SYLLABUS OF TWO YEAR POST GRADUATE PROGRAMME IN BIOTECHNOLOGY

Department of Biotechnology, Bodoland University, Kokrajhar, Assam

JUNE 18, 2024

BODOLAND UNIVERSITY

KOKRAJHAR, ASSAM

PROGRAMME OUTCOME OF 2 YEAR PG PROGRAMME IN BIOTECHNOLOGY:: DEPT. OF BIOTECHNOLOGY, BU

Introduction

MSc in Biotechnology is a 2 years programme consisting four semesters which encompasses theory, practical and research in different areas of Biotechnology. The research component contains two semester dissertation work to enhance the learner's depth of knowledge and develop their research skills. The programme consists of 80 credits in total, of which theory component bears 60 credits and practical component is of 20 credits. The course is aimed at developing skills to understand complex biological phenomena and their technological implications. The course will enable the students to apply the gained knowledge and skills to develop sustainable technologies for better future. On completion of the course the learners will be competent to take up research in future or any other jobs in academia or biotech industries. The programme also endeavors to inculcate the seed of innovation with a touch of technology so as to create potent entrepreneurs who shall be job providers in their respective arena.

Programme Outcomes:

PO 1: Students shall be able to acquire knowledge on the fundamental concepts of core areas of biotechnology such as cell biology, molecular biology, genetics and biochemistry.

PO 2: The programme is aimed to offer a broad understanding of the applied subjects of genetic engineering, microbiology, immunology, bioinformatics, stem cell, food biotechnology and environmental biotechnology.

PO 3: Students shall earn the experience and learning for implementing problem solving approach and research aptitude in the field of biotechnology.

PO 4: Students shall experience hands-on training on modern tools and techniques, gain the ability in equipment handling and other basic laboratory skills relevant to biotechnology

PO 5: Provide an environment wherein the students have the opportunity to develop their entrepreneurial ideas and encourage them for start ups and bio-enterpreneurship.

COURSE STRUCTURE OF
2-Year PG Programme Structure, Department of Biotechnology

SEMESTER I

Paper Code	Paper Name	Credits	L+T+P	Internal	External (T+P)	Marks
BITADL14014	Cell and Molecular Biology	4	2+1+1	30	50 + 20	100
BITADL14024	Advanced Biochemistry	4	2+1+1	30	50 + 20	100
BITADL14034	Advanced Immunology	4	2+1+1	30	50 + 20	100
BITADL14044	Advanced Genetics	4	2+1+1	30	50 + 20	100
BITADL14054	Research Methodology/MOOCs	4	2+1+1	30	50 + 20	100
	Total Credits	**20**				

SEMESTER II

Paper Code	Paper Name	Credits	L+T+P	Internal	External	Marks
BITSPL15064	Microbial Biotechnology	4	2+1+1	30	50 + 20	100
BITSPL15074	Computational Biology and Drug Designing	4	2+1+1	30	50 + 20	100
BITSPL15084	Emerging Technologies	4	2+1+1	30	50 + 20	100
BITSPL15094	Genetic Engineering	4	2+1+1	30	50 + 20	100
BITSPL15104	Plant and Animal Biotechnology	4	2+1+1	30	50 + 20	100
	Total Credits	**20**				

Note: After the completion of the first year of PG Programme, a student can opt from any of the three options given below for obtaining their degree.

Option A- Only Coursework
Option B- Only Research
Option C- Coursework + Research

OPTION A- (Only Coursework)

SEMESTER III

Paper Code	Paper Name	Credits	L+T+P	Internal	External	Marks
BITSPL25014	Stem Cell Biology	4	2+1+1	30	50 + 20	100
BITSPL25024	Medical Biotechnology	4	2+1+1	30	50 + 20	100
BITSPL25034	Bioprocess Engineering and Technology	4	2+1+1	30	50 + 20	100
BITSPL25044	Vaccine Biology	4	2+1+1	30	50 + 20	100
BITSPL25054	Molecular Diagnostics/MOOCs	4	2+1+1	30	50 + 20	100
	Total Credits	**20**				

SEMESTER IV

Paper Code	Paper Name	Credits	L+T+P	Internal	External	Marks
BITSPL25064	Bio-entrepreneurship	4	2+1+1	30	50 + 20	100
BITSPL25074	Enzyme Technology	4	2+1+1	30	50 + 20	100
BITSPL25084	IPR, Biosafety and Bioethics	4	2+1+1	30	50 + 20	100
BITSPL25094	Protein Engineering	4	2+1+1	30	50 + 20	100
BITSPL25104	Nanobiotechnology	4	2+1+1	30	50 + 20	100
	Total Credits	**20**				

OPTION B- (Only Research)

SEMESTER III	Dissertation
SEMESTER IV	Dissertation
Total Credits	**40**

OPTION C- (Coursework + Research)

SEMESTER III

Paper Code	Paper Name	Credits	L+T+P	Internal	External	Marks
BITSPL25014	Stem Cell Biology	4	2+1+1	30	20+50	100
BITSPL25024	Medical Biotechnology	4	2+1+1	30	20+50	100
BITSPL25034	Bioprocess Engineering and Technology	4	2+1+1	30	20+50	100
BITSPL25044	Vaccine Biology	4	2+1+1	30	20+50	100
BITSPL25054	Molecular Diagnostics/MOOCs	4	2+1+1	30	20+50	100
	Total Credits	**20**				

SEMESTER IV

SEMESTER IV	Dissertation
Total Credits	**20**

SEMESTER I

Paper Name: CELL AND MOLECULAR BILOGY	
Paper Code: BITADL14014	**Credit: 4 (2L++1T+1P)**
Total Classes: 60= 45+15 (L+P)	**Total Marks: 100 (T50+P20+IA30)**

COURSE OBJECTIVE:

The objectives of this course are to sensitize the students to the fact that as we go down the scale of magnitude from cells to organelles to molecules, the understanding of various biological processes becomes deeper and inclusive.the context of each topic.

COURSE OUTCOMES:

Student should be equipped to understand three fundamental aspects in biological phenomenon: a) what to seek; b) how to seek; c) why to seek?

CO1: Students shall get an insight into the structure and organization of the cell and the cellular organelles.

CO2: Have a conceptual knowledge about DNA as a genetic material, Structure and function of RNA, the concept of central dogma and know the importance of genetic code and Wobble hypothesis.

CO3: Students shall obtain knowledge about various activities taking place at the cellular level such as cell-cell interactions, cellular transportations, cell-communications and cell-signaling.

CO4: Learn about the cell cycle and its regulation.

CO5: Explain the various tools and techniques used in manipulating ans studying cells.

COURSE CONTENT:

Unit I: Dynamic organization of cell **8 lectures**

Universal features of cells; cell chemistry and biosynthesis: chemical organization of cells; internal organization of the cell - cell membranes: structure of cell membranes and concepts related to compartmentalization in eukaryotic cells; intracellular organelles: endoplasmic reticulum and Golgi apparatus, lysosomes and peroxisomes, ribosomes, cellular cytoskeleton, mitochondria, chloroplasts and cell energetics; nuclear compartment: nucleus, nucleolus and chromosomes.

Unit II: Chromatin structure and dynamics **12 lectures**

Chromatin organization - histone and DNA interactome: structure and assembly of eukaryotic

and prokaryotic DNA polymerases, DNA-replication, repair and recombination; chromatin control: gene transcription and silencing by chromatin-Writers,-Readers and –Erasers; Transcriptional control: Structure and assembly of eukaryotic and prokaryotic RNA Polymerases, promoters and enhancers, transcription factors as activators and repressors, trancriptional initiation, elongation and termination; post-transcriptional control: splicing and addition of cap and tail, mRNA flow through nuclear envelope into cytoplasm, breakdown of selective and specific mRNAs through interference by small non-coding RNAs (miRNAs and siRNAs), protein translation machinery, ribosomes-composition and assembly; universal genetic codes, degeneracy of codons, Wobble hypothesis; Iso-accepting tRNA; mechanism of initiation, elongation and termination; co- and post-translational modifications, mitochondrial genetic code translation product cleavage, modification and activation.

Unit III: Cellular signalling, transport and trafficking 5 lectures

Molecular mechanisms of membrane transport, nuclear transport, transport across mitochondria and chloroplasts; intracellular vesicular trafficking from endoplasmic reticulum through Golgi apparatus to lysosomes/cell exterior.

Unit IV: Cellular Processes 8 lectures

Cell cycle and its regulation; cell division: mitosis, meiosis and cytokinesis; cell differentiation: stem cells, their differentiation into different cell types and organization into specialized tissues; cell-ECM and cell-cell interactions; cell receptors and transmembrane signalling; cell motility and migration; cell death: different modes of cell death and their regulation.

Unit V: Manipulating and studying cells 4 lectures

Isolation of cells and basics of cell culture; observing cells under a microscope, different types of microscopy; analyzing and manipulating DNA, RNA and proteins.

Unit VI: Genome instability and cell transformation 8 lectures

Mutations, proto-oncogenes, oncogenes and tumour suppressor genes, physical, chemical and biological mutagens; types of mutations; intra-genic and inter-genic suppression; transpositions-transposable genetic elements in prokaryotes and eukaryotes, role of transposons in genome; viral and cellular oncogenes; tumor suppressor genes; structure, function and mechanism of action; activation and suppression of tumor suppressor genes; oncogenes as transcriptional activators.

Practical: **15 lectures**

1. Isolation of animal cells from animal tissue/plant tissue and check their viability.
2. Prepare culture media with various supplements for plant and animal tissue culture.
3. Study cell division in animal/plant/microbial cells.
4. Isolation and quantification of nucleic acids.
5. Demonstration of PCR.
6. Isolation and quantification of total proteins.
7. Prepare agarose gel and SDS-PAGE.

Suggested Readings:

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008). *Molecular Biology of the Cell* (5th Ed.). New York: Garland Science.
2. Lodish, H. F. (2016). *Molecular Cell Biology* (8th Ed.). New York: W.H. Freeman.
3. Krebs, J. E., Lewin, B., Kilpatrick, S. T., Goldstein, E. S. (2014). *Lewin's Genes XI*. Burlington, MA: Jones & Bartlett Learning.
4. Cooper, G. M., & Hausman, R. E. (2013). *The Cell: a Molecular Approach* (6th Ed.). Washington: ASM ; Sunderland.
5. Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2012). *Becker's World of the Cell*. Boston (8th Ed.). Benjamin Cummings.
6. Watson, J. D. (2008). *Molecular Biology of the Gene* (5th ed.). Menlo Park, CA: Benjamin/Cummings.

Paper Name: ADVANCED BIOCHEMISTRY	
Paper Code: BITADL14024	**Credit: 4 (2L++1T+1P)**
Total Classes: 60= 45+15 (L+P)	**Total Marks: 100 (T50+P20+IA30)**

COURSE OBJECTIVE:

The objectives of this course are to build upon undergraduate level knowledge of biochemical principles with specific emphasis on different metabolic pathways. The course shall make the students aware of various disease pathologies within the context of each topic.

