Plant virus and their transmission. Anti-viral agents; M-13, Lambda, HIV, Influenza virus, Viriods and Prions.

Suggested reading:

1. Microbiology, Jr Michael J Pelczar, Ecs Chan, Noel R Krieg, Tata Mcgraw Hill Publishing Co Ltd (2016). ISBN-13: 978-0074623206.
2. Brock Biology of Microorganisms, Michael T Madigan, John M Martinko, Kelly S Bender, Pearson Education Limited (2014). ISBN-13: 978-9332586864.
3. Microbiology: An Introduction, Gerard J Tortora, Berdell R Funke, Christine L Case, 8th Edition, Pearson/Benjamin Cummings(2015). ISBN-13: 978-9332575417.
4. Microbiology: Principles and Applications, J. Black, Prentice Hall(2004). ISBN-13: 978-0131907454.
5. Microbiology, Donald A. Klein, John P. Harley, Lansing M. Prescott, 6th Ed., McGraw Hill(2005). ISBN-13: 978-0072951752.
6. Microbiology: A Human Perspective, Eugene Nester, Denise Anderson, Jr., C. Evans Roberts, Martha Nester, 6th Ed., McGraw-Hill Science/Engineering/Math (2008). ISBN-13: 978-0077250416.

Objective: To educate the students on basic components and complex architecture of genetic material in different organisms and to introduce mechanism and regulation of replication of genetic material in different organisms.

CO-1	Remember and understand the basic concepts/Principles of Molecular Biology-1
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit-I

Genetic organization of prokaryotes and eukaryotes including nuclear genome and organelle genome; DNA as the genetic material (experimental evidences); central dogma; genome complexity; C-value paradox, Cot value, repetitive DNA, satellite DNA; gene structure in prokaryotes and eukaryotes; split genes, overlapping genes, pseudogenes, clusters and repeats.

Unit-II

Condensation of chromosome, Lampbrush chromosome, Polytene chromosome, Supercoiling of DNA, nucleosomes, DNA methylation, genetic imprinting, epigenetic inheritance, Transposable elements, types of transposable elements, mechanism of transposition, retroposons and its types, mechanism of retrotransposition, rearrangement of DNA.

Unit-III

DNA replication: models of DNA replication, enzymes of DNA replication, pprocess of DNA replication (initiation, elongation, termination), DNA replication at the telomere; organization and replication of extranuclear genome (Mitochondrial and Chloroplast) genome, DNA recombination (site specific and homologous); DNA repair (base-excision, mis-match, SOS, recombination); Phage strategies (lysogenic cycle and lytic cycle).

Suggested reading:

1. Molecular Biology of the Cell, Bruce Alberts, Alexander Johnson, Julian Lewis, 6th Ed., Taylor & Francis Group / Spon Press (2015). ISBN-13: 9780815344643.
2. Genes IX, Benjamin Lewin, Jones and Bartlett Publishers (2010). ISBN-13: 978-9380108537.
3. Molecular cell biology, Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, HiddePloegh, Angelika Amon, Kelsey Martin, 8th Ed., WH Freeman(2016). ISBN-13: 978-1464183393.
4. Molecular Biology of the Gene, James D Watson, Tania A Baker, Stephen P Bell, Pearson Education Limited (2017). ISBN-13: 978-9332585478.
5. Cell and Molecular Biology, Gerald Karp, 5th Edition, John Wiley (2013). ISBN-13: 978-1118301791.
6. Cell Biology, Thomas D. Pollard, William C. Earnshaw, Jennifer Lippincott-Schwartz, 3rd Ed., Elsevier - Health Sciences Division (2017). ISBN-13: 978-0323417402.

Objective: To educate the students on principle, instrumentations and application of various instruments regularly qualitative and quantitative analysis of chemical and biological samples in research labs.

CO-1	Remember and understand the basic concepts/Principles of Instrumentation and Techniques
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit-I

Spectrophotometry – laws of absorption of light, Beer-Lambert's Law, absorption spectra. Instrumentation for measurement of absorption of light, factors affecting the absorption properties of chromophores, fluorescence and fluometry. Chromatography (paper, column, affinity and ion-exchange): principle, instrumentation and application.

Unit-II

pH metry, Bomb calorimetry, Flame photometer, Electrophoresis (Agarose, PAGE, SDS-PAGE and IEF). Principle, instrumentation and application; GLC, HPLC, Infrared spectroscopy, atomic absorption spectroscopy, mass spectroscopy (LC-MS, GC-MS, MALDI-TOF, fluorescent spectroscopy, FTIR.

Unit-III

Centrifugation – principles and types (density gradient and differential centrifugation); Radioactivity; Principle and application of G.M. counter and liquid scintillation counter, microscopy (compound, phase contrast, fluorescence, confocal); electron microscopy (TEM, SEM), principle and application of blotting (southern, northern).

Suggested readings:

1. Biochemical Techniques Theory and Practice, John F Robyt, Cbs Publishers & Distributors (2015). ISBN-13: 978-8123926605.
2. An Introduction to Practical Biochemistry, David T Plummer, Tata Mcgraw Hill Publishing Co Ltd (2015). ISBN-13: 978-0070994874.
3. Analytical Chemistry, Gary D. Christian, John Wiley & Sons Inc (2013). ISBN-13: 978-0470887578.
4. Principle and Techniques of Biochemistry and Molecular Biology, Keith Wilson, John Walker, 7th Ed., Cambridge University Press (2010). ISBN-13: 978-0521731676.

BT-417	Practical (Genetics and Microbiology)	2 CH	50 marks
BT-418	Practical (Chemistry of Biomolecules)	2 CH	50 marks

SECOND SEMESTER

BT-421

PROBABILITY AND BIOSTATISTICS

3 CH

50 marks

Objective: To make the students acquainted with the various statistical techniques for the collection, organization, analysis and interpretation of the experimental data.

CO-1	Remember and understand the basic concepts/Principles of Probability and Biostatistics
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit I

Concepts from probability: elementary sets as events and their complements, independent and disjoint events, probability rules, permutations and combinations, probability distributions, binomial distribution, poisson distribution, random variables and their properties, continuous random variables, conditional probability and Bayes theorem.

