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(Deemed to be University)

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PIMPRI, PUNE – 411 018

DR. D. Y. PATIL BIOTECHNOLOGY & BIOINFORMATICS INSTITUTE

TATHAWADE, PUNE

SYLLABUS FOR

M. Sc. BIOTECHNOLOGY

2018-19

(As approved by the 44th Meeting of the BOM held on 21st July 2018)

DR. D.Y. PATIL VIDYAPEETH, PUNE
DR. D. Y. PATIL BIOTECHNOLOGY & BIOINFORMATICS INSTITUTE, TATHAWADE, PUNE

COURSE STRUCTURE FOR M. Sc. BIOTECHNOLOGY

SEMESTER ONE		
Course Code	**Course Name**	**Credits**
MSBT101	Biochemistry	3
MSBT102	Cell and Molecular Biology	3
MSBT103	Plant and Animal Biotechnology	3
MSBT104	Microbiology	2
MSBT105	Genetics	2
MSBT106	Basics of Mathematics and Statistics	2
MSBT107	Basics of Chemistry and Physics	2
MSBT108	Laboratory I: Biochemistry and Analytical Techniques	4
MSBT109	Laboratory II: Microbiology	2
MSBT110	Laboratory III: Plant and Animal Biotechnology	2
Total		**25**
SEMESTER TWO		
Course Code	**Course Name**	**Credits**
MSBT201	Genetic Engineering	3
MSBT202	Immunology	3
MSBT203	Bioinformatics	3
MSBT204	Genomics and Proteomics	2
MSBT205	Molecular Diagnostics	2
MSBT206	Research Methodology and Scientific Communication Skills	2
MSBT207	Elective I Nanobiotechnology	2
MSBT208	Elective I Microbial Technology	
MSBT209	Seminar	1
MSBT210	Laboratory IV: Molecular Biology and Genetic Engineering	4
MSBT211	Laboratory V: Immunology	3
Total		**25**
SEMESTER THREE		
Course Code	**Course Name**	**Credits**
MSBT301	Bioprocess Engineering and Technology	3
MSBT302	Emerging Technologies	2
MSBT303	Critical Analysis of Classical Papers	2
MSBT304	Bioentrepreneurship	2
MSBT305	Intellectual Property Rights, Biosafety and Bioethics	2
MSBT306	Project Proposal Preparation and Presentation	2

MSBT307	Seminar	1
MSBT308	Laboratory VI: Bioprocess Engineering and Technology	4
MSBT309	Laboratory VII: Bioinformatics	2
MSBT310	Elective II Biological Imaging	2
MSBT311	Elective II Computational Biology	
MSBT 312	Elective II Drug Discovery and Development	
MSBT313	Elective II Environmental Biotechnology	
MSBT314	Elective II Protein Engineering	
MSBT315	Elective II Vaccines	
	Total	**22**
SEMESTER FOUR		
MSBT401	Dissertation (5 Months)	24
Total		**24**
TOTAL CREDITS		**96**

SEMESTER ONE		
Course Code	**Course Name**	**Credits**
MSBT101	Biochemistry	3
MSBT102	Cell and Molecular Biology	3
MSBT103	Plant and Animal Biotechnology	3
MSBT104	Microbiology	2
MSBT105	Genetics	2
MSBT106	Basics of Mathematics and Statistics	2
MSBT107	Basics of Chemistry and Physics	2
MSBT108	Laboratory I: Biochemistry and Analytical Techniques	4
MSBT109	Laboratory II: Microbiology	2
MSBT110	Laboratory III: Plant and Animal Biotechnology	2
Total		**25**

Biochemistry

Course Code: #MSBT101 **Total Lecture Hr. =41**
Marks: 75 **Credits: 3**

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.

LEARNING OUTCOME:
On completion of this course, students should be able to:
• Gain fundamental knowledge in biochemistry;
• Understand the molecular basis of various pathological conditions from the perspective of biochemical reactions.

COURSE DESCRIPTION:

Sr. No.	Topics	Detail syllabus	No. of lectures
Unit I	Chemical basis of life	Chemical basis of life: Miller-Urey experiment, abiotic formation of amino acid oligomers, composition of living matter; Water – properties of water, essential role of water for life on earth pH, buffer, maintenance of blood pH and pH of gastric juice, pH optima of different enzymes (pepsin, trypsin and alkaline phosphatase), ionization and hydrophobicity, emergent properties of biomolecules in water, biomolecular hierarchy, macromolecules, molecular assemblies.	7 lectures
Unit II	Protein structure	Structure-function relationships: amino acids – structure and functional group properties, peptides and covalent structure of proteins, elucidation of primary and higher order structures, Ramachandran plot, evolution of protein structure, protein degradation and introduction to molecular pathways controlling protein degradation, structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin *etc.*; basic principles of protein purification; tools to characterize expressed proteins; Protein folding: Anfinsen's Dogma, Levinthal paradox, cooperativity in protein folding, free energy landscape of protein folding and pathways of protein folding, molten globule state, chaperons, diseases associated with protein folding, introduction to molecular dynamic simulation.	4 lectures
Unit III	Enzyme kinetics	Enzyme catalysis – general principles of catalysis; quantitation of enzyme activity and efficiency; enzyme characterization and Michaelis-Menten kinetics;	5 lectures

		relevance of enzymes in metabolic regulation, activation, inhibition and covalent modification; single substrate enzymes; concept of catalytic antibodies; catalytic strategies with specific examples of proteases, carbonic anhydrases, restriction enzymes and nucleoside monophosphate kinase; regulatory strategies with specific example of hemoglobin; isozymes; role of covalent modification in enzymatic activity; zymogens.	
Unit IV	Glycobiology	Sugars - mono, di, and polysaccharides with specific reference to glycogen, amylose and cellulose, glycosylation of other biomolecules - glycoproteins and glycolipids; lipids - structure and properties of important members of storage and membrane lipids; lipoproteins.	2 lectures
Unit V	Structure and functions of DNA & RNA and lipids	Self-assembly of lipids, micelle, biomembrane organization - sidedness and function; membrane bound proteins - structure, properties and function; transport phenomena; nucleosides, nucleotides, nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical structure; difference in RNA and DNA structure and their importance in evolution of DNA as the genetic material.	3 lectures
Unit VI	Bioenergetics	Bioenergetics-basic principles; equilibria and concept of free energy; coupled interconnecting reactions in metabolism; oxidation of carbon fuels; recurring motifs in metabolism; Introduction to GPCR, Inositol/DAG//PKC and Ca++ signaling pathways; glycolysis and gluconeogenesis; reciprocal regulations and non-carbohydrate sources of glucose; Citric acid cycle, entry to citric acid cycle, citric acid cycle as a source of biosynthetic precursors; Oxidative phosphorylation; importance of electron transfer in oxidative phosphorylation; F1-F0 ATP Synthase; shuttles across mitochondria; regulation of oxidative phosphorylation; Photosynthesis – chloroplasts and two photosystems; proton gradient across thylakoid membrane; Calvin cycle and pentose phosphate pathway	8 lectures
Unit VII	Role of vitamins & cofactors in metabolism	Glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, roles of epinephrine and glucagon and insulin in glycogen metabolism; Fatty acid metabolism; protein turnover and amino acid catabolism; nucleotide biosynthesis; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and mevalonate pathway; elucidation of metabolic pathways; logic and	12 lectures

		integration of central metabolism; entry/ exit of various biomolecules from central pathways; principles of metabolic regulation; steps for regulation; target of rapamycin (TOR) & Autophagy regulation in relation to C & N metabolism, starvation responses and insulin signaling.	

EVALUATION SCHEME (THEORY)

Examination	**Duration**	**Marks**
I Internal	45 minutes	15
II Internal	30 minutes	10
Attendance		5
End Semester Exam	2 hours 30 minutes	45
Total		**75**

BOOKS RECOMMENDED:

1. The principles of Biochemistry, Lehninger by D. Nelson, and M. Cox, 7th edition, M. W.H. Freeman and Company, New York, 2017.