COURSE OUTCOME:

CO1: Gain fundamental knowledge in biochemistry

CO2: Understand the molecular basis of various pathological conditions from the perspective of biochemical reactions.

COURSE CONTENT:

Unit I: Protein Structure **8 lectures**

Amino acids – structure and functional group properties, peptides and covalent structure of proteins, elucidation of primary and higher order structures, Ramachandran plot, evolution of protein structure, protein degradation and introduction to molecular pathways controlling protein degradation, structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin etc. Protein folding: Anfinsen's Dogma, Levinthal paradox, cooperativity in protein folding, free energy landscape of protein folding and pathways of protein folding, molten globule state, chaperons, diseases associated with protein folding, introduction to molecular dynamic simulation.

Unit II: Enzyme Kinetics **7 lectures**

Enzyme catalysis – general principles of catalysis; quantitation of enzyme activity and efficiency; enzyme characterization and Michaelis-Menten kinetics; relevance of enzymes in metabolic regulation, activation, inhibition and covalent modification; single substrate enzymes; concept of catalytic antibodies; catalytic strategies with specific examples of proteases, carbonic anhydrases, restriction enzymes and nucleoside monophosphate kinase; regulatory strategies with specific example of hemoglobin; isozymes; role of covalent modification in enzymatic activity; zymogens.

Unit III: Glycobiology **5 lectures**

Sugars - mono, di, and polysaccharides with specific reference to glycogen, amylose and cellulose, glycosylation of other biomolecules - glycoproteins and glycolipids; lipids - structure and properties of important members of storage and membrane lipids; lipoproteins.

Unit IV: Structure and functions of DNA & RNA and lipids **5 lectures**

Self-assembly of lipids, micelle, biomembrane organization - sidedness and function; membrane bound proteins - structure, properties and function; transport phenomena; nucleosides, nucleotides, nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical structure; difference in RNA and DNA structure and their importance in evolution of DNA as the genetic material.

Unit V: Bioenergetics **8 lectures**

Bioenergetics-basic principles; equilibria and concept of free energy; coupled interconnecting reactions in metabolism; oxidation of carbon fuels; recurring motifs in metabolism; Introduction to GPCR, Inositol/DAG//PKC and Ca++ signaling pathways; glycolysis and gluconeogenesis; reciprocal regulations and non-carbohydrate sources of glucose; Citric acid cycle, entry to citric acid cycle, citric acid cycle as a source of biosynthetic precursors; Oxidative phosphorylation; importance of electron transfer in oxidative phosphorylation; F1-F0 ATP Synthase; shuttles across mitochondria; regulation of oxidative phosphorylation; Photosynthesis – chloroplasts and two photosystems; proton gradient across thylakoid membrane

Unit VI: Role of vitamins and cofactors in metabolism **12 lectures**

Calvin cycle and pentose phosphate pathway; glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, roles of epinephrine and glucagon and insulin in glycogen metabolism; Fatty acid metabolism; protein turnover and amino acid catabolism; nucleotide biosynthesis; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and mevalonate pathway; elucidation of metabolic pathways; logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; principles of metabolic regulation; steps for regulation; target of rapamycin (TOR) & Autophagy regulation in relation to C & N metabolism, starvation responses and insulin signaling

Practical: **15 lectures**

1. Preparation of buffers, various stock solutions and working solutions that will be needed for the course.
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. Quantification of Carbohydrates/Proteins/Nucleic acids.
4. Blood test by SGPT
5. Demonstration of Mass Spectrometry, Circular Dichroism Spectroscopy and Fluorescence Microscopy if available

Suggested Readings

1. Stryer, L. (2015). *Biochemistry*. (8^{th} ed.) New York: Freeman.
2. Lehninger, A. L. (2012). *Principles of Biochemistry* (6^{th} ed.). New York, NY: Worth.
3. Voet, D., & Voet, J. G. (2016). *Biochemistry* (5^{th} ed.). Hoboken, NJ: J. Wiley & Sons.
4. Dobson, C. M. (2003). *Protein Folding and Misfolding*. Nature, 426(6968), 884-890. doi:10.1038/nature02261.
5. Richards, F. M. (1991). *The Protein Folding Problem*. Scientific American, 264(1), 54-63. doi:10.1038/scientificamerican0191-54.

Paper Name: ADVANCED IMMUNOLOGY	
Paper Code: BITADL14034	**Credit: 4 (2L++1T+1P)**
Total Classes: 60= 45+15 (L+P)	**Total Marks: 100 (T50+P20+IA30)**

COURSE OBJECTIVE:

The objectives of this course are to learn about structural features of components of immune system as well as their function. The major emphasis of this course will be on development of immune system and mechanisms by which our body elicits immune response. This will be imperative for students as it will help them to predict about nature of immune response that develops against bacterial, viral or parasitic infection, and prove it by designing new experiments.

Course Outcomes:

CO1: Evaluate usefulness of immunology in different pharmaceutical companies.

CO2: Identify proper research lab working in area of their own interests.

CO3: Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses and figure out kind of immune responses in the setting of infection (viral or bacterial).

Course Content:

Unit I: Immunology: fundamental concepts **7 lectures**

Components of innate and acquired immunity; phagocytosis; complement and inflammatory responses; pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP); innate immune response; mucosal immunity; antigens: immunogens, haptens; Major Histocompatibility Complex: MHC genes, MHC and immune responsiveness and disease susceptibility, Organs of immune system, primary and secondary lymphoid organs.

Unit II: Immune responses generated by B and T lymphocytes **8 lectures**

Immunoglobulins - basic structure, classes & subclasses of immunoglobulins, antigenic determinants; multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; principles of cell signaling; basis of self & non-self discrimination; kinetics of immune response, memory; B cell maturation, activation and differentiation; generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; functional T Cell subsets; cell-mediated immune responses, ADCC; cytokines: properties, receptors and therapeutic uses; antigen processing and presentation-

endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; cell-cell co-operation, Hapten-carrier system.

Unit III: Antigen-antibody interactions 7 lectures

Precipitation, agglutination and complement mediated immune reactions; advanced immunological techniques: RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence microscopy, flow cytometry and immunoelectron microscopy; surface plasmon resonance, biosensor assays for assessing ligand –receptor interaction; CMI techniques: lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays, apoptosis, microarrays, transgenic mice, gene knock outs.

Unit IV: Vaccinology 8 lectures

Active and passive immunization; live, killed, attenuated, subunit vaccines; vaccine technology: role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines; antibody genes and antibody engineering:chimeric, generation of monoclonal antibodies, hybrid monoclonal antibodies; catalytic antibodies and generation of immunoglobulin gene libraries, idiotypic vaccines and marker vaccines, viral-like particles (VLPs), dendritic cell based vaccines, vaccine against cancer, T cell based vaccine, edible vaccine and therapeutic vaccine.

Unit V: Clinical Immunology 9 lectures

Immunity to infection : bacteria, viral, fungal and parasitic infections (with examples from each group); hypersensitivity: Type I-IV; autoimmunity; types of autoimmune diseases; mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; treatment of autoimmune diseases; transplantation: immunological basis of graft rejection; clinical transplantation and immunosuppressive therapy; tumor immunology: tumor antigens; immune response to tumors and tumor evasion of the immune system, cancer immunotherapy; immunodeficiency: primary immunodeficiencies, acquired or secondary immunodeficiencies, autoimmune disorder, anaphylactic shock, immunosenescence, immune exhaustion in chronic viral infection, immune tolerance, NK cells in chronic viral infection and malignancy.

Unit VI: Immunogenetics 6 lectures

Major histocompatibility complex genes and their role in autoimmune and infectious diseases, HLA typing, human major histocompatibility complex (MHC), Complement genes of the human

major histocompatibility complex: implication for linkage disequilibrium and disease associations, genetic studies of rheumatoid arthritis, systemic lupus erythematosus and multiple sclerosis, genetics of human immunoglobulin, immunogenetics of spontaneous control of HIV, KIR complex.

Practical: **15 lectures**

1. Study of animal models used for generating immune responses.
2. Preparation of plasma and serum.
3. Demonstration of ELISA and ELISPOT.
4. SDS-PAGE and Immunoblotting.
5. Blood smear identification of leucocytes by Giemsa stain.
6. Separation of leucocytes by Dextran method.

Suggested Readings

1. Kindt, T. J., Goldsby, R. A., Osborne, B. A., & Kuby, J. (2006). *Kuby Immunology*. New York: W.H. Freeman
2. Brostoff, J., Seaddin, J. K., Male, D., & Roitt, I. M. (2002). *Clinical Immunology.* London: Gower Medical Pub.
3. Murphy, K., Travers, P., Walport, M., & Janeway, C. (2012). *Janeway's Immunobiology.* New York: Garland Science.
4. Paul, W. E. (2012). *Fundamental Immunology*. New York: Raven Press.
5. Goding, J. W. (1996). *Monoclonal Antibodies: Principles and Practice: Production and Application of Monoclonal Antibodies in Cell Biology, Biochemistry, and Immunology.* London: Academic Press.
6. Parham, P. (2005). *The Immune System*. New York: Garland Science.

Paper Name: ADVANCED GENETICS	
Paper Code: BITADL14044	**Credit: 4 (2L++1T+1P)**
Total Classes: 60= 45+15 (L+P)	**Total Marks: 100 (T50+P20+IA30)**

COURSE OBJECTIVE:

The objectives of this course are to take students through basics of genetics and classical genetics covering prokaryotic/ phage genetics to yeast and higher eukaryotic domains. On covering all classical concepts of Mendelian genetics across these life-forms, students will be exposed to concepts of population genetics, quantitative genetics encompassing complex traits, clinical genetics and genetics of evolution.

Course Outcomes:

CO1: Describe fundamental molecular principles of genetics;

CO2: Understand relationship between phenotype and genotype in human genetic traits;

CO3: Describe the basics of genetic mapping;

CO4: Understand how gene expression is regulated.

Course Content:

Unit I: Genetics of Bacteria and Bacteriophages **13 lectures**

Concept of a gene in pre-DNA era; mapping of genes in bacterial and phage chromosomes by classical genetic crosses; fine structure analysis of a gene; genetic complementation and other genetic crosses using phenotypic markers; phenotype to genotype connectivity prior to DNA-based understanding of gene.

Unit II: Yeast genetics **10 lectures**

Meiotic crosses, tetrad analyses, non-Mendelian and Mendelian ratios, gene conversion, models of genetic recombination, yeast mating type switch; dominant and recessive genes/mutations, suppressor or modifier screens, complementation groups, transposon mutagenesis, synthetic lethality, genetic epistasis

Unit III: *Drosophilla* genetics as a model of higher eukaryotes **6 lectures**

Monohybrid & dihybrid crosses, back-crosses, test-crosses, analyses of autosomal and sex linkages, screening of mutations based on phenotypes and mapping the same, hypomorphy, genetic mosaics, genetic epistasis in context of developmental mechanism.