Unit II

Systematic organization and display of data: populations, samples, types of data, frequency tables and histograms; graphical methods (histograms, box and whisker plots), measure of central tendency (arithmetic mean, median, mode, geometrical mean), measure of dispersion (range, mean deviation, variance, standard deviation, coefficient of variation), normal distribution: importance and properties; areas under standard normal curve; central limit theorem, skewness and kurtosis.

Unit III

Tests of hypothesis: student's t-test, paired t-test, hypothesis testing; categorical data and chi-square tests: 2 x 2 contingency table, correlation and linear regression: scatter diagram, pearson's correlation coefficient, regression analysis, multiple regression; analysis of variance: one-way analysis of variance, two way analysis of variance, non-parametric methods and its advantages and disadvantages, Wilcoxon rank-sum test, Wilcoxon signed-rank test. Principal component analysis.

Suggested readings:

1. Introductory Biostatistics for the Health Sciences, Michael R. Chernick, Robert H. Friis, Wiley-Interscience Publications (2003). ISBN-13: 9780471411376.
2. Statistics: Concepts and Applications, Nabendu Pal, Sahadeb Sarkar, Prentice-Hall Of India Pvt Ltd (2009). ISBN-13: 9788120334458.
3. Handbook of Computational Statistics Concepts and Methods. J. E. Gentle, Wolfgang Hardle, Yuichi Mori, Springer (2004). ISBN-13: 9783540404644.
4. Schaum's Outline of Statistics, Murray R. Spiegel, Larry J. Stephens, 3rd Ed., McGraw-Hill New Delhi (2000). ISBN-13: 9780070151536.
5. Probability and statistics for engineers and scientists, Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying E. Ye, 9th Ed., Pearson (2011). ISBN-13: 9781292161365.
6. Probability, statistics and random Processes, Veerarajan T, 3rd Ed., Tata McGraw-Hill (2015). ISBN-13: 9780070669253.

7. Data mining: Introductory and advanced topics, Margaret H Dunham, Pearson Education Limited (2013). ISBN-13: 9788177587852.

BT-422

BIOENERGETICS AND METABOLISM

3 CH

50 marks

Objective: To provide an insight into complete set of chemical reactions of metabolism as well as the regulatory interactions that guide these reactions.

CO-1	Remember and understand the basic concepts/Principles of Bioenergetics and Metabolism
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit I

Enzymes: basic concepts and kinetics, classification of enzymes, coenzymes and cofactors, effect of temperature and pH on enzyme activity, Michaelis-Menten kinetics, inhibitors and activators, enzyme inhibition (competitive, non-competitive, uncompetitive), allosteric enzymes and regulation, concepts of bioenergetics, multi-enzyme complexes, regulatory enzymes, feedback and feed forward systems, bisubstrate reaction kinetics, enzyme substituted model (ping pong model).

Unit II

Metabolism and regulation of carbohydrate (glycolysis, gluconeogenesis, pentose phosphate pathway and its physiological significance); carbohydrate biosynthesis in plants, coordinated regulation of glycogen synthesis and breakdown; citric acid cycle, regulation of citric acid cycle, glyoxylate cycle, electron transport in mitochondria and chloroplast; principle of oxidative and photophosphorylation.

Unit III

Amino acid oxidation and production of urea (metabolic fates of amino groups, fatty acid catabolism (digestion, metabolism and transport of fats), oxidation of fatty acids, ketone bodies, lipid biosynthesis, urea cycle, pathway of amino acid degradation), biosynthesis of amino acids, biosynthesis of nucleotides (purines and pyrimidines), metabolic disorders, inborn error due to metabolism, hormonal regulation of metabolism.

Suggested readings:

1. Lehninger Principles of Biochemistry, David L. Nelson, Michael M. Cox, Freeman, W. H. & Company (2008). ISBN-13: 978-0716743392.
2. Biochemistry, Jeremy M. Berg, John L. Tymoczko, Gregory J. Gatto, Lubert Stryer, 8th Ed., Freeman and company (2015). ISBN-13: 978-1464126109.
3. Fundamentals of Biochemistry: life at the molecular level, Donald Voet, Judith G. Voet, Charlotte W. Pratt, New York: Wiley (2016). ISBN-13: 978-1118129180.
4. Basic Concepts In Biochemistry: A Student's Survival Guide, Hiram F. Gilbert, 2nd Ed., McGraw-Hill Publisher (1999). ISBN-13: 9780071356572.
5. Harper's Illustrated Biochemistry, Victor W Rodwell, David A Bender, Kathleen M Botham, Victor W Rodwell, David A Bender, Kathleen M Botham, 29th Ed., McGraw-Hill Book Company (2015). ISBN-13: 9781259252860.

Objective: To educate the students on cells, organs and their mechanism of action in protecting our body from any pathogenic organism or substances. In addition, the subject educates student regarding the use of immune molecules (like antibodies and cytokines) for therapeutic and diagnostic purposes.

CO-1	Remember and understand the basic concepts/Principles of Immunology
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit-I

Basics of immunity, cell and organs of immune system in human and evolution of immune system, immunogen, antigen and haptens, factors affecting immunogenicity, immunoglobulins – classification, structure and properties, primary and secondary immune response, genetic basis of generation of antibody diversity, other B cell receptors.

Unit-II

T-cell receptors, major histocompatibility complex proteins, antigen processing and presentation, complement activation. Interleukins. Brief idea regarding immunology of allergy, AIDS, organ transplantation; autoimmune diseases; cancer types, causes and mechanisms.

Unit-III

Immunotechnology – antigen-antibody interaction, affinity and avidity, agglutination, precipitin formation, immunodiffusion (SRID and DRID). Immunoelectrophoresis – types and uses, radio immuno assay, ELISA, western blotting, ELISPOT assay, immunofluorescence, immunoelectron microscopy; surface plasmon resonance, biosensor assays for assessing ligand-receptor interaction, CMI techniques- lymphoproliferation assay, mixed lymphocyte reaction.