2. Metabolic Pathways by D. M. Greenberg, 3rd edition, Academic Press, Elsevier Science & Technology Books, 2014.

3. Biochemistry by L. Stryer, 7th edition, W.H. Freeman and Company, New York, 2012.

4. Biochemistry by J. M. Berg, J. L. Tymoczko, L. Stryer, 6th edition, W.H. Freeman and Company, New York, NY, 2007.

5. Biochemistry by G. Zubay, Addison-Wesley Educational Publishers Inc, 1983.

6. Outlines of Biochemistry by E. Conn and P. Stumpf, 5th edition, John Wiley & Sons, 2009.

7. Principles of Biochemistry by D.J. Voet, J.G. Voet, C.W. Pratt, 3rd edition, (International Student Version), John Wiley & Sons, Inc., 2008.

Cell and Molecular Biology

Course # MSBT102 **Total Lecture Hr.= 40**
Marks: 75 **Credits: 3**

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.

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

COURSE DESCRIPTION:

Sr. No.	Topics	Detail syllabus	No. of Lectures
Unit I	Dynamic organization of cell	Universal features of cells; cell chemistry and biosynthesis: chemical organization of cells; internal organization of the cell - cell membranes: structure of cell membranes and concepts related to compartmentalization in eukaryotic cells; intracellular organelles: endoplasmic reticulum and Golgi apparatus, lysosomes and peroxisomes, ribosomes, cellular cytoskeleton, mitochondria, chloroplasts and cell energetics; nuclear compartment: nucleus, nucleolus and chromosomes.	6 lectures
Unit II	Chromatin structure and dynamics	Chromatin organization - histone and DNA interactome: structure and assembly of eukaryotic and prokaryotic DNA polymerases, DNA-replication, repair and recombination; chromatin control: gene transcription and silencing by chromatin-Writers,-Readers and –Erasers; Transcriptional control: Structure and assembly of eukaryotic and prokaryotic RNA Polymerases, promoters and enhancers, transcription factors as activators and repressors, transcriptional initiation, elongation and termination; post-transcriptional control: splicing and addition of cap and tail, mRNA flow through nuclear envelope into cytoplasm, breakdown of selective and specific mRNAs through interference by small non-coding RNAs (miRNAs and siRNAs), protein translation machinery, ribosomes-composition and assembly; universal genetic codes, degeneracy of codons, Wobble	12 lectures

		hypothesis; Iso-accepting tRNA; mechanism of initiation, elongation and termination; co- and post-translational modifications, mitochondrial genetic code translation product cleavage, modification and activation.	
Unit III	Cellular signalling, transport and trafficking	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.	3 lectures
Unit IV	Cellular processes	Cell cycle and its regulation; cell division: mitosis, meiosis and cytokinesis; cell differentiation: stem cells, their differentiation into different cell types and organization into specialized tissues; cell-ECM and cell-cell interactions; cell receptors and trans-membrane signalling; cell motility and migration; cell death: different modes of cell death and their regulation.	8 lectures
Unit V	Manipulating and studying cells	Isolation of cells and basics of cell culture; observing cells under a microscope, different types of microscopy; analyzing and manipulating DNA, RNA and proteins.	3 lectures
Unit VI	Genome instability and cell transformation	Mutations, proto-oncogenes, oncogenes and tumour suppressor genes, physical, chemical and biological mutagens; types of mutations; intra-genic and inter-genic suppression; transpositions- transposable genetic elements in prokaryotes and eukaryotes, role of transposons in genome; viral and cellular oncogenes; tumor suppressor genes; structure, function and mechanism of action; activation and suppression of tumor suppressor genes; oncogenes as transcriptional activators.	8 lectures

EVALUATION SCHEME (THEORY)

Examination	**Duration**	**Marks**
I Internal	45 minutes	15
II Internal	30 minutes	10
Attendance		5
End Semester Exam	2 hours	45
Total		**75**

BOOKS RECOMMENDED:

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008).

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

Plant and Animal Biotechnology

Course # MSBT103 **Total Lecture Hr.= 40**
Marks: 75 **Credits: 3**

OBJECTIVE:
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.

LEARNING OUTCOME:
Students should be able to gain fundamental knowledge in animal and plant biotechnology and their applications.

COURSE DESCRIPTION:

Sr. No.	Topics	Detail syllabus	No. of Lectures
Unit I	Plant tissue culture and animal cell culture	Plant tissue culture: historical perspective; totipotency; organogenesis; Somatic embryogenesis; establishment of cultures – callus culture, cell suspension culture, media preparation – nutrients and plant hormones; sterilization techniques; applications of tissue culture - micropropagation; somaclonal variation; androgenesis and its applications in genetics and plant breeding; germplasm conservation and cryopreservation; synthetic seed production; protoplast culture and somatic hybridization - protoplast isolation; culture and usage; somatic hybridization - methods and applications; cybrids and somatic cell genetics; plant cell cultures for secondary metabolite production. Animal cell culture: brief history of animal cell culture; cell culture media and reagents; culture of mammalian cells, tissues and organs; primary culture, secondary culture, continuous cell lines, suspension cultures; application of animal cell culture for virus isolation and *in vitro* testing of drugs, testing of toxicity of environmental pollutants in cell culture, application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins.	10 lectures
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;	10 lectures

		screenable and selectable markers; characterization of transgenics; chloroplast transformation; marker-free methodologies; advanced methodologies - cisgenesis, intragenesis and genome editing; molecular pharming - concept of plants as biofactories, production of industrial enzymes and pharmaceutically important compounds.	
Unit III	Animal reproductive biotechnology and vaccinology	Animal reproductive biotechnology: structure of sperms and ovum; cryopreservation of sperms and ova of livestock; artificial insemination; super ovulation, embryo recovery and *in vitro* fertilization; culture of embryos; cryopreservation of embryos; embryo transfer technology; transgenic manipulation of animal embryos; applications of transgenic animal technology; animal cloning - basic concept, cloning for conservation for conservation endangered species; Vaccinology: history of development of vaccines, introduction to the concept of vaccines, conventional methods of animal vaccine production, recombinant approaches to vaccine production, modern vaccines.	8 lectures
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.	4 lectures
Unit V	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: genetic basis for disease resistance in animals; molecular diagnostics of pathogens in plants and animals; detection of meat adulteration using DNA based methods.	8 lectures

EVALUATION SCHEME (THEORY)

Examination	**Duration**	**Marks**
I Internal	45 minutes	15
II Internal	30 minutes	10
Attendance		5
End Semester Exam	2 hours 30 minutes	45
Total		**75**

BOOKS RECOMMENDED:

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. Umesha, 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.

Microbiology

Course # MSBT104 **Total Lecture Hr.= 28**
Marks: 50 **Credits: 2**

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.

LEARNING OUTCOME:
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.

COURSE DESCRIPTION:

Sr. No.	Topics	Detail syllabus	No. of Lectures
Unit I	Microbial Characteristics	Introduction to microbiology and microbes, history & scope of microbiology, morphology, structure, growth and nutrition of bacteria, bacterial growth curve, bacterial culture methods; bacterial genetics: mutation and recombination in bacteria, plasmids, transformation, transduction and conjugation; antimicrobial resistance.	6 lectures
Unit II	Microbial diversity	Microbial taxonomy and evolution of diversity, classification of microorganisms, criteria for classification; classification of bacteria; Cyanobacteria, acetic acid bacteria, Pseudomonads, lactic and propionic acid bacteria, endospore forming bacteria, Mycobacteria and Mycoplasma. Archaea: Halophiles, Methanogens, Hyperthermophilic archae, Thermoplasm; eukarya: algae, fungi, slime molds and protozoa; extremophiles and unculturable microbes.	9 lectures
Unit III	Control of microorganisms	Sterilization, disinfection and antisepsis: physical and chemical methods for control of microorganisms, antibiotics, antiviral and antifungal drugs, biological control of microorganisms.	3 lectures

Unit IV	Virology	Virus and bacteriophages, general properties of viruses, viral structure, taxonomy of virus, viral replication, cultivation and identification of viruses; sub-viral particles – viroids and prions.	5 lectures
Unit V	Host-microbes Interaction	Host-pathogen interaction, ecological impact of microbes; symbiosis (Nitrogen fixation and ruminant symbiosis); microbes and nutrient cycles; microbial communication system; bacterial quorum sensing; microbial fuel cells; prebiotics and probiotics.	5 lectures

EVALUATION SCHEME (THEORY)

Examination	**Duration**	**Marks**
Internal Exam	45 minutes	15
Attendance		5
End Semester Exam	1 hour 30 minutes	30
Total		**50**

BOOKS RECOMMENDED:

1. Pelczar, M. J., Reid, R. D., & Chan, E. C. (2001). *Microbiology* (5th 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, Principles and Explorations*. Boston, MA: John Wiley & Sons.

