

## M.Sc. Biotechnology first semester

### Programme Outcomes (POS)

<b><u>PO1</u></b>	<b>Knowledge:</b> Knowledge will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
<b><u>PO2</u></b>	<b>Critical Thinking:</b> Develop critical thinking on appropriate knowledge of <u>living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.</u>
<b><u>PO3</u></b>	<b>Skill &amp; Application Development :</b> Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
<b><u>PO4</u></b>	<b>Inter-disciplinary &amp; Multi-disciplinary Approach:</b> Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
<b><u>PO5</u></b>	<b>Ethics:</b> Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
<b><u>PO6</u></b>	<b>Problem Solving &amp; Employability:</b> Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

### M.Sc (Biotechnology) Program Specific Outcomes

<b><u>PSO 1</u></b>	<b>Disciplinary knowledge and skills:</b> Capable of demonstrating(i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologically important molecules and its application in human welfare.
<b><u>PSO 2</u></b>	<b>Skilled communicator:</b> Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
<b><u>PSO 3</u></b>	<b>Critical thinker and problem solver:</b> Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
<b><u>PSO 4</u></b>	<b>Team player/worker:</b> Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
<b><u>PSO 5</u></b>	<b>Ethical awareness/reasoning:</b> Avoiding unethical behaviors such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
<b><u>PSO 6</u></b>	<b>Lifelong learners:</b> Capable of making conscious efforts to achieve self-paced and self-directed learning aimed at personal development and for

**COURSE: Biochemistry (MBT101T); Core -1 Theory : CREDITS: 3**

**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 Contents**

**Unit-I: Bioenergetics & Glycochemistry**

Bioenergetics -basic principles; equilibrium and concept of free energy. Metabolism: basic concepts and design. Coupled reactions, Interconnecting reactions, Electron transport, Oxidative phosphorylation, energetics of chemolithotrops and autotrophs, Synthesis of ATP and other energy rich compounds. Glycolytic pathways, Citric acid cycle, energy production, Carbohydrate Biosynthesis, Glyoxylate cycle, Gluconeogenesis, Glycogenolysis.

**Unit II: Protein Biochemistry**

Protein structure (primary, secondary, tertiary & quaternary), Globular, Fibrous proteins; Ramachandran plot, Circular Dichroism, Hydrophobic and hydrophilic interactions, Protein folding, basic principles of protein purification. Nitrogen acquisition and assimilation, Biosynthesis amino acids, Mechanism of transamination reaction, Amino acid oxidation and production of urea, Urea cycle, Pathways of amino acid degradation

**Unit III: Lipid Biochemistry**

Lipid biosynthesis, de Novo biosynthesis, biosynthesis of unsaturated fatty acids, Biosynthesis of membrane lipids and steroids, Essential fatty acids and biosynthesis of eicosanoids, Degradation of fatty acids,  $\beta$  oxidation,  $\omega$  oxidation. Principles of lipid metabolic regulations

**Unit IV: Nucleic Acid**

Nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical structure; De Novo and salvage pathway of synthesis of purine and pyrimidine bases, Feedback regulation of nucleotide biosynthesis. Catabolism of purine and pyrimidine.

**Unit V: Enzyme and Enzyme Technology**

Enzyme catalysis - general principles, quantitation of enzyme activity and efficiency; enzyme characterization and Michaelis - Menten kinetics; relevance of enzymes in metabolic regulation, concept of catalytic antibodies; catalytic strategies with specific examples of proteases, carbonic anhydrases and restriction enzymes, regulatory strategies with specific example of haemoglobin; isozymes: role of covalent modification in enzymatic activities: zymogens.

Recommended Textbooks and References:

1. Stryer,L.(2002).*Biochemistry*.NewYork:Freeman.

- 2 Lehninger, A.L. (2004). *Principles of Biochemistry* (4<sup>th</sup> ed.). New York, NY: Worth.
- 3 Voet, D., & Voet, J.G. (2004). *Biochemistry* (4<sup>th</sup> 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.

<b><u>Course Outcome</u></b>	<b><u>BIOCHEMISTRY</u></b>
<b><u>CO1</u></b>	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.
<b><u>CO2</u></b>	Gain fundamental knowledge in biochemistry.
<b><u>CO3</u></b>	Understand the molecular basis of various pathological conditions from the perspective of biochemical reactions.

### **Program Matrix**

	<b><u>PO1</u></b>	<b><u>PO2</u></b>	<b><u>PO3</u></b>	<b><u>PO4</u></b>	<b><u>PO5</u></b>	<b><u>PO6</u></b>		<b><u>PSO1</u></b>	<b><u>PSO2</u></b>	<b><u>PSO3</u></b>	<b><u>PSO4</u></b>	<b><u>PSO5</u></b>	<b><u>PSO6</u></b>
<b><u>CO1</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>1</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>3</u></b>		<b><u>3</u></b>	<b><u>2</u></b>	<b><u>1</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>
<b><u>CO2</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>1</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>3</u></b>		<b><u>3</u></b>	<b><u>3</u></b>	<b><u>1</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>
<b><u>CO3</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>1</u></b>	<b><u>3</u></b>	<b><u>3</u></b>		<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>1</u></b>	<b><u>3</u></b>

## **M.Sc. BIOTECHNOLOGY**

### **Semester – I**

**COURSE: Cell and Molecular Biology (MBT 102T); Core -2 Theory**

**CREDITS: 3**

#### **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.

#### **Course Contents**

##### **Unit I: Cellular transport, trafficking and cytoskeleton**

Cell membranes: methods to study organization of membranes, 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; Cytoskeleton: Composition, organization and functions of Microfilaments, microtubules, intermediate filaments and associated proteins.

##### **Unit II: Chromatin structure and dynamics**

Chromatin structure, DNA-replication, Gene expression in prokaryotes, Genetic code, Transcription and its regulation; operons, attenuation, anti-termination and anti-sense controls. Prokaryotic translation machinery, Gene expression in eukaryotes: Transcription, general and specific transcription factors, regulatory elements and mechanism of regulation, processing of transcripts. Eukaryotic Translation, Inhibitors of Transcription and Translation in prokaryotes and eukaryotes.

##### **Unit III: Cellular Signaling and cell adhesion**

Basic concept of signal transduction, Cell receptors, Second messengers, intracellular signaling cascade, Cell adhesion; cell junctions, cell adhesion molecules.

##### **Unit IV: Cell cycles and its regulation**

Cell cycle, Cell cycle checkpoints, regulation of cell cycle; cell death: different modes of cell death and their regulation.

##### **Unit V: Cancer**

Biology of cancer cells; Carcinogens; Proto-oncogenes, viral and cellular oncogenes; oncogenic transformation; tumor suppressor genes; structure, function and mechanism of action; activation and suppression of tumor suppressor genes.

Recommended Textbooks and References:

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008). *Molecular Biology of the Cell* (5<sup>th</sup> Ed.). New York: Garland Science.



## **Subject: Plant and Animal Biotechnology**

**Credit: 03**

### **Course Objectives**

The objectives of this course are 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.

#### Unit I: Plant tissue culture and animal cell culture

Plant tissue culture: totipotency; media preparation – nutrients and plant hormones; sterilization techniques; organogenesis; Somatic embryogenesis; establishment of cultures – callus culture, cell suspension culture, 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:- methods and applications; cybrids; 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, primary culture, secondary culture, continuous cell lines, suspension cultures; application of animal cell culture for *in vitro* testing of drugs, testing of toxicity of environmental pollutants, production of human and animal viral vaccines and pharmaceutical proteins

#### Unit II: Plant genetic manipulation

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; production of industrial enzymes and pharmaceutically important compounds.

#### Unit III: Animal reproductive biotechnology and vaccinology

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 endangered species; Vaccinology: introduction to the concept of vaccines, conventional methods of animal vaccine production, recombinant approaches to vaccine production.

#### Unit IV: Plant and animal genomics

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

Molecular mapping and marker assisted selection, 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

#### Recommended Textbooks and References:

1. Chawla, H.S. (2000). *Introduction to Plant Biotechnology*. Enfield, NH: Science.
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. Buchanan, B.B., Gruissem, W., & Jones, R.L. (2015). *Biochemistry & Molecular Biology of Plants*. Chichester, West Sussex: John Wiley & Sons.
5. Umesh, S. (2013). *Plant Biotechnology*. The Energy and Resources.
6. Glick, B.R., & Pasternak, J.J. (2010). *Molecular Biotechnology: Principles and Applications of Recombinant DNA*. Washington, D.C.: ASM Press.
7. Brown, T.A. (2006). *Gene Cloning and DNA Analysis: an Introduction*. Oxford: Blackwell Pub.
8. Primrose, S.B., & Twyman, R.M. (2006). *Principles of Gene Manipulation and Genomics*. Malden, MA: Blackwell Pub.
9. Slater, A., Scott, N.W., & Fowler, M.R. (2003). *Plant Biotechnology: The Genetic Manipulation of Plants*. Oxford: Oxford University Press.
10. Gordon, I. (2005). *Reproductive Techniques in Farm Animals*. Oxford: CAB International.
11. Levine, M.M. (2004). *New Generation Vaccines*. New York: M. Dekker.
12. Pörtner, R. (2007). *Animal Cell Biotechnology: Methods and Protocols*. Totowa, NJ: Humana Press.

<b><u>Course Outcome</u></b>	<b><u>Plant and animal biotech</u></b>
<b><u>CO1</u></b>	To introduce field of animal biotechnology
<b><u>CO2</u></b>	Students should be able to gain fundamental knowledge in plant biotechnology
<b><u>CO3</u></b>	• Identify major categories and their applications.

**Program Matrix**

	<u>PO1</u>	<u>PO2</u>	<u>PO3</u>	<u>PO4</u>	<u>PO5</u>	<u>PO6</u>		<u>PSO1</u>	<u>PSO2</u>	<u>PSO3</u>	<u>PSO4</u>	<u>PSO5</u>	<u>PSO6</u>
<u>CO1</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>3</u>		<u>2</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>2</u>
<u>CO2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>3</u>		<u>3</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>2</u>
<u>CO3</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>3</u>	<u>3</u>		<u>2</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>2</u>



**COURSE: Microbiology (MBT 104T) CREDITS: 2; Core -4**

### **Course Objective**

The objectives of this course are to introduce field of microbiology with special emphasis on microbial diversity, morphology, physiology and nutrition; methods for control of microbes and host- microbe interactions.

### **Course Learning Outcomes**

Students should be able to:

- Identify major categories of microorganisms and analyze their classification, diversity, and ubiquity;
- Identify and demonstrate structural, physiological, genetic similarities and differences of major categories of microorganisms;
- Identify and demonstrate how to control microbial growth;
- Demonstrate and evaluate interactions between microbes, hosts and environment.

### **Unit I: Microbial characteristics**

History and scope of microbiology, a brief idea of microbial diversity, Principles of classification of microbes: Morphological, metabolic and molecular criteria for the classification.

### **Course Contents**

#### **Unit II: Microbial diversity**

Ultra structure and classification of bacteria, fungi, algae and virus, extremophiles. Biotechnological potential of microbes, Growth and nutrition of bacteria, bacterial growth curve, bacterial culture methods (isolation, purification, enrichment techniques and maintenance and enumeration), mode of nutrition

#### **Unit III: Control of microorganisms**

Sterilization, disinfection and antisepsis: physical and chemical methods for control of microorganisms. Antibiotics, antiviral, antifungal, antimicrobial resistance

#### **Unit IV: Microbial genetics**

Microbial genetics: modes of genetic exchange in microbe, transformation, transduction, conjugation, evolutionary significance.

#### **Unit V: Host-microbes interaction**

Host-pathogen interaction, ecological impact of microbes; symbiosis, microbes and nutrient cycles; microbial communication system; bacterial quorum sensing, microbial fuel cells, prebiotics and probiotics, industrial and environmental application of microbes

Recommended Textbooks and References:

1. Pelczar, M.J., Reid ,R.D.,& Chan, E.C.(2001).*Microbiology*(5<sup>th</sup>ed.). New York: McGraw-Hill.
2. Willey,J.M.,Sherwood,L.,Woolverton,C.J.,Prescott,L.M.,&Willey,J.M.(2011). *Prescott’s Microbiology*. New York: McGraw-Hill.
3. Matthai,W.,Berg,C.Y.,&Black,J.G.(2005).*Microbiology,Principlesand Explorations*. Boston, MA: John Wiley &Sons.

<u>Course Outcome</u>	<u>Microbiology</u>
<u>CO1</u>	To introduce field of microbiology with special emphasis on microbial diversity, morphology, physiology and nutrition; methods for control of microbes and host- microbe interactions.
<u>CO2</u>	<ul style="list-style-type: none"> <li>•Identify and demonstrate how to control microbial growth;</li> <li>•Demonstrate and evaluate interactions between microbes, hosts and environment.</li> </ul>
<u>CO3</u>	<ul style="list-style-type: none"> <li>•Identify major categories of microorganisms and analyze their classification, diversity, and ubiquity;</li> <li>•Identify and demonstrate structural, physiological, genetic similarities and differences of major categories of microorganisms;</li> </ul>

Program Matrix

	<u>PO1</u>	<u>PO2</u>	<u>PO3</u>	<u>PO4</u>	<u>PO5</u>	<u>PO6</u>		<u>PSO1</u>	<u>PSO2</u>	<u>PSO3</u>	<u>PSO4</u>	<u>PSO5</u>	<u>PSO6</u>
<u>CO1</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>2</u>		<u>2</u>	<u>2</u>	<u>1</u>	<u>3</u>	<u>2</u>	<u>3</u>
<u>CO2</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>3</u>		<u>2</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>2</u>
<u>CO3</u>	<u>3</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>3</u>		<u>2</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>3</u>

## **COURSE: Core -5 Theory**

### **Genetics (MBT 105T) CREDITS: 2**

#### **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 Learning Outcomes**

On successful completion of this course, student will be able :

- Describe fundamental molecular principles of genetics;
- Understand relationship between phenotype and genotype in human genetic traits;
- Describe the basics of genetic mapping;
- Understand how gene expression is regulated.

#### **Course Contents**

##### **Unit I: Genetics of bacteria and bacteriophages**

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**

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: Drosophila genetics as a model of higher eukaryotes**

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

##### **Unit IV: Population genetics and genetics of evolution**

Introduction to the elements of population genetics: genetic variation, genetic drift, neutral evolution; mutation selection, balancing selection, Fisher's 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**

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

## Unit VI: Plant genetics

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

Recommended Textbooks and References:

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.

<u>Course Outcome</u>	<u>Genetics</u>
<u>CO1</u>	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.
<u>CO2</u>	<ul style="list-style-type: none"> <li>• Describe the basics of genetic mapping;</li> <li>• Understand how gene expression is regulated.</li> </ul>
<u>CO3</u>	<ul style="list-style-type: none"> <li>• Describe fundamental molecular principles of genetics;</li> <li>• Understand relationship between phenotype and genotype in human genetic traits</li> </ul>

## Program Matrix

	<u>PO1</u>	<u>PO2</u>	<u>PO3</u>	<u>PO4</u>	<u>PO5</u>	<u>PO6</u>		<u>PSO1</u>	<u>PSO2</u>	<u>PSO3</u>	<u>PSO4</u>	<u>PSO5</u>	<u>PSO6</u>
<u>CO1</u>	<u>3</u>	<u>2</u>	<u>1</u>	<u>3</u>	<u>3</u>	<u>2</u>		<u>2</u>	<u>2</u>	<u>3</u>	<u>2</u>	<u>1</u>	<u>2</u>
<u>CO2</u>	<u>3</u>	<u>1</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>3</u>		<u>2</u>	<u>3</u>	<u>1</u>	<u>5</u>	<u>2</u>	<u>3</u>
<u>CO3</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>5</u>	<u>2</u>	<u>3</u>		<u>2</u>	<u>2</u>	<u>1</u>	<u>3</u>	<u>2</u>	<u>2</u>

## **Biostatistics (MBT 106T) CREDITS: 3 ; COURSE: Core -6 Theory**

### **Course Objective**

The objective of this course is to give conceptual exposure of statistics, error analysis, hypothesis testing, and design of experiments in biological systems

### **Course Learning Outcomes**

On completion of this course, students should be able to:

- Understand how to summarize statistical data;
- Apply appropriate statistical tests based on an understanding of study question, type of study and type of data;
- Interpret results of statistical tests and application in biological systems

### **Course Contents**

#### **Unit I: Introduction**

Types of biological data (ordinal scale, nominal scale, continuous and discrete logical systems data), frequency distribution and graphical representations (bar graph, histogram, box plot and frequency polygon), cumulative frequency distribution, populations, samples, simple random, stratified and systematic sampling.

#### **Unit II: Descriptive statistics, Probability and distribution**

Measures of Location, Properties of Arithmetic Mean, median, mode, range, Properties of the Variance and Standard Deviation, Coefficient of Variation, Grouped Data, Graphic Methods, Obtaining Descriptive Statistics on the Computer, Case study. Introduction to probability and laws of probability, Random Events, Events-exhaustive, Mutually exclusive and equally likely (with simple exercises), Definition and properties of binomial distribution, Poisson distribution and normal distribution.

#### **Unit III: Correlation and regression analysis, Statistical hypothesis**

Correlation, Covariance, calculation of covariance and correlation, Correlation coefficient from ungrouped data, Spearson's Rank Correlation Coefficient, scatter and dot diagram, General Concepts of regression, Fitting Regression Lines, regression coefficient, properties of Regression Coefficients, Standard error of estimate. Making assumption, Null and alternate hypothesis, error in hypothesis testing, confidence interval, one-tailed and two-tailed testing, decision making.

#### **Unit IV: Tests of significance**

Steps in testing statistical significance, selection and computation of test of significance and interpretation of results; Sampling distribution of mean and standard error, Large sample tests (test for an assumed mean and equality of two population means with known S.D.), z-test; Small sample tests (t-test for an assumed mean and equality of means of two populations when sample observations are independent); parametric and Non parametric tests (Mann-Whitney test); paired and unpaired t-test, chi square test.

## Unit V: Experimental designs

Introduction to study designs: Longitudinal, cross-sectional, retrospective and prospective study, Principles of experimental designs, Randomized block, and Simple factorial designs, Analysis of variance (ANOVA) and its use in analysis of Randomized block Design, introduction to meta-analysis and systematic reviews, ethics in statistics.

Recommended Textbooks and References:

1. Jaype Brothers, (2011), Methods in Biostatistics for Medical Students and Research Workers (English), 7th Edition
2. Norman T.J. Bailey, (1995), Statistical Methods in Biology, 3rd Edition, Cambridge University Press.
3. P. N. Arora and P. K. Malhan, (2006), Biostatistics, 2nd Edition, Himalaya Publishing House.
4. Jerold Zar, Biostatistical Analysis, 4th Edition. Pearson Education.
5. Biostatistics: a Foundation for Analysis in the Health Sciences, 7th Edition, Wiley.
6. ML Samuels, JA Witmer (2003) Statistics for the Life Sciences, 3rd edition. Prentice Hall.

<u>Course Outcome</u>	<b>Biostatistics</b>
<u>CO1</u>	to give conceptual exposure of statistics, error analysis, hypothesis testing, and design of experiments in biological systems
<u>CO2</u>	<ul style="list-style-type: none"><li>• Understand how to summarize statistical data.</li><li>• Apply appropriate statistical tests based on an understanding of study question, type of study and type of data.</li></ul>
<u>CO3</u>	<ul style="list-style-type: none"><li>• Interpret results of statistical tests and application in biological systems.</li></ul>

## Program Matrix

	<u>PO1</u>	<u>PO2</u>	<u>PO3</u>	<u>PO4</u>	<u>PO5</u>	<u>PO6</u>		<u>PSO1</u>	<u>PSO2</u>	<u>PSO3</u>	<u>PSO4</u>	<u>PSO5</u>	<u>PSO6</u>
<u>CO1</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>3</u>		<u>2</u>	<u>3</u>	<u>3</u>	<u>2</u>	<u>1</u>	<u>3</u>
<u>CO2</u>	<u>2</u>	<u>1</u>	<u>3</u>	<u>3</u>	<u>2</u>	<u>2</u>		<u>3</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>
<u>CO3</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>		<u>2</u>	<u>3</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>2</u>

## **COURSE: Lab 01**

### **Biochemistry and Analytical Techniques (MBT 107L) CREDITS: 4**

#### **Course Objective**

The objective of this laboratory course is to introduce students to experiments in biochemistry. The course is designed to teach students the utility of a set of experimental methods in biochemistry in a problem-oriented manner.

#### **Course Learning Outcomes**

On completion of this course, students should be able to:

- To elaborate concepts of biochemistry with easy-to-run experiments;
- To familiarize with basic laboratory instruments and understand the principle of measurements using those instruments with experiments in biochemistry

#### **Course Contents**

1. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer-Lambert's Law.
2. Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by thin layer chromatography.
3. Purification and characterization of an enzyme from a microbial source.
  - a) Preparation of cell-free lysates
  - b) Ammonium sulfate precipitation
  - c) Ion-exchange Chromatography
  - d) Gel Filtration
  - e) Affinity Chromatography
  - f) Dialysis of the purified protein solution against 60% glycerol as a demonstration of storage method
  - g) Generating a Purification Table
  - i) Enzyme Kinetic Parameters:  $K_m$ ,  $V_{max}$  and  $K_{cat}$ .
6. Identification of an unknown sample as DNA, RNA or protein using available laboratory tools. (Optional Experiments)
7. Biophysical methods (Circular Dichroism Spectroscopy, Fluorescence Spectroscopy).
8. Determination of mass of small molecules and fragmentation patterns by Mass spectrometry

<b><u>Course Outcome</u></b>	<b>Biochemistry and Analytical Techniques</b>
<b><u>CO1</u></b>	The objective of this laboratory course is to introduce students to experiments in biochemistry. The course is designed to teach students the utility of set of experimental methods in biochemistry in a problem oriented manner.
<b><u>CO2</u></b>	To elaborate concepts of biochemistry with easy to run experiments
<b><u>CO3</u></b>	To familiarize with basic laboratory instruments and understand the principle of measurements using those instruments with experiments in biochemistry

### **Program Matrix**

	<b><u>PO1</u></b>	<b><u>PO2</u></b>	<b><u>PO3</u></b>	<b><u>PO4</u></b>	<b><u>PO5</u></b>	<b><u>PO6</u></b>		<b><u>PSO1</u></b>	<b><u>PSO2</u></b>	<b><u>PSO3</u></b>	<b><u>PSO4</u></b>	<b><u>PSO5</u></b>	<b><u>PSO6</u></b>
<b><u>CO1</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>1</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>2</u></b>		<b><u>2</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>1</u></b>	<b><u>2</u></b>
<b><u>CO2</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>3</u></b>		<b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>
<b><u>CO3</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>		<b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>1</u></b>	<b><u>3</u></b>



**COURSE: Core – Lab 02**

**Microbiology (MBT 108L) CREDITS: 2**

**Course Objective**

The objective of this laboratory course is to provide practical skills on basic microbiological techniques

**Course Learning Outcomes**

Students should be able to:

- Isolate, characterize and identify common bacterial organisms;
- Determine bacterial load of different samples;
- Perform antimicrobial sensitivity tests;
- Preserve bacterial cultures

**Course Contents**

1. Sterilization, disinfection and safety in microbiological laboratory.
2. Preparation of media for cultivation of bacteria.
3. Isolation of bacteria in pure culture by streak plate method.
4. Study of colony and growth characteristics of some common bacteria: Bacillus, E. coli, Staphylococcus, Streptococcus, etc.
5. Preparation of bacterial smear and Gram's staining.
6. Enumeration of bacteria: standard plate count.
7. Antimicrobial sensitivity test and demonstration of drug resistance.
8. Maintenance of stock cultures: slants, stabs and glycerol stock cultures
9. Determination of phenol co-efficient of antimicrobial agents.
10. Determination of Minimum Inhibitory Concentration (MIC)
11. Isolation and identification of bacteria from soil/water samples

**Recommended Textbooks and References:**

1. Cappuccino, J.G., & Welsh, C. (2016). Microbiology: a Laboratory Manual. Benjamin-Cummings Publishing Company.
2. Collins, C.H., Lyne, P.M., Grange, J.M., & Falkinham III, J. (2004). Collins and Lyne's Microbiological Methods (8th ed.). Arnolds.
3. Tille, P.M., & Forbes, B.A. Bailey & Scott's Diagnostic Microbiology.