Suggested readings:

1. Immunology, Janis Kuby, 3rd Edition, WH Freeman (2007). ISBN-13: 9789812435163.
2. Janeway's Immunobiology, Kenneth Murphy, 8th Edition, Garland Science 2016. ISBN-13: 9780815345305
3. Cellular and Molecular Immunology, Abul K. Abbas, Andrew H. H. Lichtman, Shiv Pillai, 7th Ed., Elsevier (2001). ISBN-13: 9788131248928.
4. Kuby Immunology. Judith A Owen, Jenni Punt, Sharon A Stranford, 7th Ed., W.H. Freeman and Co., New York (2013). ISBN-13: 9781429219198
5. Essential Immunology, Ivan M Roitt, Peter J Delves, 12th Ed., Blackwell Scientific Publications (2011). ISBN-13: 9781405196833.
6. Principle of gene manipulation and Genomics, S.B Primrose, R.M Twyman, 6th Ed., Blackwell Science Ltd (2014). ISBN-13: 9788126548392

Objective: To enable the student to answer the complex mechanism of action and regulation of various timely response of cell according to the surrounding.

CO-1	Remember and understand the basic concepts/Principles of Molecular Biology-II
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit-I

Transcription: components of transcription machinery in prokaryotes and eukaryotes, transcriptional factors, transcription process (initiation, elongation and termination); post-transcriptional processing, regulation of transcription (protein-DNA interaction: zinc finger motif, homeodomain, helix-loop-helix, leucine zipper), m-RNA stability, m-RNA editing; nuclear splicing, catalytic RNA, mechanism of gene silencing.

Unit-II

Translation: genetic code- principle of translation, translation machinery in prokaryotes and eukaryotes (t-RNA, aminoacyl synthetase, ribosome), translation process (initiation, elongation and termination). Regulation of gene expression: constitutive and induced gene expression; regulation of gene expression in prokaryotes and eukaryotes; operon concept (lac, ara, trp and his).

Unit-III

Protein trafficking (glycosylation, coated vesicles, budding and fusion reactions, protein localization, receptor recycle), Signal transduction (carriers and channels, G protein mediated, Ras/MAPK pathway, cAMP mediated, JAK-STAT pathway), cell cycle and its regulation, genetics of cancer (proto-oncogenes, tumor suppressor genes), signaling pathways.

Suggested readings:

1. Molecular Biology of the Cell, Bruce Alberts, Alexander Johnson, Julian Lewis, 6th Ed., Taylor & Francis Group / Spon Press (2015). ISBN-13: 9780815344643.
2. Genes IX, Benjamin Lewin, Jones and Bartlett Publishers (2010). ISBN-13: 978-9380108537.
3. Molecular cell biology, Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Angelika Amon, Kelsey Martin, 8th Ed., WH Freeman (2016). ISBN-13: 978-1464183393.
4. Cell and Molecular Biology, Gerald Karp, 5th Edition, John Wiley (2013). ISBN-13: 978-1118301791.
5. Cell Biology, Thomas D. Pollard, William C. Earnshaw, Jennifer Lippincott-Schwartz, 3rd Ed., Elsevier - Health Sciences Division (2017). ISBN-13: 978-0323417402.
6. Molecular Biology of the Gene, James D Watson, Tania A Baker, Stephen P Bell, Pearson Education Limited (2017). ISBN-13: 978-9332585478.
7. Genetics, Monroe W Strickberger. 3rd Edition. Prentice Hall India Learning Private Limited (2015). ISBN-13: 978-9332555105.

Objective: To educate the students on components of cells and how cells divide, regulate its own division, and differentiate in millions of different types of specialized cells from single zygote cells to form complex multi-cellular organism.

CO-1	Remember and understand the basic concepts/Principles of Cell and Developmental Biology
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit-I

Structural organization and function of intracellular organelles: cell wall, nucleus, mitochondria, golgi bodies, endoplasmic reticulum, plastids, ribosome, structure & function of cytoskeleton and its role in motility; membrane structure and function: structural model of biomembrane, composition and dynamics; transport of ions and macromolecules; membrane carbohydrates and their role in cellular recognition; mechanism of sorting and regulation of intracellular transport.

Unit-II

Cellular basis of differentiation and development: gametogenesis; fertilization, cleavage – types and mechanism, gastrulation, anterior/posterior, dorsal/ventral polarity development of drosophilla, signaling cascades involved in the control of developmental program, cell specification *w.r.t.* amphibian, chick, phenomenon of the organizer *w.r.t.* amphibians: progressive determination, regional specificity of induction.

Unit-III

Tetrapod limb development; axes formation, coordination of the three axes, regeneration: epimorphic, morphallactic and compensatory; plant meristem organization and differentiation in arabidopsis, spatial and temporal regulations of gene expression during development and differentiation, programmed cell death, aging and senescence.

Suggested readings:

1. Cell: A Molecular Approach, Geoffrey M Cooper, Robert E Hausman, 6th Edition, Sinauer Associates Inc (2015). ISBN-13: 9781605352909.
2. Cell and Molecular Biology, E. D. P. De Robertis, Lea & Febiger (1987). ISBN-13: 9780812110128.
3. Molecular cell biology, Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Angelika Amon, Kelsey Martin, 8th Ed., WH Freeman (2016). ISBN-13: 978-1464183393.
4. Molecular Biology of the Cell, Bruce Alberts, Alexander Johnson, Julian Lewis, 6th Ed., Taylor & Francis Group / Spon Press (2015). ISBN-13: 9780815344643.
5. Essential Cell Biology, Bruce Alberts, Dennis Bray, Karen Hopkin, 4THEd., GarlandScience (2014). ISBN-13: 978081534455.
6. Developmental Biology, Scott F Gilbert, 8th Edition, Sinauer Associates Inc Publisher (2010). ISBN-13: 9780878933846.
7. Essential Developmental Biology, Jonathan M. W. Slack, 3rd edition, Wiley-Blackwell (20102), ISBN-13: 9781118022863.

8. Principles of Development, Louis Wolpert, 2nd Edition, Oxford University Press (2007). ISBN-13: 9780198748670.

BT-426 **INDUSTRIAL BIOTECHNOLOGY** **3 CH** **50 marks**

Objective: The course presents the fundamental aspects of the technology for using biofuels in the energy system. Global considerations, biological constraints, fuel supply systems, fuel quality and combustion technology aspects will be discussed.