Genetics

Course # MSBT105 **Total Lecture Hr.= 28**
Marks: 50 **Credits: 2**

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.

LEARNING OUTCOME:
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 DESCRIPTION:

Sr. No.	Topics	Detail syllabus	No. of Lectures
Unit 1	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.	10 lectures
Unit 2	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.	6 lectures
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, hypomorphy, genetic mosaics, genetic epistasis in context of developmental mechanism.	4 lectures
Unit IV	Population genetics	Introduction to the elements of population genetics: genetic variation, genetic drift, neutral evolution;	4 lectures

	and genetics of evolution	mutation selection, balancing selection, Fishers theorem, Hardy-Weinberg equilibrium, linkage disequilibrium; in-breeding depression & mating systems; population bottlenecks, migrations, Bayesian statistics; adaptive landscape, spatial variation & genetic fitness.	
Unit V	Quantitative genetics of complex traits (QTLs)	Complex traits, mapping QTLs, yeast genomics to understand biology of QTLs.	2 lectures
Unit VI	Plant genetics	Laws of segregation in plant crosses, inbreeding, selfing, heterosis, maintenance of genetic purity, gene pyramiding.	2 lectures

EVALUATION SCHEME (THEORY)

Examination	**Duration**	**Marks**
Internal Exam	45 minutes	15
Attendance		5
End Semester Exam	1 hour 15 minutes	30
Total		**50**

BOOKS RECOMMENDED:

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.

Basics of Mathematics and Statistics

Course # MSBT106 **Total Lecture Hr.= 19**
Marks: 50 **Credits: 2**

OBJECTIVE:
The objective of this course is to give conceptual exposure of essential contents of mathematics and statistics to students.

LEARNING OUTCOME:
On completion of this course, students should be able to:
• Gain broad understanding in mathematics and statistics;
• Recognize importance and value of mathematical and statistical thinking, training, and approach to problem solving on a diverse variety of disciplines.

COURSE DESCRIPTION:

Sr. No.	Topics	Detail syllabus	No. of Lectures
Unit 1	Algebra	Linear equations, functions: slopes-intercepts, forms of two-variable linear equations; constructing linear models in biological systems; quadratic equations (solving, graphing, features of, interpreting quadratic models *etc*.), introduction to polynomials, graphs of binomials and polynomials; Symmetry of polynomial functions, basics of trigonometric functions, Pythagorean theory, graphing and constructing sinusoidal functions, imaginary numbers, complex numbers, adding-subtracting-multiplying complex numbers, basics of vectors, introduction to matrices.	6 lectures
Unit 2	Calculus 4 lectures	Differential calculus (limits, derivatives), integral calculus (integrals, sequences and series *etc*.).	4 lectures
Unit III	Mathematical models in biology	Population dynamics; oscillations, circadian rhythms, developmental patterns, symmetry in biological systems, fractal geometries, size-limits & scaling in biology, modeling chemical reaction networks and metabolic networks.	4 lectures
Unit IV	Statistics	Probability: counting, conditional probability, discrete and continuous random variables; Error propagation; Populations and samples, expectation, parametric tests of statistical significance, nonparametric hypothesis tests, linear regression, correlation & causality, analysis of variance, factorial experiment design.	5 lectures

EVALUATION SCHEME (THEORY)

Examination	**Duration**	**Marks**
Internal Exam	45 minutes	15
Attendance		5
End Semester Exam	1 hour 15 minutes	30
Total		***50***

BOOKS RECOMMENDED:

1. Stroud, K. A., & Booth, D. J. (2009). *Foundation Mathematics*. New York, NY: Palgrave Macmillan.
2. Aitken, M., Broadhursts, B., & Haldky, S. (2009) *Mathematics for Biological Scientists*. Garland Science.
3. Billingsley, P. (1986). *Probability and Measure.* New York: Wiley.
4. Rosner, B. (2000). *Fundamentals of Biostatistics*. Boston, MA: Duxbury Press.
5. Daniel, W. W. (1987). *Biostatistics, a Foundation for Analysis in the Health Sciences*. New York: Wiley.

Basics of Chemistry and Physics

Course # MSBT107 **Total Lecture Hr.= 24**
Marks: 50 **Credits: 2**

OBJECTIVE:
The objectives of this course are to cover all essentials required to appreciate physico-chemical principles underlying biological processes.

LEARNING OUTCOME:
Students should be able to have a firm foundation in fundamentals and application of current chemical and physical scientific theories.

COURSE DESCRIPTION:

Sr. No.	Topics	Detail syllabus	No. of Lectures
Unit 1	Basic physics for biologists	Physical quantities and their dynamics: definitions and dimensions; vectors & scalars, displacement, velocity, acceleration, kinematic formulas, angular momentum, torque *etc.* force, power, work, energy (kinetic & potential/electric charge separation, electromagnetic spectrum, photons *etc.*); springs & Hookes laws; elastic and inelastic collisions; Newton's law of motions (centripetal and centrifugal forces *etc.*); simple harmonic motions, mechanical waves, Doppler effect, wave interference, amplitude, period, frequency & wavelength; diffusion, dissipation, random walks, and directed motions in biological systems; low Reynolds number - world of Biology, buoyant forces, Bernoulli's equation, viscosity, turbulence, surface tension, adhesion; laws of thermodynamics: Maxwell Boltzmann distribution, conduction, convection and radiation, internal energy, entropy, temperature and free energy, Maxwell's demon (entropic forces at work in biology, chemical assemblies, self-assembled systems, role of ATP); Coulomb's law, conductors and insulators, electric potential energy of charges, nerve impulses, voltage gated channels, ionic conductance; Ohms law (basic electrical quantities: current, voltage & power), electrolyte conductivity, capacitors and capacitance, dielectrics; various machines in biology *i.e.* enzymes, allostery and molecular motors (molecules to cells and organisms).	12 lectures: 10 hours teaching + 2 hours tutorials
Unit 2	Basic chemistry	Basic constituents of matter - elements, atoms, isotopes, atomic weights, atomic numbers, basics of mass spectrometry, molecules, Avogadro number, molarity, gas	12 lectures: 10 hours

	for biologists	constant, molecular weights, structural and molecular formulae, ions and polyatomicions; chemical reactions, reaction stoichiometry, rates of reaction, rate constants, order of reactions, Arrhenious equation, Maxwell Boltzmann distributions, rate-determining steps, catalysis, free-energy, entropy and enthalpy changes during reactions; kinetic versus thermodynamic controls of a reaction, reaction equilibrium (equilibrium constant); light and matter interactions (optical spectroscopy, fluorescence, bioluminescence, paramagnetism and diamagnetism, photoelectron spectroscopy; chemical bonds (ionic, covalent, Van der Walls forces); electronegativity, polarity; VSEPR theory and molecular geometry, dipole moment, orbital hybridizations; states of matter - vapor pressure, phase diagrams, surface tension, boiling and melting points, solubility, capillary action, suspensions, colloids and solutions; acids, bases and pH - Arrhenious theory, pH, ionic product of water, weak acids and bases, conjugate acid-base pairs, buffers and buffering action *etc*; chemical thermodynamics - internal energy, heat and temperature, enthalpy (bond enthalpy and reaction enthalpy), entropy, Gibbs free energy of ATP driven reactions, spontaneity versus driven reactions in biology; redox reactions and electrochemistry - oxidation-reduction reactions, standard cell potentials, Nernst equation, resting membrane potentials, electron transport chains (ETC) in biology, coupling of oxidative phosphorylations to ETC; theories of ATP production and dissipation across biological membranes; bond rotations and molecular conformations - Newman projections, conformational analysis of alkanes, alkenes and alkynes; functional groups, optically asymmetric carbon centers, amino acids, proteins, rotational freedoms in polypeptide backbone (Ramachandran plot).	teaching + 2 hours tutorials