<u>Course Outcome</u>	<b>Microbiology</b>
<u>CO1</u>	to provide practical skills on basic microbiological techniques

<b><u>CO2</u></b>	. •Isolate, characterize and identify common bacterial organisms; •Determine bacterial load of different samples;
<b><u>CO3</u></b>	. •Perform antimicrobial sensitivity tests; •Preserve bacterial cultures

**Program Matrix**

	<b><u>PO1</u></b>	<b><u>PO2</u></b>	<b><u>PO3</u></b>	<b><u>PO4</u></b>	<b><u>PO5</u></b>	<b><u>PO6</u></b>		<b><u>PSO1</u></b>	<b><u>PSO2</u></b>	<b><u>PSO3</u></b>	<b><u>PSO4</u></b>	<b><u>PSO5</u></b>	<b><u>PSO6</u></b>
<b><u>CO1</u></b>	<u>2</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>2</u>		<u>3</u>	<u>2</u>	<u>1</u>	<u>3</u>	<u>3</u>	<u>2</u>
<b><u>CO2</u></b>	<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>1</u>		<u>2</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>3</u>
<b><u>CO3</u></b>	<u>2</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>3</u>		<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>

## **Laboratory III: Plant and Animal Biotechnology**

**Credit: 03**

### **Course Objectives**

The objectives of this course are to provide hands-on training in basic experiments of plant and animal biotechnology.

### Syllabus

#### **Plant Biotechnology**

1. Prepare culture media with various supplements for plant tissue culture.
2. Prepare explants of *Vallerianawallichii* for inoculation under aseptic conditions.
3. Attempt *in vitro* androgenesis in plants (*Datura stramonium*).
4. Isolate plant protoplast by enzymatic and mechanical methods and attempt fusion by PEG (available material).
5. Culture *Agrobacterium tumefaciens* and attempt transformation of any dicot species.
6. Generate an RAPD and ISSR profile of *Eremurus persicus* and *Vallerianawallichii*.
7. Prepare karyotypes and study the morphology of somatic chromosomes of *Allium cepa*, *A. sativum*, *A. tuberosum* and compare them on the basis of karyotypes.
8. Pollen mother cell meiosis and recombination index of select species (one chiasmate, and the other chiasmate) and correlate with generation of variation.
9. Undertake plant genomic DNA isolation by CTAB method and its quantitation by visual as well as spectrophotometric methods.
10. Perform PCR amplification of 'n' number of genotypes of a species for studying the genetic variation among the individuals of a species using random primers.
11. Study genetic fingerprinting profiles of plants and calculate polymorphic information content.

#### **Animal Biotechnology**

1. Count cells of an animal tissue and check their viability.
2. Prepare culture media with various supplements for plant and animal tissue culture.
3. Prepare single cell suspension from spleen and thymus.
4. Monitor and measure doubling time of animal cells.
5. Chromosome preparations from cultured animal cells.
6. Isolate DNA from animal tissue by SDS method.
7. Attempt animal cell fusion using PEG.

<b><u>Course Outcome</u></b>	<b>Laboratory III: Plant and Animal Biotechnology</b>
<b><u>CO1</u></b>	to provide practical skills on basic animal biotechnology
<b><u>CO2</u></b>	to provide practical skills on basic plant biotechnology
<b><u>CO3</u></b>	On completion of course, students should be able to gain basic skills in plant and animal biotechnology.

### **Program Matrix**

	<b><u>PO1</u></b>	<b><u>PO2</u></b>	<b><u>PO3</u></b>	<b><u>PO4</u></b>	<b><u>PO5</u></b>	<b><u>PO6</u></b>		<b><u>PSO1</u></b>	<b><u>PSO2</u></b>	<b><u>PSO3</u></b>	<b><u>PSO4</u></b>	<b><u>PSO5</u></b>	<b><u>PSO6</u></b>
<b><u>CO1</u></b>	<u>2</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>2</u>		<u>3</u>	<u>2</u>	<u>1</u>	<u>3</u>	<u>3</u>	<u>2</u>
<b><u>CO2</u></b>	<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>2</u>		<u>2</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>3</u>
<b><u>CO3</u></b>	<u>2</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>1</u>		<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>

## M.Sc. Biotechnology second semester

### Programme Outcomes (POS)

<b>PO1</b>	<b>Knowledge:</b> Knowledge will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
<b>PO2</b>	<b>Critical Thinking:</b> Develop critical thinking on appropriate knowledge of <u>living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.</u>
<b>PO3</b>	<b>Skill &amp; Application Development :</b> Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
<b>PO4</b>	<b>Inter-disciplinary &amp; Multi-disciplinary Approach:</b> Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
<b>PO5</b>	<b>Ethics:</b> Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
<b>PO6</b>	<b>Problem Solving &amp; Employability:</b> Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

### M.Sc (Biotechnology) Program Specific Outcomes

<b>PSO 1</b>	<b>Disciplinary knowledge and skills:</b> Capable of demonstrating(i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologically important molecules and its application in human welfare.
<b>PSO 2</b>	<b>Skilled communicator:</b> Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
<b>PSO 3</b>	<b>Critical thinker and problem solver:</b> Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
<b>PSO 4</b>	<b>Teammaker/worker:</b> Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
<b>PSO 5</b>	<b>Ethical awareness/reasoning:</b> Avoiding unethical behaviors such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
<b>PSO 6</b>	<b>Lifelong learners:</b> Capable of making conscious efforts to achieve self-paced and self-directed learning aimed at personal development and for

**Course: Genetic engineering (MBT202T) ; Core 1**

**Credit :3**

### **Course Objectives**

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. Genetic engineering is a technology that has been developed based on our fundamental understanding of the principles of molecular biology and this is reflected in the contents of this course.

### **Course Content**

#### **Unit 1: Introduction and tools for genetic engineering**

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 2: Different types of vectors**

Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors, Phagemids; 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; Mammalian expression and replicating vectors; Baculovirus and Pichia vectors system, plant based vectors, Ti and Ri as vectors.

#### **Unit 3 : Different types of PCR techniques**

Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases; types of 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 4: Genemanipulation and protein-DNA interactions**

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 5: Gene silencing and genome editing technologies

Gene silencing techniques; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy; Transgenics- gene replacement; gene targeting; creation of transgenic and knock-out mice; disease model; introduction to genome editing by CRISPR-CAS.

#### Recommended Textbooks and References:

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* (3<sup>rd</sup> 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.

<u>Course Outcome</u>	<b>Genetic Engineering</b>
<u>CO1</u>	Teach students with various approaches to conducting genetic engineering and their applications in biological research as well as in biotechnology industries. Genetic engineering is a technology that has been developed based on our fundamental understanding of the principles of molecular biology and this is reflected in the contents of this course.
<u>CO2</u>	Given the impact of genetic engineering in modern society, the students should be endowed with strong theoretical knowledge of this technology.
<u>CO3</u>	In conjunction with the practical in molecular biology & genetic engineering, the students should be able to take up biological research as well as placement in the relevant biotech industry.

### Program Matrix

	<u>PO</u> <u>1</u>	<u>PO</u> <u>2</u>	<u>PO</u> <u>3</u>	<u>PO</u> <u>4</u>	<u>PO</u> <u>5</u>	<u>PO</u> <u>6</u>		<u>PSO</u> <u>1</u>	<u>PSO</u> <u>2</u>	<u>PSO</u> <u>3</u>	<u>PSO</u> <u>4</u>	<u>PSO</u> <u>5</u>	<u>PSO</u> <u>6</u>
<u>CO</u> <u>1</u>	<u>3</u>	<u>3</u>	<u>3</u>	<u>3</u>	<u>2</u>	<u>2</u>		<u>2</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>2</u>	<u>3</u>
<u>CO</u> <u>2</u>	<u>3</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>3</u>	<u>2</u>		<u>3</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>3</u>
<u>CO</u> <u>3</u>	<u>3</u>	<u>2</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>1</u>		<u>2</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>1</u>



**Course : Core 2 theory**

**Subject: Immunology (MBT202T)**

**Credits : 3**

### **Course Objectives**

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 content**

#### **Unit 1: Fundamental of immune system**

Introduction and History of Immunology, Molecular and Cellular components of Immune system. Lymphoid organs. Innate and adaptive immune response. Humoral and cell mediated immune response. Antigens, haptens; Antibody structure and Function; Antigen-Antibody reaction and Application.

#### **Unit 2: Immuneresponses**

Inflammatory responses; Major Histocompatibility Complex and Antigen processing and presentation; Complement System; Molecular patterns and their receptors; Cytokines; Activation of innate immune cells. Macrophages-mediated cytotoxicity

#### **Unit 3: Lymphocyte Biology**

Immunoglobulin genes; Gene rearrangement of Ig Genes and Antibody diversity; Generation, activation and differentiation of B cells and T cells maturation, Functional subsets of lymphocytes. Cell-mediated cytotoxicity – T cell; NK cell; ADCC;; Lymphocyte trafficking, immune tolerance.

#### **Unit 4 : Immunity against Infections**

Immunity to infection: Immune response against pathogens. immune exhaustion Types of Vaccines and their application; Vaccine designing; Edible vaccine; Cell based vaccines; Monoclonal Antibody; Antibody Engineering

#### **Unit 5: Clinical immunology Immunosenescence,**

Immunological Disorders: Hypersensitivity; autoimmunity; immunodeficiency; Transplantation, Tumor immunology.

Recommended Textbooks and References:

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.

<u>Course Outcome</u>	<u>Immunology theory</u>
<u>CO1</u>	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.
<u>CO2</u>	. 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
<u>CO3</u>	Evaluate usefulness of immunology in different pharmaceutical companies; Identify proper research lab working in area of their own interests; 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)

### Program Matrix

	<u>PO</u> <u>1</u>	<u>PO</u> <u>2</u>	<u>PO</u> <u>3</u>	<u>PO</u> <u>4</u>	<u>PO</u> <u>5</u>	<u>PO</u> <u>6</u>	<u>PSO</u> <u>1</u>	<u>PSO</u> <u>2</u>	<u>PSO</u> <u>3</u>	<u>PSO</u> <u>4</u>	<u>PSO</u> <u>5</u>	<u>PSO</u> <u>6</u>
<u>CO</u> <u>1</u>	<u>3</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>
<u>CO</u> <u>2</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>
<u>CO</u> <u>3</u>	<u>3</u>	<u>3</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>2</u>

**Course : core 3**

**Subject: Bioinformatics theory (MBT203T)**

**Credit 3**

### **Course Objectives**

The objectives of this course are to provide theory and practical experience of the use of common computational tools and databases which facilitate investigation of molecular biology and evolution-related concepts.

### **Course content**

#### **Unit 1:Bioinformatics basics:**

Computers in biology and medicine; Introduction to Unix and Linux systems and basic commands; Database concepts; Protein and nucleic acid databases; Structural databases; biological background for sequence analysis; Identification of protein sequence from DNA sequence; searching of databases similar sequence; NCBI; publicly available tools; resources at EBI; resources on web; database mining tools.

#### **Unit 2: DNA sequence analysis**

DNA sequence analysis: gene bank sequence database; submitting DNA sequences to databases and database searching; sequence alignment; pairwise alignment techniques; motif discovery and gene prediction; local structural variants of DNA, their relevance in molecular level processes, and their identification; assembly of data from genome sequencing.

#### **Unit 3:Multiple sequence analysis**

DNA sequence analysis: gene bank sequence database; submitting DNA sequences to databases and database searching; sequence alignment; pairwise alignment techniques; motif discovery and gene prediction; local structural variants of DNA, their relevance in molecular level processes, and their identification; assembly of data from genome sequencing.

#### **Unit 4:Protein modelling**

Protein modelling: introduction; force field methods; energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; assigning secondary structures; sequence alignment- methods, evaluation, scouring

#### **Unit 5:Protein structure prediction and virtual library**

Protein structure prediction: protein folding and model generation; secondary structure prediction; analyzing secondary structures; homology modelling: potential applications, description, methodology, homologous sequence identification; align structures, align model sequence; structure aided sequence techniques of structure prediction; structural profiles, alignment algorithms, sequence based methods of structure prediction, significance analysis,

scoring techniques, protein function prediction; elements of in silico drug design; Virtual library

Recommended Textbooks and References:

1. Lesk, A.M. (2002). *Introduction to Bioinformatics*. Oxford: Oxford University Press.
2. Mount, D.W. (2001). *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Baxevanis, A.D., & Ouellette, B.F. (2001). *Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins*. New York: Wiley-Interscience.
4. Pevsner, J. (2015). *Bioinformatics and Functional Genomics*. Hoboken, NJ: Wiley-Blackwell.
5. Bourne, P.E., & Gu, J. (2009). *Structural Bioinformatics*. Hoboken, NJ: Wiley-Liss.
6. Lesk, A.M. (2004). *Introduction to Protein Science: Architecture, Function, and Genomics*. Oxford: Oxford University Press.

<u>Course</u> <u>Outcome</u>	<b>Bioinformatics theory</b>
<u>CO1</u>	provide theory and practical experience of the use of common computational tools and databases which facilitate investigation of molecular biology and evolution-related concepts.
<u>CO2</u>	Develop an understanding of basic theory of these computational tools; Gain working knowledge of these computational tools and methods;
<u>CO3</u>	Appreciate their relevance for investigating specific contemporary biological questions; Critically analyse and interpret results of the study

**Program Matrix**

	<u>PO</u> <u>1</u>	<u>PO</u> <u>2</u>	<u>PO</u> <u>3</u>	<u>PO</u> <u>4</u>	<u>PO</u> <u>5</u>	<u>PO</u> <u>6</u>	<u>PSO</u> <u>1</u>	<u>PSO</u> <u>2</u>	<u>PSO</u> <u>3</u>	<u>PSO</u> <u>4</u>	<u>PSO</u> <u>5</u>	<u>PSO</u> <u>6</u>
<u>CO</u> <u>1</u>	<u>3</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>2</u>	<u>2</u>
<u>CO</u> <u>2</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>
<u>CO</u> <u>3</u>	<u>3</u>	<u>3</u>	<u>2</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>2</u>

**Course :core 4**

**Subject: Genomics and proteomics( MBT204T)**

**Credit 2**

### **Course Objectives**

The objectives of this course is to provide introductory knowledge concerning genomics, proteomics and their applications.

### **Course content-**

#### **Unit 1Basics of genomics**

Brief overview of prokaryotic and eukaryotic genome organization.Extra chromosomal DNA: bacterial plasmids, mitochondria and chloroplast DNA

#### **Unit II:Genome mapping**

Genetic and physical maps; markers for genetic mapping; methods and techniques used for gene mapping, physical mapping, linkage analysis, cytogenetic techniques, FISH technique in gene mapping, somatic cell hybridization, radiation hybrid maps, *in situ* hybridization, comparative gene mapping.

#### **Unit III:Genome sequencing**

Genome sequencing, methods for whole genome sequencing.Contig assembly, chromosome walking and characterization of chromosomes, gene identification, gene annotation,forward and reverse genetics. Human Genome Project, genome sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from the web.

#### **Unit IV:Comparative genomics**

Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing, SNPs; Transcriptome analysis, gene ethics; genomics as a tool for evolutionary studies, disease diagnosis and drug designing; Introduction to metabolomics, lipidomics, metagenomics and systems biology.

#### **Unit V:Proteomics**

Proteomics: Aims, strategies and challenges; proteomics technologies: 2D-PAGE, isoelectric focusing, mass spectrometry, MALDI-TOF, yeast 2-hybrid system, proteome databases, protein chips and functional proteomics; protein-protein and protein-DNA interactions, clinical and biomedical applications of proteomics

Recommended Textbooks and References:

1. Primrose,S.B.,Twyman,R.M.,Primrose,S.B.,&Primrose,S.B.(2006).  
*Principles of Gene Manipulation and Genomics*. Malden, MA: Blackwell Pub.
2. Liebler,D.C.(2002).*IntroductiontoProteomics:ToolsfortheNewBiology*.

Totowa, NJ: Humana Press.

- Campbell, A.M., & Heyer, L.J. (2003). *Discovering Genomics, Proteomics, and Bioinformatics*. San Francisco: Benjamin Cummings.

<b><u>Course Outcome</u></b>	<b>Genomics and proteomics</b>
<b><u>CO1</u></b>	The objectives of this course is to provide introductory knowledge concerning genomics, proteomics and their applications.
<b><u>CO2</u></b>	Students should be able to acquire knowledge and understanding of fundamentals of genomics and proteomics, transcriptomics and metabolomics
<b><u>CO3</u></b>	Applications in various applied areas of biology.

### **Program Matrix**

	<b><u>PO</u></b> <b><u>1</u></b>	<b><u>PO</u></b> <b><u>2</u></b>	<b><u>PO</u></b> <b><u>3</u></b>	<b><u>PO</u></b> <b><u>4</u></b>	<b><u>PO</u></b> <b><u>5</u></b>	<b><u>PO</u></b> <b><u>6</u></b>		<b><u>PSO</u></b> <b><u>1</u></b>	<b><u>PSO</u></b> <b><u>2</u></b>	<b><u>PSO</u></b> <b><u>3</u></b>	<b><u>PSO</u></b> <b><u>4</u></b>	<b><u>PSO</u></b> <b><u>5</u></b>	<b><u>PSO</u></b> <b><u>6</u></b>
<b><u>CO</u></b> <b><u>1</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>1</u></b>		<b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>
<b><u>CO</u></b> <b><u>2</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>		<b><u>3</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>
<b><u>CO</u></b> <b><u>3</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>		<b><u>1</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>2</u></b>

**COURSE : Core 5**

**Subject: MOLECULAR DIAGNOSTIC( MBT203T)**

**CREDIT:2**

### **Course Objectives**

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 content**

#### **Unit I:Genome biology in health and disease**

Central dogma of molecular biology; human identity; chromosomal aberrations and diseases; gene linked disorders; clinical variability and genetically determined adverse reactions to drugs.

#### **Unit II:Genome: resolution, detection & analysis**

PCR and its variants (Real-time; ARMS, Multiplex); In-situ hybridization; Fluorescence in-situ hybridization (FISH); Nucleic acid sequencing; Microarray; Molecular markers; Diagnostic proteomics

#### **Unit III:Detection of inherited diseases**

Direct detection and identification of pathogenic organisms (culturable and unculturable) Detection of inherited diseases, mutational mechanism of unstable triplet repeats, familial cancer syndromes.

#### **Unit VI:Molecular oncology**

Detection of recognized genetic aberrations in clinical samples from cancer patients; Predictive biomarkers for personalized onco-therapy of human diseases such as chronic myeloid leukemia, colon, breast, lung cancer and melanoma, targeted therapies

#### **Unit VII:Diagnostic metabolomics, Quality assurance and control**

Metabolite profile for biomarker detection in the body fluids/tissues in various metabolic disorders by using LCMS & NMR technological platforms. Quality oversight; regulations and approved testing.

Recommended text books

1. Campbell, A.M., & Heyer, L.J. (2006). *Discovering Genomics, Proteomics, and Bioinformatics*. San Francisco: Benjamin Cummings.

Brooker, R.J. (2009). *Genetics: Analysis & Principles*. New York, NY: McGraw-Hill

2. Glick, B.R., Pasternak, J.J., & Patten, C.L. (2010). *Molecular Biotechnology: Principles and Applications of Recombinant DNA*. Washington, DC: ASM Press.

3. Coleman, W.B., & Tsongalis, G.J. (2010). *Molecular Diagnostics: for the Clinical Laboratorian*. Totowa, NJ: Humana Press

<b><u>Course</u></b>	MOLECULAR DIAGNOSTIC
<b><u>Outcome</u></b>	
<b><u>CO1</u></b>	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
<b><u>CO2</u></b>	should be able to understand various facets of molecular procedures and basics of genomics, proteomics and metabolomics that could be employed in early diagnosis and prognosis of human diseases.
<b><u>CO3</u></b>	sensitize students about recent advances in molecular biology

### **Program Matrix**

	<b><u>PO</u></b> <b><u>1</u></b>	<b><u>PO</u></b> <b><u>2</u></b>	<b><u>PO</u></b> <b><u>3</u></b>	<b><u>PO</u></b> <b><u>4</u></b>	<b><u>PO</u></b> <b><u>5</u></b>	<b><u>PO</u></b> <b><u>6</u></b>	<b><u>PSO</u></b> <b><u>1</u></b>	<b><u>PSO</u></b> <b><u>2</u></b>	<b><u>PSO</u></b> <b><u>3</u></b>	<b><u>PSO</u></b> <b><u>4</u></b>	<b><u>PSO</u></b> <b><u>5</u></b>	<b><u>PSO</u></b> <b><u>6</u></b>
<b><u>CO</u></b> <b><u>1</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>
<b><u>CO</u></b> <b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>
<b><u>CO</u></b> <b><u>3</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>2</u></b>



## **COURSE :CORE 6**

**Subject: Research methodology and scientific communication(MBT206T)**

**Credit 2**

### **Course Objectives**

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 content**

#### **Unit I:History of science and science methodologies**

Empirical science; scientific method; manipulative experiments and controls; deductive and inductive reasoning; descriptive science; reductionist vs holistic biology.

#### **Unit II:Preparation for research**

Choosing a mentor, lab and research question; maintaining a lab notebook

#### **Unit III:Process of communication**

Concept of effective communication- setting clear goals for communication; determining outcomes and results; initiating communication; avoiding breakdowns while communicating; creating value in conversation; barriers to effective communication; non-verbal communication- interpreting non-verbal cues; importance of body language, power of effective listening; recognizing cultural differences; Presentation skills- formal presentation skills; preparing and presenting using over-head projector, 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 IV:Scientific communication**

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.

Recommended Textbooks and References:

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.
5. Movie: *Naturally Obsessed, The Making of a Scientist*.

<b><u>Course</u></b>	MOLECULAR DIAGNOSTIC
<b><u>Outcome</u></b>	
<b><u>CO1</u></b>	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.
<b><u>CO2</u></b>	Understand history and methodologies of scientific research, applying these to recent published papers
<b><u>CO3</u></b>	Understand and practice scientific reading, writing and presentations; Appreciate scientific ethics through case studies

### **Program Matrix**

	<b><u>PO</u></b> <b><u>1</u></b>	<b><u>PO</u></b> <b><u>2</u></b>	<b><u>PO</u></b> <b><u>3</u></b>	<b><u>PO</u></b> <b><u>4</u></b>	<b><u>PO</u></b> <b><u>5</u></b>	<b><u>PO</u></b> <b><u>6</u></b>		<b><u>PSO</u></b> <b><u>1</u></b>	<b><u>PSO</u></b> <b><u>2</u></b>	<b><u>PSO</u></b> <b><u>3</u></b>	<b><u>PSO</u></b> <b><u>4</u></b>	<b><u>PSO</u></b> <b><u>5</u></b>	<b><u>PSO</u></b> <b><u>6</u></b>
<b><u>CO</u></b> <b><u>1</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>3</u></b>		<b><u>3</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>3</u></b>
<b><u>CO</u></b> <b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>		<b><u>3</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>3</u></b>
<b><u>CO</u></b> <b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>3</u></b>		<b><u>3</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>2</u></b>

**Course : Elective 1**

**Subject: Environmental BIOTECHNOLOGY (MBT207T)**

**CREDIT:2**

### **Course Objectives**

This course aims to introduce fundamentals of Environmental Biotechnology. The course will introduce major groups of microorganisms-tools in biotechnology and their most important environmental applications. The environmental applications of biotechnology will be presented in detail and will be supported by examples from the national and international literature.

### **Course content**

#### **Unit I:Introduction to environment**

Introduction to environment; Pollution:air, water, soil, noise; pollution indicators; Climate change, Biodiversity and its conservation; bio geochemical cycles; microbial ecology.

#### **Unit II:Waste Management**

Waste management: domestic, industrial, and hazardous wastes (storage, transportation, treatment and disposal); solid waste management, wastewater characteristics and treatment, treatment strategies for effluent generated by distillery, paper and pulp industries, textile industries; waste to energy, recycling and reuse.

#### **Unit III:Bioremediation**

Bioremediation: Fundamentals, technological aspects and strategies, bioremediation of metals, radionuclides, organicpollutants/xenobiotic; Application of bacteria and fungi in bioremediation; Phytoremediation: Fundamentals and description of major methods of application (phytoaccumulation, phytovolatilization, rhizofiltration, phytostabilization).

#### **Unit IV:Biotechnology and agriculture**

Biopesticides, Bioinsecticides, Biofungicides, Bioherbicides: genetic modifications, mode of actions; Biofertilizers: Symbiotic systems between plants–microorganisms, Plant growth promoting rhizobacteria (PGPR) – uses, practical aspects and problems in application.

#### **Unit V:Biofuels**

Biofuels: production of biogas; bioethanol; biodiesel; Utilizable biomass, microorganisms and biotechnological interventions for optimization of production, Microbial Fuel

Cells, Microbiologically enhanced oil recovery (MEOR); Bioleaching of metals; Bioplastic.

#### RECOMONDED BOOKS

1. G.M.Evans and J.C.Furlong (2003), *Environmental Biotechnology: Theory and Applications*, Wiley Publishers.
2. B.Ritmann and P.L.McCarty, (2000), *Environmental Biotechnology: Principle & Applications*, 2<sup>nd</sup> Ed., McGraw Hill Science.
3. Scragg A., (2005) *Environmental Biotechnology*. Pearson Education Limited.
4. J.S.Devinny, M.A.Deshusses and T.S.Webster, (1998), *Biofiltration for Air Pollution Control*, CRC Press.
5. H.J.Rehman and G.Reed, (2001), *Biotechnology – A Multi-volume Comprehensive Treatise*, Vol. 11, 2<sup>nd</sup> Ed., VCH Publishers Inc.