CO-1	Remember and understand the basic concepts/Principles of Industrial Biotechnology
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit-I

Introduction to industrial biotechnology: history and scope, commercial strain development-induced mutation, over producing decontrolled mutants, genetically engineered strain; industrial production of enzymes, fuels and industrial chemicals (alkanes, butanol, ethanol, electricity, amino acids, organic acids, exo-polysaccharides). Antibiotic, alkaloids, steroids, therapeutic peptides and proteins.

Unit-II

Fermentation technology, microbial technology for alcoholic beverages production (beer, wine & cider), vinegar production, dairy fermentation (butter & cheese), single cell protein and microbial leaching of metals, industrial biotechnology in chemical, pharmaceutical, food and allied sectors.

Unit-III

Principle of food preservation, method of food preservation (thermal processing, cold preservation, pascalisation, irradiation, chemical and natural food preservatives). Operational units in food industry, preservation by fermentation. Food safety and standards (adulteration, contamination, food laws, HACCP: a state of art for food safety, ISO 9000 series and other standards).

Suggested readings:

1. Bioprocess Engineering Principles, Pauline M. Doran, 2nd Ed., Academic Press (2012), ISBN-13: 9780122208515.
2. Bioprocess Engineering-Basic Concepts, Michael L Shuler, Fikret Kargi, Pearson Education Limited (2015). ISBN-13: 9789332549371.
3. Fermentation Microbiology and Biotechnology, C F A Bryce, E M T El Mansi, 2nd Ed., anebooks - T & F / Routledge (2006), ISBN-13: 9780849353345.
4. Biotechnology- A text book of Industrial Biotechnology, Wulf Crueger, Anneliese Crueger, Kr Aneja, Medtec (2017). ISBN-13: 9789385998638.

BT-427	Practical (Immunology and Molecular Biology)	2 CH	50 marks
BT-428	Practical (Cell Biology and Industrial Biotechnology)	2 CH	50 marks

THIRD SEMESTER

BT-531

RECOMBINANT DNA TECHNOLOGY

3 CH

50 marks

Objective: The objective of the course is to familiarize the students with the techniques and applications of recombinant DNA technology from a academic and industrial perspective.

CO-1	Remember and understand the basic concepts/Principles of Recombinant DNA Technology
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit-I

DNA isolation and purification; restriction endonuclease, ligase and other modifying enzymes; DNA & RNA markers, linker, adapter and MCS; gene cloning vectors- plasmid, bacteriophage, cosmid, BAC, YAC; expression vectors: bacteria and yeast based expression vector; gene library- genomic and c-DNA, contig library; PCR, blotting techniques: Southern, Northern, Western, Dot and Slot; Nucleic acid hybridization.

Unit-II

Concept of gene cloning; cloning of interacting gene: two hybrid and three hybrid assay; cloning of differentially expressed gene, gene regulation analysis-DNA transfection, Primer extension, SI mapping, RNase protection assay, reporter assay and phage display; DNA microarrays and chips- principle and process; DNA finger printing and DNA foot printing; DNA sequencing; site directed mutagenesis; expression of heterologous gene; *In vitro* transcription and translation; gene knock out strategies; RNA interference: antisense RNA, siRNA, mi RNA; Ribozyme Technology.

Unit-III

Molecular markers- types (RFLP, RAPD, AFLP, SCAR, SSR, SNP, EST), principle and methodology; application of molecular markers: in diagnostics, gene tagging, gene mapping, physical mapping, map based cloning of gene and cloning of QTLs. Gene therapy and its applications; DNA vaccines and rDNA products; Genetic engineering regulations and safety guidelines.

Suggested readings:

1. Principle of gene manipulation and Genomics, S.B Primrose, R.M Twyman, 6th Ed., Blackwell Science Ltd (2014). ISBN-13: 9788126548392
2. From Genes to Genomes: Concepts and Applications of DNA Technology, Jeremy W. Dale, Malcolm von Schantz, Wiley, John & Sons (2007) ISBN-13: 9780470017340.
3. Biotechnology: Expanding Horizons, BD Singh, Kalyani Publishers / Lyall Bk Depot (2016). ISBN-13: 9789327222982.
4. Elements of Biotechnology, P K Gupta, Rastogi Publication (2015). ISBN-13: 9788171339372.
5. Recombinant DNA: A Short Course, Amy A. Caudy, James D. Watson, Jan A. Witkowski, Richard M. Myers, WH Freeman (2006), ISBN-13: 9780716728665.

Objective: To develop the ability to use tools in bioinformatics to analyze and predict the phylogeny, expression, structure, and function of genes and proteins.

CO-1	Remember and understand the basic concepts/Principles of Bioinformatics
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit-I

Major Bioinformatics resources: NCBI, EBI, ExPASy, RCSB; open access bibliographic resources and literature databases: PubMed, BioMed Central; sequence database; structural database; genomic resources; data access, retrieval and submission; data access standard search engines, data retrieval tools Entrez, DBGET and SRS.

Unit-II

Sequence analysis: Introduction to sequence analysis; local and global alignment; pairwise and multiple string alignment, sequence alignment algorithm: dot matrix, Needleman and Wunsch algorithm, Smith-Waterman algorithm; Substitution Matrix (PAM, BLOSUM), BLAST, FASTA algorithms. methods of phylogenetic analysis; steps of phylogenetic analysis; classification of phylogeny: graphs, trees and cladograms.

Unit-III

Patterns, motifs and profiles in sequences; structure classification of proteins (SCOP, CATH); protein secondary structure prediction; tertiary structure prediction methods; protein structure prediction by comparative modeling approaches, introduction to molecular modeling and drug designing.