Unit IV: Population genetics and genetics of evolution **8 lectures**

Introduction to the elements of population genetics: genetic variation, genetic drift, neutral evolution; mutation selection, balancing selection, Fishers theorem, Hardy- Weinberg equilibrium, linkage disequilibrium; in-breeding depression & mating systems; population bottlenecks, migrations, Bayesian statistics; adaptive landscape, spatial variation & genetic fitness.

Unit V: Quantitative genetics of complex traits (QTLs) **3 lectures**

Complex traits, mapping QTLs, yeast genomics to understand biology of QTLs.

Unit VI: Plant genetics **5 lectures**

Laws of segregation in plant crosses, inbreeding, selfing, heterosis, maintenance of genetic purity, gene pyramiding

Practical: **15 lectures**

1. Demonstrate Mendelian inheritance patterns.
2. Isolation of DNA from biological samples.
3. PCR Amplification and Gel Electrophoresis.
4. Karyotyping and Chromosome Analysis.
5. Bacterial transformation.
6. Quantitative Trait Analysis in Plants.

Suggested Readings:

1. Hartl, D. L., & Jones, E. W. (1998). *Genetics: Principles and Analysis*. Sudbury, MA: Jones and Bartlett.
2. Pierce, B. A. (2005). *Genetics: a Conceptual Approach*. New York: W.H. Freeman.
3. Tamarin, R. H., & Leavitt, R. W. (1991). *Principles of Genetics*. Dubuque, IA: Wm. C. Brown.
4. Smith, J. M. (1998). *Evolutionary Genetics*. Oxford: Oxford University Press.

Paper Name: Research Methodology/MOOCs	
Paper Code: BITADL14054	**Credit: 4 (2L++1T+1P)**
Total Classes: 60= 45+15 (L+P)	**Total Marks: 100 (T70+IA30)**

COURSE OBJECTIVE:

The objectives of this course are to give background on history of science, emphasizing methodologies used to do research, use framework of these methodologies for understanding effective lab practices and scientific communication and appreciate scientific ethics.

COURSE OUTCOME:

CO1: Understand history and methodologies of scientific research, applying these to recent published papers;

CO2: Understand and practice scientific reading, writing and presentations;

CO3: Appreciate scientific ethics through case studies.

COURSE CONTENT:

Unit I: Defining the Research Problem **5 Lectures**

Defining Research Problem, Selection of research Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem, An Illustration Conclusion.

Unit II: Literature Collection **5 Lectures**

Need for review of literature, Review process and bibliography, Research Reading, Discriminative Reading, Consulting Source Material, Working Bibliography, Index Card and Reference Card, Different system of Citing References.

Unit III: **Research Design/ Experimental Design** **15 Lectures**

Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs, Developing a Research Plan

Sampling Design: Census and Sample Survey, Implications of a Sample Design, Steps in Sampling Design, Criteria of Selecting a Sampling Procedure, Characteristics of a Good Sample Design, Different Types of Sample Designs, Selection of Random Sample, Random Sample from an Infinite Universe, Complex Random Sampling Designs.

Methods of Data Collection: Collection of Primary Data, Observation Method, Interview Method, Collection of Data through Questionnaires, Collection of Data through Schedules,

Difference between Questionnaires and Schedules, Some Other Methods of Data Collection, Collection of Secondary Data.

Unit IV: Interpretation and Report Writing **8 Lectures**

Meaning of Interpretation, importance of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports.

Unit V Process of communication **7 Lectures**

Presentation skills - formal presentation skills, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions; Computing skills for scientific research - web browsing for information search; search engines and their mechanism of searching; hidden Web and its importance in scientific research; internet as a medium of interaction between scientists; effective email strategy using the right tone and conciseness.

Unit VI Scientific Communication **5 lectures**

Technical writing skills - types of reports; layout of a formal report; scientific writing skills - importance of communicating science; problems while writing a scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers - peer review process and problems, recent developments such as open access and non- blind review; plagiarism; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.

Practicals:

1. Perform Literature Review and Bibliography Construction
2. Study on the Formulation of Research Questions and Hypotheses
3. Demonstrate on Designing a Survey Questionnaire
4. Demonstrate Data Collection and Entry
5. Demonstrate the use Basic Statistical Analysis Using Software
6. Demonstrate on Writing a Research Proposal

Suggested readings:

1. Valiela, I. (2001). *Doing Science: Design, Analysis, and Communication of Scientific Research.* Oxford: Oxford University Press.

2. *On Being a Scientist: a Guide to Responsible Conduct in Research.* (2009). Washington, D.C.: National Academies Press.
3. Gopen, G. D., & Smith, J. A. *The Science of Scientific Writing*. American Scientist, 78 (Nov-Dec 1990), 550-558.
4. Mohan, K., & Singh, N. P. (2010). *Speaking English Effectively*. Delhi: Macmillan India.

SEMESTER II

Paper Name: MICROBIAL BIOTECHNOLOGY	
Paper Code: BITSPL15064	**Credit: 4 (2L++1T+1P)**
Total Classes: 60= 45+15 (L+P)	**Total Marks: 100 (T50+P20+IA30)**

COURSE OBJECTIVE:

The objectives of this course are to introduce students to developments/ advances made in field of microbial technology for use in human welfare and solving problems of the society.

COURSE OUTCOME:

CO1: On completion of this course, students would develop deeper understanding of the various aspects of microbial technology and its applications.

CO2: The students would be able to use their skills learned in the course at industrial level

COURSE CONTENT

Unit I: Introduction to microbial technology 11 lectures

Microbial technology in human welfare; Isolation and screening of microbes important for industry – advances in methodology and its application; Advanced genome and epigenome editing tools (*e.g.*, engineered zinc finger proteins, TALEs/TALENs, and the CRISPR/Cas9 system as nucleases for genome editing, transcription factors for epigenome editing, and other emerging tools) for manipulation of useful microbes/ strains and their applications; Strain improvement to increase yield of selected molecules, *e.g.*, antibiotics, enzymes, biofuels.

Unit II: Environmental applications of microbial technology 6 lectures

Environmental application of microbes; Ore leaching; Biodegradation - biomass recycle and removal; Bioremediation - toxic waste removal and soil remediation; Global Biogeochemical cycles; Environment sensing (sensor organisms/ biological sensors); International and National guidelines regarding use of genetically modified organisms in environment, food and pharmaceuticals.

Unit III: Pharmaceutical applications of microbial technology 10 lectures

Recombinant protein and pharmaceuticals production in microbes – common bottlenecks and issues (technical/operational, commercial and ethical); Attributes required in industrial microbes (*Streptomyces* sp., Yeast) to be used as efficient cloning and expression hosts (biologicals production); Generating diversity and introduction of desirable properties in industrially

important microbes (*Streptomyces*/Yeast); Microbial cell factories; Downstream processing approaches used in industrial production process (*Streptomyces* sp., Yeast).

Unit IV: Food applications of microbial technology **10 lectures**

Application of microbes and microbial processes in food and healthcare industries - food processing and food preservation, antibiotics and enzymes production, microbes in targeted delivery application – drugs and vaccines (bacterial and viral vectors); Non- recombinant ways of introducing desirable properties in Generally recognized as safe (GRAS) microbes to be used in food (*e.g.*, Yeast) - exploiting the existing natural diversity or the artificially introduced diversity through conventional acceptable techniques (mutagenesis, protoplast fusion, breeding, genome shuffling, directed evolution *etc.*).

Unit V: Advances in microbial technology **8 lectures**

Microbial genomics for discovery of novel enzymes, drugs/ antibiotics; Limits of microbial genomics with respect to use in human welfare; Metagenomics and metatranscriptomics – their potential, methods to study and applications/use (animal and plant health, environmental clean-up, global nutrient cycles & global sustainability, understanding evolution), Global metagenomics initiative - surveys/projects and outcome, metagenomic library construction and functional screening in suitable hosts – tools and techniques for discovery/identification of novel enzymes, drugs (*e.g.*, protease, antibiotic) *etc.*

Practical: **15 lectures**

1. Isolation and Identification of Microorganisms from Environmental Samples
2. Antibiotic Production by Soil Bacteria
3. Plasmid DNA Isolation and Restriction Digestion
4. Bioremediation: Degradation of Pollutants by Microorganisms
5. Fermentation Technology: Production of Ethanol by Yeast
6. Microbial Enzyme Production and Activity Assay

Suggested readings:

1. Lee, Y. K. (2013). *Microbial Biotechnology: Principles and Applications*. Hackensack, NJ: World Scientific .
2. Moo-Young, M. (2011). *Comprehensive Biotechnology*. Amsterdam: Elsevier.
3. Nelson, K. E. (2015). Encyclopedia of Metagenomics. *Genes, Genomes and Metagenomes: Basics, Methods, Databases and Tools*. Boston, MA: Springer US.
4. *The New Science of Metagenomics Revealing the Secrets of Our Microbial Planet*. (2007). Washington, D.C.: National Academies Press.

Paper Name: COMPUTATIONAL BIOLOGY AND DRUG DESIGNING	
Paper Code: BITSPL15074	**Credit: 4 (2L++1T+1P)**
Total Classes: 60= 45+15 (L+P)	**Total Marks: 100 (T50+P20+IA30)**

COURSE OBJECTIVE:

The objective of this course is to provide students with theory and practical experience of essentials to aid for genomic, proteomic and metabolomics courses and drug design program.

COURSE OUTCOME:

CO1: Develop an understanding of the basic theory of these computational tools;

CO2: Develop required database extraction, integration, coding for computational tools and methods necessary for all Omics;

CO3: Create hypothesis for investigating specific contemporary biological questions, provide help to experiment with or develop appropriate tools;

CO4: Critically analyze and interpret results of their study with respect to whole systems.

COURSE CONTENT:

Unit I: Introduction to computational biology basics and biological databases 8 lectures

Computers in biology and medicine; Overview of biological databases, nucleic acid & protein databases, primary, secondary, functional, composite, structural classification database, Sequence formats & storage, Access databases, Extract and create sub databases, limitations of existing databases.

Unit II: Pairwise and multiple sequence alignments 7 lectures

Local alignment, Global alignment, Scoring matrices - PAM, BLOSUM, Gaps and penalties, Dot plots. Dynamic programming approach: Needleman and Wunsch Algorithm, Smith and Waterman Algorithm, Hidden Markov Model: Viterbi Algorithm. Heuristic approach: BLAST, FASTA. Building Profiles, Profile based functional identification.

Unit III: Genome analysis 6 lectures

Polymorphisms in DNA sequence, Introduction to Next Generation Sequencing technologies, Whole Genome Assembly and challenges, Sequencing and analysis of large genomes, Gene prediction, Functional annotation, Comparative genomics, Probabilistic functional gene networks, Human genome project, Genomics and crop improvement. Study available GWAS, ENCODE, HUGO projects, extract and build sub databases; Visualization tools including

Artemis and Vista for genome comparison; Functional genomics case studies.

Unit IV: Structure visualization **6 lectures**

Retrieving and drawing structures, Macromolecule viewing platforms, Structure validation and correction, Structure optimization, Analysis of ligand-protein interactions; Tools such as PyMol or VMD.