<b><u>Course</u></b>	ENVIRONMENTAL BIOTECHNOLOGY
<b><u>Outcome</u></b>	
<b><u>CO1</u></b>	The course will introduce major groups of microorganisms-tools in biotechnology and their most important environmental applications
<b><u>CO2</u></b>	The environmental applications of biotechnology will be presented in detail and will be supported by examples from the national and international literature.
<b><u>CO3</u></b>	On completion of course, students will be able to understand use of basic microbiological, molecular and analytical methods, which are extensively used in environmental biotechnology

#### **Program Matrix**

	<b><u>PO</u></b> <b><u>1</u></b>	<b><u>PO</u></b> <b><u>2</u></b>	<b><u>PO</u></b> <b><u>3</u></b>	<b><u>PO</u></b> <b><u>4</u></b>	<b><u>PO</u></b> <b><u>5</u></b>	<b><u>PO</u></b> <b><u>6</u></b>	<b><u>PSO</u></b> <b><u>1</u></b>	<b><u>PSO</u></b> <b><u>2</u></b>	<b><u>PSO</u></b> <b><u>3</u></b>	<b><u>PSO</u></b> <b><u>4</u></b>	<b><u>PSO</u></b> <b><u>5</u></b>	<b><u>PSO</u></b> <b><u>6</u></b>
<b><u>CO</u></b> <b><u>1</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>2</u></b>
<b><u>CO</u></b> <b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>
<b><u>CO</u></b> <b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>

**Course : ELECTIVE :2**

**Subject: HUMAN GENOMICS(MBT208T)**

**CREDITS:2**

### **Course Objectives**

The objectives of this course is to provide introductory knowledge concerning human genomics and their applications.

### **Course content**

#### **Unit I: Studying human chromosomes**

Chromosomes identification by size and staining pattern, Chromosome banding (G-banding, Q-banding, R-banding, T-banding, C-banding), Molecular cytogenetics (Chromosome fluorescence *in situ* hybridization (FISH), Chromosome painting and molecular karyotyping, Comparative genome hybridization (CGH)); Chromosome abnormalities (Numerical chromosomal abnormalities involve gain or loss of complete chromosomes: Polyploidy, Aneuploidy, Mixoploidy, Clinical consequences); Structural chromosomal abnormalities resulting from misrepair or recombination errors.

#### **Unit II: Analyzing the Structure and Expression of Genes and Genomes**

DNA library: Genomic DNA libraries, cDNA libraries, Library screening, Library amplification and dissemination. Sequencing DNA: Dideoxy DNA sequencing involving enzymatic DNA synthesis using base-specific chain terminators, Automation of dideoxy DNA sequencing, Iterative pyrosequencing, Massively parallel DNA sequencing for simultaneous sequencing of huge numbers of different DNA fragments. Genome structure analysis and genome projects, The linear ordering of genomic DNA clones in a contig and matching their original subchromosomal locations. The Human Genome Project as an international endeavor and biology's first Big Project, Major milestones in mapping and sequencing the human genome.

#### **Unit III: Basic gene expression analyses**

Different levels of expression mapping: tissue *in situ* hybridization, cellular *in situ* hybridization, northern blot hybridization, RNA dot-blot hybridization, ribonuclease protection assay, RT-PCR/qPCR, DNA microarray hybridization; Detection methods used in quantitative real timePCR: Nonspecific detection using SYBR Green I Dye, Specific detection by hybridization probes by Molecular Beacon probes and TaqMan double-dye probes.

#### **Unit IV: Organization of the Human Genome**

General organization of the human mitochondrial and nuclear genome, Distribution of genes within chromosomes, Duplication of DNA segments resulting in copy-number variation and

gene families, Protein-coding genes, The origins, prevalence, and functionality of pseudogenes, RNA genes (Ribosomal RNA genes, Transfer RNA genes, Spliceosomal small nuclear RNA (snRNA) genes, Non-spliceosomal small nuclear RNA genes, Small nucleolar RNA (snoRNA) genes, Small Cajal body RNA genes, major classes of human noncoding RNA), Highly repetitive DNA: heterochromatin and transposon repeats

### Unit V: Human Genetic Variability and Its Consequences

Types of variation between human genomes, Single nucleotide polymorphisms, Polymorphic variation in interspersed and tandem repeated sequences, Large-scale variations in copy number in human genomes, Common markers used in constructing framework DNA maps of complex genomes: Restriction fragment length polymorphism (RFLP), Microsatellite, Single nucleotide polymorphism (SNP); Sequence-tagged site (STS) Expressed sequence tag (EST).

#### Recommended Textbooks and References:

- Human Molecular Genetics By Tom Strachan and Andrew Read
- Brown TA. Genomes. 2nd edition. Oxford: Wiley-Liss; 2002. Chapter 1, The Human Genome. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK21134/>

<b><u>Course</u></b>	<b>HUMAN GENOMICS</b>
<b><u>Outcome</u></b>	
<b><u>CO1</u></b>	The objectives of this course is to provide introductory knowledge concerning human genomics, and their applications.
<b><u>CO2</u></b>	Students should be able to acquire knowledge and understanding of fundamentals of genomics of humans.
<b><u>CO3</u></b>	Metabolomics and their applications in various applied areas of biology

#### Program Matrix

	<u>PO</u> <u>1</u>	<u>PO</u> <u>2</u>	<u>PO</u> <u>3</u>	<u>PO</u> <u>4</u>	<u>PO</u> <u>5</u>	<u>PO</u> <u>6</u>		<u>PSO</u> <u>1</u>	<u>PSO</u> <u>2</u>	<u>PSO</u> <u>3</u>	<u>PSO</u> <u>4</u>	<u>PSO</u> <u>5</u>	<u>PSO</u> <u>6</u>
<b><u>CO</u> <u>1</u></b>	<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>		<u>2</u>	<u>2</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>
<b><u>CO</u> <u>2</u></b>	<u>3</u>	<u>3</u>	<u>3</u>	<u>3</u>	<u>2</u>	<u>2</u>		<u>3</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>2</u>	<u>2</u>
<b><u>CO</u> <u>3</u></b>	<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>2</u>		<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>

**Course : ELECTIVE 3**

**Subject: NANOTECHNOLOGY (MBT209T)**

**CREDIT :3**

### **Course Objectives**

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 every day life

### **Course Content**

#### **Unit I:Introduction to nanobiotechnology**

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

#### **Unit II:Nano – films**

Nano - films      Thin films; Colloidal nanostructures; Self Assembly, Nanovesicles; Nanospheres; Nanocapsules and their characterisation. Nanomaterials for catalysis, development and characterization of nanobiocatalysts, applications of nanobiocatalysis in the production of drugs

#### **Unit III:Nano – particles**

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 nano-particles**

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

#### **Unit V:Nano-toxicity**

Nano-toxicity: 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.

<b><u>Course</u></b>	<b>Nanotechnology</b>
<b><u>Outcome</u></b>	
<b><u>CO1</u></b>	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.
<b><u>CO2</u></b>	give an insight into complete systems where nanotechnology can be used to improve our every day life
<b><u>CO3</u></b>	Students should be able to describe science behind the properties of materials at nanometer scale .

**Program Matrix**

	<b><u>PO1</u></b>	<b><u>PO2</u></b>	<b><u>PO3</u></b>	<b><u>PO4</u></b>	<b><u>PO5</u></b>	<b><u>PO6</u></b>		<b><u>PSO1</u></b>	<b><u>PSO2</u></b>	<b><u>PSO3</u></b>	<b><u>PSO4</u></b>	<b><u>PSO5</u></b>	<b><u>PSO6</u></b>
<b><u>CO1</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>		<b><u>3</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>3</u></b>
<b><u>CO2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>		<b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>
<b><u>CO3</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>2</u></b>		<b><u>3</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>



**Course: Lab 01**

**Molecular biology and genetic engineering (MBT211L)**

**Credits : 4**

**Course Objectives**

The objectives of this course are to provide students with experimental knowledge of molecular biology and genetic engineering

**Syllabus**

1. Concept of lac-operon:
  - a. Lactose induction of B-galactosidase.
  - b. Glucose Repression.
  - c. Diauxic growth curve of *E.coli*
2. UV mutagenesis to isolate amino acid auxotroph
3. Phage titre with epsilon phage/M13
4. Genetic Transfer-Conjugation, gene mapping
5. Plasmid DNA isolation and DNA quantitation
6. Restriction Enzyme digestion of plasmid DNA
7. Agarose gel electrophoresis
8. Polymerase Chain Reaction and analysis by agarose gel electrophoresis
9. Vector and Insert Ligation
10. Preparation of competent cells
11. Transformation of *E.coli* with standard plasmids, Calculation of transformation efficiency
12. Confirmation of the insert by Colony PCR and Restriction mapping

**Recommended Textbooks and References:**

1. Green, M. R., & Sambrook, J. (2012). *Molecular Cloning: a Laboratory Manual*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

<b><u>Course</u></b>	
<b><u>Outcome</u></b>	<b>Lab 01: Molecular Biology and Genetic Engineering</b>

<b><u>CO1</u></b>	provide students with experimental knowledge of molecular biology and genetic engineering
<b><u>CO2</u></b>	Students should be able to gain hands- on experience in gene cloning, protein expression and purification.
<b><u>CO3</u></b>	This experience would enable them to begin a career in industry that engages in genetic engineering as well as in research laboratories conducting fundamental research

### **Program Matrix**

	<b><u>PO</u></b> <b><u>1</u></b>	<b><u>PO</u></b> <b><u>2</u></b>	<b><u>PO</u></b> <b><u>3</u></b>	<b><u>PO</u></b> <b><u>4</u></b>	<b><u>PO</u></b> <b><u>5</u></b>	<b><u>PO</u></b> <b><u>6</u></b>		<b><u>PSO</u></b> <b><u>1</u></b>	<b><u>PSO</u></b> <b><u>2</u></b>	<b><u>PSO</u></b> <b><u>3</u></b>	<b><u>PSO</u></b> <b><u>4</u></b>	<b><u>PSO</u></b> <b><u>5</u></b>	<b><u>PSO</u></b> <b><u>6</u></b>
<b><u>CO</u></b> <b><u>1</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>3</u></b>		<b><u>2</u></b>	<b><u>2</u></b>	<b><u>1</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>3</u></b>
<b><u>CO</u></b> <b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>		<b><u>2</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>
<b><u>CO</u></b> <b><u>3</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>1</u></b>		<b><u>3</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>1</u></b>

## M.Sc. Biotechnology third semester

### Programme Outcomes (POS)

<b>PO1</b>	<b>Knowledge:</b> Knowledge will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements
<b>PO2</b>	<b>Critical Thinking:</b> Develop critical thinking on appropriate knowledge of <u>living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.</u>
<b>PO3</b>	<b>Skill &amp; Application Development :</b> Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine & Environment for sustainable development of the society.
<b>PO4</b>	<b>Inter-disciplinary &amp; Multi-disciplinary Approach:</b> Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized
<b>PO5</b>	<b>Ethics:</b> Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.
<b>PO6</b>	<b>Problem Solving &amp; Employability:</b> Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific temperament in research and development issues in the society.

### M.Sc (Biotechnology) Program Specific Outcomes

<b>PSO 1</b>	<b>Disciplinary knowledge and skills:</b> Capable of demonstrating(i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologically important molecules and its application in human welfare.
<b>PSO 2</b>	<b>Skilled communicator:</b> Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
<b>PSO 3</b>	<b>Critical thinker and problem solver:</b> Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
<b>PSO 4</b>	<b>Team player/worker:</b> Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
<b>PSO 5</b>	<b>Ethical awareness/reasoning:</b> Avoiding unethical behaviors such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
<b>PSO 6</b>	<b>Lifelong learners:</b> Capable of making conscious efforts to achieve self-paced and self-directed learning aimed at personal development and for

<u>P</u> <u>S</u> <u>O</u> <u>6</u>	Lifelong learners: Capable of making conscious efforts to achieve self-paced and self-directed learning aimed at personal development and for
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## **Msc. Biotechnology (Semester Three)**

### **Course- Core-1 Theory**

### **Bioprocess Engineering & Technology (MBT 301 T) Credits 3**

#### **Course Objectives**

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.

Students should be able to:

- Appreciate relevance of microorganisms from industrial context;
- Carry out stoichiometric calculations and specify models of their growth;
- Give an account of design and operations of various fermenters;
- Present unit operations together with the fundamental principles for basic methods in production technique for bio-based products;
- Calculate yield and production rates in a biological production process, and also, interpret data;
- Calculate the need for oxygen and oxygen transfer;
- Critically analyze any bioprocess from market point of view;
- Give an account of important microbial/enzymatic industrial processes in food and fuel industry.

#### **Unit I**

##### **Basic principles of biochemical engineering**

Isolation, screening and maintenance of industrially important microbes; microbial growth and death kinetics, strain improvement for increased yield and other desirable characteristics.

Yield coefficients; unstructured models of microbial growth; structured models of microbial Growth.

#### **Unit II**

##### **Bioreactor design and analysis**

Batch, fed-batch and continuous fermenters; immobilized cell systems; large scale animal and plant cell cultivation; 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 III**

##### **Downstream processing and product recovery**

Downstream processing: 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, effluent treatment and disposal.

#### **Unit IV**

##### **Applications of enzyme technology in food processing**

Mechanism of enzyme function and reactions in process techniques; enzymatic bioconversions e.g., starch and sugar conversion processes, inter-esterified 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 V

#### Applications of microbial technology

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.

Course Outcome	Bioprocess Engineering & Technology
<u>CO1</u>	The students should be well-versed with 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.
<u>CO2</u>	The students should have basic knowledge of microorganisms from industrial context, carry out stoichiometric calculations and specify models of their growth.
<u>CO3</u>	The students should have knowledge to give an account of design and operations of various fermenters, present unit operations together with the fundamental principles for basic methods in production technique for Bio-based products.

#### Program Matrix

	<u>PO1</u>	<u>PO2</u>	<u>PO3</u>	<u>PO4</u>	<u>PO5</u>	<u>PO6</u>		<u>PSO1</u>	<u>PSO2</u>	<u>PSO3</u>	<u>PSO4</u>	<u>PSO5</u>	<u>PSO6</u>
<u>CO1</u>	<u>2</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>		<u>2</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>3</u>
<u>CO2</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>		<u>2</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>2</u>
<u>CO3</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>3</u>		<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>3</u>	<u>3</u>

### Laboratory VI: Bioprocess Engineering & Technology (Laboratory)

#### Course – Lab 1 (MBT315L) Credit 4

#### Course Objectives

The objectives of this laboratory Course are to provide hands-on training to students in upstream and

Downstream unit operations.

#### Student Learning Outcomes

Students should be able to:

- Investigate, design and conduct experiments, analyze and interpret data, and apply the laboratory skills

to solve complex bioprocess engineering problems;

- Apply skills and knowledge gained will be useful in solving problems typical of bio industries and research.

Syllabus

1. Basic Microbiology techniques
2. Scale up from frozen vial to agar plate to shake flask culture
3. Instrumentation: Microplate reader, spectrophotometer microscopy
4. Isolation of microorganisms from soil samples
5. Experimental setup
6. Assembly of bioreactor and sterilization
7. Growth kinetics
8. Substrate and product inhibitions
9. Measurement of residual substrates
10. Data analysis
11. Introduction to metabolic flux analysis
12. Fermentation
13. Batch
14. Fedbatch
15. Continuous
16. Unit Operations
17. Microfiltrations: Separation of cells from broth
18. Bioseparations: Various chromatographic techniques and extractions
19. Bioanalytics
20. Analytical techniques like HPLC

Recommended Textbooks and References:

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 Fermentation Technology*. 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.
5. El-Mansi, M., & Bryce, C.F. (2007). *Fermentation Microbiology and Biotechnology*. Boca Raton: CRC/Taylor & Francis.

<b>Course Outcome</b>	<b>Bioprocess Engineering &amp; Technology</b>
<u>CO1</u>	The students should be able to handle experiment and hands-on training to students in upstream and downstream unit operations.
<u>CO2</u>	Students should be able to Investigate, design and conduct experiments, analyse and interpret data, and apply the laboratory skills to solve complex bioprocess engineering problems.
<u>CO3</u>	The students should have educated to apply skills and knowledge gained will be useful in solving problems typical of Bio industries and research.

### Program Matrix

	<u>PO1</u>	<u>PO2</u>	<u>PO3</u>	<u>PO4</u>	<u>PO5</u>	<u>PO6</u>		<u>PSO1</u>	<u>PSO2</u>	<u>PSO3</u>	<u>PSO4</u>	<u>PSO5</u>	<u>PSO6</u>
<u>CO1</u>	<u>2</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>		<u>2</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>3</u>
<u>CO2</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>		<u>2</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>2</u>
<u>CO3</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>3</u>		<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>3</u>	<u>3</u>

### Course- Core-2 Theory

### Emerging Technology (MBT 302 T) Credits 2

#### Course Objectives

This course is broad-based in nature encompassing ever al new technologies that current experimental researchers are employing to probe complex system biology questions in life-sciences. 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.

#### Student Learning Outcomes

Students should be to learn history, theoretical basis and basic understanding of latest technologies in area of biotechnology. They should also be able to learn about various applications of these technologies. The students may also learn one application in depth through an assignment and/or seminar.

#### Unit I

##### Optical microscopy methods

##### 8 lectures

##### Basic Microscopy:

Light Microscopy: lenses and microscopes, resolution: Rayleigh's Approach, Darkfield; Phase Contrast; Differential Interference Contrast; fluorescence and fluorescence microscopy: what is fluorescence, what makes a molecule fluorescent, fluorescence microscope; optical arrangement, light source; filter sets: excitation filter, dichroic mirror, and barrier, optical layout for image capture; CCD cameras; back illumination, binning; recording color; three CCD elements with dichroic beam splitters, boosting the signal.

#### Unit II

##### Mass spectroscopy

##### 4 lectures

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

## Unit III

### Systems biology

#### 3 lectures

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

## Unit IV

### Structural biology

#### 3 lectures

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

Scattering, Atomic force microscopy.

## Unit V

### CRISPR-CAS

#### 6 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 VI

### Nanobodies

#### 4 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.

### Recommended Textbooks and References:

1. Campbell, I.D. (2012). *Biophysical Techniques*. Oxford: Oxford University Press.
2. Serdyuk, I.N., Zaccai, N.R., & Zaccai, G. (2007). *Methods in Molecular Biophysics: Structure, Dynamics, Function*. Cambridge: Cambridge University Press.
3. Phillips, R., Kondev, J., & Theriot, J. (2009). *Physical 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. doi:10.1146/annurev.biochem.77.061906.092014.
6. Mohanraju, P., Makarova, K.S., Zetsche, B., Zhang, F., Koonin, E.V., & Oost, J.V. (2016). *Diverse Evolutionary Roots and Mechanistic Variations of the CRISPR-Cas*



- Systems. Science*, 353(6299).doi:10.1126/science.aad5147.
7. Lander, E. (2016). *The Heroes of CRISPR*. Cell, 164(1-2), 18-28. doi:10.1016/j.cell.2015.12.041.
  8. Ledford, H. (2016). *The Unsung Heroes of CRISPR*. Nature, 535(7612), 342-344. doi:10.1038/535342a.
  9. Jinek, M., Chylinski, K., Fonfara, I., Hauer, M., Doudna, J. A., & Charpentier, E. (2012). *A Programmable Dual-RNA-Guided DNA Endonuclease in Adaptive Bacterial Immunity*. Science, 337(6096), 816-821. doi:10.1126/science.1225829.
  10. Hamers-Casterman, C., Atarhouch, T., Muyldermans, S., Robinson, G., Hammers, C., Songa, E. B., Hammers, R. (1993). *Naturally Occurring Antibodies Devoid of Light Chains*. Nature, 363(6428), 446-448. doi:10.1038/363446a0.
  11. Sidhu, S. S., & Koide, S. (2007). *Phage Display for Engineering and Analyzing Protein Interaction Interfaces*. Current Opinion in Structural Biology, 17(4), 481-487. doi:10.1016/j.sbi.2007.08.007.
  12. Steyaert, J., & Kobilka, B. K. (2011). *Nanobody Stabilization of G Protein-Coupled Receptor Conformational States*. Current Opinion in Structural Biology, 21(4), 567-572. doi:10.1016/j.sbi.2011.06.011.
  13. Vincke, C., & Muyldermans, S. (2012). *Introduction to Heavy Chain Antibodies and Derived Nanobodies*. Single Domain Antibodies, 15-26. doi:10.1007/978-1-61779-968-6\_2.
  14. Verheesen, P., & Laeremans, T. (2012). *Selection by Phage Display of Single Domain Antibodies Specific to Antigens in their Native Conformation*. Single Domain Antibodies, 81-104. doi:10.1007/978-1-61779-968-6\_6.
  15. Li, J., Xia, L., Su, Y., Liu, H., Xia, X., Lu, Q., Rehemian, K. (2012). *Molecular Imprint of Enzyme Active Site by Camel Nanobodies*. Journal of Biological Chemistry J. Biol. Chem., 287(17), 13713-13721. doi:10.1074/jbc.m111.336370.
  16. Sohier, J., Laurent, C., Chevigné, A., Pardon, E., Srinivasan, V., Wernery, U., Galleni, M. (2013). *Allosteric Inhibition of VIM Metallo- $\beta$ -Lactamases by a Camelid Nanobody*. Biochemical Journal, 450(3), 477-486. doi:10.1042/bj20121305.
  17. Chakravarty, R., Goel, S., & Cai, W. (2014). *Nanobody: The "Magic Bullet" for*

<u>Course Outcome</u>	<b>Bioprocess Engineering &amp; Technology</b>
<u>CO1</u>	The students should be able to learn basics of the new principles to students so as to appreciate current-day research tool-kit better.
<u>CO2</u>	Students should be to learn history, theoretical basis and basic understanding of latest technologies in area of biotechnology.
<u>CO3</u>	Students should also be able to learn about various applications of the latest technologies. The students may also learn one application in depth through an assignment and/or seminar.

#### Program Matrix

	<u>PO1</u>	<u>PO2</u>	<u>PO3</u>	<u>PO4</u>	<u>PO5</u>	<u>PO6</u>	<u>PSO1</u>	<u>PSO2</u>	<u>PSO3</u>	<u>PSO4</u>	<u>PSO5</u>	<u>PSO6</u>
<u>CO1</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>2</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>2</u>

CO2	<u>2</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>2</u>
CO3	<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>3</u>

**Corse- Critical Analysis of Classical Papers**  
**Core-3 (MBT303T) credit-2**

**Course Objectives**

The objectives of this course are to familiarize students with classic literature to make them appreciate how ground- breaking discoveries were made without, necessarily, use of high-end technologies.

**Student Learning Outcomes**

Students should be able to train in the exercise of hypothesis building and Methods of addressing the hypothesis with readily available technology.