Suggested readings:

1. Bioinformatics: Sequence and Genome Analysis, David Mount, CBS Publishers & Distributors. ISBN-13: 9788123912417.
2. Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids, Durbin R., Eddy S., Krogh A. and Mitchison G., Cambridge University Press (2012). ISBN-13: 9780521540797.
3. Bioinformatics and Functional Genomics, Jonathan Pevsner, Wiley-Blackwell (2015) ISBN-13: 9781118581780.
4. Bioinformatics – A practical guide to the Analysis of Genes and Proteins, Andreas D Baxevanis, Bf Francis Ouellette, Wiley India Pvt. Ltd (2014). ISBN-13: 9788126521920.
5. Nucleic Acid and Protein Sequence Analysis: A Practical Approach (The Practical Approach Series), M. J. Bishop, C. J. Rawlings, Oxford University Press. ISBN-13: 9781852210069.

BT-533 BIOPROCESS ENGINEERING & TECHNOLOGY 3 CH 50 marks

Objective: To enable the students to develop and apply innovative techniques for the development of novel products and process for the benefit of human welfare.

CO-1	Remember and understand the basic concepts/Principles of Bioprocess Engineering and Technology
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit-I

Concepts of bioprocesses: concepts of basic modes of fermentation (batch, fed batch and continuous); types of fermenter, solid substrate fermentation and submerged fermentation, conventional fermentation v/s biotransformation; fermentation economics. Upstream processes: media formulation; sterilization; aeration and agitation; heat transfer and mass transfer; fermenter design- mechanically agitated; pneumatic and hydrodynamic fermenters. Measurement and control of parameters; scale up and scale down process.

Unit II

Bioreactor specific applications: tubular flow, packed bed, plug flow reactor, CSTR, bubble columns, fluidized bed and trickle bed bioreactors. Bioreactor design and analysis: ideal and non-ideal reactors; residence time distribution in bioreactor.

Growth models: unstructured models of growth, substrate inhibition kinetics; product formation, transient growth kinetics, structured kinetic models of growth and product formation, compartment models, metabolic models, cybernetic models. Modeling mass and heat transfer in bioreactor.

Unit-III

Downstream processing: bioseparation (filtration, ultrafiltration, centrifugation and sedimentation, flocculation); cell disruption; liquid-liquid extraction; purification by chromatographic techniques; reverse osmosis and; drying; crystallization; storage and packaging.

Immobilized cell based bioreactor; immobilized enzyme and its application in bioreactor; bioreactor design for animal cell culture; strategies of maximizing the productivity of amino acid and SCP; bioreactor design for waste treatment.

Suggested readings:

1. Bioprocess Engineering Principles, Pauline M. Doran, 2nd Ed., Academic Press (2012), ISBN-13: 9780122208515.
2. Bioprocess Engineering-Basic Concepts, Michael L Shuler, Fikret Kargi, Pearson Education Limited (2015). Isbn-13: 9789332549371.
3. Fermentation Microbiology and Biotechnology, El Mansi Emt, Cfa Bryce, Al Demain, Taylor & Francis Group / Spon Press (2012).ISBN-13: 9781439855799.
4. Biotechnology- A text book of Industrial Biotechnology, Wulf Crueger, Anneliese Crueger, Kr Aneja, Medtec (2017). ISBN-13: 9789385998638.

Objective: To enable the students to culture the plant, animal and stem cells *in vitro* as well as their molecular characterization, production of plantlets and differentiated tissue.

CO-1	Remember and understand the basic concepts/Principles of Cell Culture Techniques
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit-I

Plant tissue culture concepts and methods: concept of totipotency and plasticity, tissue culture media and its composition, plant growth regulators; initiation and establishment of culture: explant preparation, callus culture, single cell culture, suspension culture, microspore culture, embryo rescue; micropropagation: organogenesis, somatic embryogenesis, artificial seed; protoplast technology: isolation and culture of protoplast, somatic hybridization, screening and selection of somatic hybrid.

Unit-II

Animal cell culture: equipments and safety parameters, aseptic techniques, cell culture reagents, media (defined and undefined media, complete-incomplete media), culture condition, maintenance of cell culture: culturing, sub-culturing, primary and continuous culture; *in vitro* transformation of animal cells; anchorage-dependent, monolayer and suspension culture; cryopreservation and cell revival; cell line banking; contamination check and prevention; biological characterization of cultured cell; measuring parameter of growth; cytotoxicity assay; cell viability measurement.

Unit-III

Embryonic stem cells and adult stem cell; differences between stem cells and differentiated cells; isolation and culture of stem cells; use of embryonic stem cells and adult stem cells for health care; tissue engineering; three-dimensional culture: multi-cellular tumour spheroids (mcts)-mono and co-cultures, re-aggregate organ cultures; drug testing *in-vitro*. Immunolabeling of cells to study molecular expression pattern—microscopy, flow cytometry, cytospin, immunohistochemistry, transfection, transient and stable cell line generation.

Suggested readings:

1. Animal Cell Culture and Technology, Michael Butler, BIOS Scientific Publishers (2004). ISBN-13: 9781859960493.
2. Animal Cell Culture-A Practical Approach, John R.W. Masters, Oxford University Press (2000). ISBN-13: 9780199637966.
3. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, Rlan Freshney, Oxford University Press (2000). ISBN-13: 9780199632138.
4. Introduction to Plant biotechnology, H.S Chawala, Oxford & Ibh Publishing Co. Pvt Ltd (2016). ISBN-13: 9788120417328.
5. Plant tissue culture: Theory and Practice, S.S.Bhojwani, M.K Razadan, Reed Elsevier India Pvt.Ltd (2016). ISBN-13: 9788181473257.
6. Elements of Biotechnology, P K Gupta, Rastogi Publication (2015). ISBN-13: 9788171339372.
7. Plant cell and tissue culture, Narayan Swamy, McGraw Hill Education (2013). ISBN-13: 9780074602775.

Objective: To make the student understand the tools and techniques require for the development of transgenic crops, commercial scale production of plantlets and genetic characterization of plants.

CO-1	Remember and understand the basic concepts/Principles of Plant Biotechnology
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit-I

Tools of plant genetic engineering: *agrobacterium* biology, basis of tumor and hairy root formation, mechanisms of T-DNA transfer, role of virulence genes, plant gene vector based on Ti plasmid, direct transformation (gene gun, electroporation, microinjection, calcium phosphate, PEG, DEAE, liposomes *etc.*); selection of clones, marker and reporter genes involved in screening, application of genetic transformation: promoter tagging, activation tagging; terminator seed technology; transgene stability and gene silencing; chloroplast transformation – advantages sectors success with tobacco and potato.