Unit V: Molecular Modelling **6 lectures**

Significance and need, force field methods, energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; mapping properties onto surfaces; RMS fit of conformers and protein chains, assigning secondary structures; sequence alignment: methods, evaluation, scoring; protein curation: backbone construction and side chain addition; different types of protein chain modelling: ab initio, homology, hybrid, loop; Template recognition and alignments; Modelling parameters and considerations; Model analysis and validation; Model optimization; Substructure manipulations, annealing, protein folding and model generation; loop generating methods; loop analysis; Analysis of active sites using different methods in studying protein–protein interactions.

Unit VI: Structure based drug development **6 lectures**

Molecular docking: Types and principles, Semi-flexible docking, Flexible docking; Ligand and protein preparation, Macromolecule and ligand optimization, Ligand conformations, Clustering, Analysis of docking results and validation with known information. Extra- precision docking platforms, Use of Small-molecule libraries, Natural compound libraries for virtual high throughput screenings.

Unit VII: Ligand-based drug development **6 lectures**

Quantitative structure activity relationships; Introduction to chemical descriptors like 2D, 3D and Group-based; Radar plots and contribution plots and Activity predictions, Pharmacophore modeling, Pharmacophore-based screenings of compound library, analysis and experimental validation.

Practical: **15 lectures**

1. Introduction to Bioinformatics: Tools and Databases
2. Protein Structure Visualization and Analysis
3. Molecular Docking Studies
4. Demonstrate drug designing by ligand based, structure based and pharmacophore

modeling and virtual Screening

5. Gene Expression Data Analysis
6. Pathway Analysis and Network Biology

Suggested readings:

1. Mount, D. W. (2001). *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
2. Bourne, P. E., & Gu, J. (2009). *Structural Bioinformatics*. Hoboken, NJ: Wiley-Liss.
3. Lesk, A. M. (2004). *Introduction to Protein Science: Architecture, Function, and Genomics*. Oxford: Oxford University Press.
4. Campbell, M & Heyer, L. J. (2006), *Discovering Genomics, Proteomics and Bioinformatics*, Pearson Education.
5. Oprea, T. (2005). C*hemoinformatics in Drug Discovery,* Volume 23. Wiley Online Library.
6. Gasteiger, J. & Engel,T. (2003), *Chemoinformatics: a Textbook*, Wiley Online Library.

Paper Name: Emerging Technologies	
Paper Code: BITSPL15084	**Credit: 4 (2L++1T+1P)**
Total Classes: 60= 45+15 (L+P)	**Total Marks: 100 (T50+P20+IA30)**

COURSE OBJECTIVE:

The objectives of this course are to teach basics of the new principles to students so as to appreciate current-day research tool-kit better.

COURSE OUTCOMES:

1. Learn history, theoretical basis and basic understanding of latest technologies in area of biotechnology.
2. Students will be able to explain the fundamental principles and advancements in emerging biotechnologies.
3. Learn about various applications of these technologies.
4. Students will acquire hands-on experience with advanced biotechnological tools and techniques.

COURSE CONTENT:

Unit I: Optical microscopy methods **10 Lectures**

Basic Microscopy: Light Microscopy: lenses and microscopes, resolution: Rayleigh's Approach, Darkfield; Phase Contrast; Differential Interference Contrast; fluorescence and fluorescence microscopy.

Advanced Microscopy: Confocal microscope: scanning optical microscope, confocal principle, resolution and point spread function. Advanced fluorescence techniques: FLIM, FRET, and FCS, Fluorescence Lifetime, Fluorescence Resonant Energy Transfer (FRET), Fluorescence Correlation Spectroscopy (FCS), Evanescent Wave Microscopy; Near-Field and Evanescent Waves, Total Internal Reflection Microscopy; Near-Field Microscopy; Super-Resolution Imaging with Stochastic Optical Reconstruction Microscopy (STORM) and Photoactivated Localization Microscopy (PALM).

Unit II: Mass spectroscopy **7 Lectures**

Ionization techniques; mass analyzers/overview MS; FT-ICR and Orbitrap, fragmentation of peptides; proteomics, nano LC-MS; Phospho-proteomics; interaction proteomics, mass spectroscopy in structural biology; imaging mass spectrometry.

Unit III: Systems biology **7 Lectures**

High throughput screens in cellular systems, target identification, validation of experimental methods to generate the omics data, bioinformatics analyses, mathematical modelling and designing testable predictions.

Unit IV: Structural Biology **6 Lectures**

X-ray diffraction methods, solution & solid-state NMR, cryo-electron microscopy, small- angle X-ray scattering, Atomic force microscopy.

Unit IV: CRISPR-CAS **7 Lectures**

History of its discovery, elucidation of the mechanism including introduction to all the molecular players, development of applications for *in vivo* genome engineering for genetic studies, promise of the technology as a next generation therapeutic method.

Unit V: Nanobodies **8 Lectures**

Introduction to nanobodies, combining nanobody with phage-display method for development of antibody against native proteins, nanobody as a tool for protein structure-function studies, use of nanobodies for molecular imaging, catabolic antibodies using nanobodies.

Practical: **15 Lectures**

1. Demonstration of working principle of basic microscopy (light microscopy) and advanced microscopy (Confocal microscopy).
2. Demonstration of Mass spectroscopy, X-Ray Crystallography, NMR and System Biology
3. CRISPR-Cas9 Gene Editing Simulation
4. DNA Barcoding for Species Identification
5. Bioinformatics Analysis of Next-Generation Sequencing Data

Suggested Readings:

1. Campbell, I. D. (2012). *Biophysical Techniques*. Oxford: Oxford University Press.
2. Serdyuk, I. N., Zaccai, N. R., & Zaccai, G. (2007). *Method in Molecular Biophysics: Structure, Dynamics, Function*. Cambridge: Cambridge University Press.
3. Phillips, R., Kondev, J., & Theriot, J. (2009). P*hysical Biology of the Cell*. New York: Garland Science.
4. Nelson, P. C., Radosavljević, M., & Bromberg, S. (2004). *Biological Physics: Energy, Information, Life*. New York: W.H. Freeman.
5. Huang, B., Bates, M., & Zhuang, X. (2009). *Super Resolution Fluorescence Microscopy.* Annual Review of Biochemistry, 78(1), 993-1016.

Paper Name: GENETIC ENGINEERING	
Paper Code: BITSPL15094	**Credit: 4 (2L++1T+1P)**
Total Classes: 60= 45+15 (L+P)	**Total Marks: 100 (T50+P20+IA30)**

COURSE OBJECTIVE:

The objectives of this course are to teach students with various approaches to conducting genetic engineering and their applications in biological research as well as in biotechnology industries.

COURSE OUTCOMES:

CO1: Students will be able to explain the basic principles and mechanisms of genetic engineering, including recombinant DNA technology, gene cloning, and genome editing techniques.

CO2: Students will evaluate the applications of genetic engineering in various fields, including medicine (gene therapy, genetic vaccines), agriculture (GMOs), and industry (biopharmaceuticals).

CO3: Students will design, execute, and analyze genetic engineering experiments, demonstrating an understanding of experimental controls, variable manipulation, and data interpretation.

CO4: The students shall be able to take up biological research as well as placement in the relevant biotech industry.

COURSE CONTENT:

Unit I: Introduction and tools for genetic engineering **8 lectures**

Impact of genetic engineering in modern society; general requirements for performing a genetic engineering experiment; restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing; labeling of DNA: nick translation, random priming, radioactive and non-radioactive probes, hybridization techniques: northern, southern, south-western and far-western and colony hybridization, fluorescence in situ hybridization.

Unit II: Different types of vectors **10 lectures**

Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors, hagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Principles for maximizing gene expression expression vectors; pMal; GST; pET-based

vectors; Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors; Inclusion bodies; methodologies to reduce formation of inclusion bodies; mammalian expression and replicating vectors; Baculovirus and Pichia vectors system, plant based vectors, Ti and Ri as vectors, yeast vectors, shuttle vectors.

Unit III: Different types of PCR techniques **9 lectures**

Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, cloning of PCR products; T-vectors; proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP, DGGE, RFLP.

Unit IV: Gene manipulation and protein DNA interaction **8 lectures**

Insertion of foreign DNA into host cells; transformation, electroporation, transfection; construction of libraries; isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; construction of microarrays – genomic arrays, cDNA arrays and oligo arrays; study of protein-DNA interactions: electrophoretic mobility shift assay; DNase footprinting; methyl interference assay, chromatin immunoprecipitation; protein-protein interactions using yeast two-hybrid system; phage display.

Unit V: Gene silencing and genome editing technologies **10 lectures**

Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy; creation of transgenic plants; debate over GM crops; introduction to methods of genetic manipulation in different model systems *e.g.* fruit flies (*Drosophila*), worms (*C. elegans*), frogs (*Xenopus*), fish (zebra fish) and chick; Transgenics - gene replacement; gene targeting; creation of transgenic and knock-out mice; disease model; introduction to genome editing by CRISPR-CAS with specific emphasis on Chinese and American clinical trials.

Practicals: **15 lectures**

1. Isolation of DNA from Plant cells/E.coli/Animal cells
2. DNA estimation.
3. Agarose gel electrophoresis

4. Plasmid DNA isolation
5. Demonstration of PCR
6. Restriction digestion of DNA
7. Preparation of rDNA
8. Preparation and transformation of competent cells with plasmid
9. Screening of transformed cells

Suggested Readings:

1. Old, R. W., Primrose, S. B., & Twyman, R. M. (2001). Principles of Gene Manipulation: an Introduction to Genetic Engineering. Oxford: Blackwell Scientific Publications.
2. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub.
4. Selected papers from scientific journals, particularly Nature & Science.
5. Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc

Paper Name: PLANT AND ANIMAL BIOTECHNOLOGY	
Paper Code: BITSPL15104	**Credit: 4 (2L++1T+1P)**
Total Classes: 60= 45+15 (L+P)	**Total Marks: 100 (T50+P20+IA30)**

COURSE OBJECTIVE:

The objective of this course is to introduce students to the principles, practices and application of animal biotechnology, plant tissue culture, plant and animal genomics, genetic transformation and molecular breeding of plants and animals.

COURSE OUTCOMES:

CO1: Have a clear theoretical concept on micropropagation, tissue culture media, sterilization techniques and different techniques for culturing shoot tip, embryo, pollen, anther and ovary etc. and developing haploids, hybrids and homozygous lines.

CO2: Have an understanding about the different plant transformation terms and technology viz. Ti-plasmid & Ri-plasmid, binary vectors, vector-less DNA transfer, promoters for plant transformation and chloroplast transformation.

CO3: Explain and apply the knowledge of recombinant DNA technology for plant breeding. Also have a clear concept on techniques involved in germplasm conservation.

CO4: Enables the students about understanding of design and layout of tissue culture lab and basic instrumentation.

CO5: Enables the students to understand various application of animal biotechnology.