**Syllabus**

**Molecular Biology**

1. Studies on the chemical nature of the substance inducing transformation of Pneumococcal types: Induction of transformation by adenoxy ribonucleic acid fraction isolated from *Pneumococcus typhii*.  
Avery OT, Macleod CM, McCarty M.; J Exp Med. 1944 Feb 1;79(2):137-58. Note: This paper demonstrates that DNA is the transforming Principle originally described by Fredrick Griffith.
2. Independent functions of viral protein and nucleic acid in growth of bacteriophage  
HersheyADandChaseM.;JGenPhysiol.1952May;36(1):39-56.  
Note: Note: This paper demonstrates that DNA, and not protein, component of phages enter bacterial cells.
3. Molecularstructureofnucleicacids;astructurefordeoxyribosenucleicacid  
WatsonJDandCrickFH;Nature.1953Apr25;171(4356):737-8  
Note: In this one page paper Watson and Crick first described the structure of DNA double helix  
Study help - Watson\_Crick\_Nature\_1953\_annotated
4. Transposable mating type genes in*Saccharomycescerevisiae*  
James Hicks, Jeffrey N. Strathern& Amar J.S. Klar; Nature 282, 478-483,1979Note:Thispaperprovidedevidencefor‘cassettehypothesis’ofyeastmatingtype switches *i.e.* interconversion of mating types in yeast (*S. cerevisiae*) occurs by DNArearrangement.
5. Messelson&Stahlexperimentdemonstratingsemi-conservativereplicationofDNA.  
Meselson M and Stahl FW.; ProcNatAcadSci U S A. 1958 Jul 15;44(7):671-82  
Note:Theexperimentdemonstratingsemi-conservativemodeofDNAreplicationis referred to as "the most beautiful experiment inbiology"
6. *In vivo*alterationoftelomere sequencesandsenescencecausedbymutated *Tetrahymenatelomerase* RNAs  
Guo-Liang Yu,JohnD.Bradley,LauraD.Attardi&ElizabethH.Blackburn; Nature 344, 126-132,1990

Note: This paper demonstrates that the telomerase contains the template for telomere synthesis

## Syllabus

### Cell Biology

1. Identification of 23 complementation groups required for post-translational events in the yeast secretory pathway  
Novick P, Field C, Schekman R.; Cell. 1980 Aug;21(1):205-15  
Note: In this groundbreaking paper Randy Schekman's group used a mutagenesis screen for fast sedimenting yeast mutants to identify genes involved in cell secretion
2. A yeast mutant defective at an early stage in import of secretory protein precursors into the endoplasmic reticulum  
Deshaies RJ and Schekman R.; J Cell Biol. 1987 Aug;105(2):633-45  
Note: Using another yeast mutation screen Schekman lab identifies Sec61, a component of ER protein Conducting Channel (PCC)  
Suggested reference paper - A biochemical assay for identification of PCC.
3. Reconstitution of the Transport of Protein between Successive Compartments of the Golgi  
Balch WE, Dunphy WG, Braell WA, Rothman JE.; Cell. 1984 Dec;39(2Pt1):405-16 Note: This paper describes setting up of an *in vitro* reconstituted system for transport between Golgi stacks which eventually paved the way for identification of most of the molecular players involved in these steps including NSF, SNAP *etc.*
4. A complete immunoglobulin gene is created by somatic recombination  
Brack C, Hiram M, Lenhard-Schuller R, Tonegawa S.; Cell. 1978 Sep;15(1):1-14 Note: This study demonstrates DNA level molecular details of somatic rearrangement of immunoglobulin gene sequences leading to the generation of functionally competent antibody generating gene following recombination.
5. A novel multigene family may encode odorant receptors: a molecular basis for odor recognition  
Buck L and Axel R; Cell. 1991 Apr 5;65(1):175-87  
Note: This paper suggests that different chemical odorants associate with different cell-specific expression of a transmembrane receptor in *Drosophila* olfactory epithelium where a large family of odorant receptors is expressed.
6. Kinesin walks hand-over-hand  
Yildiz A, Tomishige M, Vale RD, Selvin PR.; Science. 2004 Jan 30;303(5658):676-8 Note: This paper shows that kinesin motor works as a two-headed dimeric motor walking hand-over-hand rather than like an inchworm on microtubule tract using the energy of ATP hydrolysis.

## Syllabus

### Developmental Biology/ Genetics

1. Mutations affecting segment number and polarity in *Drosophila*

Christiane Nusslein-Volhard and Eric Weischaus; Nature 287, 795-801, 1980

Note: This single mutagenesis screen identified majority of the developmentally important genes not only in flies but in other metazoans as well.

- Information for the dorsal--ventral pattern of the *Drosophila* embryo is stored as maternal mRNA

Anderson KV and Nüsslein-Volhard C; Nature. 1984 Sep 20-26;311(5983):223-7

Note: This landmark paper demonstrated that early dorsal-ventral pattern information is stored as maternal mRNA in flies and devised the method of identifying genes encoding such genes

- Hedgehog signalling in the mouse requires intraflagellar transport proteins Huangfu D, Liu A, Rakeman AS, Murcia NS, Niswander L, Anderson KV.; Nature. 2003 Nov 6;426(6962):83-7

Note: One of the architects of original fly mutagenesis screens conducted a mouse mutagenesis screen which identified a gene Kif3a as a major component of hedgehog signaling pathway. Eventually this discovery revolutionizes our understanding of mechanisms of action of signaling pathways by demonstrating central role of cilia in it.

Suggested Reference paper - Design and execution of an embryonic lethal mutation screen in mouse.

Course Outcome	Critical Analysis of Classical Papers
<u>CO1</u>	The students will be able to familiarize with classic literature to make them appreciate how ground-breaking discoveries were made without, necessarily, use of high-end technologies.
<u>CO2</u>	Students should be able to train in the exercise of hypothesis building and Methods of addressing the hypothesis with readily available technology.
<u>CO3</u>	Students should have skilled methodology of addressing the hypothesis with readily available technology.

#### Program Matrix

	<u>PO1</u>	<u>PO2</u>	<u>PO3</u>	<u>PO4</u>	<u>PO5</u>	<u>PO6</u>		<u>PSO1</u>	<u>PSO2</u>	<u>PSO3</u>	<u>PSO4</u>	<u>PSO5</u>	<u>PSO6</u>
<u>CO1</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>3</u>		<u>2</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>3</u>
<u>CO2</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>		<u>2</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>1</u>
<u>CO3</u>	<u>3</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>		<u>1</u>	<u>2</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>3</u>

## **Bioentrepreneurship Course code (MBT 304T) Core -4 Credits-3**

### **Course Objectives**

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.

### **Student Learning Outcomes**

Students should be able to gain entrepreneurial skills, understand the various operations involved in venture creation, identify scope for entrepreneurship in biosciences and utilize the schemes promoted through knowledge centers and various agencies. The knowledge pertaining to management should also help students to be able to build up a strong network within the industry.

### **Unit I**

#### **Innovation and entrepreneurship in bio-business**

##### **8 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

### **Unit II**

#### **Management and funding agencies**

##### **4 lectures**

Management definition, scope, function, levels, roles, Entrepreneurship development programs of public and private agencies including Small & Medium Enterprises (MSME), DBT, BIRAC, Make in India, strategic dimensions of patenting & commercialization strategies

### **Unit III**

#### **Bio markets and Marketing**

##### **4 lectures**

Negotiating the road from lab to the market, strategies and processes of negotiation with financiers, government and regulatory authorities, Pricing strategy, market development expansion, Ansoff Matrix, market development tools and concepts, PTM matrix

## Unit IV

### Finance and accounting

#### 4 lectures

Basic contract principles, different types of agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills. Business plan preparation including statutory and legal requirements, Business feasibility study, Collaborations & partnership, Information technology

## Unit V

### Technology management

#### 8 lectures

Quality control & transfer of foreign technologies, Knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures of Central Drugs Standard Control Organisation (CDSCO), differences between Good Laboratory Practice (GLP) regulations, Good Clinical Practice (GCP), and Good Manufacturing Practice (GMP) regulations.

#### Recommended Textbooks and References

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.

<u>Course Outcome</u>	<b>Bioentrepreneurship</b>
<u>CO1</u>	The students will be able to gain 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.
<u>CO2</u>	The students will be able to learn 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.

<u>CO3</u>	Students should be able to gain entrepreneurial skills, 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. The knowledge pertaining to management should also help students to be able to build up a strong network within the industry.
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Program Matrix

	<u>PO1</u>	<u>PO2</u>	<u>PO3</u>	<u>PO4</u>	<u>PO5</u>	<u>PO6</u>		<u>PSO1</u>	<u>PSO2</u>	<u>PSO3</u>	<u>PSO4</u>	<u>PSO5</u>	<u>PSO6</u>
<u>CO1</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>3</u>		<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>1</u>
<u>CO2</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>1</u>		<u>2</u>	<u>3</u>	<u>3</u>	<u>2</u>	<u>3</u>	<u>3</u>
<u>CO3</u>	<u>1</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>2</u>		<u>1</u>	<u>1</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>3</u>

### **Intellectual Property Rights, Biosafety and Bioethics (MBT305T) core-5**

#### **Credits-2**

#### **Course Objectives**

The objectives of this course are:

- 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.

#### **Student Learning Outcomes On completion of this course, students should be able to:**

- Understand the rationale for and against IPR and especially patents;
- Understand why India has adopted an IPR Policy and be familiar with broad outline of patent regulations
- 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
- 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;
- Understand ethical aspects related to biological, biomedical, health care and biotechnology research

#### **Unit I Introduction of IPR**

#### **5 lectures**

Introduction to intellectual property; 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; 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

## **Unit II Patenting**

### **5 lectures**

databases - country-wise patent searches (USPTO, India); analysis and report formation. Basics of patents: types of patents; History about patent; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; types of patent applications: provisional and complete specifications; PCT and conventional patent applications; 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; international patenting-requirement, 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**

#### **5 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; recommender 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 cis genic plants or products derived from RNAi, genome editing tools.

## **Unit IV National and international regulations**

### **5 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 labeling – Food Safety and Standards Authority of India (FSSAI).

## **Unit V Bioethics**

### **5 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

**Recommended Textbooks and References:**

1. Ganguli,P.(2001).IntellectualPropertyRights:UnleashingtheKnowledgeEconomy. New Delhi: Tata McGraw-Hill Pub.
2. NationalIPRPolicy,Department of IndustrialPolicy&Promotion,Ministryof Commerce,GoI
3. CompleteReferencetoIntellectualPropertyRightsLaws.(2007). Snow White PublicationOct.
4. Kuhse,H.(2010).Bioethics:anAnthology.Malden,MA:Blackwell.
5. OfficeoftheControllerGeneralofPatents,Design&Trademarks;Departmentof Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India.<http://www.ipindia.nic.in/>
6. KarenF.GreifandJonF.Merz,CurrentControversiesintheBiologicalSciences -Case Studies of Policy Challenges from New Technologies, MIT Press
7. World Trade Organisation.<http://www.wto.org>
8. World Intellectual Property Organisation.<http://www.wipo.int>
9. International Union for the Protection of New Varieties ofPlants. <http://www.upov.int>
10. National Portal of India.<http://www.archive.india.gov.in>
11. National Biodiversity Authority.<http://www.nbaindia.org>
12. RecombinantDNASafetyGuidelines,1990DepartmentofBiotechnology,Ministry ofScienceandTechnology,Govt.ofIndia.Retrievedfrom<http://www.envfor.nic.in/divisions/csurv/geac/annex-5.pdf>
13. Wolt,J.D.,Keese,P.,Raybould,A.,Fitzpatrick,J.W.,Burachik,M.,Gray,A.,Wu, F.(2009).ProblemFormulationintheEnvironmentalRiskAssessmentforGeneticallyModifiedPlants. TransgenicResearch,19(3),425-436.doi:10.1007/s11248-009-9321-9
14. Craig, W.,Tepfer,M.,Degrassi,G.,&Ripandelli,D.(2008).AnOverviewofGeneral FeaturesofRiskAssessmentsofGeneticallyModifiedCrops.Euphytica, 164(3), 853-880. doi:10.1007/s10681-007-9643-8

<b>Course Outcome</b>	<b>Intellectual Property Rights, Biosafety and Bioethics</b>
<u>CO1</u>	The students have learnt basic knowledge on intellectual property rights and their implications in biological research and product development and familiar with India’s IPR Policy.
<u>CO2</u>	Student should have learnt biosafety and risk assessment of products derived from biotechnology and regulation of such products, to become familiar with ethical issues in biological research.

<u>CO3</u>	The students should have gain understanding of ethical issues that must be considered during statistical analyses of biological data. Students will be able to work in team to analyse the data of biological, medical and agricultural field. The students will be able to analyse the biological data of real world by keep updating themselves on new statistical tools.
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### Program Matrix

	<u>PO1</u>	<u>PO2</u>	<u>PO3</u>	<u>PO4</u>	<u>PO5</u>	<u>PO6</u>		<u>PSO1</u>	<u>PSO2</u>	<u>PSO3</u>	<u>PSO4</u>	<u>PSO5</u>	<u>PSO6</u>
<u>CO1</u>	<u>3</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>3</u>		<u>2</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>1</u>
<u>CO2</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>		<u>2</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>1</u>
<u>CO3</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>		<u>2</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>2</u>

## **Project Proposal Preparation & Presentation (MBT 307T) Core-7 Credits-2**

### **Course Objectives**

The purpose of this course is to help students organize ideas, material and objectives for their dissertation and to begin development of communication skills and to prepare the students to present their topic of research and explain its importance to their fellow classmates and teachers.

### **Student Learning Outcomes Students should be able to demonstrate the following abilities:**

- Formulate a scientific question;
- Present scientific approach to solve the problem
- Interpret, discuss and communicate scientific results in written form;
- Gain experience in writing a scientific proposal
- Learn how to present and explain their research findings to the audience effectively.

### **Syllabus**

#### **Project Proposal Preparation**

Selection of research lab and research topic: Students should first select a lab wherein they would like to pursue their dissertation. The supervisor or senior researchers should be able to help the students to read papers in the areas of interest of the lab and help them select a topic for their project. The topic of the research should be hypothesis driven.

Review of literature: Students should engage in systematic and critical review of appropriate and relevant information sources and appropriately apply qualitative and/or quantitative evaluation processes to original data; keeping in mind ethical standards of conduct in the collection and evaluation of data and other resources.

Writing Research Proposal: With the help of the senior researchers, students should be able to discuss the research questions, goals, approach, methodology, data collection, *etc.* Students should be able to construct a logical outline for the project including analysis steps and expected outcomes and prepare a complete proposal in scientific proposal Format for dissertation.

## Syllabus

### Poster Presentation

Students will have to present the topic of their project proposal after few months of their selection of the topic. They should be able to explain the novelty and importance of their research topic.

## Syllabus

### Oral Presentation

At the end of their project, presentation will have to be given by the students to explain work done by them in detail. Along with summarizing their findings they should also be able to discuss the future expected outcome of their work.

<u>Course Outcome</u>	<b>Project Proposal Preparation &amp; Presentation</b>
<u>CO1</u>	The students should have able to organize ideas, material and objectives for their dissertation and to begin development of communication skills and to prepare the students to present their topic of research and explain its importance to their fellow classmates and teachers.
<u>CO2</u>	The students should have able to formulate a scientific question. Present scientific approach to solve the problem, discuss and communicate scientific results in written form, Gain experience in writing a scientific proposal.
<u>CO3</u>	The students should have well informed to how to present and explain their research findings to the audience effectively.

### Program Matrix

	<u>PO1</u>	<u>PO2</u>	<u>PO3</u>	<u>PO4</u>	<u>PO5</u>	<u>PO6</u>		<u>PSO1</u>	<u>PSO2</u>	<u>PSO3</u>	<u>PSO4</u>	<u>PSO5</u>	<u>PSO6</u>
<u>CO1</u>	<u>2</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>1</u>		<u>2</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>2</u>
<u>CO2</u>	<u>2</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>1</u>		<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>
<u>CO3</u>	<u>2</u>	<u>1</u>	<u>3</u>	<u>2</u>	<u>1</u>	<u>1</u>		<u>2</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>2</u>

## Laboratory VII: Bioinformatics

### Credits

#### Course Objectives

The aim of this course is to provide practical training in bioinformatics methods including accessing major public sequence databases, use of different computational tools to find sequences, analysis of protein and nucleic acid sequences by various software packages.

**Student Learning Outcomes On completion of this course, students should be able to:**

- Describe contents and properties of most important bioinformatics databases;
- Perform text- and sequence-based searches and analyze and discuss results in light of molecular biological knowledge;
- Explain major steps in pairwise and multiple sequence alignment, explain principle and execute pairwise sequence alignment by dynamic programming;
- Predict secondary and tertiary structures of protein sequences.

**Syllabus**

1. Using NCBI and Uniprot web resources.
2. Introduction and use of various genome databases.
3. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/ TrEMBL, UniProt.
4. Similarity searches using tools like BLAST and interpretation of results.
5. Multiple sequence alignment using Clustal.
6. Phylogenetic analysis of protein and nucleotide sequences.
7. Use of gene prediction methods (GRAIL, Genscan, Glimmer).
8. Use of various primer designing and restriction site prediction tools.
9. Use of different protein structure prediction resources
10. Construction and study of protein structures using Deepview/ PyMol.
11. Homology modelling of protein.

Course Outcome	Statistics in Biological Research (BTUFTT1) CREDITS: 3
<u>CO1</u>	The students should have gain basic and advanced The aim of this course is to provide practical training in bioinformatics methods including accessing major public sequence databases, use of different computational tools to find sequences, analysis of protein and nucleic acid sequences by various software packages.
<u>CO2</u>	The students would have abled to analyse describe contents and properties of most important bioinformatics databases. Perform text- and sequence-based searches and analyse and discuss results in light of molecular biological knowledge
<u>CO3</u>	The students should have educated major steps in pairwise and multiple sequence alignment explain principle and execute pairwise sequence alignment by dynamic programming. Predict secondary and tertiary structures of protein sequences

Program Matrix

	<u>PO1</u>	<u>PO2</u>	<u>PO3</u>	<u>PO4</u>	<u>PO5</u>	<u>PO6</u>		<u>PSO1</u>	<u>PSO2</u>	<u>PSO3</u>	<u>PSO4</u>	<u>PSO5</u>	<u>PSO6</u>
<u>CO1</u>	<u>2</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>		<u>3</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>3</u>
<u>CO2</u>	<u>2</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>		<u>3</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>2</u>
<u>CO3</u>	<u>2</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>		<u>3</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>2</u>

**Semester Four**  
**Dissertation**  
**Credits 24**

**Course Objectives**

The objectives of this course are to prepare the students to adapt to the research environment and understand how projects are executed in a research laboratory. It will also enable students to learn practical aspects of research and train students in the art of analysis and thesis writing.

**Student Learning Outcomes**

Students should be able to learn how to select and defend a topic of their research, how to effectively plan, execute, evaluate and discuss their experiments. Students should be able to demonstrate considerable improvement in the following areas:

- In-depth knowledge of the chosen area of research.
- Capability to critically and systematically integrate knowledge to identify issues that must be addressed within framework of specific thesis.
- Competence in research design and planning.
- Capability to create, analyse and critically evaluate different technical solutions.
- Ability to conduct research independently.
- Ability to perform analytical techniques/experimental methods.
- Project management skills.
- Report writing skills.
- Problem solving skills.
- Communication and interpersonal skills.

**Syllabus**

**Planning & performing experiments**

Based on the project proposal submitted in earlier semester, students should be able to plan, and engage in, an independent and sustained critical investigation and evaluate a chosen research topic relevant to biological sciences and society. They should be able to systematically identify relevant theory and concepts, relate these to appropriate methodologies and evidence, apply appropriate techniques and draw appropriate conclusions. Senior researchers should be able to train the students such that they can work independently and are able to understand the aim of each experiment performed by them. They should also be able to understand the possible outcomes of each experiment.

**Syllabus**

**Thesis writing**

At the end of their project, thesis has to be written giving all the details such as aim, methodology, results, discussion and future work related to their project. Students may aim to get their research findings published in a peer-reviewed journal. If the research findings have application-oriented outcomes, the students may file patent application.

<u>Course Outcome</u>	<b>Dissertation</b>
<u>CO1</u>	The students should have educated to adapt to the research environment and understand how projects are executed in a research laboratory. It will also enable students to learn practical aspects of research and train students in the art of analysis and thesis writing.
<u>CO2</u>	The students will be able to Students should be able to learn how to select and defend a topic of their research, how to effectively plan, execute, evaluate and discuss their experiments.
<u>CO3</u>	Students should have In-depth knowledge of the chosen area of research as well as have capability to create, analyse and critically evaluate different technical solutions, ability to conduct research independently to perform analytical techniques/experimental methods. The student should have skilled in project management skills, report writing skills, Problem solving skills, communication and interpersonal skills

Program Matrix

	<u>PO1</u>	<u>PO2</u>	<u>PO3</u>	<u>PO4</u>	<u>PO5</u>	<u>PO6</u>		<u>PSO1</u>	<u>PSO2</u>	<u>PSO3</u>	<u>PSO4</u>	<u>PSO5</u>	<u>PSO6</u>
<u>CO1</u>	<u>3</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>2</u>		<u>1</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>2</u>
<u>CO2</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>2</u>		<u>1</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>2</u>
<u>CO3</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>2</u>		<u>1</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>2</u>

## **Recommended Electives**

### **Biological Imaging**

#### **Course Objectives**

The objectives of this course are to provide complete overview of state-of-art live-cell imaging techniques using microscopes currently available in literature .Live- cell imaging techniques allow real-time examination of almost every aspect of cellular function under normal and experimental conditions. With live-cell imaging experiments, main challenges are to keep cells alive and healthy over a period of time. The growing number of live-cell imaging techniques means one can obtain greater amounts of information without stressing out cells.

#### **Student Learning Outcomes**

On completion of this course, students shall be able to gain a complete overview of super-resolution field from fundamentals to state-of-art methods and applications in biomedical research. The students shall learn the comparative advantages and disadvantages of each technique, covers all key techniques in field of biomedical science. The students shall also learn how to use new tools to increase resolution in sub-nanometer-scale images of living cells and tissue, which leads to new information about molecules, pathways and dynamics and state-of-the art examples of applications using microscopes.

## **Unit I**

### **Widefield fluorescent microscopy**

### **3 lectures**

One of the most basic techniques for live-cell imaging is wide field fluorescent microscopy. Standard inverted research grade microscopes can yield valuable results if you are imaging adherent cells, large regions of interest (such as organelles) or very thin tissue sections (less than 5 micrometer). In wide field, a CCD camera is usually used to capture images and the epi-fluorescence illumination source can be a mercury lamp, xenon lamp, LED's, etc. Each of light sources require carefully matched interference filters for specific excitation and emission wavelengths of your fluorophore of interest. With wide field microscopy, your specimen is only exposed to excitation light for relatively short time periods as the full aperture of emission light is collected by the objectives. Wide field fluorescence microscopy can be used in combination with other Common contrast techniques such as phase contrast and differential interference contract (DIC) microscopy. This combination is useful when performing live-cell imaging to examine general cell morphology or viability while also imaging regions of interest within cells.

## **Unit II**

### **Confocal laser scanning microscopy (CLSM)**

#### **3 lectures**

CLSM has ability to eliminate out-of-focus light and information. It is also possible to obtain optical serial sections from thicker specimens. A conjugate pinhole in optical path of confocal microscope prevents fluorescence from outside of focal plane from being collected by photomultiplier detector or imaged by camera. In CLSM, a single pinhole (and single focused laser spot) is scanned across specimen by scanning system. This spot forms a reflected epi-fluorescence image back on original pinhole. When specimen is in focus, fluorescent light from it passes through pinhole to detector. Any out-of-focus light is defocused at pinhole and very little of this signal passes through to detector meaning that background fluorescence is greatly reduced. The pinhole acts as a spatial filter for emission light from the specimen.

## **Unit III**

### **Spinning disc confocal microscopy (SDCM)**

#### **2 lectures**

This method utilises a 'Nipkow Disc' which is a mechanical opaque disc which has a series of thousands of drilled or etched pin holes arranged in spiral pattern. Each illuminated pinhole on disc is imaged by microscope objective to a diffraction-limited spot on region of interest on specimen. The emission from fluorophores passes back through Nipkow disc pinholes and can be observed and captured by a CCD camera. The effect of spinning disc is that many thousands of points on specimen are simultaneously illuminated. Using SDCM to examine a specimen means that real-time imaging (30-frames-per-second or faster) can be achieved, which is extremely use full if you are looking at dynamic changes within living cells over a wide spectrum of time-scales.

## **Unit IV**

### **Light-sheet fluorescence microscopy (LSFM, or SPIM)**

#### **2 lectures**

This method enables one to perform live- cell imaging on whole embryos, tissues and cells periods in vivo in a gentle manner with high temporal resolution and in three dimensions. One is able to track cell movement over extended periods of time and follow development of organs and tissues on a cellular level. The next evolution of light-sheet fluorescence microscopy, termed lattice light-sheet microscopy as developed by Eric Betzig (Nobel Prize Laureate 2014 for PALM super-resolution microscopy) will even allow live-cell imaging with super-resolved in vivo cellular localization capabilities.

## Unit V

### Super-resolved fluorescence microscopy

#### 8 lectures

Super-Resolution in a Standard Microscope: From Fast Fluorescence Imaging to Molecular Diffusion Laws in Live Cells; Photoswitching Fluorophores in Super- Resolution Fluorescence Microscopy; Image Analysis for Single-Molecule Localization Microscopy Deconvolution of Nanoscopic Images; Super-Resolution Fluorescence Microscopy of the Nanoscale Organization in cells; Correlative Live-Cell and Super- Resolution Microscopy and Its Biological Applications; SAX Microscopy and Its Application to Imaging of 3D-Cultured Cells; Quantitative Super-Resolution Microscopy for Cancer Biology and Medicine.

## Unit VI

### Re-scan confocal microscopy

#### 4 lectures

Structured Illumination Microscopy; Correlative Nanoscopy: AFM Super-Resolution (STED/STORM) ; Stochastic Optical Fluctuation Imaging.

### Recommended Textbooks and References:

1. RajagopalVadivambal,DigvirS.Jayas.(2015).Bio-Imaging:Principles,Techniques, and Applications. ISBN 9781466593671 -CAT#K20618.
2. AlbertoDiaspro,MarcA.M.J.vanZandvoort.(2016).Super-ResolutionImagingin Biomedicine. ISBN 9781482244342 -CAT#K23483.
3. Taatjes,Douglas,Roth,Jürgen(Eds.).(2012).CellImagingTechniquesMethodsand Protocols. ISBN978-1-62703-056-4.