Unit-II

Biotechnology of secondary metabolites: secondary metabolites of plant origin and its types; production of secondary metabolites through tissue culture, factors affecting the production and its optimization, bioreactor based production of secondary metabolites and its kinetics; isolation and purification of secondary metabolites, biotransformation (case studies).
Molecular breeding: molecular markers- types, principle and applications in plant biotechnology; SITL and QTL mapping, physical mapping, map based cloning; molecular marker-assisted selection. DNA profiling techniques and genetic diversity analysis, RAPD, ISSR, SSR, AFLP, popgene, AMOVA, dendrogram analysis, chromosome map construction, QTL mapping,

Unit-III

Manipulation of plant product quality and quantity: photosynthesis, nitrogen fixation, solute uptake, nutritional quality; manipulation of reproductive biology and development: pollen production, pollen-stigma interactions, seed development, seed germination and mobilization of food reserves; phytochrome; regulation of flower development.

Suggested readings:

1. Plant Biotechnology Genetic Manipulation Of Plants, Adrian Slater, Nigel W. Scott and Mark R. Fowler, Oxford University Press (2017). ISBN-13: 9780199560875.
2. Biotechnology: Expanding Horizons, BD Singh, Kalyani Publishers / Lyall Bk Depot (2016). ISBN-13: 9789327222982.
3. Introduction to Plant biotechnology, H.S Chawala, Oxford & Ibh Publishing Co. Pvt Ltd (2016). ISBN-13: 9788120417328.
4. Elements of Biotechnology, P K Gupta, Rastogi Publication (2015). ISBN-13: 9788171339372.

Objective: To make the student understand the tools and techniques require for the development of transgenic animals, animal cell cultures and development of in vivo animal models.

CO-1	Remember and understand the basic concepts/Principles of Animal Biotechnology
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit-I

Micromanipulation of animal cells, cell cloning, cell fusion and somatic cell hybrids, Principles and methods of hybridoma technology, Production and characterization of monoclonal antibodies and their application in animal health and production. Cytokines: structure and function, Cytokine receptors, Regulation of immune response, Cytokine related diseases, diagnosis and therapeutic application.

Unit-II

Induction of superovulation, Embryo collection and evaluation, Embryo splitting, Embryo sexing, Embryo transfer, Advantages of embryo transfer in farm animals, *In vitro* fertilization, Embryo cloning, Nuclear transplantation, Production of transgenic animals and gene farming, Identification and transfer of gene influencing production and disease resistance.

Unit-III

Immune studies *in vivo* animal models and human subjects: Assessment of protective immunity, Transfer of protective immunity, Assessment of immune responses in humans, Adoptive transfer of lymphocytes and hematopoietic stem-cell transfers, Animal models: Transgenic mice and gene knockout by targeted disruption, *In vivo* cell tracking techniques, Cell imaging techniques *in vitro* and *in vivo*.

Suggested readings:

1. Cellular and Molecular Immunology, Abul K. Abbas, Andrew H. H. Lichtman, Shiv Pillai, 7th Ed., Elsevier (2001). ISBN-13: 9788131248928.
2. Immunology, Janis Kubly, 3rd Edition, WH Freeman (2007). ISBN-13: 9789812435163.
3. Kubly Immunology. Judith A Owen, Jenni Punt, Sharon A Stranford, 7th Ed., W.H. Freeman and Co., New York (2013). ISBN-13: 9781429219198
4. Essential Immunology, Ivan M Roitt, Peter J Delves, 12th Ed., Blackwell Scientific Publications (2011). ISBN-13: 9781405196833.
5. Principle of gene manipulation and Genomics, S.B Primrose, R.M Twyman, 6th Ed., Blackwell Science Ltd (2014). ISBN-13: 9788126548392.

BT-537	Practical (Cell Culture Tech. and Bioinformatics)	2 CH	50 marks
BT-538	Practical (Plant and Animal Biotechnology)	2 CH	50 marks

FOURTH SEMESTER

BT-541 GENOMICS, PROTEOMICS & METABOLOMICS 3 CH 50 marks

Objective: The course is intended to provide thorough understanding modern technologies of the genomics pertaining to whole genome sequencing, genome mining, comparative genomics, global gene function technologies, protein structure & function technologies at the genome level, etc.

CO-1	Remember and understand the basic concepts/Principles of Genomics, Proteomics and Metabolomics
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit I

Concept of genome organization and minimal cell genome; genome sequencing strategies, principles and methodology; genome sequencing projects- microbes, plants and animals; accessing and retrieving genome project information from web; recognition of coding and non-coding sequences and gene annotation.

Reverse genetics- strategies and applications, concept of TILLING, structural genomics, functional genomics and comparative genomics; high throughput screening in genome for drug discovery-identification of gene targets and drug development.

Unit II

Introduction to proteome, protein analysis (includes measurement of concentration, amino-acid composition, N-terminal sequencing); 2-D electrophoresis of proteins; isoelectrofocusing; peptide fingerprinting; LC/MS-MS for identification of proteins and modified proteins; MALDI-TOF; SAGE and differential display proteomics, protein-protein interactions, yeast two hybrid and three hybrid system; protein microarray; structural proteomics; proteomics and drug delivery.

Unit-III

Introduction to metabolomics: metabolome, metabonomics, metabolite profiling, metabolome fingerprinting, role of biomarker in metabolomics, tools of metabolome studies: NMR, MS, GC, LC, IR and its application, metabolome projects of plant and human, future prospective of metabolomics.

Suggested readings:

1. Principle of gene manipulation and Genomics, S.B Primrose, R.M Twyman, 6th Ed., Blackwell Science Ltd (2014). ISBN-13: 9788126548392
2. Discovering Genomics, proteomics & bioinformatics, Malcolm Campbell, Laurie J Heyer, Pearson Education Limited (2013). ISBN-13: 9788131715598.
3. From Genes to Genomes: Concepts and Applications of DNA Technology, Jeremy W. Dale, Malcolm von Schantz, Wiley, John & Sons (2007) ISBN-13: 9780470017340.
4. Molecular Biotechnology: Principles and Applications of Recombinant DNA, Bernard R Glick, Jack J Pasternak, Panima Book Distributors (2002). ISBN-13: 9788186535080.