COURSE CONTENT:

Unit I: Plant tissue culture and animal cell culture **10 lectures**

Plant tissue culture: historical perspective; totipotency; organogenesis; Somatic embryogenesis; establishment of cultures – callus culture, cell suspension culture, media preparation – nutrients and plant hormones; sterilization techniques; applications of tissue culture - micropropagation; somaclonal variation; androgenesis and its applications in genetics and plant breeding; germplasm conservation and cryopreservation; synthetic seed production; protoplast culture and somatic hybridization - protoplast isolation; culture and usage; somatic hybridization - methods and applications; cybrids and somatic cell genetics; plant cell cultures for secondary metabolite production.

Animal cell culture: brief history of animal cell culture; cell culture media and reagents; culture of mammalian cells, tissues and organs; primary culture, secondary culture, continuous cell

lines, suspension cultures; application of animal cell culture for virus isolation and in vitro testing of drugs, testing of toxicity of environmental pollutants in cell culture, application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins.

Unit II: Plant genetic manipulation **11 lectures**

Genetic engineering: Agrobacterium-plant interaction; virulence; Ti and Ri plasmids; opines and their significance; T-DNA transfer; disarmed Ti plasmid; Genetic transformation - Agrobacterium-mediated gene delivery; cointegrate and binary vectors and their utility; direct gene transfer - PEG-mediated, electroporation, particle bombardment and alternative methods; screenable and selectable markers; characterization of transgenics; chloroplast transformation; marker-free methodologies; advanced methodologies - cisgenesis, intragenesis and genome editing; molecular pharming - concept of plants as biofactories, production of industrial enzymes and pharmaceutically important compounds.

Unit III: Animal reproductive biotechnology and vaccinology **9 lectures**

Animal reproductive biotechnology: structure of sperms and ovum; cryopreservation of sperms and ova of livestock; artificial insemination; super ovulation, embryo recovery and in vitro fertilization; culture of embryos; cryopreservation of embryos; embryo transfer technology; transgenic manipulation of animal embryos; applications of transgenic animal technology; animal cloning - basic concept, cloning for conservation for conservation endangered species; Vaccinology: history of development of vaccines, introduction to the concept of vaccines, conventional methods of animal vaccine production, recombinant approaches to vaccine production, modern vaccines.

Unit IV: Plant and animal genomics **7 lectures**

Overview of genomics – definition, complexity and classification; need for genomics level analysis; methods of analyzing genome at various levels – DNA, RNA, protein, metabolites and phenotype; genome projects and bioinformatics resources for genome research – databases; overview of forward and reverse genetics for assigning function for genes.

Unit V: Molecular mapping and marker assisted selection **8 lectures**

Molecular markers - hybridization and PCR based markers RFLP, RAPD, STS, SSR, AFLP, SNP markers; DNA fingerprinting-principles and applications; introduction to mapping of genes/QTLs; marker-assisted selection - strategies for Introducing genes of biotic and abiotic

stress resistance in plants: genetic basis for disease resistance in animals; molecular diagnostics of pathogens in plants and animals; detection of meat adulteration using DNA based methods.

Practicals: **15 lectures**

1. Preparation of media needed for plant and animal tissue culture.
2. Grow and propagate plant/animal cells.
3. Isolation and quantification of DNA from plant/animal tissues.
4. Electrophoresis of DNA.
5. Isolation and quantification of total proteins from plant/animal tissues
6. Analysis of proteins by SDS -PAGE and Immunoblotting.

Suggested Readings

1. Chawla, H. S. (2000). Introduction to Plant Biotechnology. Enfield, NH: Science.
2. 2. Razdan, M. K. (2003). Introduction to Plant Tissue Culture. Enfield, NH: Science.
3. Slater, A., Scott, N. W., & Fowler, M. R. (2008). Plant Biotechnology: an Introduction to Genetic Engineering. Oxford: Oxford University Press.
4. Pörtner, R. (2007). Animal Cell Biotechnology: Methods and Protocols. Totowa, NJ: Humana Press.

SEMESTER III

Paper Name: STEM CELL BIOLOGY	
Paper Code: BITSPL25014	**Credit: 4 (2L++1T+1P)**
Total Classes: 60= 45+15 (L+P)	**Total Marks: 100 (T50+P20+IA30)**

COURSE OBJECTIVE:

To equip the students with a foundational understanding of stem cells by demystifying their defining properties – self-renewal, the ability to replicate themselves, and differentiation, the potential to transform into specialized cell types. To introduce students to the diverse landscape of stem cells, focusing on pluripotent and adult stem cells, with a particular emphasis on epithelial stem cells and their crucial role in maintaining tissues throughout the body.

COURSE OUTCOME:

CO1: Describe the characteristics of stem cells and the different types of stem cells.

CO2: Gain an understanding of stem cell regeneration techniques.

CO3: Understand basic biology/mechanisms of pluripotency, self-renewal of stem cells and epithelial stem developmental concepts.

CO4: Understand the reproductive biology of germ and somatic stem cells.

CO5: Describe the immunological aspects of stem cells in diseases and therapy.

CO6: Gain knowledge on stem cells tissue engineering techniques and their applications.

CO7: Obtain information on therapeutic approaches generated through use of stem cells for medical applications

COURSE CONTENT:

Unit I: Stem cell: An introduction **6 lectures**

Definition and Meaning of Stem Cells, Biological Roles and properties of Stem Cells, Functions and Origin of Stem Cells, Asymmetric Division of Stem Cells, Types of Stem Cells, Therapeutic Cloning of Embryonic Stem Cells. Present Perspective and future challenges.

Unit II: Ectoderm and mesoderm development **8 lectures**

Endoderm specification and differentiation: Molecular basis of Pleuripotency, Mechanism of Stem Cell Self renewal, Tissue and Organ development.The Development of Epithelial Stem Cell concept and adult stem cell concept. Imaging chromatin in embryonic stem. **Mesoderm specification and differentiation:** Niche biology, homing and migration: Hematopoietic stem cell trafficking, The neural stem cell microenvironment.

Unit III: Germ cell and somatic stem cell biology in reproduction **8 lectures**

Regulation of spermatogonia, piRNA function in germline development, The role of microRNAs in germline differentiation, Germline stem cell niches, Uterine stem cells, Modeling germ cell differentiation, Lineage analysis of stem cells, Somatic stem cells of the ovary and their relationship to human ovarian cancers, Sex differentiation in mouse and man and subsequent development of the female reproductive organs.

Unit IV: Stem cell immunology **6 lectures**

Immunologic targeting of the cancer stem cell, Immunological considerations for cell therapy using human embryonic stem cell derivatives, Mouse models of graft-versus-host disease, Prospects for ensuring acceptance of ES cell-derived tissues.

Unit V: Tissue engineering **10 lectures**

Combining stem cells and biomaterial scaffolds for constructing tissues and cell delivery, Autologous approaches to tissue engineering, Flow perfusion culture of mesenchymal stem cells for bone tissue engineering, Engineering microenvironments to control stem cell fate and function, The role of bone marrow-derived stem cells in lung regeneration and repair, Mechanical control of stem cell differentiation, Skin tissue engineering, Molecular imaging of stem cells.

Unit VI: Therapeutic prospects **7 lectures**

The hematopoietic stem cell niche, Medical applications of epidermal stem cells, Mesenchymal stromal cells as a drug delivery system, Egress and mobilization of hematopoietic stem and progenitor cells: a dynamic multi-facet process, Cord blood hematopoietic stem cell transplantation, Cell Replacement therapy, Cardiovascular Therapy, Neurological Disorders, Diabetes, Liver Therapy.

Practicals **15 lectures**

1. Luteal Cell isolation, culture and characterization in buffaloes
2. Derivation of Embryonic stem cells from IVF derived embryos in goat
3. Generating parthenogenetic embryos in Goat.
4. Cryopreservation of goat oocytes.
5. Lymphocyte isolation and preparation of metaphase plate
6. Amplification of OCT gene.

7. Counting of viable spermatozoa by eosin, necrosin stain
8. Establishment of primary fibroblast culture
9. Preparation of feeder layer
10. Gene Expression Analysis in Stem Cells Using RT-PCR

Suggested Readings:

1. Essentials of Stem Cell Biology: Robert Lanza: Elsevier Academic Press
2. Stem Cells. EapanCherian& G Nandhini. Jaypee Publications
3. Stem Cells (Basic and applications). KaushikD Deb&Satish M Tootey.McGraw Hill Education(India) Private Limited (10 October 2009)
4. The Stem Cell Divide: The Facts, the Fiction, and the Fear Driving the Greatest . MichaelBellomo. Amacom Publishing

Paper Name: MEDICAL BIOTECHNOLOGY	
Paper Code BITSPL25024	**Credit: 4 (2L++1T+1P)**
Total Classes: 60= 45+15 (L+P)	**Total Marks: 100 (T50+P20+IA30)**

COURSE OBJECTIVE: To provide students with a multifaceted understanding of cancer biology, drug metabolism, pharmacokinetics, drug design, stem cell biology, and diagnostic microbiology, enabling them to apply theoretical knowledge and practical skills in research, therapy, and disease control.

COURSE OUTCOME:

CO1: Student will learn the basic concepts of cancer biology, various stages in carcinogenesis, molecular cell biology of cancer, cancer metastasis, and cancer therapy.

CO2: Student will learn the concepts of drug metabolism and pharmokinetics, manufacturing principles, and product development and its quality.

CO3: Student will learn the basic concepts in the field of drug design followed by advanced methodology in the molecular aspects of drug design.

CO4: Student will gain knowledge in 1. Stem cell basics 2. Growing of ES cells in lab 3. Differentiation of stem cells 4. Application of stem cells.

CO5: Students will acquire comprehensive knowledge and practical skills in the pathogenesis, laboratory diagnosis, prevention, and control of important microbial diseases, including bacterial, fungal, viral, and protozoan infections, utilizing various diagnostic microbiology techniques

COURSE CONTENT:

Unit I: Fundamentals of cancer biology **10 lectures**

Regulation of Cell cycle, Mutations that cause changes in signal molecules, effects on receptor, signal switches, tumour suppressor genes, Modulation of cell cycle-in cancer, Different forms of cancers, Diet and cancer**. Principles of carcinogenesis**: Chemical Carcinogenesis, Metabolism of Carcinogenesis, Targets of Chemical Carcinogenesis, Principles of Physical Carcinogenesis, X-Ray radiation – Mechanism of radiation Carcinogenesis. **Molecular cell biology of cancer:** Oncogenes, Identification of Oncogenes, Retroviruses and Oncogenes, detection of Oncogenes, Growth factor and Growth factor receptors that are Oncogenes. Oncogenes / Proto Oncogenes activity. Growth factors related to transformations. **New molecules for cancer therapy**:

Different forms of therapy, Chemotherapy, Radiation Therapy, Detection of Cancers, Prediction of aggressiveness of Cancer, Advances in Cancer detection.