Course Outcome	Biological Imaging
<u>CO1</u>	The students should have well informed to provide complete overview of state-of-art live-cell imaging techniques using microscopes currently available in literature. Live- cell imaging techniques allow real-time examination of almost every aspect of cellular function under normal and experimental conditions.
<u>CO2</u>	Students should have skilled with live-cell imaging experiments, main challenges are to keep cells alive and healthy over a period of time. The growing number of live-cell imaging techniques means one can obtain greater amounts of information without stressing out cells.



<u>CO3</u>	The students should have learnt how to use new tools to increase resolution in sub-nanometer-scale images of living cells and tissue, which leads to new information about molecules, pathways and dynamics and state-of-the art examples of applications using microscopes.
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Program Matrix

	<u>PO1</u>	<u>PO2</u>	<u>PO3</u>	<u>PO4</u>	<u>PO5</u>	<u>PO6</u>		<u>PSO1</u>	<u>PSO2</u>	<u>PSO3</u>	<u>PSO4</u>	<u>PSO5</u>	<u>PSO6</u>
<u>CO1</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>2</u>		<u>2</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>1</u>
<u>CO2</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>2</u>		<u>2</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>1</u>
<u>CO3</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>2</u>		<u>2</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>1</u>

### **Computational Biology (MBT 309 T) Elective**

**Credits-2**

#### **Course Objectives**

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.

**Student Learning Outcomes** On completion of this course, the students are expected to:

- Develop an understanding of the basic theory of these computational tools;
- Develop required database extraction, integration, coding for computational tools and methods necessary for all Omics;
- Create hypothesis for investigating specific contemporary biological questions, provide help to experiment with or develop appropriate tools;
- Critically analyze and interpret results of their study with respect to whole systems.

#### **Unit I**

##### **Introduction to computational biology basics and biological databases**

**4 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**

**5 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 subdatabases; Visualization tools including Artemis and VISTA for genome comparison; Functional genomics case studies.

#### **Unit IV**

##### **Structure visualization**

###### **3 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 through put 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.

#### **Recommended Textbooks and References:**

1. Mount, D.W. (2001). *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

- Bourne, P.E., & Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss.
- Lesk, A.M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press.
- Campbell, M. & Heyer, L.J. (2006). Discovering Genomics, Proteomics and Bioinformatics, Pearson Education.
- Oprea, T. (2005). Chemoinformatics in Drug Discovery, Volume 23. Wiley Online Library.
- Gasteiger, J. & Engel, T. (2003). Chemoinformatics: a Textbook, Wiley Online Library.

<b>Course Outcome</b>	<b>Computational Biology</b>
<b>CO1</b>	The students should be able to gain theory and practical experience of essentials to aid for genomic, proteomic and metabolomics courses and drug design program.
<b>CO2</b>	The students have learnt of the basic theory of various computational tools and develop required database extraction, integration, coding for computational tools and methods necessary for all Omics;
<b>CO3</b>	Student would be able to Create hypothesis for investigating specific contemporary biological questions, provide help to experiment with or develop appropriate tools; Critically analyse and interpret results of their study with respect to whole systems.

**Program Matrix**

	<u>PO 1</u>	<u>PO 2</u>	<u>PO 3</u>	<u>PO 4</u>	<u>PO 5</u>	<u>PO 6</u>	<u>PSO 1</u>	<u>PSO 2</u>	<u>PSO 3</u>	<u>PSO 4</u>	<u>PSO 5</u>	<u>PSO 6</u>
<u>CO 1</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>
<u>CO 2</u>	<u>2</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>
<u>CO 3</u>	<u>3</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>2</u>

**Drug Discovery and Development (MBT 310 T) Elective Credits-2**

**Course Objectives**

This course will give a broad overview of research and development carried out in industrial setup towards drug discovery.

**Student Learning Outcomes**

On completion of this course, students should be able to understand basics of R&D in drug

discovery and should be able to apply knowledge gained in respective fields of pharmaceutical industry.

## **Unit I**

### **Target identification and molecular modelling**

#### **7 lectures**

Identification of target or drug leads associated with a particular disease by a number of different techniques including combinations of molecular modeling, combinatorial libraries and high-throughput screening (HTS); Conceptualizing the automation of the HTS process and the importance of bioinformatics and data processing in identification of lead compounds; Rational drug design, based on understanding the three-dimensional

## **Unit II**

### **Lead optimization**

#### **5 lectures**

structures and physicochemical properties of drugs and receptors; Modelling drug/ receptor interactions with the emphasis on molecular mechanisms, molecular dynamics simulations and homology modelling; Conformational sampling, macromolecular folding, structural bioinformatics, receptor-based and ligand-based design and docking methods, in silico screening of libraries, semi-empirical and ab-initio methods, QSAR methods, molecular diversity, design of combinatorial libraries of drug-like molecules, macromolecular and chemical databases.

Identification of relevant groups on a molecule that interact with a receptor and are responsible for biological activity; Understanding structure activity relationship; Structure modification to increase potency and therapeutic index; Concept of quantitative drug design using Quantitative structure–activity relationship models (QSAR models) based on the fact that the biological properties of a compound are a function of its physicochemical parameters such as solubility, lipophilicity, electronic effects, ionization, stereochemistry, etc.; Bioanalytical assay development in support of in vitro and in vivo studies (LC/MS/MS, GC/MS and ELISA).

## **Unit III**

### **Preclinical development**

#### **5 lectures**

Principles of drug absorption, drug metabolism and distribution - intestinal absorption, metabolic stability, drug-drug interactions, plasma protein binding assays, metabolite profile studies, Principles of toxicology, Experimental design for preclinical and clinical PK/PD/TK studies, Selection of animal model; Regulatory guidelines for preclinical PK/PD/TK studies; Scope of GLP, SOP for conduct of clinical & non-clinical testing, control on animal house, report preparation and documentation Integration of non-clinical and preclinical data to aid design of clinical studies.

## **Unit IV**

### **Drug manufacturing**

#### 4 lectures

Requirements of GMP implementation, Documentation of GMP practices, CoA, Regulatory certification of GMP, Quality control and Quality assurance, concept and philosophy of TQM, ICH and ISO 9000; ICH guidelines for Manufacturing, Understanding Impurity Qualification Data, Stability Studies

#### Unit V

##### Clinical trial design

#### 4 lectures

Objectives of Phase I, II, III and IV clinical studies, Clinical study design, enrollment, sites and documentation, Clinical safety studies: Adverse events and adverse drug reactions, Clinical PK, pharmacology, drug-drug interaction studies, Statistical analysis and documentation.

#### Unit VI

##### Fundamentals of regulatory affairs and bioethics

#### 4 lectures

Global Regulatory Affairs and different steps involved, Regulatory Objectives, Regulatory Agencies; FDA guidelines on IND and NDA submissions, Studies required for IND and NDA submissions for oncology, HIV, cardiovascular indications, On-label vs. off-label drug use GCP and Requirements of GCP Compliance, Ethical issues and Compliance to current ethical guidelines, Ethical Committees and their set up, Animal Ethical issues and compliance.

#### Recommended Textbooks and References:

1. Krogsgaard-Larsen et al. Textbook of Drug Design and Discovery. 4th Edition. CRC Press.
2. Kuhse, H. (2010). Bioethics: an Anthology. Malden, MA: Blackwell.
3. Nally, J. D. (2006) GMP for Pharmaceuticals. 6th edition. CRC Press
4. Brody, T. (2016) Clinical Trials: Study Design, Endpoints and Biomarkers, Drug Safety, and FDA and ICH Guidelines. Academic Press.

<b>Course Outcome</b>	<b>Drug Discovery and Development</b>
<b>CO1</b>	The students should have knowledge overview of research and development carried out in drug discovery.
<b>CO2</b>	The students should have knowledge in industrial setup towards drug discovery.
<b>CO3</b>	The students should be able to understand basics of R&D in drug discovery and should be able to apply knowledge gained in respective fields of pharmaceutical industry.

#### Program Matrix

	<b>PO</b>	<b>PO</b>	<b>PO</b>	<b>PO</b>	<b>PO</b>	<b>PO</b>	<b>PSO</b>	<b>PSO</b>	<b>PSO</b>	<b>PSO</b>	<b>PSO</b>	<b>PSO</b>
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	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
<u>CO</u> <u>1</u>	<u>3</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>2</u>		<u>2</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>3</u>
<u>CO</u> <u>2</u>	<u>3</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>1</u>		<u>2</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>3</u>
<u>CO</u> <u>3</u>	<u>3</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>2</u>		<u>3</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>3</u>

## **Environmental Biotechnology (MBT 310 T) Elective**

### **Credits-2**

#### **Course Objectives**

This course aims to introduce fundamentals of Environmental Biotechnology. The course will introduce major groups of microorganisms-tools in biotechnology and their most important environmental applications. The environmental applications of biotechnology will be presented in detail and will be supported by examples from the national and international literature.

#### **Student Learning Outcomes**

On completion of course, students will be able to understand use of basic microbiological, molecular and analytical methods, which are extensively used in environmental biotechnology.

#### **Unit I**

##### **Introduction to environment**

##### **6 lectures**

Introduction to environment; Pollution:air, water, soil, noise; pollution indicators; Climate change, Biodiversity and its conservation; bio geochemical cycles; microbial ecology.

#### **Unit II**

##### **Waste Management**

##### **8 lectures**

Waste management: domestic, industrial, and hazardous wastes (storage, transportation, treatment and disposal); solid waste management, wastewater characteristics and treatment, treatment strategies for effluent generated by distillery, paper and pulp industries, textile industries; waste to energy, recycling and reuse.

#### **Unit III**

##### **Bioremediation**

##### **8 lectures**

Bioremediation: Fundamentals, technological aspects and strategies, bioremediation of metals, radionuclides, organicpollutants/xenobiotic; Application of bacteria and fungi in

bioremediation; Phytoremediation: Fundamentals and description of major methods of application (phytoaccumulation, phytovolatilization, rhizofiltration, phytostabilization).

**Unit IV**

**Biotechnology and agriculture**

**11 lectures**

Biopesticides, Bioinsecticides, Biofungicides, Bioherbicides: genetic modifications, mode of actions; Biofertilizers: Symbiotic systems between plants–microorganisms, Plant growth promoting rhizobacteria (PGPR) – uses, practical aspects and problems in application.

**Unit V**

**Biofuels**

**8 lectures**

Biofuels: production of biogas; bioethanol; biodiesel; Utilizable biomass, microorganisms and biotechnological interventions for optimization of production, Microbial Fuel Cells, Microbiologically enhanced oil recovery (MEOR); Bioleaching of metals; Bioplastic.

**Recommended Textbooks and References:**

1. G.M.Evans and J.C.Furlong (2003), Environmental Biotechnology: Theory and Applications, Wiley Publishers.
2. B.Ritmann and P.L.McCarty, (2000), Environmental Biotechnology: Principle & Applications, 2nd Ed., McGraw Hill Science.
3. Scragg A., (2005) Environmental Biotechnology. Pearson Education Limited.
4. J.S.Devinny, M.A.Deshusses and T.S.Webster, (1998), Biofiltration for Air Pollution Control, CRC Press.
5. H.J.Rehman and G.Reed, (2001), Biotechnology – A Multi-volume Comprehensive Treatise, Vol. 11, 2nd Ed., VCH Publishers Inc.
6. H.S.Peavy, D.R.Rowe and G.Tchobanoglous, (2013), Environmental Engineering, McGraw-Hill Inc.

<u>Course Outcome</u>	<b>Environmental Biotechnology</b>
<b><u>CO1</u></b>	The students should have knowledge fundamentals of Environmental Biotechnology. The course will introduce major groups of microorganisms-tools in biotechnology and their most important environmental applications.
<b><u>CO2</u></b>	The students should be able to well known in environmental applications of biotechnology will be presented in detail and will be supported by examples from the national and international literature.

<b><u>CO3</u></b>	The students should be able to understand use of basic microbiological, molecular and analytical methods, which are extensively used in environmental biotechnology.
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#### **Program Matrix**

	<u>PO</u> <u>1</u>	<u>PO</u> <u>2</u>	<u>PO</u> <u>3</u>	<u>PO</u> <u>4</u>	<u>PO</u> <u>5</u>	<u>PO</u> <u>6</u>	<u>PSO</u> <u>1</u>	<u>PSO</u> <u>2</u>	<u>PSO</u> <u>3</u>	<u>PSO</u> <u>4</u>	<u>PSO</u> <u>5</u>	<u>PSO</u> <u>6</u>
<u>CO</u> <u>1</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>2</u>	<u>1</u>
<u>CO</u> <u>2</u>	<u>3</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>1</u>
<u>CO</u> <u>3</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>2</u>	<u>1</u>

### **Microbial Technology (MBT 308T) Elective Credits-2**

#### **Course Objectives**

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.

#### **Student Learning Outcomes**

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

#### **Unit I**

##### **Introduction to microbial technology**

##### **8 lectures**

Microbial technology in human welfare; Isolation and screening of microbes important for industry; extremophiles: halophiles, thermophiles, psychrophiles as source of industrially important products, advantages of microbial technology

#### **Unit II**

##### **Environmental applications of microbial technology**

##### **6 lectures**

Environmental application of microbes; bioleaching; Biodegradation; 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**

##### **8 lectures**

Microbial products in pharmaceutical industry, Recombinant protein and pharmaceuticals production in microbes; Antibiotics and enzymes production, Microbial cell factories;



Downstream processing approaches used in industrial production process, microbes in targeted delivery application – drugs and vaccines (bacterial and viral vectors)

#### **Unit IV**

#### **Food applications of microbial technology**

**7 lectures**

Application of microbes and microbial processes in food, food preservation, Non-recombinant ways of introducing desirable properties in Generally recognized as safe (GRAS); microbes to be used in food (e.g., Yeast), fermented food products (beverages and dairy products), genetically modified foods.

#### **Unit V**

#### **Advances in microbial technology**

**8 lectures**

Microbial genomics for discovery of novel enzymes, drugs/ antibiotics; Metagenomics and metatranscriptomics, metagenomic library construction and functional screening in suitable hosts, Advanced genome and epigenome editing tools

#### **Recommended Textbooks and References:**

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.
5. Journals: (a) Nature, (b) Nature Biotechnology, (c) Applied microbiology and biotechnology, (d) Trends in Biotechnology, (e) Trends in Microbiology, (f) Current opinion in Microbiology, (g) Biotechnology Advances, (h) Genome Research
6. Websites: <http://jgi.doe.gov/our-science/>

<b><u>Course Outcome</u></b>	<b>Microbial Technology</b>
<b><u>CO1</u></b>	The students should have learn advances made in field of microbial technology for use in human welfare and solving problems of the society.
<b><u>CO2</u></b>	The students have developed advances made in field of microbial technology for use in human welfare.
<b><u>CO3</u></b>	The students should be skill to develop deeper understanding of the microbial technology and its applications.

### Program Matrix

	<u>PO</u> <u>1</u>	<u>PO</u> <u>2</u>	<u>PO</u> <u>3</u>	<u>PO</u> <u>4</u>	<u>PO</u> <u>5</u>	<u>PO</u> <u>6</u>	<u>PSO</u> <u>1</u>	<u>PSO</u> <u>2</u>	<u>PSO</u> <u>3</u>	<u>PSO</u> <u>4</u>	<u>PSO</u> <u>5</u>	<u>PSO</u> <u>6</u>
<u>CO</u> <u>1</u>	<u>3</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>
<u>CO</u> <u>2</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>3</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>
<u>CO</u> <u>3</u>	<u>3</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>1</u>

### Protein Engineering (MBT 312 T) ELECTIVE

Credits - 2

#### Course Objectives

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

#### Student Learning Outcomes

On completion of this course, students should be able to:

- Analyse structure and construction of proteins by computer-based methods;
- Describe structure and classification of proteins;
- Analyse purity and stability of proteins and explain how to store them in best way;
- Explain how proteins can be used for different industrial and academic purposes such as structure determination, organic synthesis and drug design.

#### Unit I

##### Introduction to protein engineering

5 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

5 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**  
**5 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**  
**5 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; Proteindesign, Directed evolution for protein engineering and its potential.

**Unit V**  
**Case studies**  
**1 lecture**  
**Case Studies.**

**Recommended Textbooks and References:**

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.

<b>Course Outcome</b>	<b>Protein Engineering</b>
<b>CO1</b>	The students should have well versed with methods and strategies commonly used in protein engineering.

<b><u>CO2</u></b>	The students should have understand and analyse structure and construction of proteins by computer-based methods. Describe structure and classification of protein. Analyse purity and stability of protein.
<b><u>CO3</u></b>	The students should have learn how proteins can be used for different industrial and academic purposes such as structure determination, organic synthesis and drug design.

### **Program Matrix**

	<b><u>PO</u></b> <b><u>1</u></b>	<b><u>PO</u></b> <b><u>2</u></b>	<b><u>PO</u></b> <b><u>3</u></b>	<b><u>PO</u></b> <b><u>4</u></b>	<b><u>PO</u></b> <b><u>5</u></b>	<b><u>PO</u></b> <b><u>6</u></b>		<b><u>PSO</u></b> <b><u>1</u></b>	<b><u>PSO</u></b> <b><u>2</u></b>	<b><u>PSO</u></b> <b><u>3</u></b>	<b><u>PSO</u></b> <b><u>4</u></b>	<b><u>PSO</u></b> <b><u>5</u></b>	<b><u>PSO</u></b> <b><u>6</u></b>
<b><u>CO</u></b> <b><u>1</u></b>	<b><u>3</u></b>	<b><u>1</u></b>	<b><u>1</u></b>	<b><u>1</u></b>	<b><u>1</u></b>	<b><u>1</u></b>		<b><u>3</u></b>	<b><u>1</u></b>	<b><u>1</u></b>	<b><u>1</u></b>	<b><u>1</u></b>	<b><u>3</u></b>
<b><u>CO</u></b> <b><u>2</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>1</u></b>	<b><u>1</u></b>	<b><u>1</u></b>		<b><u>2</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>1</u></b>	<b><u>1</u></b>	<b><u>3</u></b>
<b><u>CO</u></b> <b><u>3</u></b>	<b><u>1</u></b>	<b><u>1</u></b>	<b><u>1</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>		<b><u>1</u></b>	<b><u>1</u></b>	<b><u>1</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>3</u></b>

### **Vaccines ( MBT 311 T ) ELECTIVE**

**Credits -2**

#### **Course Objectives**

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

#### **Student Learning Outcomes Bytheendofthiscourse,students should be ableto:**

- Understand fundamental concepts of human immune system and basic immunology;
- Differentiateandunderstandimmuneresponses in relation to infection and vaccination;
- Understand requirement and designing of different typesofvaccines;
- Understand importance of conventional and new emerging vaccinetchnologies.

#### **Unit I**

##### **Fundamentals of immune system**

**6 lectures**

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 and Cancer**

**9 lectures**

Protective immune response in Infections (bacterial; viral and parasitic infections;) and Cancer. Antigen presenting cells: Dendritic cells in immune response; Cell mediated responses: T cell, B Cell, DC, NK: Memory and effector T and B cells, Generation and Maintenance of memory T and B cells.

### **Unit III**

#### **Immune response to vaccination**

#### **8 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,LiposomalandMicroparticlesasdelivery systems; Chemokines and cytokines; Role of soluble mediators in vaccination; Oral immunization and Mucosal Immunity.

### **Unit IV**

#### **Vaccine types & design**

#### **3 lectures**

History of vaccines, Conventional vaccines; Bacterialvaccines; ViralVaccines; Vaccines based on routes of administration: parenteral, oral, mucosal; Live attenuated and inactivated vaccine; Subunit Vaccines and Toxoids; PeptideVaccine.

### **Unit V**

#### **Vaccine technologies**

#### **4 lectures**

New Vaccine Technologies; Rationally designed Vaccines; DNA Vaccination; Mucosal vaccination; New approaches for vaccine delivery; Reverse Vaccinology; Engineering virus vectors for vaccination; Vaccines for targeted delivery (Vaccine Delivery systems); Disease specific vaccine design: Tuberculosis Vaccine; Malaria Vaccine; HIV/AIDS vaccine; New emerging diseases and vaccine needs (Ebola, Zika).

#### **Recommended Textbooks and References:**

1. Janeway,C.A.,Travers,P.,Walport,M.,&Shlomchik,M.J.(2005).ImmunoBiology: theImmuneSysteminHealthandDisease.USA:GarlandSciencePub.
2. Kindt,T.J.,Osborne,B.A.,Goldsby,R.A.,&Kuby,J.(2013).KubyImmunology. New York: W.H.Freeman.
3. Kaufmann,S.H.(2004).NovelVaccinationStrategies.Weinheim:Wiley-VCH.
4. JournalArticles(relevantissues)from:AnnualReviewofImmunology,Annual ReviewofMicrobiology,CurrentOpinioninImmunology,NatureImmunology, Expert review ofvaccines.

<b>Course Outcome</b>	<b>Vaccines</b>
<b>CO1</b>	The students learn about the basics of vaccines.

<b><u>CO2</u></b>	The students should have understand fundamental concepts of human immune system and basic immunology; Differentiateandunderstandimmuneresponses in relation to infection and vaccination; Understand requirement and designing of different typesofvaccines;
<b><u>CO3</u></b>	Finally, Understand importance of conventional and new emerging vaccine technologies.

### Program Matrix

	<u>PO</u> <u>1</u>	<u>PO</u> <u>2</u>	<u>PO</u> <u>3</u>	<u>PO</u> <u>4</u>	<u>PO</u> <u>5</u>	<u>PO</u> <u>6</u>	<u>PSO</u> <u>1</u>	<u>PSO</u> <u>2</u>	<u>PSO</u> <u>3</u>	<u>PSO</u> <u>4</u>	<u>PSO</u> <u>5</u>	<u>PSO</u> <u>6</u>
<u>CO</u> <u>1</u>	<u>3</u>	3	2	3	2	<u>1</u>	<u>3</u>	<u>1</u>	<u>1</u>	2	2	3
<u>CO</u> <u>2</u>	<u>2</u>	<u>3</u>	2	3	2	<u>1</u>	<u>2</u>	<u>3</u>	<u>3</u>	2	2	3
<u>CO</u> <u>3</u>	<u>3</u>	2	2	3	<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>3</u>

## **Medical Microbiology and Infection Biology (MBT 313 T) ELECTIVE**

**Credits-2**

### **Course Objectives**

This course will provide a perspective and exposure to medical aspects of bacteriology, virology, mycology, parasitology and infectious diseases along with concepts of symptoms,pathogenesis, transmission, prophylaxis andcontrol, a conceptual understanding of host – pathogen interactions using well charac- terized systems as examples. The student should have a good grasp of disease causing microbes and their interactions with host.

### **Student Learning Outcomes**

On completion of this course, students should be able to:

- Compare and contrast different microbial diseases, including properties of different types of patho- gens,andmechanismsofpathogenesis;
- Summarize role of host in infectious disease, including natural barriers to infection, innate and acquired immune responses toinfection, and inflammation;
- Compare and contrast experimental approaches for identifying virulence genesandadvantages/disadvantagesof each approach for specificpathogens.

### **Unit I**

**Bacterial diseases**

**8 lectures**

Normal microflora (microbiome) of human body and its role – Skin, mouth and respiratory tract, intestinal tract, urogenital tract; Pathogenesis and virulence factors  
- Koch's postulates, Adherence and invasion, Toxins, Enzymes, Antiphagocytic factors, Antigen heterogeneity, Iron acquisition; Bacillus anthracis, Clostridium spp., Corynebacterium diphtheriae; E. coli, Vibrio cholerae, Helicobacter pylori, Salmonella typhi and paratyphi, Shigella dysenteriae; Listeria monocytogenes, Mycobacterium spp., Rickettsial diseases; Haemophilus influenzae, Bordetella pertussis, Brucellosis, Streptococcal and Staphylococcal infections; Antibacterial chemotherapy (with examples of antibiotics) - Inhibition of cell wall synthesis, inhibition of cell membrane function, inhibition of protein and nucleic acid synthesis, antimetabolites; Drug resistance - origin (genetic and non-genetic), mechanisms, antimicrobial activity in vitro and in vivo, Multi-drug resistance and its mechanisms e.g. MDR-TB.

## **Unit II**

### **Viral diseases**

#### **7 lectures**

Viral Pathogenesis - Routes of entry, Viral spread (local and systemic infection), Viral persistence (chronic and latent infection); Polio, Chicken pox, Mumps, Measles, Rubella; Viral hemorrhagic fever, viral encephalitis, Dengue and Yellow fever; Influenza virus infection (emphasis on Avian and swine flu), Rabies and Prion diseases; Hepatitis and Human Cancer viruses; Emerging viral diseases – Ebola, Marburg, SARS, Hanta, Chikungunya, Zika, Chandipura; Antiviral chemotherapy and Viral vaccines; Nucleotide and nucleoside analogs, Reverse transcriptase inhibitor, protease inhibitor, fusion inhibitor etc., Interferons, Killed and attenuated vaccines.