5. Genetic Engineering, Smita Rastogi, Neelam Pathak, Oxford University Press (2009). ISBN-13: 9780195696578.

BT-542 IPRs, BIOSAETY AND BIOETHICS 3 CH 50 marks

Objective: To educate the students on protection of intellectual property developed through the research and ethical issues related to biotechnological research.

CO-1	Remember and understand the basic concepts/Principles of IPRs, Biosafety and Bioethics
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit I

Intellectual property rights and its types-patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; process patent vs product patent; IPs of relevance to biotechnology and few case studies; introduction to GATT, WTO, WIPO and TRIPS.

Unit II

Basic requirement of a patentable invention, prior art and state of art; patent databases; Indian Patent Act 1970 and recent amendments; patent database; procedure for filing a patent, international patenting-requirement, patent infringement- meaning, scope, litigation, remedies; case studies and examples-Rice, Neem *etc.*

Unit-III

Introduction to biosafety regulations; primary containment for biohazards and biosafety levels; biosafety guidelines - government of india. Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC. Bioethics, public concerns on human genome research and transgenics- genetic testing and screening, ethics in clinical trials and GCP, ELSI & human genome project; ethics in human cloning (case study).

Suggested readings:

1. Biotechnology and Intellectual Property Rights, Kshitij Kumar Singh, Springer (2016), ISBN-13: 9788132229759.
2. Intellectual Property and Biotechnology: Biological Inventions, Rimmer Matthew, Edward Elgar, U.K. - Edward Elgar (2009). ISBN-13: 9781845429478.
3. Synthetic Biology and Intellectual Property Rights, Rajendra K. Bera, ISBN-13: 978-9535120407.
4. Intellectual Property Rights and the Life Science Industries: Past, Present and Future, Graham Dutfield, World Scientific Pub Co Inc (2009), ISBN-13: 9789812832276.
5. Bioethics and Biosafety, M. K. Sateesh, Ik International Pvt Ltd (2014), ISBN-13: 9788190675703.
6. Biosafety and Bioethics, Rajmohan Josi, Isha Books (2006). ISBN-13: 9788182053779.
7. IPR, Biosafety and Bioethics, Deepa Goel, Shomini Parshar, Pearson Education Limited (2013), ISBN-13: 9788131774700.

BT-543 (A) AGRICULTURAL BIOTECHNOLOGY 3 CH 50 marks

Objective: The course is intended to provide the technology involve in crop improvements, molecular farming and production of transgenic crops.

CO-1	Remember and understand the basic concepts/Principles of Agricultural Biotechnology
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit -I

Introduction to agricultural biotechnology: conventional method of crop improvements vs. Biotechnological interventions, manipulation of resistance: fungal and bacterial disease, viral disease, strategies for engineering insect resistance (bt genes, protease inhibitors, α -amylase inhibitors), strategies for engineering herbicide resistance, strategies for engineering stress resistance (drought stress, salt stress, temperature stress).

Unit-II

Plant disease resistance: introduction, plant pathogen interaction, major type of plant pathogens, natural disease resistance pathways, biotechnological approaches to disease resistance (case studies), improvement of crop yield and quality: long shelf life of fruits and flowers, use of ACC synthase, poly-galactorunase, ACC oxidase; modification of fruit and flower color, seed storage protein quality, vitamin e fortification, fe and mineral fortification, case studies of phytase production and golden rice.

Unit-III

Genetic manipulation of crop yield by photosynthesis, nitrogen fixation, advances in agricultural biotechnology: molecular farming: plants as factories for pharmaceuticals and biomaterials, smart breeding: marker-assisted selection: non-invasive biotechnology alternative to genetic engineering of plant varieties, biofertilizers and biopesticides.

Suggested readings:

1. Plant Biotechnology Genetic Manipulation Of Plants, Adrian Slater, Nigel W. Scott and Mark R. Fowler, Oxford University Press (2017). ISBN-13: 9780199560875.
2. Biotechnology: Expanding Horizons, BD Singh, Kalyani Publishers / Lyall Bk Depot (2016). ISBN-13: 9789327222982.
3. Introduction to Plant biotechnology, H.S Chawala, Oxford & Ibh Publishing Co. Pvt Ltd (2016). ISBN-13: 9788120417328.
4. Elements of Biotechnology, P K Gupta, Rastogi Publication (2015). ISBN-13: 9788171339372.
5. Modern Food Microbiology, James M. Jay, CBS Publishers & Distributors (2005). ISBN-13: 9788123904757.
6. Food Microbiology: Fundamentals and frontiers, M.P. Doyle, L.R. Beuchat, Thoma J. Montville, ASM press (2007). ISBN-13: 9781555814076.

7. Genetic transformation of plants, J.F. Jackson, H.F. Linskens, CBSPD (2009). ISBN-13: 9788184891065.

BT-543 (B) CLINICAL PATHOLOGY & DIAGNOSTICS 3 CH 50 marks

Objective: To enable the students to interpret and understand the various pathological tests report pertaining to diagnosis of different diseases.

CO-1	Remember and understand the basic concepts/Principles of Clinical Pathology and Diagnostics
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit- I

General pathology: introduction to systemic pathology haematology, cytopathology, chemical pathology, immunopathology, and general neoplasia. Histopathology: collection of specimen, labelling, documentation, fixation. Grossing techniques and tissue processing. Cutting and staining of sections, use of special stains and immunocytochemistry, frozen sections, interpretation and reporting.

Unit- II

Haematology: haemoglobin estimation , blood counts, staining and reporting of smears, LE cells , ESR , packed cell volume and absolute values, staining methods for blood cells, blood bank serology , ABO grouping , Rh typing , special blood groups, blood banking
Clinical and chemical pathology: examination of urine, body fluids and stool, collection of blood , anti-coagulants, protein precipitants, estimation of blood sugar, urea, creatinine, proteins, bilirubin, cholesterol, uric acid, electrolytes, calcium and enzymes, use of autoanalyzer techniques.