Unit II: Drug and pharmaceutical biotechnology 10 lectures

Development of Drug and Pharmaceutical Industry: Therapeutic agents, their use and economics; Regulatory aspects. **Drug metabolism and pharmacokinetics**: Drug metabolism-physico-chemical principles, radio activity-pharmacokinetic action of drugs in human bodies. **Important unit processes and their applications**: Bulk drug manufacturers, Type of reactions in bulk drug manufacture and processes. Special requirement for bulk drug manufacture. **Manufacturing principles:** Compressed table, wet granulation-dry granulation or slugging-direct compression-tablet presses, coating of tablets, capsules, sustained action dosage forms-parental solution-oral liquids-injections-ointment-topical applications, Preservation, analytical methods and test for various drug and pharmaceuticals, packing-packing techniques, quality management, GMP. **Pharmaceutical product and their control:** Therapeutic categories such as vitamins, laxatives, analgesics, non-steroidal contraceptives, Antibiotics, biologicals, hormones.

Unit III: Molecular modeling and drug design 10 lectures

Empirical force fields molecular mechanism: Bond Stretching – Angle Bending – Torsional terms – Out plane bonding motions – Electrostatic interactions – Van Der Waals interactions – Effective pair Potentials – Hydrogen Bonding – Simulation of liquid water. **Computer simulation methods** : Calculation of thermodynamic properties – Phase space – Practical aspects pf computer simulation – Boundaries monitoring Equilibrium – Long range Process – Analyzing result of simulation and estimating errors. **Molecular dynamics simulation methods**: Molecular Dynamics using simple modules – Molecular Dynamics with continuous potentials – Running Molecular Dynamics simulation – Constant dynamics – Time dependent properties – Molecular Dynamics at constant temperature and pressure - Monte Carlo simulation methods. **Metropolis methods**: Monte Carlo simulation of molecules – Monte Carlo simulation of polymers – Calculating chemical potentials – Monte Carlo or Molecular Dynamics, Molecular modeling to discover and design new molecules. **Molecular modeling in drug discovery:** Deriving and using 3D Pharma cores – Molecular docking – Structure Based methods to identify lead components- De novo ligand design.

Unit IV: Stem cells in health care 10 lectures

Stem Cell Basics : Unique properties of stem cells – embryonic stem cells - adult stem cells – umbilical cord stem cells – similarities and differences between embryonic and adult stem cells. Properties of stem cells – pluripotency – totipotency. **Stem cell in drug discovery and tissue engieering:** Target identification – Manipulating differentiation pathways – stem cell therapy Vs cell protection - stem cell in cellular assays for screening – stem cell based drug discovery, drug screening and toxicology. **Genetic engineering and therapeutic application of stem cells**: Gene therapy – genetically engineered stem cells – stem cells and Animal cloning – transgenic animals and stem cells – Therapeutic applications – Parkinson disease - Neurological disorder – limb amputation – heart disease - spinal cord injuries – diabetes –burns - HLA typing- Alzheimer's disease –tissue engineering application – production of complete organ - kidney – eyes - heart – brain.

Unit V: Medical Microbiology **5 lectures**

Pathogenesis: Lab diagnosis, prevention and control of important microbial diseases. Pathogenic bacterial diseases, Fungal diseases, Viral Diseases and Protozoan diseases. **Diagnostic Microbiology:** Sample collection and processing, Microscopy techniques (light, fluorescence, electron microscopy), Culture methods and identification of pathogens, Molecular diagnostics (PCR, qPCR, next-generation sequencing), Serological methods (ELISA, Western blot).

Practicals **15 lectures**

1. ELISA (Enzyme-Linked Immunosorbent Assay)/PCR for Disease Diagnosis
2. Cell Culture Techniques and Cytotoxicity Assay
3. DNA Fingerprinting Using Restriction Fragment Length Polymorphism (RFLP)
4. Western Blotting for Disease Diagnosis
5. Molecular docking study to predict the binding modes of ligands to target proteins and identify potential lead compounds for drug design.
6. Derivation of Embryonic stem cells from IVF derived embryos in goat.
7. Counting of viable spermatozoa by eosin, necrosin stain.
8. Establishment of primary fibroblast culture.
9. Extraction of DNA/RNA from clinical samples.
10. Conduction of PCR and for pathogen detection.

Suggested Readings:

1. Ruddon.R.W., Cancer Biology, Oxford University Press, Oxford, 1995.
2. King R.J.B., Cancer Biology, Addision Wesley Longmann Ltd, U.K., 1996.
3. Maly B.W.J., Virology a practical approach, IRL press, Oxford, 1987.
4. Dunmock.N.J and Primrose S.B., Introduction to modern Virology, Blackwell Scientific Publications, Oxford, 1988.
5. Leon Lachman et al Theory and Practice of Industrial Pharmacy, 3 Edition,
6. Lea and Febiger, 1986 2. Remington's Pharmaceutical Science, Mark Publishing and Co.
7. A.R Leach, Molecular Modeling Principles and Applications, Longman, 1996
8. J.M. Haile , Molecular Dynamics Simulation Elementary methods, , John Wiley and Sons ,1997
9. Patrick R. Murray, Ken S. Rosenthal, and Michael A. Pfaller. Medical Microbiology, 8th edition, 2016.

Paper Name: BIOPROCESS ENGINEERING AND TECHNOLOGY	
Paper Code BITSPL25034	**Credit: 4 (2L++1T+1P)**
Total Classes: 60= 45+15 (L+P)	**Total Marks: 100 (T50+P20+IA30)**

COURSE OBJECTIVE:

The objectives of this course are to educate students about the fundamental concepts of bioprocess technology and its related applications, thus preparing them to meet the challenges of the new and emerging areas of biotechnology industry.

COURSE OUTCOME:

CO1: Understand the relevance of microorganisms from industrial context;

CO2: Carry out stoichiometric calculations and specify models of their growth;

CO3: Give an account of design and operations of various fermenters;

CO4: Present unit operations together with the fundamental principles for basic methods in production technique for bio-based products;

CO5: Calculate yield and production rates in a biological production process, and also interpret data;

CO6: Calculate the need for oxygen and oxygen transfer;

CO7: Critically analyze any bioprocess from market point of view;

CO8: Give an account of important microbial/enzymatic industrial processes in food and fuel industry

COURSE CONTENT:

Unit I: Basic principles of biochemical engineering **5 lectures**

Isolation, screening and maintenance of industrially important microbes; microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); strain improvement for increased yield and other desirable characteristics.

Unit II: Stoichiometry and models ofmicrobial growth Yeast genetics **5 lectures**

Elemental balance equations; metabolic coupling – ATP and NAD+; yield coefficients; unstructured models of microbial growth; structured models of microbial growth.

Unit III: Bioreactor design and analysis **9 lectures**

Batch and continuous fermenters; modifying batch and continuous reactors: chemostat with

recycle, multistage chemostat systems, fed-batch operations; conventional fermentation v/s biotransformation; immobilized cell systems; large scale animal and plant cell cultivation; fermentation economics; upstream processing: media formulation and optimization; sterilization; aeration, agitation and heat transfer in bioprocess; scale up and scale down; measurement and control of bioprocess parameters.

Unit IV: Downstream processing and product recovery **6 lectures**

Separation of insoluble products - filtration, centrifugation, sedimentation, flocculation; Cell disruption; separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis; final purification: drying; crystallization; storage and packaging.

Unit V: Fermentation economics **6 lectures**

Isolation of micro-organisms of potential industrial interest; strain improvement; market analysis; equipment and plant costs; media; sterilization, heating and cooling; aeration and agitation; bath-process cycle times and continuous cultures; recovery costs; water usage and recycling; effluent treatment and disposal.

Unit VI: Applications of enzyme technology in food processing **6 lectures**

Mechanism of enzyme function and reactions in process techniques; enzymatic bioconversions *e.g.* starch and sugar conversion processes; high-fructose corn syrup; interesterified fat; hydrolyzed protein *etc.* and their downstream processing; baking by amylases, deoxygenation and desugaring by glucoses oxidase, beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing.

Unit VII: Applications of microbial technology in food process operations and production, biofuels and biorefinery **8 lectures**

Fermented foods and beverages; food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; microbes and their use in pickling, producing colours and flavours, alcoholic beverages and other products; process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; bacteriocins from lactic acid bacteria – production and applications in food preservation; biofuels and biorefinery.

Practicals: **15 lectures**

1. Basic Microbiology techniques
    a) Scale up from frozen vial to agar plate to shake flask culture.
    b) Instrumentation: Microplate reader, spectrophotometer, microscopy.
    c) Isolation of microorganisms from soil samples.
2. Experimental set-up
    a) Assembly of bioreactor and sterilization.
    b) Growth kinetics.
    c) Substrate and product inhibitions.
    d) Measurement of residual substrates.
3. Data Analysis
    a) Introduction to Metabolic Flux Analysis (MFA).
4. Fermentation
    a) Batch.
    b) Fed-batch.
    c) Continuous.
5. Unit operations
    a) Microfiltrations: Separation of cells from broth.
    b) Bioseparations: Various chromatographic techniques and extractions.
6. Bioanalytics

    Analytical techniques like HPLC, FPLC, GC, GC-MS *etc.* for measurement of amounts of products/substrates.

Suggested readings:

1. Shuler, M. L., & Kargi, F. (2002). *Bioprocess Engineering: Basic Concepts.* Upper Saddle River, NJ: Prentice Hall.
2. Stanbury, P. F., & Whitaker, A. (2010). *Principles of FermentationTechnology*. Oxford: Pergamon Press.
3. Blanch, H. W., & Clark, D. S. (1997). *Biochemical Engineering.* New York: M. Dekker.
4. Bailey, J. E., & Ollis, D. F. (1986). *Biochemical Engineering Fundamentals*. New York: McGraw-Hill.

Paper Name: VACCINE BIOLOGY	
Paper Code BITSPL25044	**Credit: 4 (2L++1T+1P)**
Total Classes: 60= 45+15 (L+P)	**Total Marks: 100 (T50+P20+IA30)**

COURSE OBJECTIVE:

This course will provide students with an overview of current developments in different areas of vaccines.

COURSE OUTCOME:

CO1: Understand fundamental concepts of human immune system and basic immunology;

CO2: Differentiate and understand immune responses in relation to infection and vaccination;

CO3: Understand requirement and designing of different types of vaccines;

CO4: Understand importance of conventional and new emerging vaccine technologies.

COURSE CONTENT:

Unit I: Fundamentals of immune system **9 lectures**

Overview of Immune system; Human Immune system: Effectors of immune system; Innate & Adaptive Immunity; Activation of the Innate Immunity; Adaptive Immunity; T and B cells in adaptive immunity; Immune response in infection; Correlates of protection.

Unit II: Immune response to infection **9 lectures**

Protective immune response in bacterial; viral and parasitic infections; Primary and Secondary immune responses during infection; Antigen presentation and Role of Antigen presenting cells: Dendritic cells in immune response; Innate immune response; Humoral (antibody mediated) responses; Cell mediated responses: role of CD4+ and CD8+ T cells; Memory responses: Memory and effector T and B cells, Generation and Maintenance of memory T and B cells.

Unit III: Immune response to vaccination **9 lectures**

Vaccination and immune response; Adjuvants in Vaccination; Modulation of immune responses: Induction of Th1 and Th2 responses by using appropriate adjuvants and antigen delivery systems - Microbial adjuvants, Liposomal and Microparticles as delivery systems; Chemokines and cytokines; Role of soluble mediators in vaccination; Oral immunization and Mucosal Immunity.