## **Unit III**

### **Fungal and protozoan infections**

#### **7 lectures**

Types of Mycoses (with specific example of causative fungi) – Superficial, Cutaneous, Subcutaneous; Types of Mycoses (with specific example of causative fungi) - Endemic and Opportunistic; Mycotoxins and Antifungal chemotherapy – Mycetismus, Aflatoxins, classes of currently available drugs and new inhibitors in the pipeline; Protozoan diseases - Giardiasis, Amoebiasis; Leishmaniasis, African sleeping sickness; Malaria, Cryptosporidiosis; Infection by Helminths – Nematodes, Trematodes, Cestodes.

## **Unit IV**

### **Sexually transmitted diseases and congenital infections**

#### **6 lectures**

Syphilis and Gonorrhoeal infections; AIDS and Lentiviral infection; Herpes infections; Chlamydial infections (Chlamydia trachomatis); Mycoplasma and Ureaplasma infection; Toxoplasmosis; Congenital viral infections – Cytomegalovirus, Varicella zoster, HBV, Enterovirus, Parvovirus B19 etc.

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**Unit V**  
**Host-pathogen interaction**  
**6 lectures**

Intracellular and extracellular pathogens, Principles of microbial pathogenesis, host damage, inflammatory responses, adaptation strategies of pathogen- impact of host and pathogen metabolism on immunity and pathogen survival; Chronic pathogens and mechanisms of persistence; Evasion mechanisms of pathogens; Bacterial–host interaction- Mycobacterium tuberculosis, Borrelia burgdorferi; Viruses – host interaction: HIV, Influenza; Protozoan – host interaction: Plasmodium spp., Leishmania major.

**Recommended Textbooks and References:**

1. KCCarroll, SAMorse, TMietzner, SMiller. (2016) Jawetz, Melnick and Adelberg's Medical Microbiology 27th edition, McGraw Hill.
2. JOwen, JPunt and Sharon Stranford, (2012), Kuby Immunology; 7th edition, W.H. Freeman and Co.
3. ITKudva, NA.Cornick, PJPlummer, QZhang, TLNicholson, JPBannantine and BH Bellaire. Virulence Mechanisms of Bacterial Pathogens, (2016) 5th edition, ASM Press.
4. VKumar, AK.Abbas and JCAster, (2015), Robbins & Cotran Pathologic Basis of Disease. 9th Edition, Elsevier.
5. KMurphy and KWeaver, (2016), Janeway's Immunobiology, 9th Edition, Garland Science.
6. AKAbbas, (2015), Cellular and Molecular Immunology. 8th Edition, Elsevier.
7. Ananthanarayan and Paniker, Textbook of Microbiology, 8th Edition.
8. Baveja CP, (2001) Textbook of Microbiology. 5th Ed., McGraw Hill Education.

<b>Course Outcome</b>	<b>Medical Microbiology and Infection Biology</b>
<b><u>CO1</u></b>	The students should be able to gain perspective and exposure to medical aspects of bacteriology, virology, mycology, parasitology and infectious diseases along with concepts of symptoms, pathogenesis, transmission, prophylaxis and control, a conceptual understanding of host – pathogen interactions using well characterized systems as examples. The student should have a good grasp of disease causing microbes and their interactions with host.
<b><u>CO2</u></b>	The students understand and are able to compare and contrast different microbial diseases, including properties of different types of pathogens, and mechanisms of pathogenesis;
<b><u>CO3</u></b>	In totality, student should know the role of host in infectious disease, including natural barriers to infection, innate and acquired immune responses to infection, and inflammation; Compare and contrast experimental approaches for identifying virulence genes and advantages/disadvantages of each approach for specific



	pathogens.
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**Program Matrix**

	<u>PO</u> <u>1</u>	<u>PO</u> <u>2</u>	<u>PO</u> <u>3</u>	<u>PO</u> <u>4</u>	<u>PO</u> <u>5</u>	<u>PO</u> <u>6</u>	<u>PSO</u> <u>1</u>	<u>PSO</u> <u>2</u>	<u>PSO</u> <u>3</u>	<u>PSO</u> <u>4</u>	<u>PSO</u> <u>5</u>	<u>PSO</u> <u>6</u>
<u>CO</u> <u>1</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>
<u>CO</u> <u>2</u>	<u>2</u>	<u>3</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>1</u>
<u>CO</u> <u>3</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>1</u>

POs Post-Graduate Programme

Programme Outcomes (POS)

<u>PO1</u>	<u>Knowledge: Knowledge will be provided on basics and advance fields of the core and applied disciplines to fulfil the professional requirements</u>
<u>PO2</u>	<u>Critical Thinking: Develop critical thinking on appropriate knowledge of living beings/ organisms, non-living components and environmental basis of life, which will enable students for critical analysis of day-to-day problems.</u>
<u>PO3</u>	<u>Skill &amp; Application Development: Skill based knowledge on theoretical and methodological understandings of use of different descriptive and inferential statistical tools and techniques for application of biological materials in food, health, medicine &amp; Environment for sustainable development of the society.</u>
<u>PO4</u>	<u>Inter-disciplinary &amp; Multi-disciplinary Approach: Understanding of the vital connections of flora, fauna and the physical environment so is to enable to integrate and synthesized</u>
<u>PO5</u>	<u>Ethics: Internalisation of and sensitiveness to sound professional ethics for use in day-to-day life in the society.</u>
<u>PO6</u>	<u>Problem Solving &amp; Employability: Special skill through vocational trainings, field visits, entrepreneurial and career development approach to develop capability to handle various problems and development of scientific</u>

temperament in research and development issues in the society.
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### M.Sc (Biotechnology) Program Specific Outcomes

<u>P</u> <u>S</u> <u>O</u> <u>1</u>	Disciplinary knowledge and skills: Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and applications of different areas of biotechnology such as Molecular Biology, Recombinant DNA technology, Bioinformatics, Microbiology, Immunology, Plant and Animal Biotechnology and Environmental Biotechnology (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologically important molecules and its application in human welfare.
<u>P</u> <u>S</u> <u>O</u> <u>2</u>	Skilled communicator: Ability to convey complex technical information relating to Biotechnology in a clear and concise manner both in writing as well as orally.
<u>P</u> <u>S</u> <u>O</u> <u>3</u>	Critical thinker and problem solver: Ability to employ critical thinking and efficient problem solving skills in different areas related to Biotechnology like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Biotechnology, Plant Biotechnology and Bioprocess engineering.
<u>P</u> <u>S</u> <u>O</u> <u>4</u>	Team player/worker: Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations improving knowledge and developing skill.
<u>P</u> <u>S</u> <u>O</u> <u>5</u>	Ethical awareness/reasoning: Avoiding unethical behaviors such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
<u>P</u> <u>S</u> <u>O</u> <u>6</u>	Lifelong learners: Capable of making conscious efforts to achieve self-paced and self-directed learning aimed at personal development and for

### **Msc. Biotechnology (Semester Three)**

#### **Course- Core-1 Theory**

#### **Bioprocess Engineering & Technology (MBT 301 T) Credits 3**

#### **Course Objectives**

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.

Students should be able to:

- Appreciate relevance of microorganisms from industrial context;
- Carry out stoichiometric calculations and specify models of their growth;
- Give an account of design and operations of various fermenters;
- Present unit operations together with the fundamental principles for basic methods in production technique for bio-based products;
- Calculate yield and production rates in a biological production process, and also, interpret data;

- Calculate the need for oxygen and oxygen transfer;
- Critically analyze any bioprocess from market point of view;
- Give an account of important microbial/enzymatic industrial processes in food and fuel industry.

### **Unit I**

#### **Basic principles of biochemical engineering**

Isolation, screening and maintenance of industrially important microbes; microbial growth and death kinetics, strain improvement for increased yield and other desirable characteristics. Yield coefficients; unstructured models of microbial growth; structured models of microbial Growth.

### **Unit II**

#### **Bioreactor design and analysis**

Batch, fed-batch and continuous fermenters; immobilized cell systems; large scale animal and plant cell cultivation; 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 III**

#### **Downstream processing and product recovery**

Downstream processing: 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, effluent treatment and disposal.

### **Unit IV**

#### **Applications of enzyme technology in food processing**

Mechanism of enzyme function and reactions in process techniques; enzymatic bioconversions e.g., starch and sugar conversion processes, inter-esterified 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 V**

#### **Applications of microbial technology**

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.

<u>Course Outcome</u>	<u>Bioprocess Engineering &amp;Technology</u>
<u>CO1</u>	The students should be well-versed with 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.
<u>CO2</u>	The students should have basic knowledge of microorganisms from industrial context, carry out stoichiometric calculations and specify models of their growth.

<u>CO3</u>	The students should have knowledge to give an account of design and operations of various fermenters, present unit operations together with the fundamental principles for basic methods in production technique for Bio-based products.
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### Program Matrix

	<u>PO1</u>	<u>PO2</u>	<u>PO3</u>	<u>PO4</u>	<u>PO5</u>	<u>PO6</u>		<u>PSO1</u>	<u>PSO2</u>	<u>PSO3</u>	<u>PSO4</u>	<u>PSO5</u>	<u>PSO6</u>
<u>CO1</u>	<u>2</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>		<u>2</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>3</u>
<u>CO2</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>		<u>2</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>2</u>
<u>CO3</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>3</u>		<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>3</u>	<u>3</u>

### Laboratory VI: Bioprocess Engineering & Technology (Laboratory)

#### Course – Lab 1 (MBT315L) Credit 4

#### Course Objectives

The objectives of this laboratory Course are to provide hands-on training to students in upstream and

Downstream unit operations.

#### Student Learning Outcomes

Students should be able to:

- Investigate, design and conduct experiments, analyze and interpret data, and apply the laboratory skills to solve complex bioprocess engineering problems;
- Apply skills and knowledge gained will be useful in solving problems typical of bio industries and research.

#### Syllabus

1. Basic Microbiology techniques
2. Scale up from frozen vial to agar plate to shake flask culture
3. Instrumentation: Microplate reader, spectrophotometer microscopy
4. Isolation of microorganisms from soil samples
5. Experimental setup
6. Assembly of bioreactor and sterilization
7. Growth kinetics
8. Substrate and product inhibitions
9. Measurement of residual substrates
10. Data analysis
11. Introduction to metabolic flux analysis
12. Fermentation
13. Batch
14. Fedbatch
15. Continuous
16. Unit Operations
17. Microfiltrations: Separation of cells from broth
18. Bioseparations: Various chromatographic techniques and extractions
19. Bioanalytics

## 20. Analytical techniques like HPLC

### Recommended Textbooks and References:

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 Fermentation Technology*. 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.
5. El-Mansi, M., & Bryce, C.F. (2007). *Fermentation Microbiology and Biotechnology*. Boca Raton: CRC/Taylor & Francis.

<b>Course Outcome</b>	<b>Bioprocess Engineering &amp; Technology</b>
<u>CO1</u>	The students should be able to handle experiment and hands-on training to students in upstream and downstream unit operations.
<u>CO2</u>	Students should be able to Investigate, design and conduct experiments, analyse and interpret data, and apply the laboratory skills to solve complex bioprocess engineering problems.
<u>CO3</u>	The students should have educated to apply skills and knowledge gained will be useful in solving problems typical of Bio industries and research.

### Program Matrix

	<u>PO1</u>	<u>PO2</u>	<u>PO3</u>	<u>PO4</u>	<u>PO5</u>	<u>PO6</u>		<u>PSO1</u>	<u>PSO2</u>	<u>PSO3</u>	<u>PSO4</u>	<u>PSO5</u>	<u>PSO6</u>
<u>CO1</u>	<u>2</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>		<u>2</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>3</u>
<u>CO2</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>		<u>2</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>2</u>
<u>CO3</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>3</u>		<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>3</u>	<u>3</u>

### Course- Core-2 Theory

### Emerging Technology (MBT 302 T) Credits 2

#### Course Objectives

This course is broad-based in nature encompassing ever al new technologies that current experimental researchers are employing to probe complex system biology questions in life-sciences. 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.

## **Student Learning Outcomes**

Students should be to learn history, theoretical basis and basic understanding of latest technologies in area of biotechnology. They should also be able to learn about various applications of these technologies. The students may also learn one application in depth through an assignment and/or seminar.

### **Unit I**

#### **Optical microscopy methods**

##### **8 lectures**

##### **Basic Microscopy:**

Light Microscopy: lenses and microscopes, resolution: Rayleigh's Approach, Darkfield; Phase Contrast; Differential Interference Contrast; fluorescence and fluorescence microscopy: what is fluorescence, what makes a molecule fluorescent, fluorescence microscope; optical arrangement, light source; filter sets: excitation filter, dichroic mirror, and barrier, optical layout for image capture; CCD cameras; back illumination, binning; recording color; three CCD elements with dichroic beam splitters, boosting the signal.

### **Unit II**

#### **Mass spectroscopy**

##### **4 lectures**

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

### **Unit III**

#### **Systems biology**

##### **3 lectures**

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

### **Unit IV**

#### **Structural biology**

##### **3 lectures**

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

### **Unit V**

## CRISPR-CAS

### 6 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 VI

## Nanobodies

### 4 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.

### Recommended Textbooks and References:

7. Campbell, I.D. (2012). *Biophysical Techniques*. Oxford: Oxford University Press.
8. Serdyuk, I.N., Zaccai, N.R., & Zaccai, G. (2007). *Methods in Molecular Biophysics: Structure, Dynamics, Function*. Cambridge: Cambridge University Press.
9. Phillips, R., Kondev, J., & Theriot, J. (2009). *Physical Biology of the Cell*. New York: Garland Science.
10. Nelson, P.C., Radosavljević, M., & Bromberg, S. (2004). *Biological Physics: Energy, Information, Life*. New York: W.H. Freeman.
11. Huang, B., Bates, M., & Zhuang, X. (2009). *Super-Resolution Fluorescence Microscopy*. *Annual Review of Biochemistry*, 78(1), 993-1016. doi: 10.1146/annurev.biochem.77.061906.092014.
12. Mohanraju, P., Makarova, K.S., Zetsche, B., Zhang, F., Koonin, E.V., & Oost, J.V. (2016). *Diverse Evolutionary Roots and Mechanistic Variations of the CRISPR-Cas Systems*. *Science*, 353(6299). doi: 10.1126/science.aad5147.
7. Lander, E. (2016). *The Heroes of CRISPR*. *Cell*, 164(1-2), 18-28. doi: 10.1016/j.cell.2015.12.041.
18. Ledford, H. (2016). *The Unsung Heroes of CRISPR*. *Nature*, 535(7612), 342-344. doi: 10.1038/535342a.
19. Jinek, M., Chylinski, K., Fonfara, I., Hauer, M., Doudna, J.A., & Charpentier, E. (2012). *A Programmable Dual-RNA-Guided DNA Endonuclease in Adaptive Bacterial Immunity*. *Science*, 337(6096), 816-821. doi: 10.1126/science.1225829.
20. Hamers-Casterman, C., Atarhouch, T., Muyldermans, S., Robinson, G., Hammers, C., Songa, E.B., Hammers, R. (1993). *Naturally Occurring Antibodies Devoid of Light Chains*. *Nature*, 363(6428), 446-448. doi: 10.1038/363446a0.
21. Sidhu, S. S., & Koide, S. (2007). *Phage Display for Engineering and Analyzing Protein Interaction Interfaces*. *Current Opinion in Structural Biology*, 17(4), 481-487. doi: 10.1016/j.sbi.2007.08.007.
22. Steyaert, J., & Kobilka, B.K. (2011). *Nanobody Stabilization of G Protein-Coupled Receptor Conformational States*. *Current Opinion in Structural Biology*, 21(4), 567-572. doi: 10.1016/j.sbi.2011.06.011.

23. Vincke, C., & Muyldermans, S. (2012). *Introduction to Heavy Chain Antibodies and Derived Nanobodies*. *Single Domain Antibodies*, 15-26. doi:10.1007/978-1-61779-968-6\_2.
24. Verheesen, P., & Laeremans, T. (2012). *Selection by Phage Display of Single Domain Antibodies Specific to Antigens in their Native Conformation*. *Single Domain Antibodies*, 81-104. doi:10.1007/978-1-61779-968-6\_6.
25. Li, J., Xia, L., Su, Y., Liu, H., Xia, X., Lu, Q., Reheman, K. (2012). *Molecular Imprint of Enzyme Active Site by Camel Nanobodies*. *Journal of Biological Chemistry* J. Biol. Chem., 287(17), 13713-13721. doi:10.1074/jbc.m111.336370.
26. Sohier, J., Laurent, C., Chevigné, A., Pardon, E., Srinivasan, V., Wernery, U., Galleni, M. (2013). *Allosteric Inhibition of VIM Metallo- $\beta$ -Lactamases by a Camelid Nanobody*. *Biochemical Journal*, 450(3), 477-486. doi:10.1042/bj20121305.
27. Chakravarty, R., Goel, S., & Cai, W. (2014). *Nanobody: The "Magic Bullet" for*

Course Outcome	Bioprocess Engineering & Technology
CO1	The students should be able to learn basics of the new principles to students so as to appreciate current-day research tool-kit better.
CO2	Students should be to learn history, theoretical basis and basic understanding of latest technologies in area of biotechnology.
CO3	Students should also be able to learn about various applications of the latest technologies. The students may also learn one application in depth through an assignment and/or seminar.

#### Program Matrix

	PO1	PO2	PO3	PO4	PO5	PO6		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	<u>2</u>	<u>3</u>	<u>3</u>	<u>2</u>	<u>1</u>	<u>3</u>		<u>1</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>2</u>
CO2	<u>2</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>2</u>		<u>2</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>2</u>
CO3	<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>3</u>		<u>1</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>3</u>

#### Corse- Critical Analysis of Classical Papers

#### Core-3 (MBT303T) credit-2

#### Course Objectives

The objectives of this course are to familiarize students with classic literature to make them appreciate how ground- breaking discoveries were made without, necessarily, use of high-end technologies.

#### Student Learning Outcomes

Students should be able to train in the exercise of hypothesis building and Methods of addressing the hypothesis with readily available technology.

#### Syllabus

#### Molecular Biology



7. Studies on the chemical nature of the substance inducing transformation of Pneumococcal types: Induction of transformation by adenoxy ribonucleic acid fraction isolated from *Pneumococcus typhii*.  
Avery OT, Macleod CM, McCarty M.; J Exp Med. 1944 Feb 1;79(2):137-58. Note: This paper demonstrates that DNA is the transforming Principle originally described by Fredrick Griffith.
8. Independent functions of viral protein and nucleic acid in growth of bacteriophage Hershey AD and Chase M.; J Gen Physiol. 1952 May;36(1):39-56.  
Note: Note: This paper demonstrates that DNA, and not protein, component of phages enter bacterial cells.
9. Molecular structure of nucleic acids; a structure for deoxyribonucleic acid  
Watson JD and Crick FH; Nature. 1953 Apr 25;171(4356):737-8  
Note: In this one page paper Watson and Crick first described the structure of DNA double helix  
Study help - Watson\_Crick\_Nature\_1953\_annotated
10. Transposable mating type genes in *Saccharomyces cerevisiae*  
James Hicks, Jeffrey N. Strathern & Amar J.S. Klar; Nature 282, 478-483, 1979 Note: This paper provided evidence for 'cassette hypothesis' of yeast mating type switches *i.e.* interconversion of mating types in yeast (*S. cerevisiae*) occurs by DNA rearrangement.
11. Messelson & Stahl experiment demonstrating semi-conservative replication of DNA.  
Meselson M and Stahl FW.; Proc Natl Acad Sci U S A. 1958 Jul 15;44(7):671-82  
Note: The experiment demonstrating semi-conservative mode of DNA replication is referred to as "the most beautiful experiment in biology"
12. *In vivo* alteration of telomere sequences and senescence caused by mutated *Tetrahymena* telomerase RNAs  
Guo-Liang Yu, John D. Bradley, Laura D. Attardi & Elizabeth H. Blackburn; Nature 344, 126-132, 1990  
Note: This paper demonstrates that the telomerase contains the template for telomere synthesis

## Syllabus

### Cell Biology

7. Identification of 23 complementation groups required for post-translational events in the yeast secretory pathway  
Novick P, Field C, Schekman R.; Cell. 1980 Aug;21(1):205-15  
Note: In this groundbreaking paper Randy Schekman's group used a mutagenesis screen for fast sedimenting yeast mutants to identify genes involved in cell secretion
8. A yeast mutant defective at an early stage in import of secretory protein precursors into the endoplasmic reticulum  
Deshaies RJ and Schekman R.; J Cell Biol. 1987 Aug;105(2):633-45  
Note: Using another yeast mutation screen Schekman lab identifies Sec61, a component of ER protein Conducting Channel (PCC)

Suggested reference paper - A biochemical assay for identification of PCC.

9. Reconstitution of the Transport of Protein between Successive Compartments of the Golgi  
Balch WE, Dunphy WG, Braell WA, Rothman JE.; Cell. 1984 Dec; 39(2Pt1):405-16 Note: This paper describes setting up of an *in vitro* reconstituted system for transport between Golgi stacks which eventually paved the way for identification of most of the molecular players involved in these steps including NSF, SNAP etc.
10. A complete immunoglobulin gene is created by somatic recombination  
Brack C, Hiram M, Lenhard-Schuller R, Tonegawa S.; Cell. 1978 Sep; 15(1):1-14 Note: This study demonstrates DNA level molecular details of somatic rearrangement of immunoglobulin gene sequences leading to the generation of functionally competent antibody generating gene following recombination.
11. A novel multigene family may encode odorant receptors: a molecular basis for odor recognition  
Buck L and Axel R; Cell. 1991 Apr 5; 65(1):175-87  
Note: This paper suggests that different chemical odorants associate with different cell-specific expression of a transmembrane receptor in *Drosophila* olfactory epithelium where a large family of odorant receptors is expressed.
12. Kinesin walks hand-over-hand  
Yildiz A, Tomishige M, Vale RD, Selvin PR.; Science. 2004 Jan 30; 303(5658):676-8 Note: This paper shows that kinesin motor works as a two-headed dimeric motor walking hand-over-hand rather than like an inchworm on microtubule tract using the energy of ATP hydrolysis.

## Syllabus

### Developmental Biology/ Genetics

4. Mutations affecting segment number and polarity in *Drosophila*  
Christiane Nüsslein-Volhard and Eric Weischaus; Nature 287, 795-801, 1980  
Note: This single mutagenesis screen identified majority of the developmentally important genes not only in flies but in other metazoans as well.
5. Information for the dorsal--ventral pattern of the *Drosophila* embryo is stored as maternal mRNA  
Anderson KV and Nüsslein-Volhard C; Nature. 1984 Sep 20-26; 311(5983):223-7  
Note: This landmark paper demonstrated that early dorsal-ventral pattern information is stored as maternal mRNA in flies and devised the method of identifying genes encoding such genes
6. Hedgehog signalling in the mouse requires intraflagellar transport proteins  
Huangfu D, Liu A, Rakeman AS, Murcia NS, Niswander L, Anderson KV.; Nature. 2003 Nov 6; 426(6962):83-7  
Note: One of the architects of original fly mutagenesis screens conducted a mouse mutagenesis screen which identified a gene Kif3a as a major component of hedgehog signaling pathway. Eventually this discovery revolutionizes our understanding of mechanisms of action of signaling pathways by demonstrating central role of cilia in it.

Suggested Reference paper - Design and execution of a embryonic lethal mutation screen in mouse.

<u>Course Outcome</u>	Critical Analysis of Classical Papers
<u>CO1</u>	The students will be able to familiarize with classic literature to make them appreciate how ground- breaking discoveries were made without, necessarily, use of high-end technologies.
<u>CO2</u>	Students should be able to train in the exercise of hypothesis building and Methods of addressing the hypothesis with readily available technology.
<u>CO3</u>	Students should have skilled methodology of addressing the hypothesis with readily available technology.

Program Matrix

	<u>PO1</u>	<u>PO2</u>	<u>PO3</u>	<u>PO4</u>	<u>PO5</u>	<u>PO6</u>		<u>PSO1</u>	<u>PSO2</u>	<u>PSO3</u>	<u>PSO4</u>	<u>PSO5</u>	<u>PSO6</u>
<u>CO1</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>3</u>		<u>2</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>3</u>
<u>CO2</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>		<u>2</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>1</u>
<u>CO3</u>	<u>3</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>		<u>1</u>	<u>2</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>3</u>

## **Bioentrepreneurship Course code (MBT 304T) Core -4 Credits-3**

### **Course Objectives**

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.

### **Student Learning Outcomes**

Students should be able to gain entrepreneurial skills, understand the various operations involved in venture creation, identify scope for entrepreneurship in biosciences and utilize the schemes promoted through knowledge centers and various agencies. The knowledge pertaining to management should also help students to be able to build up a strong network within the industry.