EVALUATION SCHEME (THEORY)

Examination	**Duration**	**Marks**
Internal Exam	45 minutes	15
Attendance		5
End Semester Exam	1 hour 15 minutes	30
Total		***50***

BOOKS RECOMMENDED:

1. Baaquie, B. E. (2000). *Laws of Physics: a Primer*. Singapore: National University of Singapore.
2. Matthews, C. P., & Shearer, J. S. (1897). *Problems and Questions in Physics*. New York: Macmillan Company.
3. Halliday, D., Resnick, R., & Walker, J. (1993). *Fundamentals of Physics.* New York: Wiley.
4. Ebbing, D. D., & Wrighton, M. S. (1990). *General Chemistry*. Boston: Houghton Mifflin.

5. Averill, B., & Eldredge, P. (2007). *Chemistry: Principles, Patterns, and Applications*. San Francisco: Benjamin Cummings.
6. Mahan, B. H. (1965). *University Chemistry*. Reading, MA: Addison-Wesley Pub.
7. Cantor, C. R., & Schimmel, P. R. (2004). *Biophysical Chemistry*. San Francisco: W.H. Freeman.

Laboratory I: Biochemistry & Analytical Techniques

Course # MSBT108
Marks: 100 **Credits: 4**

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 set of experimental methods in biochemistry in a problem-oriented manner.

LEARNING OUTCOME:
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.

SYLLABUS:

1. Preparing various stock solutions and working solutions that will be needed for the course.
2. To prepare an Acetic-Na Acetate Buffer and validate the Henderson-Hasselbach equation.
3. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law.
4. Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by thin layer chromatography.
5. Purification and characterization of an enzyme from a recombinant source (such as Alkaline Phosphatase or Lactate Dehydrogenase or any enzyme of the institution's choice).
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 (protein concentration, amount of total protein; Computing specific activity of the enzyme preparation at each stage of purification)
h) Assessing purity of samples from each step of purification by SDS-PAGE Gel Electrophoresis
i) Enzyme Kinetic Parameters: Km, Vmax and Kcat.
6. Experimental verification that absorption at OD_{260} is more for denatured DNA as compared to native double stranded DNA. reversal of the same following DNA renaturation. Kinetics of DNA renaturation as a function of DNA size.
7. Identification of an unknown sample as DNA, RNA or protein using available laboratory tools. (Optional Experiments)
8. Biophysical methods (Circular Dichroism Spectroscopy, Fluorescence Spectroscopy).
9. Determination of mass of small molecules and fragmentation patterns by Mass Spectrometry.

PRACTICAL EVALUATION SCHEME

Examination	**Marks**
Practical Internal (Continuous) assessment:	40
End semester examination:	60
Total:	**100**

Laboratory II: Microbiology

Course # MSBT109
Marks: 50 **Credits: 2**

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

LEARNING OUTCOME:
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.

SYLLABUS:

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.

BOOKS RECOMMENDED:
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.*

PRACTICAL EVALUATION SCHEME

Examination	**Marks**
Practical Internal (Continuous) assessment:	20
End semester examination:	30
Total:	**50**

Laboratory III: Plant and Animal Biotechnology

Course # MSBT110
Marks: 50 **Credits: 2**

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

STUDENT LEARNING OUTCOMES:
On completion of course, students should be able to gain basic skills in plant and animal biotechnology.

SYLLABUS:

Plant Biotechnology

1. Prepare culture media with various supplements for plant tissue culture.
2. Prepare explants of *Valleriana wallichii* for inoculation under aseptic conditions.
3. Attempt *in vitro* andro and gynogenesis 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 *Valleriana wallichii*.
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 achiasmate, 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.

PRACTICAL EVALUATION SCHEME

Examination	**Marks**
Practical Internal (Continuous) assessment:	20
End semester examination:	30
Total:	**50**

SEMESTER TWO		
Course Code	**Course Name**	**Credits**
MSBT201	Genetic Engineering	3
MSBT202	Immunology	3
MSBT203	Bioinformatics	3
MSBT204	Genomics and Proteomics	2
MSBT205	Molecular Diagnostics	2
MSBT206	Research Methodology and Scientific Communication Skills	2
MSBT207	Elective I Nanobiotechnology	2
MSBT208	Elective I Microbial Technology	
MSBT209	Seminar	1
MSBT210	Laboratory IV: Molecular Biology and Genetic Engineering	4
MSBT211	Laboratory V: Immunology	3
Total		**25**

Genetic Engineering

Course # MSBT201 **Total Lecture Hr.= 40**
Marks: 75 **Credits: 3**

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

LEARNING OUTCOME:
Given the impact of genetic engineering in modern society, the students should be endowed with strong theoretical knowledge of this technology. In conjunction with the practicals in molecular biology & genetic engineering, the students should be able to take up biological research as well as placement in the relevant biotech industry.

COURSE DESCRIPTION:

Sr. No.	Topics	Detail syllabus	No. of Lectures
Unit I	Introduction and tools for genetic engineering	Impact of genetic engineering in modern society; general requirements for performing a genetic engineering experiment; restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing; labelling 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.	6 lectures
Unit II	Different types of vectors	Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors, hagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Principles for maximizing gene expression expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag *etc.*; Intein-based vectors; Inclusion bodies; methodologies to reduce formation of inclusion bodies; mammalian expression and replicating vectors; Baculovirus and *Pichia* vectors system, plant based vectors, Ti and Ri as vectors, yeast vectors, shuttle vectors..	7 lectures

Unit III	Different types of PCR techniques	Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, cloning of PCR products; T-vectors; proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP, DGGE, RFLP.	7 lectures
Unit IV	Gene manipulation and protein-DNA Interaction	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.	7 lectures
Unit V	Gene silencing and genome editing technologies	Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy; creation of transgenic plants; debate over GM crops; introduction to methods of genetic manipulation in different model systems *e.g.* fruit flies(*Drosophila*), worms (*C. elegans*), frogs (*Xenopus*), fish (zebra fish) and chick; Transgenics - gene replacement; gene targeting; creation of transgenic and knock-out mice; disease model; introduction to genome editing by CRISPR-CAS with specific emphasis on Chinese and American clinical trials.	13 lectures

EVALUATION SCHEME (THEORY)

Examination	**Duration**	**Marks**
I Internal	45 minutes	15
II Internal	30 minutes	10
Attendance		5
End Semester Exam	2 hours 30 minutes	45

Total **75**

BOOKS RECOMMENDED:

1. Primrose, S. B., & Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics. *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*rd *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.

Immunology

Course # MSBT202 **Total Lecture Hr.= 38**
Marks: 75 **Credits: 3**

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

LEARNING OUTCOME
On completion of this course, students should be able to:
• 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).