Unit IV: Vaccine types & design **9 lectures**

History of vaccines, Conventional vaccines; Bacterial vaccines; Viral Vaccines; Vaccines based on routes of administration: parenteral, oral, mucosal; Live attenuated and inactivated vaccine;

Subunit Vaccines and Toxoids; Peptide Vaccine.

Unit V: Vaccine technologies **9 lectures**

Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers.

Practicals **15 lectures**

1. Preparation of Bacterial Cultures for Vaccine Development
2. Demonstration of immunization for generating antibodies
3. ELISA (Enzyme-Linked Immunosorbent Assay) for Vaccine Efficacy
4. Use of Adjuvant and its effect on Immune Response
5. DNA Vaccine Plasmid Preparation
6. Demonstration of cell culture technique for virus propagation for vaccine development

Suggested Books:

1. Janeway, C. A., Travers, P., Walport, M., & Shlomchik, M. J. (2005). *Immuno Biology: the Immune System in Health and Disease*. USA: Garland Science Pub.

2. Kindt, T. J., Osborne, B. A., Goldsby, R. A., & Kuby, J. (2013). *Kuby Immunology*. New York: W.H. Freeman.

3. Kaufmann, S. H. (2004). *Novel Vaccination Strategies*. Weinheim: Wiley-VCH.

4. Journal Articles (relevant issues) from: Annual Review of Immunology, Annual Review of Microbiology, Current Opinion in Immunology, Nature Immunology, Expert review of vaccines.

Paper Name: MOLECULAR DIAGNOSTICS/MOOCs	
Paper Code BITSPL25054	**Credit: 4 (2L++1T+1P)**
Total Classes: 60= 45+15 (L+P)	**Total Marks: 100 (T50+P20+IA30)**

COURSE OBJECTIVE:

The objectives of this course are to sensitize students about recent advances in molecular biology and various facets of molecular medicine which has potential to profoundly alter many aspects of modern medicine including pre- or post-natal analysis of genetic diseases and identification of individuals predisposed to disease ranging from common cold to cancer.

COURSE OUTCOME:

CO1: This course will equip the students with the basics of life's building blocks - DNA, RNA, and proteins - exploring their structure, function, and how DNA variations influence health, individuality, and medication responses.

CO2: It will navigate students to the world of molecular analysis techniques, from differentiating PCR methods for research and diagnostics to understanding FISH, ISH, microarrays, next-generation sequencing, and bioinformatics tools for data analysis.

CO3: Students will be able to explain the concept of metabolomics and its role in biomarker discovery for various diseases.

CO4: Students will be able to analyze case studies demonstrating the impact of molecular diagnosis on improving healthcare for specific diseases.

CO5: Students will be able to identify common genetic alterations associated with various cancers.

CO6: Students will understand the importance of quality control measures in diagnostic testing and become familiar with relevant regulations and approvals for genetic testing.

COURSE CONTENT:

Unit I: Genome Biology in health and disease **5 lectures**

DNA, RNA, Protein: An overview; chromosomal structure & mutations; DNA polymor- phism: human identity; clinical variability and genetically determined adverse reactions to drugs.

Unit II: Genome: resolution, detection and analysis **8 lectures**

PCR: Real-time; ARMS; Multiplex; ISH; FISH; ISA; RFLP; DHPLC; DGGE; CSCE; SSCP; Nucleic acid sequencing: new generations of automated sequencers; Microarray chips; EST;

SAGE; microarray data normalization & analysis; molecular markers: 16S rRNA typing; Diagnostic proteomics: SELDI-TOF-MS; Bioinformatics data acquisition & analysis.

Unit III: Diagnostics metabolomics **5 lectures**

Metabolite profile for biomarker detection the body fluids/tissues in various metabolic disorders by making using LCMS & NMR technological platforms.

Unit IV: Detection and identity of microbial diseases **8 lectures**

Exemplified by two inherited diseases for which molecular diagnosis has provided a dramatic improvement of quality of medical care: Fragile X Syndrome: Paradigm of new mutational mechanism of unstable triplet repeats, von-Hippel Lindau disease: recent acquisition in growing number of familial cancer syndromes.

Unit V: Detection of inherited diseases **7 lectures**

Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers.

Unit VI: Molecular oncology **8 lectures**

Detection of recognized genetic aberrations in clinical samples from cancer patients; types of cancer-causing alterations revealed by next-generation sequencing of clinical isolates; predictive biomarkers for personalized onco-therapy of human diseases such as chronic myeloid leukemia, colon, breast, lung cancer and melanoma as well as matching targeted therapies with patients and preventing toxicity of standard systemic therapies.

Unit VII: Quality assurance and control **4 lectures**

Quality oversight; regulations and approved testing.

Practicals: **15 lectures**

1. DNA/Protein Extraction from Biological Samples
2. Agarose Gel Electrophoresis
3. Immunoblotting
4. Polymerase Chain Reaction (PCR) Amplification
5. Demonstrate the role of PCR/ELISA/Western blotting in disease diagnosis

Suggested readings:

1. Campbell, A. M., & Heyer, L. J. (2006). Discovering Genomics, Proteomics, and Bioinformatics. San Francisco: Benjamin Cummings.
2. Brooker, R. J. (2009). Genetics: Analysis & Principles. New York, NY: McGraw-Hill.
3. Glick, B. R., Pasternak, J. J., & Patten, C. L. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, DC: ASM Press
4. Coleman, W. B., & Tsongalis, G. J. (2010). Molecular Diagnostics: for the Clinical Laboratorian. Totowa, NJ: Humana Press

SEMESTER IV

Paper Name: BIOENTREPRENEURSHIP	
Paper Code: BITSPL25064	**Credit: 4 (2L++1T+1P)**
Total Classes: 60= 45+15 (L+P)	**Total Marks: 100 (T50+P20+IA30)**

COURSE OBJECTIVE:

Research and business belong together and both are needed. In a rapidly developing life science industry, there is an urgent need for people who combine business knowledge with the understanding of science & technology. Bio-entrepreneurship, an interdisciplinary course, revolves around the central theme of how to manage and develop life science companies and projects. The objectives of this course are to teach students about concepts of entrepreneurship including identifying a winning business opportunity, gathering funding and launching a business, growing and nurturing the organization and harvesting the rewards.

COURSE OUTCOME:

CO1: Students should be able to gain entrepreneurial skills

CO2: The students should be able to understand the various operations involved in venture creation, identify scope for entrepreneurship in biosciences and utilize the schemes promoted through knowledge centres and various agencies.

CO3: The knowledge pertaining to management should also help students to be able to build up a strong network within the industry.

COURSE CONTENT:

Unit I: Innovation and entrepreneurship in bio-business 12 lectures

Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (*e.g.* pharmaceuticals *vs.* Industrial biotech), Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities, Alternatives faced by emerging bio-firms and the relevant tools for strategic decision, Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies.

Unit II: Bio markets - business strategy and marketing 12 lectures

Negotiating the road from lab to the market (strategies and processes of negotiation with financiers, government and regulatory authorities), Pricing strategy, Challenges in marketing in bio business (market conditions & segments; developing distribution channels, the nature, analysis and management of customer needs), Basic contract principles, different types of agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills.

Unit III: Finance and accounting **12 lectures**

Business plan preparation including statutory and legal requirements, Business feasibility study, financial management issues of procurement of capital and management of costs, Collaborations & partnership, Information technology.

Unit IV: Technology management **9 lectures**

Technology – assessment, development & upgradation, Managing technology transfer, Quality control & transfer of foreign technologies, Knowledge centres and Technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP).

Practical:

1. Market Research and Analysis for a Biotechnology Product:
2. Business Plan Development for a Biotech Startup
3. Regulatory Pathway Analysis for a Biotechnology Product
4. Intellectual Property (IP) Management and Patent Search
5. Pitch Presentation for a Biotechnology Venture

Suggested Readings:

1. Adams, D. J., & Sparrow, J. C. (2008). *Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences*. Bloxham: Scion.
2. Shimasaki, C. D. (2014). *Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies*. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.
3. Onetti, A., & Zucchella, A. *Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge*. Routledge.
4. Jordan, J. F. (2014). *Innovation, Commercialization, and Start-Ups in Life Sciences*. London: CRC Press.
5. Desai, V. (2009). *The Dynamics of Entrepreneurial Development and Management*. New Delhi: Himalaya Pub. House.

Paper Name: ENZYME TECHNOLOGY	
Paper Code: BITSPL25074	**Credit: 4 (2L++1T+1P)**
Total Classes: 60= 45+15 (L+P)	**Total Marks: 100 (T50+P20+IA30)**

COURSE OBJECTIVE:

To introduce the theory as well as applications of enzyme technology in food, medical, and household industries.

COURSE OUTCOMES:

CO1: To familiarize students to nomenclature and properties of enzymes

CO2: To acquaint students with the fundamentals of enzyme properties, nomenclatures, characteristics and mechanisms and apply biochemical calculation for enzyme kinetics.

CO3: Students will compare methods for production, purification, characterization and immobilization of enzymes that can benefit human life and plot graphs based on kinetics data.

CO4: To discuss various application of enzymes that can benefit human life.

CO5: Discover the current and future trends of applying enzyme technology for the commercialization purpose of biotechnological products.

CO6: Students will gain practical knowledge on enzyme kinetics and hands on skills in enzyme immobilization techniques.

COURSE CONTENT:

Unit 1: Enzyme preparation **12 lectures**

General properties of enzymes like effect of pH, temperature ions, etc. Potential Sources and Screening for novel Enzymes, Media used for enzyme production. Extraction, assay and large-scale purification of Enzymes-Extraction of soluble and membrane-bound enzymes. Preliminary and Advanced purification procedures, Criteria of purity. Determination of molecular weights of enzymes

Unit 2: Immobilized Enzymes **10 lectures**

Preparation and properties of immobilized enzymes. Application of Immobilized enzymes: General principles. Genetic immobilization of enzymes on yeast cell surface

Unit 3: Industrial Use of Enzymes **13 lectures**

Use of enzymes in detergents. Enzymes in the fruit juices, wine, brewing and distillation industries. Use of proteases in the leather and wool industry. Applications of glucose oxidase

and catalase in the food industry.Use of enzymes in cellulose and starch hydrolysis. Use of lactases in the dairy industry. Medical applications of enzymes

Unit 4: Advances and future prospects in Enzyme Technology **10 lectures**

Enzymes and recombinant DNA technology. Synthesis of artificial enzymes: Enzyme engineering. Use of 'unnatural' substrates. Coenzyme-regenerating systems. Enzymes and Bioinformatics.