### **Unit I**

#### **Innovation and entrepreneurship in bio-business**

##### **8 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

### **Unit II**

#### **Management and funding agencies**

##### **4 lectures**

Management definition, scope, function, levels, roles, Entrepreneurship development programs of public and private agencies including Small & Medium Enterprises (MSME), DBT, BIRAC, Make in India, strategic dimensions of patenting & commercialization strategies

### **Unit III**

#### **Bio markets and Marketing**

##### **4 lectures**

Negotiating the road from lab to the market, strategies and processes of negotiation with financiers, government and regulatory authorities, Pricing strategy, market development expansion, Ansoff Matrix, market development tools and concepts, PTM matrix

## Unit IV

### Finance and accounting

#### 4 lectures

Basic contract principles, different types of agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills. Business plan preparation including statutory and legal requirements, Business feasibility study, Collaborations & partnership, Information technology

## Unit V

### Technology management

#### 8 lectures

Quality control & transfer of foreign technologies, Knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures of Central Drugs Standard Control Organisation (CDSCO), differences between Good Laboratory Practice (GLP) regulations, Good Clinical Practice (GCP), and Good Manufacturing Practice (GMP) regulations.

#### Recommended Textbooks and References

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.

<u>Course Outcome</u>	<b>Bioentrepreneurship</b>
<u>CO1</u>	The students will be able to gain 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.
<u>CO2</u>	The students will be able to learn 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.

<u>CO3</u>	Students should be able to gain entrepreneurial skills, 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. The knowledge pertaining to management should also help students to be able to build up a strong network within the industry.
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Program Matrix

	<u>PO1</u>	<u>PO2</u>	<u>PO3</u>	<u>PO4</u>	<u>PO5</u>	<u>PO6</u>		<u>PSO1</u>	<u>PSO2</u>	<u>PSO3</u>	<u>PSO4</u>	<u>PSO5</u>	<u>PSO6</u>
<u>CO1</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>3</u>		<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>1</u>
<u>CO2</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>1</u>		<u>2</u>	<u>3</u>	<u>3</u>	<u>2</u>	<u>3</u>	<u>3</u>
<u>CO3</u>	<u>1</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>2</u>		<u>1</u>	<u>1</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>3</u>

### **Intellectual Property Rights, Biosafety and Bioethics (MBT305T) core-5**

#### **Credits-2**

#### **Course Objectives**

The objectives of this course are:

- 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.

#### **Student Learning Outcomes On completion of this course, students should be able to:**

- Understand the rationale for and against IPR and especially patents;
- Understand why India has adopted an IPR Policy and be familiar with broad outline of patent regulations
- 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
- 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;
- Understand ethical aspects related to biological, biomedical, health care and biotechnology research

#### **Unit I Introduction of IPR**

#### **5 lectures**

Introduction to intellectual property; 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; 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

## **Unit II Patenting**

### **5 lectures**

databases - country-wise patent searches (USPTO, India); analysis and report formation. Basics of patents: types of patents; History about patent; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; types of patent applications: provisional and complete specifications; PCT and conventional patent applications; 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; international patenting-requirement, 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**

#### **5 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; recommender 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 cis genic plants or products derived from RNAi, genome editing tools.

## **Unit IV National and international regulations**

### **5 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 labeling – Food Safety and Standards Authority of India (FSSAI).

## **Unit V Bioethics**

### **5 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

**Recommended Textbooks and References:**

1. Ganguli,P.(2001).IntellectualPropertyRights:UnleashingtheKnowledgeEconomy. New Delhi: Tata McGraw-Hill Pub.
2. NationalIPRPolicy,Department of IndustrialPolicy&Promotion,Ministryof Commerce,GoI
3. CompleteReferencetoIntellectualPropertyRightsLaws.(2007). Snow White PublicationOct.
4. Kuhse,H.(2010).Bioethics:anAnthology.Malden,MA:Blackwell.
5. OfficeoftheControllerGeneralofPatents,Design&Trademarks;Departmentof Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India.<http://www.ipindia.nic.in/>
6. KarenF.GreifandJonF.Merz,CurrentControversiesintheBiologicalSciences -Case Studies of Policy Challenges from New Technologies, MIT Press
7. World Trade Organisation.<http://www.wto.org>
8. World Intellectual Property Organisation.<http://www.wipo.int>
9. International Union for the Protection of New Varieties ofPlants. <http://www.upov.int>
10. National Portal of India.<http://www.archive.india.gov.in>
11. National Biodiversity Authority.<http://www.nbaindia.org>
12. RecombinantDNASafetyGuidelines,1990DepartmentofBiotechnology,Ministry ofScienceandTechnology,Govt.ofIndia.Retrievedfrom<http://www.envfor.nic.in/divisions/csurv/geac/annex-5.pdf>
13. Wolt,J.D.,Keese,P.,Raybould,A.,Fitzpatrick,J.W.,Burachik,M.,Gray,A.,Wu, F.(2009).ProblemFormulationintheEnvironmentalRiskAssessmentforGeneticallyModifiedPlants. TransgenicResearch,19(3),425-436.doi:10.1007/s11248-009-9321-9
14. Craig, W.,Tepfer,M.,Degrassi,G.,&Ripandelli,D.(2008).AnOverviewofGeneral FeaturesofRiskAssessmentsofGeneticallyModifiedCrops.Euphytica, 164(3), 853-880. doi:10.1007/s10681-007-9643-8

<b>Course Outcome</b>	<b>Intellectual Property Rights, Biosafety and Bioethics</b>
<u>CO1</u>	The students have learnt basic knowledge on intellectual property rights and their implications in biological research and product development and familiar with India’s IPR Policy.
<u>CO2</u>	Student should have learnt biosafety and risk assessment of products derived from biotechnology and regulation of such products, to become familiar with ethical issues in biological research.



<u>CO3</u>	The students should have gain understanding of ethical issues that must be considered during statistical analyses of biological data. Students will be able to work in team to analyse the data of biological, medical and agricultural field. The students will be able to analyse the biological data of real world by keep updating themselves on new statistical tools.
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### **Program Matrix**

	<u>PO1</u>	<u>PO2</u>	<u>PO3</u>	<u>PO4</u>	<u>PO5</u>	<u>PO6</u>		<u>PSO1</u>	<u>PSO2</u>	<u>PSO3</u>	<u>PSO4</u>	<u>PSO5</u>	<u>PSO6</u>
<u>CO1</u>	<u>3</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>3</u>		<u>2</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>1</u>
<u>CO2</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>		<u>2</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>1</u>
<u>CO3</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>		<u>2</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>2</u>

## **Project Proposal Preparation & Presentation (MBT 307T) Core-7 Credits-2**

### **Course Objectives**

The purpose of this course is to help students organize ideas, material and objectives for their dissertation and to begin development of communication skills and to prepare the students to present their topic of research and explain its importance to their fellow classmates and teachers.

### **Student Learning Outcomes Students should be able to demonstrate the following abilities:**

- Formulate a scientific question;
- Present scientific approach to solve the problem
- Interpret, discuss and communicate scientific results in written form;
- Gain experience in writing a scientific proposal
- Learn how to present and explain their research findings to the audience effectively.

### **Syllabus**

#### **Project Proposal Preparation**

Selection of research lab and research topic: Students should first select a lab wherein they would like to pursue their dissertation. The supervisor or senior researchers should be able to help the students to read papers in the areas of interest of the lab and help them select a topic for their project. The topic of the research should be hypothesis driven.

Review of literature: Students should engage in systematic and critical review of appropriate and relevant information sources and appropriately apply qualitative and/or quantitative evaluation processes to original data; keeping in mind ethical standards of conduct in the collection and evaluation of data and other resources.

Writing Research Proposal: With the help of the senior researchers, students should be able to discuss the research questions, goals, approach, methodology, data collection, *etc.* Students should be able to construct a logical outline for the project including analysis steps and expected outcomes and prepare a complete proposal in scientific proposal Format for dissertation.

## Syllabus

### Poster Presentation

Students will have to present the topic of their project proposal after few months of their selection of the topic. They should be able to explain the novelty and importance of their research topic.

## Syllabus

### Oral Presentation

At the end of their project, presentation will have to be given by the students to explain work done by them in detail. Along with summarizing their findings they should also be able to discuss the future expected outcome of their work.

<u>Course Outcome</u>	<b>Project Proposal Preparation &amp; Presentation</b>
<u>CO1</u>	The students should have able to organize ideas, material and objectives for their dissertation and to begin development of communication skills and to prepare the students to present their topic of research and explain its importance to their fellow classmates and teachers.
<u>CO2</u>	The students should have able to formulate a scientific question. Present scientific approach to solve the problem, discuss and communicate scientific results in written form, Gain experience in writing a scientific proposal.
<u>CO3</u>	The students should have well informed to how to present and explain their research findings to the audience effectively.

### Program Matrix

	<u>PO1</u>	<u>PO2</u>	<u>PO3</u>	<u>PO4</u>	<u>PO5</u>	<u>PO6</u>		<u>PSO1</u>	<u>PSO2</u>	<u>PSO3</u>	<u>PSO4</u>	<u>PSO5</u>	<u>PSO6</u>
<u>CO1</u>	<u>2</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>1</u>		<u>2</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>2</u>
<u>CO2</u>	<u>2</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>1</u>		<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>
<u>CO3</u>	<u>2</u>	<u>1</u>	<u>3</u>	<u>2</u>	<u>1</u>	<u>1</u>		<u>2</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>2</u>

## Laboratory VII: Bioinformatics

### Credits

#### Course Objectives

The aim of this course is to provide practical training in bioinformatics methods including accessing major public sequence databases, use of different computational tools to find sequences, analysis of protein and nucleic acid sequences by various software packages.

**Student Learning Outcomes On completion of this course, students should be able to:**

- Describe contents and properties of most important bioinformatics databases;
- Perform text- and sequence-based searches and analyze and discuss results in light of molecular biological knowledge;
- Explain major steps in pairwise and multiple sequence alignment, explain principle and execute pairwise sequence alignment by dynamic programming;
- Predict secondary and tertiary structures of protein sequences.

**Syllabus**

1. Using NCBI and Uniprot web resources.
2. Introduction and use of various genome databases.
3. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/ TrEMBL, UniProt.
4. Similarity searches using tools like BLAST and interpretation of results.
5. Multiple sequence alignment using Clustal.
6. Phylogenetic analysis of protein and nucleotide sequences.
7. Use of gene prediction methods (GRAIL, Genscan, Glimmer).
8. Use of various primer designing and restriction site prediction tools.
9. Use of different protein structure prediction resources
10. Construction and study of protein structures using Deepview/ PyMol.
11. Homology modelling of protein.

Course Outcome	Statistics in Biological Research (BTUFTT1) CREDITS: 3
<u>CO1</u>	The students should have gain basic and advanced The aim of this course is to provide practical training in bioinformatics methods including accessing major public sequence databases, use of different computational tools to find sequences, analysis of protein and nucleic acid sequences by various software packages.
<u>CO2</u>	The students would have abled to analyse describe contents and properties of most important bioinformatics databases. Perform text- and sequence-based searches and analyse and discuss results in light of molecular biological knowledge
<u>CO3</u>	The students should have educated major steps in pairwise and multiple sequence alignment explain principle and execute pairwise sequence alignment by dynamic programming. Predict secondary and tertiary structures of protein sequences

Program Matrix

	<u>PO1</u>	<u>PO2</u>	<u>PO3</u>	<u>PO4</u>	<u>PO5</u>	<u>PO6</u>		<u>PSO1</u>	<u>PSO2</u>	<u>PSO3</u>	<u>PSO4</u>	<u>PSO5</u>	<u>PSO6</u>
<u>CO1</u>	<u>2</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>		<u>3</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>3</u>
<u>CO2</u>	<u>2</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>		<u>3</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>2</u>
<u>CO3</u>	<u>2</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>		<u>3</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>2</u>

**Semester Four**  
**Dissertation**  
**Credits 24**

**Course Objectives**

The objectives of this course are to prepare the students to adapt to the research environment and understand how projects are executed in a research laboratory. It will also enable students to learn practical aspects of research and train students in the art of analysis and thesis writing.

**Student Learning Outcomes**

Students should be able to learn how to select and defend a topic of their research, how to effectively plan, execute, evaluate and discuss their experiments. Students should be able to demonstrate considerable improvement in the following areas:

- In-depth knowledge of the chosen area of research.
- Capability to critically and systematically integrate knowledge to identify issues that must be addressed within framework of specific thesis.
- Competence in research design and planning.
- Capability to create, analyse and critically evaluate different technical solutions.
- Ability to conduct research independently.
- Ability to perform analytical techniques/experimental methods.
- Project management skills.
- Report writing skills.
- Problem solving skills.
- Communication and interpersonal skills.

**Syllabus**

**Planning & performing experiments**

Based on the project proposal submitted in earlier semester, students should be able to plan, and engage in, an independent and sustained critical investigation and evaluate a chosen research topic relevant to biological sciences and society. They should be able to systematically identify relevant theory and concepts, relate these to appropriate methodologies and evidence, apply appropriate techniques and draw appropriate conclusions. Senior researchers should be able to train the students such that they can work independently and are able to understand the aim of each experiment performed by them. They should also be able to understand the possible outcomes of each experiment.

**Syllabus**

**Thesis writing**

At the end of their project, thesis has to be written giving all the details such as aim, methodology, results, discussion and future work related to their project. Students may aim to get their research findings published in a peer-reviewed journal. If the research findings have application-oriented outcomes, the students may file patent application.

<u>Course Outcome</u>	<b>Dissertation</b>
<u>CO1</u>	The students should have educated to adapt to the research environment and understand how projects are executed in a research laboratory. It will also enable students to learn practical aspects of research and train students in the art of analysis and thesis writing.
<u>CO2</u>	The students will be able to Students should be able to learn how to select and defend a topic of their research, how to effectively plan, execute, evaluate and discuss their experiments.
<u>CO3</u>	Students should have In-depth knowledge of the chosen area of research as well as have capability to create, analyse and critically evaluate different technical solutions, ability to conduct research independently to perform analytical techniques/experimental methods. The student should have skilled in project management skills, report writing skills, Problem solving skills, communication and interpersonal skills

Program Matrix

	<u>PO1</u>	<u>PO2</u>	<u>PO3</u>	<u>PO4</u>	<u>PO5</u>	<u>PO6</u>		<u>PSO1</u>	<u>PSO2</u>	<u>PSO3</u>	<u>PSO4</u>	<u>PSO5</u>	<u>PSO6</u>
<u>CO1</u>	<u>3</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>2</u>		<u>1</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>2</u>
<u>CO2</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>2</u>		<u>1</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>2</u>
<u>CO3</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>2</u>		<u>1</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>2</u>

## **Recommended Electives**

### **Biological Imaging**

#### **Course Objectives**

The objectives of this course are to provide complete overview of state-of-art live-cell imaging techniques using microscopes currently available in literature .Live- cell imaging techniques allow real-time examination of almost every aspect of cellular function under normal and experimental conditions. With live-cell imaging experiments, main challenges are to keep cells alive and healthy over a period of time. The growing number of live-cell imaging techniques means one can obtain greater amounts of information without stressing out cells.

#### **Student Learning Outcomes**

On completion of this course, students shall be able to gain a complete overview of super-resolution field from fundamentals to state-of-art methods and applications in biomedical research. The students shall learn the comparative advantages and disadvantages of each technique, covers all key techniques in field of biomedical science. The students shall also learn how to use new tools to increase resolution in sub-nanometer-scale images of living cells and tissue, which leads to new information about molecules, pathways and dynamics and state-of-the art examples of applications using microscopes.

## **Unit I**

### **Widefield fluorescent microscopy**

### **3 lectures**

One of the most basic techniques for live-cell imaging is wide field fluorescent microscopy. Standard inverted research grade microscopes can yield valuable results if you are imaging adherent cells, large regions of interest (such as organelles) or very thin tissue sections (less than 5 micrometer). In wide field, a CCD camera is usually used to capture images and the epi-fluorescence illumination source can be a mercury lamp, xenon lamp, LED's, etc. Each of light sources require carefully matched interference filters for specific excitation and emission wavelengths of your fluorophore of interest. With wide field microscopy, your specimen is only exposed to excitation light for relatively short time periods as the full aperture of emission light is collected by the objectives. Wide field fluorescence microscopy can be used in combination with other Common contrast techniques such as phase contrast and differential interference contract (DIC) microscopy. This combination is useful when performing live-cell imaging to examine general cell morphology or viability while also imaging regions of interest within cells.

## **Unit II**

### **Confocal laser scanning microscopy (CLSM)**

#### **3 lectures**

CLSM has ability to eliminate out-of-focus light and information. It is also possible to obtain optical serial sections from thicker specimens. A conjugate pinhole in optical path of confocal microscope prevents fluorescence from outside of focal plane from being collected by photomultiplier detector or imaged by camera. In CLSM, a single pinhole (and single focused laser spot) is scanned across specimen by scanning system. This spot forms a reflected epi-fluorescence image back on original pinhole. When specimen is in focus, fluorescent light from it passes through pinhole to detector. Any out-of-focus light is defocused at pinhole and very little of this signal passes through to detector meaning that background fluorescence is greatly reduced. The pinhole acts as a spatial filter for emission light from the specimen.

## **Unit III**

### **Spinning disc confocal microscopy (SDCM)**

#### **2 lectures**

This method utilises a 'Nipkow Disc' which is a mechanical opaque disc which has a series of thousands of drilled or etched pin holes arranged in spiral pattern. Each illuminated pinhole on disc is imaged by microscope objective to a diffraction-limited spot on region of interest on specimen. The emission from fluorophores passes back through Nipkow disc pinholes and can be observed and captured by a CCD camera. The effect of spinning disc is that many thousands of points on specimen are simultaneously illuminated. Using SDCM to examine a specimen means that real-time imaging (30-frames-per-second or faster) can be achieved, which is extremely use full if you are looking at dynamic changes within living cells over a wide spectrum of time-scales.

## **Unit IV**

### **Light-sheet fluorescence microscopy (LSFM, or SPIM)**

#### **2 lectures**

This method enables one to perform live- cell imaging on whole embryos, tissues and cells periods in vivo in a gentle manner with high temporal resolution and in three dimensions. One is able to track cell movement over extended periods of time and follow development of organs and tissues on a cellular level. The next evolution of light-sheet fluorescence microscopy, termed lattice light-sheet microscopy as developed by Eric Betzig (Nobel Prize Laureate 2014 for PALM super-resolution microscopy) will even allow live-cell imaging with super-resolved in vivo cellular localization capabilities.

## Unit V

### Super-resolved fluorescence microscopy

#### 8 lectures

Super-Resolution in a Standard Microscope: From Fast Fluorescence Imaging to Molecular Diffusion Laws in Live Cells; Photoswitching Fluorophores in Super- Resolution Fluorescence Microscopy; Image Analysis for Single-Molecule Localization Microscopy Deconvolution of Nanoscopic Images; Super-Resolution Fluorescence Microscopy of the Nanoscale Organization in cells; Correlative Live-Cell and Super- Resolution Microscopy and Its Biological Applications; SAX Microscopy and Its Application to Imaging of 3D-Cultured Cells; Quantitative Super-Resolution Microscopy for Cancer Biology and Medicine.

## Unit VI

### Re-scan confocal microscopy

#### 4 lectures

Structured Illumination Microscopy; Correlative Nanoscopy: AFM Super-Resolution (STED/STORM) ; Stochastic Optical Fluctuation Imaging.

### Recommended Textbooks and References:

1. RajagopalVadivambal,DigvirS.Jayas.(2015).Bio-Imaging:Principles,Techniques, and Applications. ISBN 9781466593671 -CAT#K20618.
2. AlbertoDiaspro,MarcA.M.J.vanZandvoort.(2016).Super-ResolutionImagingin Biomedicine. ISBN 9781482244342 -CAT#K23483.
3. Taatjes,Douglas,Roth,Jürgen(Eds.).(2012).CellImagingTechniquesMethodsand Protocols. ISBN978-1-62703-056-4.

Course Outcome	Biological Imaging
<u>CO1</u>	The students should have well informed to provide complete overview of state-of-art live-cell imaging techniques using microscopes currently available in literature. Live- cell imaging techniques allow real-time examination of almost every aspect of cellular function under normal and experimental conditions.
<u>CO2</u>	Students should have skilled with live-cell imaging experiments, main challenges are to keep cells alive and healthy over a period of time. The growing number of live-cell imaging techniques means one can obtain greater amounts of information without stressing out cells.

<u>CO3</u>	The students should have learnt how to use new tools to increase resolution in sub-nanometer-scale images of living cells and tissue, which leads to new information about molecules, pathways and dynamics and state-of-the art examples of applications using microscopes.
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Program Matrix

	<u>PO1</u>	<u>PO2</u>	<u>PO3</u>	<u>PO4</u>	<u>PO5</u>	<u>PO6</u>		<u>PSO1</u>	<u>PSO2</u>	<u>PSO3</u>	<u>PSO4</u>	<u>PSO5</u>	<u>PSO6</u>
<u>CO1</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>2</u>		<u>2</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>1</u>
<u>CO2</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>2</u>		<u>2</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>1</u>
<u>CO3</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>2</u>		<u>2</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>1</u>

### **Computational Biology (MBT 309 T) Elective**

**Credits-2**

#### **Course Objectives**

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.

**Student Learning Outcomes** On completion of this course, the students are expected to:

- Develop an understanding of the basic theory of these computational tools;
- Develop required database extraction, integration, coding for computational tools and methods necessary for all Omics;
- Create hypothesis for investigating specific contemporary biological questions, provide help to experiment with or develop appropriate tools;
- Critically analyze and interpret results of their study with respect to whole systems.

#### **Unit I**

##### **Introduction to computational biology basics and biological databases**

**4 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**

**5 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 subdatabases; Visualization tools including Artemis and VISTA for genome comparison; Functional genomics case studies.

#### **Unit IV**

##### **Structure visualization**

###### **3 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 through put 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.

#### **Recommended Textbooks and References:**

1. Mount, D.W. (2001). *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

- Bourne, P.E., & Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss.
- Lesk, A.M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press.
- Campbell, M. & Heyer, L.J. (2006). Discovering Genomics, Proteomics and Bioinformatics, Pearson Education.
- Oprea, T. (2005). Chemoinformatics in Drug Discovery, Volume 23. Wiley Online Library.
- Gasteiger, J. & Engel, T. (2003). Chemoinformatics: a Textbook, Wiley Online Library.

<b>Course Outcome</b>	<b>Computational Biology</b>
<b>CO1</b>	The students should be able to gain theory and practical experience of essentials to aid for genomic, proteomic and metabolomics courses and drug design program.
<b>CO2</b>	The students have learnt of the basic theory of various computational tools and develop required database extraction, integration, coding for computational tools and methods necessary for all Omics;
<b>CO3</b>	Student would be able to Create hypothesis for investigating specific contemporary biological questions, provide help to experiment with or develop appropriate tools; Critically analyse and interpret results of their study with respect to whole systems.

#### **Program Matrix**

	<u>PO 1</u>	<u>PO 2</u>	<u>PO 3</u>	<u>PO 4</u>	<u>PO 5</u>	<u>PO 6</u>	<u>PSO 1</u>	<u>PSO 2</u>	<u>PSO 3</u>	<u>PSO 4</u>	<u>PSO 5</u>	<u>PSO 6</u>
<u>CO 1</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>
<u>CO 2</u>	<u>2</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>
<u>CO 3</u>	<u>3</u>	<u>1</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>2</u>

### **Drug Discovery and Development (MBT 310 T) Elective Credits-2**

#### **Course Objectives**

This course will give a broad overview of research and development carried out in industrial setup towards drug discovery.

#### **Student Learning Outcomes**

On completion of this course, students should be able to understand basics of R&D in drug

discovery and should be able to apply knowledge gained in respective fields of pharmaceutical industry.

## **Unit I**

### **Target identification and molecular modelling**

#### **7 lectures**

Identification of target or drug leads associated with a particular disease by a number of different techniques including combinations of molecular modeling, combinatorial libraries and high-throughput screening (HTS); Conceptualizing the automation of the HTS process and the importance of bioinformatics and data processing in identification of lead compounds; Rational drug design, based on understanding the three-dimensional

## **Unit II**

### **Lead optimization**

#### **5 lectures**

structures and physicochemical properties of drugs and receptors; Modelling drug/ receptor interactions with the emphasis on molecular mechanisms, molecular dynamics simulations and homology modelling; Conformational sampling, macromolecular folding, structural bioinformatics, receptor-based and ligand-based design and docking methods, in silico screening of libraries, semi-empirical and ab-initio methods, QSAR methods, molecular diversity, design of combinatorial libraries of drug-like molecules, macromolecular and chemical databases.

Identification of relevant groups on a molecule that interact with a receptor and are responsible for biological activity; Understanding structure activity relationship; Structure modification to increase potency and therapeutic index; Concept of quantitative drug design using Quantitative structure–activity relationship models (QSAR models) based on the fact that the biological properties of a compound are a function of its physicochemical parameters such as solubility, lipophilicity, electronic effects, ionization, stereochemistry, etc.; Bioanalytical assay development in support of in vitro and in vivo studies (LC/MS/MS, GC/MS and ELISA).