COURSE DESCRIPTION:

Sr. No.	Topics	Detail syllabus	No. of Lectures
Unit I	Immunology: fundamental concepts and overview of the immune system	Components of innate and acquired immunity; phagocytosis; complement and inflammatory responses; pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP); innate immune response; mucosal immunity; antigens: immunogens, haptens; Major Histocompatibility Complex: MHC genes, MHC and immune responsiveness and disease susceptibility, Organs of immune system, primary and secondary lymphoid organs.	5 lectures
Unit II	Immune responses generated by B and T lymphocytes	Immunoglobulins - basic structure, classes & subclasses of immunoglobulins, antigenic determinants; multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; principles of cell signaling; basis of self & non-self discrimination; kinetics of immune response, memory; B cell maturation, activation and differentiation; generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; functional T Cell subsets; cell-mediated immune responses, ADCC; cytokines: properties, receptors and therapeutic uses; antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; cell-	6 lectures

		cell co-operation, Hapten-carrier system.	
Unit III	Antigen-antibody interactions	Precipitation, agglutination and complement mediated immune reactions; advanced immunological techniques: RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence microscopy, flow cytometry and immunoelectron microscopy; surface plasmon resonance, biosensor assays for assessing ligand –receptor interaction; CMI techniques: lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays, apoptosis, microarrays, transgenic mice, gene knock outs.	6 lectures
Unit IV	Vaccinology	Active and passive immunization; live, killed, attenuated, subunit vaccines; vaccine technology: role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines; antibody genes and antibody engineering:chimeric, generation of monoclonal antibodies, hybrid monoclonal antibodies; catalytic antibodies and generation of immunoglobulin gene libraries, idiotypic vaccines and marker vaccines, viral-like particles (VLPs), dendritic cell based vaccines, vaccine against cancer, T cell based vaccine, edible vaccine and therapeutic vaccine.	8 lectures
Unit V	Clinical immunology	Immunity to infection : bacteria, viral, fungal and parasitic infections (with examples from each group); hypersensitivity: Type I-IV; autoimmunity; types of autoimmune diseases; mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; treatment of autoimmune diseases; transplantation: immunological basis of graft rejection; clinical transplantation and immunosuppressive therapy; tumor immunology: tumor antigens; immune response to tumors and tumor evasion of the immune system, cancer immunotherapy; immunodeficiency: primary immunodeficiencies, acquired or secondary immunodeficiencies, autoimmune disorder, anaphylactic shock, immunosenescence, immune exhaustion in chronic viral infection, immune tolerance, NK cells in chronic viral infection and malignancy.	8 lectures
Unit VI	Immunogenetics	Major histocompatibility complex genes and their role in autoimmune and infectious diseases, HLA typing, human major histocompatibility complex (MHC), Complement genes of the human major histocompatibility complex: implication for linkage disequilibrium and disease associations, genetic studies of rheumatoid arthritis,	5 lectures

		systemic lupus erythematosus and multiple sclerosis, genetics of human immunoglobulin, immunogenetics of spontaneous control of HIV, KIR complex.	

EVALUATION SCHEME (THEORY)

Examination	**Duration**	**Marks**
I Internal	45 minutes	15
II Internal	30 minutes	10
Attendance		5
End Semester Exam	2 hours 30 minutes	45
Total		**75**

BOOKS RECOMMENDED:

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.

Bioinformatics

Course # MSBT203 **Total Lecture Hr.= 26**
Marks: 75 **Credits: 3**

OBJECTIVE
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.

LEARNING OUTCOME
Student should be able to:
• Develop an understanding of basic theory of these computational tools;
• Gain working knowledge of these computational tools and methods;
• Appreciate their relevance for investigating specific contemporary biological questions;
• Critically analyse and interpret results of their study.

COURSE DESCRIPTION:

Sr. No.	Topics	Detail syllabus	No. of lectures
Unit I	Bioinformatics basics	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 XML DTD's; pattern matching algorithm basics; databases and search tools: 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.	5 lectures
Unit II	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.	5 lectures
Unit III	Multiple sequence analysis	Multiple sequence analysis; multiple sequence alignment; flexible sequence similarity searching with the FASTA3 program package; use of CLUSTALW and CLUSTALX for multiple sequence alignment; submitting DNA protein	5 lectures

		sequence to databases: where and how to submit, SEQUIN, genome centres; submitting aligned sets of sequences, updating submitted sequences, methods of phylogenetic analysis.	
Unit IV	Protein modelling	Protein modelling: introduction; force field methods; energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; mapping properties onto surfaces; fitting monomers; RMS fit of conformers; assigning secondary structures; sequence alignment- methods, evaluation, scoring; protein completion: backbone construction and side chain addition; small peptide methodology; software accessibility; building peptides; protein displays; substructure manipulations, annealing.	5 lectures
Unit V	Protein structure prediction and virtual library	Protein structure prediction: protein folding and model generation; secondary structure prediction; analyzing secondary structures; protein loop searching; loop generating methods; homology modelling: potential applications, description, methodology, homologous sequence identification; align structures, align model sequence; construction of variable and conserved regions; threading techniques; topology fingerprint approach for prediction; evaluation of alternate models; structure prediction on a mystery sequence; structure aided sequence techniques of structure prediction; structural profiles, alignment algorithms, mutation tables, prediction, validation, sequence based methods of structure prediction, prediction using inverse folding, fold prediction; significance analysis, scoring techniques, sequence-sequence scoring; protein function prediction; elements of in silico drug design;Virtual library: Searching PubMed, current content, science citation index and current awareness services, electronic journals, grants and funding information.	6 lectures

EVALUATION SCHEME (THEORY)

Examination	**Duration**	**Marks**
I Internal	45 minutes	15
II Internal	30 minutes	10
Attendance		5
End Semester Exam	2 hours 30 minutes	45

Total **75**

BOOKS RECOMMENDED:

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.

Genomics and Proteomics

Course # MSBT204 **Total Lecture Hr.= 28**
Marks: 50 **Credits: 2**

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

LEARNING OUTCOME
Students should be able to acquire knowledge and understanding of fundamentals of genomics and proteomics, transcriptomics and metabolomics and their applications in various applied areas of biology.

COURSE DESCRIPTION:

Sr. No.	Topics	Detail syllabus	No. of lectures
Unit I	Basics of genomics and proteomics	Brief overview of prokaryotic and eukaryotic genome organization; extra-chromosomal DNA: bacterial plasmids, mitochondria and chloroplast.	3 lectures
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.	4 lectures
Unit III	Genome sequencing projects	Human Genome Project, genome sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from the web.	3 lectures
Unit IV	Comparative genomics	Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing, SNPs; use of genomes to understand evolution of eukaryotes, track emerging diseases and design new drugs; determining gene location in genome sequence.	5 lectures
Unit V	Proteomics	Aims, strategies and challenges in proteomics; proteomics technologies: 2D-PAGE, isoelectric focusing, mass spectrometry, MALDI-TOF, yeast 2-hybrid system, proteome databases.	5 lectures
Unit VI	Functional genomics and	Transcriptome analysis for identification and functional annotation of gene, Contig assembly, chromosome walking and characterization of	8 lectures

	proteomics	chromosomes, mining functional genes in genome, gene function- forward and reverse genetics, gene ethics; protein-protein and protein-DNA interactions; protein chips and functional proteomics; clinical and biomedical applications of proteomics; introduction to metabolomics, lipidomics, metagenomics and systems biology.	

EVALUATION SCHEME (THEORY)

Examination	**Duration**	**Marks**
Internal Exam	45 minutes	15
Attendance		5
End Semester Exam	1 hour 15 minutes	30
Total		***50***

BOOKS RECOMMENDED:

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). *Introduction to Proteomics: Tools for the New Biology*. Totowa, NJ: Humana Press.
3. Campbell, A. M., & Heyer, L. J. (2003). *Discovering Genomics, Proteomics, and Bioinformatics*. San Francisco: Benjamin Cummings.

Molecular Diagnostics

Course # MSBT205 **Total Lecture Hr.= 25**
Marks: 50 **Credits: 2**

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

LEARNING OUTCOME
Students 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.