Unit-III

Microbiology and serology: collection , handling , documentation and section of material for important procedures, use of various microbiological stains, use of various culture media and identification of bacterias by specific procedures, antibiotic sensitivity tests, sterilization and disinfection . Identification of fungi in specimen and culture. Diagnostic procedures in important viral infections. Serological techniques, widal, weil felix, VDRL, HIV, HBV, CRP, RF, ASO and pregnancy tests. ELISA and CLIA, medical imaging techniques: CT scan, X-ray, ultra Sound.

Suggested readings:

1. District Laboratory Practice In Tropical Countries, Monica Cheesbrough, Cambridge University Press (2006), ISBN-13: 9780521684590.
2. Basic Medical Microbiology, Patrick R. Murray, Elsevier (2017). ISBN-13: 9780323476768.
3. Medical Microbiology, David Greenwood, Richard Slack, John Peutherer, Churchill Livingstone (2012). ISBN-13: 9780702040900.

BT-543 (C) ENVIRONMENTAL BIOTECHNOLOGY 3 CH 50 marks

Objective: To enable the students to design and develop innovative process or techniques pertaining to bioremediation and management of pollutants in the environment.

CO-1	Remember and understand the basic concepts/Principles of Environmental Biotechnology
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit-I

Biological treatment of waste water: microbial processes in waste water treatment, microbial biofilm and waste water treatment, secondary treatment system, microbial removal of nitrogen and phosphorous, nutrient removal through biomass production. Bioremediation: bioreactors for bioremediation, types of bioremediation, application of bioremediation, biodegradation of xenobiotics and pollutants, biodegradation of pesticides, biosorption: use of bacteria, fungi and algae in biosorption, biomineralization and bioleaching.

Unit-II

Biotechnology for pollution control: air pollution abatement (bioscrubber and biofilter), water pollution abatement: aerobic (activated sludge process, biological filters, rotating biological contractors, fluidized bed reactors, inverse fluidized bed biofilm reactor, expanded bed reactor); anaerobic biological treatment (contact digester, packed bed or packed volume reactor, anaerobic baffled digester, upflow anaerobic sludge blanket reactors); membrane bioreactor and biocatalyst.

Unit-III

Management and remediation of problem/contaminated soil: bioremediation of organic pollutant contaminated soil, biotechnology for solid waste management (composting of crop residue, principles and advantages of composting, factors influencing composting, techniques of compost enrichment), vermicomposting and crop productivity. Bioleaching. Biotechnology of waste land reclamation and restoration, biomass as source of energy, concept of biofuels, bioethanol and biohydrogen.

Suggested readings:

1. Environmental Biotechnology, A.K. Chatterjee, Prentice-Hall Of India Pvt Ltd (2011). ISBN-13: 9788120342989.
2. Environmental Biotechnology, Mh Fulekar, Oxford & Ibh Publishing Co Pvt Ltd (2006). ISBN-13: 9788120416918.
3. Environmental Biology by Varma and Agarwal (2012)
4. Environment Problems and Solution, DK Asthana, Meera Asthana, S Chand & Company Pvt Ltd (2010). ISBN-13: 9788121916547.

5. Environmental Biotechnology, Monika Jain, Narosa Publishing House (2014). ISBN-13: 9788184872705.

BT-543 (D) PHARMACEUTICAL BIOTECHNOLOGY 3 CH 50 marks

Objective: To enable the students to develop the novel drugs in Pharma industry and experimental evaluation of their efficacy.

CO-1	Remember and understand the basic concepts/Principles of Pharmaceutical Biotechnology
CO-2	Analyze the Various Concepts to understand them through case studies
CO-3	Apply the knowledge in understanding practical problems
CO-4	Execute/Create the Project or field assignment as per the knowledge gained in the course

Unit- I

Introduction to pharmaceutical industry & development of drugs; economics and regulatory aspects; quality management; GMP. Bioavailability and factor affecting bioavailability; drug kinetics and bio pharmaceuticals mechanism of drug absorption, distribution, biotransformation and excretion; factors affecting the ADME process; bioequivalence; pharmacokinetics.

Unit- II

Principles of drug manufacture; liquid dosage forms (solutions, suspensions and emulsions); topical applications (ointments, creams, suppositories); solid dosage forms (powders, granules, capsules, tablets, coating of tablets); aerosols; preservation; packing techniques. Advanced drug delivery systems; sustained release drug delivery system and controlled release; transdermals, liposomes; drug targeting.

Unit-III

Biopharmaceuticals understanding principles of pharmacology, pharmacodynamics; study of a few classes of therapeutics like recombinant therapeutics, monoclonal antibodies, vaccines, gene therapy, antibiotics and hormones. Immunogenicity of biopharmaceuticals: immunogenicity; factors contributing to immunogenicity (product related factors, host-related factors), consequence of immunogenicity to biopharmaceuticals; measurement of immunogenicity. Case studies: insulin, somatotropin, interleukin-2, interferon, factor VIIa, factor IX, factor VIII, monoclonal antibodies etc.

Suggested readings:

1. Pharmaceutical Biotechnology, Manoj Kumar, Anmol Publications Pvt Ltd (2010). ISBN-13: 9788126142231.
2. Pharmaceutical Biotechnology: Fundamentals and Applications, Daan J. A. Crommelin, Robert D. Sindelar, Bernd Meibohm, Springer (2016). ISBN-13: 9781493943395.
3. Handbook of Pharmaceutical Biotechnology, Shayne Cox Gad, Wiley, John & Sons (2007). ISBN-13: 9780471213864.
4. Biopharmaceuticals: Biochemistry and Biotechnology, Gary Walsh, 2nd Ed., John Wiley & Sons Inc (Sea) Pte Ltd (2011). ISBN-13: 9788126530014.
5. Pharmaceutical Biotechnology: Concepts and Applications, Gary Walsh, cbspd (2007). ISBN-13: 9780470012451.

6. Handbook of Pharmaceutical Biotechnology, Jay P Rho, Stan G Louie, Viva Books Private Ltd (2004).ISBN-13: 9788176497855.

BT-544	Seminar	3 CH	50 marks
BT-545	Project work and Viva Voce	12 CH	200 marks

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