## **Unit III**

### **Preclinical development**

#### **5 lectures**

Principles of drug absorption, drug metabolism and distribution - intestinal absorption, metabolic stability, drug-drug interactions, plasma protein binding assays, metabolite profile studies, Principles of toxicology, Experimental design for preclinical and clinical PK/PD/TK studies, Selection of animal model; Regulatory guidelines for preclinical PK/PD/TK studies; Scope of GLP, SOP for conduct of clinical & non-clinical testing, control on animal house, report preparation and documentation Integration of non-clinical and preclinical data to aid design of clinical studies.

## **Unit IV**

### **Drug manufacturing**

#### 4 lectures

Requirements of GMP implementation, Documentation of GMP practices, CoA, Regulatory certification of GMP, Quality control and Quality assurance, concept and philosophy of TQM, ICH and ISO 9000; ICH guidelines for Manufacturing, Understanding Impurity Qualification Data, Stability Studies

#### Unit V

##### Clinical trial design

#### 4 lectures

Objectives of Phase I, II, III and IV clinical studies, Clinical study design, enrollment, sites and documentation, Clinical safety studies: Adverse events and adverse drug reactions, Clinical PK, pharmacology, drug-drug interaction studies, Statistical analysis and documentation.

#### Unit VI

##### Fundamentals of regulatory affairs and bioethics

#### 4 lectures

Global Regulatory Affairs and different steps involved, Regulatory Objectives, Regulatory Agencies; FDA guidelines on IND and NDA submissions, Studies required for IND and NDA submissions for oncology, HIV, cardiovascular indications, On-label vs. off-label drug use GCP and Requirements of GCP Compliance, Ethical issues and Compliance to current ethical guidelines, Ethical Committees and their set up, Animal Ethical issues and compliance.

#### Recommended Textbooks and References:

1. Krogsgaard-Larsen et al. Textbook of Drug Design and Discovery. 4th Edition. CRC Press.
2. Kuhse, H. (2010). Bioethics: an Anthology. Malden, MA: Blackwell.
3. Nally, J. D. (2006) GMP for Pharmaceuticals. 6th edition. CRC Press
4. Brody, T. (2016) Clinical Trials: Study Design, Endpoints and Biomarkers, Drug Safety, and FDA and ICH Guidelines. Academic Press.

<b>Course Outcome</b>	<b>Drug Discovery and Development</b>
<b>CO1</b>	The students should have knowledge overview of research and development carried out in drug discovery.
<b>CO2</b>	The students should have knowledge in industrial setup towards drug discovery.
<b>CO3</b>	The students should be able to understand basics of R&D in drug discovery and should be able to apply knowledge gained in respective fields of pharmaceutical industry.

#### Program Matrix

	<b>PO</b>	<b>PO</b>	<b>PO</b>	<b>PO</b>	<b>PO</b>	<b>PO</b>	<b>PSO</b>	<b>PSO</b>	<b>PSO</b>	<b>PSO</b>	<b>PSO</b>	<b>PSO</b>
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	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
<u>CO</u> <u>1</u>	<u>3</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>2</u>		<u>2</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>3</u>
<u>CO</u> <u>2</u>	<u>3</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>1</u>		<u>2</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>3</u>
<u>CO</u> <u>3</u>	<u>3</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>2</u>		<u>3</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>3</u>

## **Environmental Biotechnology (MBT 310 T) Elective**

### **Credits-2**

#### **Course Objectives**

This course aims to introduce fundamentals of Environmental Biotechnology. The course will introduce major groups of microorganisms-tools in biotechnology and their most important environmental applications. The environmental applications of biotechnology will be presented in detail and will be supported by examples from the national and international literature.

#### **Student Learning Outcomes**

On completion of course, students will be able to understand use of basic microbiological, molecular and analytical methods, which are extensively used in environmental biotechnology.

#### **Unit I**

##### **Introduction to environment**

##### **6 lectures**

Introduction to environment; Pollution:air, water, soil, noise; pollution indicators; Climate change, Biodiversity and its conservation; bio geochemical cycles; microbial ecology.

#### **Unit II**

##### **Waste Management**

##### **8 lectures**

Waste management: domestic, industrial, and hazardous wastes (storage, transportation, treatment and disposal); solid waste management, wastewater characteristics and treatment, treatment strategies for effluent generated by distillery, paper and pulp industries, textile industries; waste to energy, recycling and reuse.

#### **Unit III**

##### **Bioremediation**

##### **8 lectures**

Bioremediation: Fundamentals, technological aspects and strategies, bioremediation of metals, radionuclides, organicpollutants/xenobiotic; Application of bacteria and fungi in

bioremediation; Phytoremediation: Fundamentals and description of major methods of application (phytoaccumulation, phytovolatilization, rhizofiltration, phytostabilization).

#### **Unit IV**

#### **Biotechnology and agriculture**

#### **11 lectures**

Biopesticides, Bioinsecticides, Biofungicides, Bioherbicides: genetic modifications, mode of actions; Biofertilizers: Symbiotic systems between plants–microorganisms, Plant growth promoting rhizobacteria (PGPR) – uses, practical aspects and problems in application.

#### **Unit V**

#### **Biofuels**

#### **8 lectures**

Biofuels: production of biogas; bioethanol; biodiesel; Utilizable biomass, microorganisms and biotechnological interventions for optimization of production, Microbial Fuel Cells, Microbiologically enhanced oil recovery (MEOR); Bioleaching of metals; Bioplastic.

#### **Recommended Textbooks and References:**

1. G.M.Evans and J.C.Furlong (2003), Environmental Biotechnology: Theory and Applications, Wiley Publishers.
2. B.Ritmann and P.L.McCarty, (2000), Environmental Biotechnology: Principle & Applications, 2nd Ed., McGraw Hill Science.
3. Scragg A., (2005) Environmental Biotechnology. Pearson Education Limited.
4. J.S.Devinny, M.A.Deshusses and T.S.Webster, (1998), Biofiltration for Air Pollution Control, CRC Press.
5. H.J.Rehman and G.Reed, (2001), Biotechnology – A Multi-volume Comprehensive Treatise, Vol. 11, 2nd Ed., VCH Publishers Inc.
6. H.S.Peavy, D.R.Rowe and G.Tchobanoglous, (2013), Environmental Engineering, McGraw-Hill Inc.

<b><u>Course Outcome</u></b>	<b>Environmental Biotechnology</b>
<b><u>CO1</u></b>	The students should have knowledge fundamentals of Environmental Biotechnology. The course will introduce major groups of microorganisms-tools in biotechnology and their most important environmental applications.
<b><u>CO2</u></b>	The students should be able to well known in environmental applications of biotechnology will be presented in detail and will be supported by examples from the national and international literature.

<b><u>CO3</u></b>	The students should be able to understand use of basic microbiological, molecular and analytical methods, which are extensively used in environmental biotechnology.
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#### **Program Matrix**

	<u>PO</u> <u>1</u>	<u>PO</u> <u>2</u>	<u>PO</u> <u>3</u>	<u>PO</u> <u>4</u>	<u>PO</u> <u>5</u>	<u>PO</u> <u>6</u>	<u>PSO</u> <u>1</u>	<u>PSO</u> <u>2</u>	<u>PSO</u> <u>3</u>	<u>PSO</u> <u>4</u>	<u>PSO</u> <u>5</u>	<u>PSO</u> <u>6</u>
<u>CO</u> <u>1</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>2</u>	<u>1</u>
<u>CO</u> <u>2</u>	<u>3</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>1</u>	<u>1</u>
<u>CO</u> <u>3</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>2</u>	<u>1</u>

### **Microbial Technology (MBT 308T) Elective Credits-2**

#### **Course Objectives**

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.

#### **Student Learning Outcomes**

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

#### **Unit I**

##### **Introduction to microbial technology**

##### **8 lectures**

Microbial technology in human welfare; Isolation and screening of microbes important for industry; extremophiles: halophiles, thermophiles, psychrophiles as source of industrially important products, advantages of microbial technology

#### **Unit II**

##### **Environmental applications of microbial technology**

##### **6 lectures**

Environmental application of microbes; bioleaching; Biodegradation; 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**

##### **8 lectures**

Microbial products in pharmaceutical industry, Recombinant protein and pharmaceuticals production in microbes; Antibiotics and enzymes production, Microbial cell factories;

Downstream processing approaches used in industrial production process, microbes in targeted delivery application – drugs and vaccines (bacterial and viral vectors)

#### **Unit IV**

#### **Food applications of microbial technology**

**7 lectures**

Application of microbes and microbial processes in food, food preservation, Non-recombinant ways of introducing desirable properties in Generally recognized as safe (GRAS); microbes to be used in food (e.g., Yeast), fermented food products (beverages and dairy products), genetically modified foods.

#### **Unit V**

#### **Advances in microbial technology**

**8 lectures**

Microbial genomics for discovery of novel enzymes, drugs/ antibiotics; Metagenomics and metatranscriptomics, metagenomic library construction and functional screening in suitable hosts, Advanced genome and epigenome editing tools

#### **Recommended Textbooks and References:**

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.
5. Journals: (a) Nature, (b) Nature Biotechnology, (c) Applied microbiology and biotechnology, (d) Trends in Biotechnology, (e) Trends in Microbiology, (f) Current opinion in Microbiology, (g) Biotechnology Advances, (h) Genome Research
6. Websites: <http://jgi.doe.gov/our-science/>

<b><u>Course Outcome</u></b>	<b>Microbial Technology</b>
<b><u>CO1</u></b>	The students should have learn advances made in field of microbial technology for use in human welfare and solving problems of the society.
<b><u>CO2</u></b>	The students have developed advances made in field of microbial technology for use in human welfare.
<b><u>CO3</u></b>	The students should be skill to develop deeper understanding of the microbial technology and its applications.



### Program Matrix

	<u>PO</u> <u>1</u>	<u>PO</u> <u>2</u>	<u>PO</u> <u>3</u>	<u>PO</u> <u>4</u>	<u>PO</u> <u>5</u>	<u>PO</u> <u>6</u>	<u>PSO</u> <u>1</u>	<u>PSO</u> <u>2</u>	<u>PSO</u> <u>3</u>	<u>PSO</u> <u>4</u>	<u>PSO</u> <u>5</u>	<u>PSO</u> <u>6</u>
<u>CO</u> <u>1</u>	<u>3</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>
<u>CO</u> <u>2</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>3</u>	<u>3</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>
<u>CO</u> <u>3</u>	<u>3</u>	<u>2</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>1</u>	<u>1</u>

### Protein Engineering (MBT 312 T) ELECTIVE

Credits - 2

#### Course Objectives

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

#### Student Learning Outcomes

On completion of this course, students should be able to:

- Analyse structure and construction of proteins by computer-based methods;
- Describe structure and classification of proteins;
- Analyse purity and stability of proteins and explain how to store them in best way;
- Explain how proteins can be used for different industrial and academic purposes such as structure determination, organic synthesis and drug design.

#### Unit I

##### Introduction to protein engineering

5 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

5 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**  
**5 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**  
**5 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; Proteindesign, Directed evolution for protein engineering and its potential.

**Unit V**  
**Case studies**  
**1 lecture**  
**Case Studies.**

**Recommended Textbooks and References:**

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.

<b>Course Outcome</b>	<b>Protein Engineering</b>
<b>CO1</b>	The students should have well versed with methods and strategies commonly used in protein engineering.

<b><u>CO2</u></b>	The students should have understand and analyse structure and construction of proteins by computer-based methods. Describe structure and classification of protein. Analyse purity and stability of protein.
<b><u>CO3</u></b>	The students should have learn how proteins can be used for different industrial and academic purposes such as structure determination, organic synthesis and drug design.

### **Program Matrix**

	<b><u>PO</u></b> <b><u>1</u></b>	<b><u>PO</u></b> <b><u>2</u></b>	<b><u>PO</u></b> <b><u>3</u></b>	<b><u>PO</u></b> <b><u>4</u></b>	<b><u>PO</u></b> <b><u>5</u></b>	<b><u>PO</u></b> <b><u>6</u></b>		<b><u>PSO</u></b> <b><u>1</u></b>	<b><u>PSO</u></b> <b><u>2</u></b>	<b><u>PSO</u></b> <b><u>3</u></b>	<b><u>PSO</u></b> <b><u>4</u></b>	<b><u>PSO</u></b> <b><u>5</u></b>	<b><u>PSO</u></b> <b><u>6</u></b>
<b><u>CO</u></b> <b><u>1</u></b>	<b><u>3</u></b>	<b><u>1</u></b>	<b><u>1</u></b>	<b><u>1</u></b>	<b><u>1</u></b>	<b><u>1</u></b>		<b><u>3</u></b>	<b><u>1</u></b>	<b><u>1</u></b>	<b><u>1</u></b>	<b><u>1</u></b>	<b><u>3</u></b>
<b><u>CO</u></b> <b><u>2</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>1</u></b>	<b><u>1</u></b>	<b><u>1</u></b>		<b><u>2</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	<b><u>1</u></b>	<b><u>1</u></b>	<b><u>3</u></b>
<b><u>CO</u></b> <b><u>3</u></b>	<b><u>1</u></b>	<b><u>1</u></b>	<b><u>1</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>2</u></b>		<b><u>1</u></b>	<b><u>1</u></b>	<b><u>1</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>3</u></b>

### **Vaccines ( MBT 311 T ) ELECTIVE**

**Credits -2**

#### **Course Objectives**

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

#### **Student Learning Outcomes Bytheendofthiscourse,students should be ableto:**

- Understand fundamental concepts of human immune system and basic immunology;
- Differentiateandunderstandimmuneresponses in relation to infection and vaccination;
- Understand requirement and designing of different typesofvaccines;
- Understand importance of conventional and new emerging vaccinetchnologies.

#### **Unit I**

##### **Fundamentals of immune system**

**6 lectures**

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 and Cancer**

**9 lectures**

Protective immune response in Infections (bacterial; viral and parasitic infections;) and Cancer. Antigen presenting cells: Dendritic cells in immune response; Cell mediated responses: T cell, B Cell, DC, NK: Memory and effector T and B cells, Generation and Maintenance of memory T and B cells.

**Unit III**

**Immune response to vaccination**

**8 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,LiposomalandMicroparticlesasdelivery systems; Chemokines and cytokines; Role of soluble mediators in vaccination; Oral immunization and Mucosal Immunity.

**Unit IV**

**Vaccine types & design**

**3 lectures**

History of vaccines, Conventional vaccines; Bacterialvaccines; ViralVaccines; Vaccines based on routes of administration: parenteral, oral, mucosal; Live attenuated and inactivated vaccine; Subunit Vaccines and Toxoids; PeptideVaccine.

**Unit V**

**Vaccine technologies**

**4 lectures**

New Vaccine Technologies; Rationally designed Vaccines; DNA Vaccination; Mucosal vaccination; New approaches for vaccine delivery; Reverse Vaccinology; Engineering virus vectors for vaccination; Vaccines for targeted delivery (Vaccine Delivery systems); Disease specific vaccine design: Tuberculosis Vaccine; Malaria Vaccine; HIV/AIDS vaccine; New emerging diseases and vaccine needs (Ebola, Zika).

**Recommended Textbooks and References:**

1. Janeway,C.A.,Travers,P.,Walport,M.,&Shlomchik,M.J.(2005).ImmunoBiology: theImmuneSysteminHealthandDisease.USA:GarlandSciencePub.
2. Kindt,T.J.,Osborne,B.A.,Goldsby,R.A.,&Kuby,J.(2013).KubyImmunology. New York: W.H.Freeman.
3. Kaufmann,S.H.(2004).NovelVaccinationStrategies.Weinheim:Wiley-VCH.
4. JournalArticles(relevantissues)from:AnnualReviewofImmunology,Annual ReviewofMicrobiology,CurrentOpinioninImmunology,NatureImmunology, Expert review ofvaccines.

<b>Course Outcome</b>	<b>Vaccines</b>
<b>CO1</b>	The students learn about the basics of vaccines.

<b><u>CO2</u></b>	The students should have understand fundamental concepts of human immune system and basic immunology; Differentiateandunderstandimmuneresponses in relation to infection and vaccination; Understand requirement and designing of different typesofvaccines;
<b><u>CO3</u></b>	Finally, Understand importance of conventional and new emerging vaccine technologies.

#### **Program Matrix**

	<b><u>PO</u></b> <b><u>1</u></b>	<b><u>PO</u></b> <b><u>2</u></b>	<b><u>PO</u></b> <b><u>3</u></b>	<b><u>PO</u></b> <b><u>4</u></b>	<b><u>PO</u></b> <b><u>5</u></b>	<b><u>PO</u></b> <b><u>6</u></b>	<b><u>PSO</u></b> <b><u>1</u></b>	<b><u>PSO</u></b> <b><u>2</u></b>	<b><u>PSO</u></b> <b><u>3</u></b>	<b><u>PSO</u></b> <b><u>4</u></b>	<b><u>PSO</u></b> <b><u>5</u></b>	<b><u>PSO</u></b> <b><u>6</u></b>
<b><u>CO</u></b> <b><u>1</u></b>	<b><u>3</u></b>	3	2	3	2	<b><u>1</u></b>	<b><u>3</u></b>	<b><u>1</u></b>	<b><u>1</u></b>	2	2	3
<b><u>CO</u></b> <b><u>2</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	2	3	2	<b><u>1</u></b>	<b><u>2</u></b>	<b><u>3</u></b>	<b><u>3</u></b>	2	2	3
<b><u>CO</u></b> <b><u>3</u></b>	<b><u>3</u></b>	2	2	3	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>1</u></b>	<b><u>1</u></b>	<b><u>1</u></b>	<b><u>2</u></b>	<b><u>2</u></b>	<b><u>3</u></b>

### **Medical Microbiology and Infection Biology (MBT 313 T) ELECTIVE**

**Credits-2**

#### **Course Objectives**

This course will provide a perspective and exposure to medical aspects of bacteriology, virology, mycology, parasitology and infectious diseases along with concepts of symptoms, pathogenesis, transmission, prophylaxis and control, a conceptual understanding of host – pathogen interactions using well characterized systems as examples. The student should have a good grasp of disease causing microbes and their interactions with host.

#### **Student Learning Outcomes**

On completion of this course, students should be able to:

- Compare and contrast different microbial diseases, including properties of different types of pathogens, and mechanisms of pathogenesis;
- Summarize role of host in infectious disease, including natural barriers to infection, innate and acquired immune responses to infection, and inflammation;
- Compare and contrast experimental approaches for identifying virulence genes and advantages/disadvantages of each approach for specific pathogens.

#### **Unit I**

**Bacterial diseases**

**8 lectures**

Normal microflora (microbiome) of human body and its role – Skin, mouth and respiratory tract, intestinal tract, urogenital tract; Pathogenesis and virulence factors  
- Koch's postulates, Adherence and invasion, Toxins, Enzymes, Antiphagocytic factors, Antigen heterogeneity, Iron acquisition; Bacillus anthracis, Clostridium spp., Corynebacterium diphtheriae; E. coli, Vibrio cholerae, Helicobacter pylori, Salmonella typhi and paratyphi, Shigella dysenteriae; Listeria monocytogenes, Mycobacterium spp., Rickettsial diseases; Haemophilus influenzae, Bordetella pertussis, Brucellosis, Streptococcal and Staphylococcal infections; Antibacterial chemotherapy (with examples of antibiotics) - Inhibition of cell wall synthesis, inhibition of cell membrane function, inhibition of protein and nucleic acid synthesis, antimetabolites; Drug resistance - origin (genetic and non-genetic), mechanisms, antimicrobial activity in vitro and in vivo, Multi-drug resistance and its mechanisms e.g. MDR-TB.

## **Unit II**

### **Viral diseases**

#### **7 lectures**

Viral Pathogenesis - Routes of entry, Viral spread (local and systemic infection), Viral persistence (chronic and latent infection); Polio, Chicken pox, Mumps, Measles, Rubella; Viral hemorrhagic fever, viral encephalitis, Dengue and Yellow fever; Influenza virus infection (emphasis on Avian and swine flu), Rabies and Prion diseases; Hepatitis and Human Cancer viruses; Emerging viral diseases – Ebola, Marburg, SARS, Hanta, Chikungunya, Zika, Chandipura; Antiviral chemotherapy and Viral vaccines; Nucleotide and nucleoside analogs, Reverse transcriptase inhibitor, protease inhibitor, fusion inhibitor etc., Interferons, Killed and attenuated vaccines.

## **Unit III**

### **Fungal and protozoan infections**

#### **7 lectures**

Types of Mycoses (with specific example of causative fungi) – Superficial, Cutaneous, Subcutaneous; Types of Mycoses (with specific example of causative fungi) - Endemic and Opportunistic; Mycotoxins and Antifungal chemotherapy – Mycetismus, Aflatoxins, classes of currently available drugs and new inhibitors in the pipeline; Protozoan diseases - Giardiasis, Amoebiasis; Leishmaniasis, African sleeping sickness; Malaria, Cryptosporidiosis; Infection by Helminths – Nematodes, Trematodes, Cestodes.

## **Unit IV**

### **Sexually transmitted diseases and congenital infections**

#### **6 lectures**

Syphilis and Gonorrhoeal infections; AIDS and Lentiviral infection; Herpes infections; Chlamydial infections (Chlamydia trachomatis); Mycoplasma and Ureaplasma infection; Toxoplasmosis; Congenital viral infections – Cytomegalovirus, Varicella zoster, HBV, Enterovirus, Parvovirus B19 etc.

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**Unit V**  
**Host-pathogen interaction**  
**6 lectures**

Intracellular and extracellular pathogens, Principles of microbial pathogenesis, host damage, inflammatory responses, adaptation strategies of pathogen- impact of host and pathogen metabolism on immunity and pathogen survival; Chronic pathogens and mechanisms of persistence; Evasion mechanisms of pathogens; Bacterial–host interaction- Mycobacterium tuberculosis, Borrelia burgdorferi; Viruses – host interaction: HIV, Influenza; Protozoan – host interaction: Plasmodium spp., Leishmania major.

**Recommended Textbooks and References:**

1. KCCarroll, SAMorse, TMietzner, SMiller. (2016) Jawetz, Melnick and Adelberg's Medical Microbiology 27th edition, McGraw Hill.
2. JOwen, JPunt and Sharon Stranford, (2012), Kuby Immunology; 7th edition, W.H. Freeman and Co.
3. ITKudva, NA.Cornick, PJPlummer, QZhang, TLNicholson, JPBannantine and BH Bellaire. Virulence Mechanisms of Bacterial Pathogens, (2016) 5th edition, ASM Press.
4. VKumar, AK.Abbas and JCAster, (2015), Robbins & Cotran Pathologic Basis of Disease. 9th Edition, Elsevier.
5. KMurphy and KWeaver, (2016), Janeway's Immunobiology, 9th Edition, Garland Science.
6. AKAbbas, (2015), Cellular and Molecular Immunology. 8th Edition, Elsevier.
7. Ananthanarayan and Paniker, Textbook of Microbiology, 8th Edition.
8. Baveja CP, (2001) Textbook of Microbiology. 5th Ed., McGraw Hill Education.

<b>Course Outcome</b>	<b>Medical Microbiology and Infection Biology</b>
<b><u>CO1</u></b>	The students should be able to gain perspective and exposure to medical aspects of bacteriology, virology, mycology, parasitology and infectious diseases along with concepts of symptoms, pathogenesis, transmission, prophylaxis and control, a conceptual understanding of host – pathogen interactions using well characterized systems as examples. The student should have a good grasp of disease causing microbes and their interactions with host.
<b><u>CO2</u></b>	The students understand and are able to compare and contrast different microbial diseases, including properties of different types of pathogens, and mechanisms of pathogenesis;
<b><u>CO3</u></b>	In totality, student should know the role of host in infectious disease, including natural barriers to infection, innate and acquired immune responses to infection, and inflammation; Compare and contrast experimental approaches for identifying virulence genes and advantages/disadvantages of each approach for specific

	pathogens.
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**Program Matrix**

	<u>PO</u> <u>1</u>	<u>PO</u> <u>2</u>	<u>PO</u> <u>3</u>	<u>PO</u> <u>4</u>	<u>PO</u> <u>5</u>	<u>PO</u> <u>6</u>		<u>PSO</u> <u>1</u>	<u>PSO</u> <u>2</u>	<u>PSO</u> <u>3</u>	<u>PSO</u> <u>4</u>	<u>PSO</u> <u>5</u>	<u>PSO</u> <u>6</u>
<u>CO</u> <u>1</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>		<u>3</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>1</u>
<u>CO</u> <u>2</u>	<u>2</u>	<u>3</u>	2	<u>1</u>	2	<u>1</u>		<u>2</u>	<u>3</u>	<u>3</u>	<u>1</u>	<u>1</u>	<u>1</u>
<u>CO</u> <u>3</u>	<u>1</u>	<u>1</u>	<u>1</u>	<u>2</u>	3	<u>2</u>		<u>1</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>1</u>