COURSE DESCRIPTION:

Sr. No.	Topics	Detail syllabus	No. of lectures
Unit I	Genome biology in health and disease	DNA, RNA, Protein: An overview; chromosomal structure & mutations; DNA polymorphism: human identity; clinical variability and genetically determined adverse reactions to drugs.	4 lectures
Unit II	Genome: resolution, detection & analysis	PCR: Real-time; ARMS; Multiplex; ISH; FISH; ISA; RFLP; DHPLC; DGGE; CSCE; SSCP; Nucleic acid sequencing: new generations of automated sequencers; Microarray chips; EST; SAGE; microarray data normalization & analysis; molecular markers: 16S rRNA typing; Diagnostic proteomics: SELDI-TOF-MS; Bioinformatics data acquisition & analysis.	5 lectures
Unit III	Diagnostic metabolomics	Metabolite profile for biomarker detection the body fluids/tissues in various metabolic disorders by making using LCMS & NMR technological platforms.	2 lectures
Unit IV	Detection and identity of microbial diseases	Direct detection and identification of pathogenic-organisms that are slow growing or currently lacking a system of *in vitro* cultivation as well as genotypic markers of microbial resistance to specific antibiotics.	4 lectures
Unit V	Detection of inherited diseases	Exemplified by two inherited diseases for which molecular diagnosis has provided a dramatic improvement of quality of medical care: Fragile X	4 lectures

		Syndrome: Paradigm of new mutational mechanism of unstable triplet repeats, von-Hippel Lindau disease: recent acquisition in growing number of familial cancer syndromes.	
Unit VI	Molecular oncology	Detection of recognized genetic aberrations in clinical samples from cancer patients; types of cancer-causing alterations revealed by next-generation sequencing of clinical isolates; predictive biomarkers for personalized onco-therapy of human diseases such as chronic myeloid leukemia, colon, breast, lung cancer and melanoma as well as matching targeted therapies with patients and preventing toxicity of standard systemic therapies.	5 lectures
Unit VII	Quality assurance and control	Quality oversight; regulations and approved testing.	1 lecture

EVALUATION SCHEME (THEORY)

Examination	**Duration**	**Marks**
Internal Exam	45 minutes	15
Attendance		5
End Semester Exam	1 hour 15 minutes	30
Total		***50***

BOOKS RECOMMENDED:

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

Research Methodology and Scientific Communication Skills

Course # MSBT206 **Total Lecture Hr.= 24**
Marks: 50 **Credits: 2**

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

LEARNING OUTCOME
Students should be able to:
• Understand history and methodologies of scientific research, applying these to recent published papers;
• Understand and practice scientific reading, writing and presentations;
• Appreciate scientific ethics through case studies.

COURSE DESCRIPTION:

Sr. No.	Topics	Detail syllabus	No. of lectures
Unit 1	History of science and science methodologies	Empirical science; scientific method; manipulative experiments and controls; deductive and inductive reasoning; descriptive science; reductionist *vs* holistic biology.	8 lectures
Unit 2	Preparation for research	Choosing a mentor, lab and research question; maintaining a lab notebook.	2 lectures
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	5 lectures

		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.	9 lectures

EVALUATION SCHEME (THEORY)

Examination	**Duration**	**Marks**
Internal Exam	45 minutes	15
Attendance		5
End Semester Exam	1 hour 15 minutes	30
Total		**50**

BOOKS RECOMMENDED:

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

Elective I Nanobiotechnology

Course # MSBT207 **Total Lecture Hr.=30**
Marks: 50 **Credits: 2**

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 everyday life.

LEARNING OUTCOME

On successful completion of this course, students should be able to describe basic science behind the properties of materials at nanometer scale, and the principles behind advanced experimental and computational techniques for studying nanomaterials.

COURSE DESCRIPTION:

Sr. No.	Topics	Detail syllabus	No. of lectures
Unit I	Introduction to nanobiotechnology	Introduction to Nanobiotechnology; Concepts, historical perspective; Different formats of nanomaterials and applications with example for specific cases; Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures, Synthesis and characterization of different nanomaterials.	5 lectures
Unit II	Nano – films	Thin films; Colloidal nanostructures; Self Assembly, Nanovesicles; Nanospheres; Nanocapsules and their characterisation.	5 lectures
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.	5 lectures
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.	5 lectures
Unit V	Nano – materials	Nanomaterials for catalysis, development and characterization of nanobiocatalysts, application of nanoscaffolds in sythesis, applications of nanobiocatalysis in the production of drugs and drug intermediates.	5 lectures

Unit VI	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; Life Cycle Assessment, containment.	5 lectures

EVALUATION SCHEME (THEORY)

Examination	**Duration**	**Marks**
Internal Exam	45 minutes	15
Attendance		5
End Semester Exam	1 hour 15 minutes	30
Total		***50***

BOOKS RECOMMENDED:

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

Elective I Microbial Technology

Course # MSBT 208 **Total Lecture Hr.=37**
Marks: 50 **Credits: 2**

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.

LEARNING OUTCOME

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

COURSE DESCRIPTION:

Sr. No.	Topics	Detail syllabus	No. of lectures
Unit I	Introduction to microbial technology	Microbial technology in human welfare; Isolation and screening of microbes important for industry – advances in methodology and its application; Advanced genome and epigenome editing tools (*e.g.*, engineered zinc finger proteins, TALEs/TALENs, and the CRISPR/Cas9 system as nucleases for genome editing, transcription factors for epigenome editing, and other emerging tools) for manipulation of useful microbes/strains and their applications; Strain improvement to increase yield of selected molecules, *e.g.*, antibiotics, enzymes, biofuels.	8 lectures
Unit II	Environmental applications of microbial technology	Environmental application of microbes; Ore leaching; Biodegradation - biomass recycle and removal; Bioremediation - toxic waste removal and soil remediation; Global Biogeochemical cycles; Environment sensing (sensor organisms/ biological sensors); International and National guidelines regarding use of genetically modified organisms in environment, food and pharmaceuticals.	6 lectures
Unit III	Pharmaceutical applications of microbial technology	Recombinant protein and pharmaceuticals production in microbes – common bottlenecks and issues (technical/operational, commercial and ethical); Attributes required in industrial microbes (*Streptomyces* sp., Yeast) to be used as efficient cloning and expression hosts (biologicals production); Generating diversity and introduction of desirable properties in industrially important microbes (*Streptomyces*/Yeast); Microbial cell factories; Downstream processing approaches used in industrial production process (*Streptomyces* sp.,	8 lectures

		Yeast).	
Unit IV	Food applications of microbial technology	Application of microbes and microbial processes in food and healthcare industries - food processing and food preservation, antibiotics and enzymes production, microbes in targeted delivery application – drugs and vaccines (bacterial and viral vectors); Non-recombinant ways of introducing desirable properties in Generally recognized as safe (GRAS) microbes to be used in food (*e.g.*, Yeast) - exploiting the existing natural diversity or the artificially introduced diversity through conventional acceptable techniques (mutagenesis, protoplast fusion, breeding, genome shuffling, directed evolution *etc.*).	7 lectures
Unit V	Advances in microbial technology	Microbial genomics for discovery of novel enzymes, drugs/ antibiotics; Limits of microbial genomics with respect to use in human welfare; Metagenomics and metatranscriptomics – their potential, methods to study and applications/use (animal and plant health, environmental clean-up, global nutrient cycles & global sustainability, understanding evolution), Global metagenomics initiative - surveys/projects and outcome, metagenomic library construction and functional screening in suitable hosts – tools and techniques for discovery/identification of novel enzymes, drugs (*e.g.*, protease, antibiotic) *etc.*	8 lecture

EVALUATION SCHEME (THEORY)

Examination	**Duration**	**Marks**
Internal Exam	45 minutes	15
Attendance		5
End Semester Exam	1 hour 15 minutes	30
Total		***50***

BOOKS RECOMMENDED:

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). ashington, 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/

Seminar

Course # MSBT 209
Marks: 25 **Credit: 1**

Laboratory IV: Molecular Biology and Genetic Engineering

Course # MSBT210
Marks: 100 **Credits: 4**

OBJECTIVE

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

LEARNING OUTCOME

Students should be able to gain hands-on experience in gene cloning, protein expression and purification. 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.