Practical: **15 lectures**

1. Enzyme preparation- purification procedures
2. Determination of Enzyme Activity Using a Simple Substrate**:**
3. Analysis of Effect of pH/Temperature on Enzyme Activity
4. Analysis of Substrate Specificity of Enzymes
5. Enzyme Immobilization and Activity Assay
6. Enzyme production by microbes/plants/animals.
7. Detection of isozymes on gel by staining
8. Assay of Glutamate dehydrogenase/Urease/Alkaline phosphatase
9. Immobilization of whole cells (Yeast/Bacteria) by calcium alginate method

Suggested Readings:

- Enzymes: Biochemistry, Biotechnology and Clinical Chemistry- Palmer T, Horwood Publishing Chichester, England.
- Method of Enzymatic Analysis- Bergmeyer HU. Academic Press, NY R.A. Copland Enzymes, Wiley VCH
- Enzymes and Immobilized Cells in Biotechnology. Laskin AI. The Benjamin/Cummings Publishing Company, INC., California.
- Fermentation Microbiology and Biotechnology. Mansi ME & Bryce C, Taylor & Francis Ltd, London.
- Industrial Biotechnology. Jogdand SN, Himalaya Publishing House, Mumbai.
- Fundamentals of Enzymology: Price NC and Stevens L, Oxford Univ. Press. Demonstration of the principles of enzyme-catalysed reactions using alkaline phosphatase – Pricea N and Newman L. Biochemistry and Molecular Biology Education.

Paper Name: IPR, Biosafety and Bioethics	
Paper Code: BITSPL25084	**Credit: 4 (2L++1T+1P)**
Total Classes: 60= 45+15 (L+P)	**Total Marks: 100 (T50+P20+IA30)**

COURSE OBJECTIVE:

To provide basic knowledge on intellectual property rights and their implications in biological research and product development. To become familiar with India's IPR Policy. To learn biosafety and risk assessment of products derived from biotechnology and regulation of such products. To become familiar with ethical issues in biological research. This course will focus on consequences of biomedical research technologies such as cloning of whole organisms, genetic modifications, DNA testing.

COURSE OUTCOME:

CO1: Understand the rationale for and against IPR and especially patents;

CO2: Understand why India has adopted an IPR Policy and be familiar with broad outline of patent regulations;

CO3: Understand different types of intellectual property rights in general and protection of products derived from biotechnology research and issues related to application and obtaining patents;

CO4: Gain knowledge of biosafety and risk assessment of products derived from recombinant DNA research and environmental release of genetically modified organisms, national and international regulations;

CO5: Understand ethical aspects related to biological, biomedical, health care and biotechnology research.

COURSE CONTENT:

Unit I: Introduction to IPR **10 Lectures**

Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; introduction to history of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; concept of 'prior art': invention in context of

"prior art"; patent databases - country-wise patent searches (USPTO, EPO, India); analysis and report formation.

Unit II: Patenting **10 Lectures**

Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application; role of a Country Patent Office; filing of a patent application; precautions before patenting-disclosure/non-disclosure - patent application- forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications; PCT and conventional patent applications; international patenting-requirement, procedures and costs; financial assistance for patenting- introduction to existing schemes; publication of patents-gazette of India, status in Europe and US; patent infringement- meaning, scope, litigation, case studies and examples; commercialization of patented innovations; licensing – outright sale, licensing, royalty; patenting by research students and scientists-university/organizational rules in India and abroad, collaborative research - backward and forward IP; benefit/credit sharing among parties/community, commercial (financial) and non-commercial incentives.

Unit III: Biosafety **9 Lectures**

Biosafety and Biosecurity - introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs; principles of safety assessment of transgenic plants – sequential steps in risk assessment; concepts of familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation – protection goals, compilation of relevant information, risk characterization and development of analysis plan; risk assessment of transgenic crops *vs* cisgenic plants or products derived from RNAi, genome editing tools.

Unit IV: National and International Regulations **9 Lectures**

International regulations – Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; Draft bill of Biotechnology Regulatory authority of India - containments – biosafety levels and category of rDNA

experiments; field trails – biosafety research trials – standard operating procedures - guidelines of state governments; GM labelling – Food Safety and Standards Authority of India (FSSAI).

Unit V: Bioethics **7 Lectures**

Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. Bioethics in research – cloning and stem cell research, Human and animal experimentation, animal rights/welfare, Agricultural biotechnology - Genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations - Protection of environment and biodiversity – biopiracy.

Practical: **15 Lectures**

1. Understanding and Conducting a Patent Search
2. Case Study Analysis of Biosafety Regulations
3. Developing an Informed Consent Form for a Biotech Study
4. Ethical Analysis of a Biotechnology Case Study
5. Patent infringement-Case Studies (Basmati rice, Turmeric, Neem)
6. Proxy filing of Indian Product patent
7. Proxy filing of Indian Process patent
8. Exploring patent database

Suggested readings:

1. *National IPR Policy*, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI
2. *Complete Reference to Intellectual Property Rights Laws*. (2007). Snow White Publication Oct. Kuhse, H. (2010). *Bioethics: an Anthology*. Malden, MA: Blackwell.
3. Recombinant DNA Safety Guidelines, 1990 Department of Biotechnology, Ministry of Science and Technology, Govt. of India. Retrieved from http://www.envfor.nic.in/ divisions/csurv/geac/annex-5.pdf
4. Craig, W., Tepfer, M., Degrassi, G., & Ripandelli, D. (2008). *An Overview of General Features of Risk Assessments of Genetically Modified Crops*. Euphytica, 164(3), 853-880. doi:10.1007/s10681-007-9643-8.

Paper Name: PROTEIN ENGINEERING	
Paper Code: BITSPL25094	**Credit: 4 (2L++1T+1P)**
Total Classes: 60= 45+15 (L+P)	**Total Marks: 100 (T50+P20+IA30)**

COURSE OBJECTIVE:

The aim of this course is to introduce methods and strategies commonly used in protein engineering.

COURSE OUTCOME:

CO1: Analyse structure and construction of proteins by computer-based methods;

CO2: Describe structure and classification of proteins;

CO3: Analyse purity and stability of proteins and explain how to store them in best way;

CO4: Explain how proteins can be used for different industrial and academic purposes such as structure determination, organic synthesis and drug design.

COURSE CONTENT:

Unit I: Introduction to protein Engineering **11 Lectures**

Protein engineering – definition, applications; Features or characteristics of proteins that can be engineered (definition and methods of study) – affinity and specificity; Spectroscopic properties; Stability to changes in parameters as pH, temperature and amino acid sequence, aggregation propensities, *etc.* Protein engineering with unnatural amino acids and its applications

Unit II: Stability of Protein structure **11 Lectures**

Methods of measuring stability of a protein; Spectroscopic methods to study physicochemical properties of proteins: far-UV and near-UV CD; Fluorescence; UV absorbance; ORD; Hydrodynamic properties–viscosity, hydrogen-deuterium exchange; Brief introduction to NMR spectroscopy – emphasis on parameters that can be measured/obtained from NMR and their interpretation.

Unit III: Applications **13 Lectures**

Forces stabilizing proteins – Van der waals, electrostatic, hydrogen bonding and weakly polar interactions, hydrophobic effects; Entropy – enthalpy compensation; Experimental methods of protein engineering: directed evolution like gene site saturation mutagenesis; Module shuffling; Guided protein recombination, *etc.*, Optimization and high throughput screening methodologies like GigaMetrix, High throughput microplate screens *etc.*, Application to devices with

bacteriorhodopsin as an example; Engineering antibody affinity by yeast surface display; Applications to vaccines, Peptidomimetics and its use in drug discovery.

Unit IV: Computational approaches **10 Lectures**

Computational approaches to protein engineering: sequence and 3D structure analysis, Data mining, Ramachandran map, Mechanism of stabilization of proteins from psychrophiles and thermophiles *vis-à-vis* those from mesophiles; Protein design, Directed evolution for protein engineering and its potential.

Practical: **15 lectures**

1. Site-Directed Mutagenesis of a Protein Gene
2. Expression and Purification of a Recombinant Protein
3. Enzyme Kinetics of a Mutant Protein
4. Protein Stability Assay
5. Computational Modeling of Protein Mutations

Suggested Readings:

1. Edited by T E Creighton, (1997), *Protein Structure: a Practical Approach*, 2nd Edition, Oxford university press.
2. Cleland and Craik, (2006), *Protein Engineering, Principles and Practice*, Vol 7, Springer Netherlands.
3. Mueller and Arndt, *Protein Engineering Protocols*, 1st Edition, Humana Press.
4. Ed. Robertson DE, Noel JP, (2004), *Protein Engineering Methods in Enzymology*, 388, Elsevier Academic Press.
5. J Kyte; (2006), *Structure in Protein Chemistry*, 2nd Edition, Garland publishers

Paper Name: NANOBIOTECHNOLOGY	
Paper Code: BITSPL25104	**Credit: 4 (2L++1T+1P)**
Total Classes: 60= 45+15 (L+P)	**Total Marks: 100 (T50+P20+IA30)**

COURSE OBJECTIVE:

The course aims at providing a general and broad introduction to multi-disciplinary field of nanotechnology. It will familiarize students with the combination of the top-down approach of microelectronics and micromechanics with the bottom- up approach of chemistry/biochemistry; a development that is creating new and exciting cross-disciplinary research fields and technologies. The course will also give an insight into complete systems where nanotechnology can be used to improve our everyday life.

COURSE OUTCOME:

CO1: On successful completion of this course, students should be able to describe basic science behind the properties of materials at nanometre scale

CO2: They will know the principles behind advanced experimental and computational techniques for studying nanomaterials.

COURSE CONTENT:

Unit I: Introduction to Nanobiotechnology **5 Lectures**

Introduction to Nanobiotechnology; Concepts, historical perspective; Different formats of nanomaterials and applications with example for specific cases; Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures, Synthesis and characterization of different nanomaterials.

Unit II: Nano-films **7 Lectures**

Thin films; Colloidal nanostructures; Self Assembly, Nanovesicles; Nanospheres; Nanocapsules and their characterisation.

Unit III: Nanoparticles **10 Lectures**

Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers.

Unit IV: Applications of Nanoparticles **10 Lectures**

Nanoparticles for diagnostics and imaging (theranostics); concepts of smart stimuli responsive nanoparticles, implications in cancer therapy, nanodevices for biosensor development.

Unit V: Nanomaterials **8 Lectures**

Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers.

Unit VI: Nanotoxicity **5 Lectures**

Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment; Fate of nanomaterials in different stratas of environment; Ecotoxicity models and assays; Life Cycle Assessment, containment.

Practical: **15 lectures**

1. Basics of preparation and characterization of nanomaterials.
2. Preparation of DNA/Protein/Lipid coupled nanoparticles.
3. Demonstration of nanoparticle-mediated drug delivery.
4. *In vitro* and *in vivo* assessment of nanotoxicity

Suggested Readings:

1. GeroDecher, Joseph B. Schlenoff, (2003); *Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials*, Wiley-VCH Verlag GmbH & Co. KGaA
2. David S. Goodsell, (2004); *Bionanotechnology: Lessons from Nature*; Wiley-Liss
3. Neelina H. Malsch (2005), *Biomedical Nanotechnology*, CRC Press
4. Greg T. Hermanson, (2013); *Bioconjugate Techniques*, (3rd Edition); Elsevier
5. Recent review papers in the area of Nanomedicine.