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
13. Expression of recombinant protein, concept of soluble proteins and inclusion body formation in *E.coli*, SDS-PAGE analysis
14. Purification of His-Tagged protein on Ni-NTA columns
a) Random Primer labeling
b) Southern hybridization.

BOOKS RECOMMENDED:

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

PRACTICAL EVALUATION SCHEME

Examination	**Marks**
Practical Internal (Continuous) assessment:	40
End semester examination:	60
Total:	**100**

Laboratory V: Immunology

Course # MSBT211 **Credits: 3**
Marks: 75

OBJECTIVE
The objectives of this laboratory course are to develop an understanding about practical aspects of components of immune system as well as their function. Basic as well as advanced methods will be taught to detect different antigen and antibody interactions, isolation of different lymphocyte cells *etc.* and how they can be used in respective research work.

LEARNING OUTCOME
Students should be able to:
• 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 setting of infection (viral or bacterial) by looking at cytokine profile.

SYLLABUS

1. Selection of animals, preparation of antigens, immunization and methods of blood collection, serum separation and storage.
2. Antibody titre by ELISA method.
3. Double diffusion, Immuno-electrophoresis and Radial Immuno diffusion.
4. Complement fixation test.
5. Isolation and purification of IgG from serum or IgG from chicken egg.
6. SDS-PAGE, Immunoblotting, Dot blot assays.
7. Blood smear identification of leucocytes by Giemsa stain.
8. Separation of leucocytes by dextran method.
9. Demonstration of Phagocytosis of latex beads and their cryopreservation.
10. Separation of mononuclear cells by Ficoll-Hypaque and their cryopreservation.
11. Demonstration of ELISPOT.
12. Demonstration of FACS.

PRACTICAL EVALUATION SCHEME

Examination	**Marks**
Practical Internal (Continuous) assessment:	30
End semester examination:	45
Total:	**75**

SEMESTER THREE		
Course Code	**Course Name**	**Credits**
MSBT301	Bioprocess Engineering and Technology	3
MSBT302	Emerging Technologies	2
MSBT303	Critical Analysis of Classical Papers	2
MSBT304	Bioentrepreneurship	2
MSBT305	Intellectual Property Rights, Biosafety and Bioethics	2
MSBT306	Project Proposal Preparation and Presentation	2
MSBT307	Seminar	1
MSBT308	Laboratory VI: Bioprocess Engineering and Technology	4
MSBT309	Laboratory VII: Bioinformatics	2
MSBT310	Elective II Biological Imaging	2
MSBT311	Elective II Computational Biology	
MSBT 312	Elective II Drug Discovery and Development	
MSBT313	Elective II Environmental Biotechnology	
MSBT314	Elective II Protein Engineering	
MSBT315	Elective II Vaccines	
	Total	**22**

Bioprocess Engineering & Technology

Course # MSBT301 **Total Lecture Hr.= 36**
Marks: 75 **Credits: 3**

OBJECTIVE

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

LEARNING OUTCOME

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.

COURSE DESCRIPTION:

Sr. No.	Topics	Detail syllabus	No. of lectures
Unit I	Basic principles of biochemical engineering	Isolation, screening and maintenance of industrially important microbes; microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); strain improvement for increased yield and other desirable characteristics.	4 lectures
Unit II	Stoichiometry and models of microbial growth	Elemental balance equations; metabolic coupling – ATP and NAD+; yield coefficients; unstructured models of microbial growth; structured models of microbial growth.	4 lectures
Unit III	Bioreactor design and analysis	Batch and continuous fermenters; modifying batch and continuous reactors: chemostat with recycle, multistage chemostat systems, fed-batch operations; conventional fermentation v/s biotransformation; immobilized cell systems; large scale animal and plant cell cultivation; fermentation economics; upstream processing: media formulation and optimization; sterilization; aeration, agitation and heat transfer in bioprocess; scale up and scale down; measurement and control of bioprocess parameters.	8 lectures
Unit IV	Downstream	Separation of insoluble products - filtration,	8 lectures

	processing and product recovery	centrifugation, sedimentation, flocculation; Cell disruption; separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis; final purification: drying; crystallization; storage and packaging.	
Unit V	Fermentation Economics	Isolation of micro-organisms of potential industrial interest; strain improvement; market analysis; equipment and plant costs; media; sterilization, heating and cooling; aeration and agitation; bath-process cycle times and continuous cultures; recovery costs; water usage and recycling; effluent treatment and disposal.	4 lectures
Unit VI	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; high-fructose corn syrup; interesterified fat; hydrolyzed protein *etc.* and their downstream processing; baking by amylases, deoxygenation and desugaring by glucoses oxidase, beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing.	4 lectures
Unit VII	Applications of microbial technology in food process operations and production, biofuels and biorefinery	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	4 lectures

EVALUATION SCHEME (THEORY)

Examination	**Duration**	**Marks**
I Internal	45 minutes	15
II Internal	30 minutes	10
Attendance		5
End Semester Exam	2 hours 30 minutes	45
Total		**75**

BOOKS RECOMMENDED:

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.

Emerging Technologies

Course # MSBT302 **Total Lecture Hr.= 30**
Marks: 50 **Credits: 2**

OBJECTIVE

This course is broad-based in nature encompassing several 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.

LEARNING OUTCOME

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.

COURSE DESCRIPTION:

Sr. No.	Topics	Detail syllabus	No. of lectures
Unit I	Optical microscopy methods	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 beamsplitters, boosting the signal. Advanced Microscopy: Confocal microscope: scanning optical microscope, confocal principle, resolution and point spread function, light source: gas lasers & solid-state, primary beamsplitter; beam scanning, pinhole and signal channel configurations, detectors; pixels and voxels; contrast, spatial sampling: temporal sampling: signal-to-noise ratio, multichannel images. nonlinear microscopy: multiphoton microscopy; principles of two-photon fluorescence, advantages of two-photon excitation, tandem scanning (spinning disk) microscopes, deconvolving confocal images; image processing, three-dimensional reconstruction; advanced fluorescence techniques: FLIM, FRET, and FCS, Fluorescence Lifetime, Fluorescence Resonant Energy Transfer (FRET), Fluorescence Correlation Spectroscopy (FCS), Evanescent Wave Microscopy; Near-Field and Evanescent Waves, Total Internal Reflection Microscopy; Near-Field Microscopy; Beyond the Diffraction Limit:	8 lectures

		Stimulated Emission Depletion (STED), Super-Resolution Summary, Super-Resolution Imaging with Stochastic Optical Reconstruction Microscopy (STORM) and Photoactivated Localization Microscopy (PALM).	
Unit II	Mass spectroscopy	Ionization techniques; mass analyzers/overview MS; FT-ICR and Orbitrap, fragmentation of peptides; proteomics, nano LC-MS; Phospho proteomics; interaction proteomics, mass spectroscopy in structural biology; imaging mass spectrometry.	4 lectures
Unit III	Systems biology	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.	3 lectures
Unit IV	Structural biology	X-ray diffraction methods, solution & solid-state NMR, cryo-electron microscopy, small-angle X-ray scattering, Atomic force microscopy.	3 lectures
Unit V	CRISPR-CAS	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.	6 lectures
Unit VI	Nanobodies	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.	4 lectures

EVALUATION SCHEME (THEORY)

Examination	**Duration**	**Marks**
Internal Exam	45 minutes	15
Attendance		5
End Semester Exam	1 hour 15 minutes	30
Total		***50***

BOOKS RECOMMENDED:

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). P*hysical Biology of the Cell*. New York: Garland Science.

4. Nelson, P. C., Radosavljević, M., & Bromberg, S. (2004). *Biological Physics: Energy, Information, Life*. New York: W.H. Freeman.
5. Huang, B., Bates, M., & Zhuang, X. (2009). *Super-Resolution Fluorescence Microscopy.* Annual Review of Biochemistry, 78(1), 993-1016. 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. 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.
16. Sohier, J., Laurent, C., Chevigné, A., Pardon, E., Srinivasan, V., Wernery, U. Galleni, M. (2013). *Allosteric Inhibition of VIM Metallo-β-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 Molecular Imaging?* Theranostics, 4(4), 386-398. doi:10.7150/thno.8006.

Critical Analysis of Classical Papers

Course # MSBT303
Marks: 50 **Credits: 2**

OBJECTIVE
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.

LEARNING OUTCOME
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 a desoxyribonucleic acid fraction isolated from *Pneumococcus* type III.
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
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.
3. Molecular structure of nucleic acids; a structure for deoxyribose nucleic 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
4. 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.
5. 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"
6. *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

1. A protein-conducting channel in the endoplasmic reticulum
Simon SM AND Blobel G.; Cell. 1991 May 3;65(3):371-80
Note: This paper demonstrates the existence of a protein conducting channel

Study help - A brief history of Signal Hypothesis

2. 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

3. 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.

4. Reconstitution of the Transport of Protein between Successive Compartments of the Golgi
Balch WE, Dunphy WG, Braell WA, Rothman JE.; Cell. 1984 Dec;39(2 Pt 1):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.*

5. A complete immunoglobulin gene is created by somatic recombination
Brack C, Hirama 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.

6. 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 odorat receptors is expressed.

7. 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.
2. 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
3. Hedgehog signaling 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 mutagenes 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 cillia in it.
Suggested Reference paper - Design and execution of a embryonic lethal mutation screen in mouse.

EVALUATION SCHEME (THEORY)

Examination	**Marks**
Internal Exam Presentation	15
Attendance	5
External Exam Presentation	30
Total	***50***

Bioentrepreneurship

Course # MSBT304 **Total Lecture Hr.= 32**
Marks: 50 **Credits: 2**

OBJECTIVE

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

LEARNING OUTCOME

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.

COURSE DESCRIPTION:

Sr. No.	Topics	Detail syllabus	No. of lectures
Unit I	Innovation and entrepreneurship in bio-business	Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (*e.g.* pharmaceuticals *vs.* Industrial biotech), Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities, Alternatives faced by emerging bio-firms and the relevant tools for strategic decision, Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies.	8 lectures
Unit II	Bio markets - business strategy and marketing	Negotiating the road from lab to the market (strategies and processes of negotiation with financiers, government and regulatory authorities), Pricing strategy, Challenges in marketing in bio business (market conditions & segments; developing distribution channels, the nature, analysis and management of customer needs), Basic contract principles, different types of agreement and contract terms typically found	8 lectures

		in joint venture and development agreements, Dispute resolution skills.	
Unit III	Finance and accounting	Business plan preparation including statutory and legal requirements, Business feasibility study, financial management issues of procurement of capital and management of costs, Collaborations & partnership, Information technology.	8 lectures
Unit IV	Technology management	Technology – assessment, development & upgradation, Managing technology transfer, Quality control & transfer of foreign technologies, Knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP).	8 lectures

EVALUATION SCHEME (THEORY)

Examination	**Duration**	**Marks**
Internal Exam	45 minutes	15
Attendance		5
End Semester Exam	1 hour 15 minutes	30
Total		***50***

BOOKS RECOMMENDED:

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.

Intellectual Property Rights, Biosafety and Bioethics

Course # MSBT305 **Total Lecture Hr.=29**
Marks: 50 **Credits: 2**

OBJECTIVE
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.

LEARNING OUTCOME
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.

COURSE DESCRIPTION:

Sr. No.	Topics	Detail syllabus	No. of lectures
Unit 1	Introduction to IPR	Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; introduction to history of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; concept of 'prior art': invention in context of "prior art"; patent databases - country-wise patent searches (USPTO, EPO, India); analysis and report formation.	5 lectures
Unit 2	Patenting	Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application; role of a Country Patent Office; filing	5 lectures

		of a patent application; precautions before patenting-disclosure/non-disclosure - patent application- forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications; PCT and conventional patent applications; international patenting-requirement, procedures and costs; financial assistance for patenting-introduction to existing schemes; publication of patents-gazette of India, status in Europe and US; patent infringement- meaning, scope, litigation, case studies and examples; commercialization of patented innovations; licensing – outright sale, licensing, royalty; patenting by research students and scientists-university/organizational rules in India and abroad, collaborative research - backward and forward IP; benefit/credit sharing among parties/community, commercial (financial) and non-commercial incentives.	
Unit III	Biosafety	Biosafety and Biosecurity - introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs; principles of safety assessment of transgenic plants – sequential steps in risk assessment; concepts of familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation – protection goals, compilation of relevant information, risk characterization and development of analysis plan; risk assessment of transgenic crops *vs* cisgenic plants or products derived from RNAi, genome editing tools.	7 lectures
Unit IV	National and international regulations	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	7 lectures

		research trials – standard operating procedures - guidelines of state governments; GM labeling – Food Safety and Standards Authority of India (FSSAI).	
Unit V	Bioethics	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.	5 lectures

EVALUATION SCHEME (THEORY)

Examination	**Duration**	**Marks**
Internal Exam	45 minutes	15
Attendance		5
End Semester Exam	1 hour 15 minutes	30
Total		***50***

BOOKS RECOMMENDED:

1. Ganguli, P. (2001). *Intellectual Property Rights: Unleashing the Knowledge Economy.* New Delhi: Tata McGraw-Hill Pub.
2. *National IPR Policy*, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI
3. *Complete Reference to Intellectual Property Rights Laws*. (2007). Snow White Publication Oct.
4. Kuhse, H. (2010). *Bioethics: an Anthology*. Malden, MA: Blackwell.
5. Office of the Controller General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India. http://www.ipindia.nic.in/
6. Karen F. Greif and Jon F. Merz, *Current Controversies in the Biological Sciences -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 of Plants. http://www.upov.int
10. National Portal of India. http://www.archive.india.gov.in
11. National Biodiversity Authority. http://www.nbaindia.org
12. Recombinant DNA Safety Guidelines, 1990 Department of Biotechnology, Ministry of Science and Technology, Govt. of India. Retrieved from http://www.envfor.nic.in/ divisions/csurv/geac/annex-5.pdf
13. Wolt, J. D., Keese, P., Raybould, A., Fitzpatrick, J. W., Burachik, M., Gray, A., Wu, F. (2009). *Problem Formulation in the Environmental Risk Assessment for Genetically Modified Plants*. Transgenic Research, 19(3), 425-436. doi:10.1007/s11248-009-9321-9

14. Craig, W., Tepfer, M., Degrassi, G., & Ripandelli, D. (2008). *An Overview of General Features of Risk Assessments of Genetically Modified Crops*. Euphytica, 164(3), 853-880. doi:10.1007/s10681-007-9643-8
15. Guidelines for Safety Assessment of Foods Derived from Genetically Engineered Plants. 2008.
16. Guidelines and Standard Operating Procedures for Confined Field Trials of Regulated Genetically Engineered Plants. 2008. Retrieved from http://www.igmoris.nic.in/guidelines1.asp
17. Alonso, G. M. (2013). *Safety Assessment of Food and Feed Derived from GM Crops: Using Problem Formulation to Ensure "Fit for Purpose" Risk Assessments*.
Retrieved from http://biosafety.icgeb.org/inhousepublicationscollectionbiosafetyreviews.

Project Proposal Preparation & Presentation

Course # MSBT306
Marks: 50 **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.

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.

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.

Seminar

Course # MSBT307
Marks: 25 **Credit: 1**

Laboratory VI: Bioprocess Engineering & Technology

Course # MSBT308
Marks: 100 **Credits: 4**

OBJECTIVES

The objectives of this laboratory course are to provide hands-on training to students in upstream and downstream unit operations.

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
a) Scale up from frozen vial to agar plate to shake flask culture.
b) Instrumentation: Microplate reader, spectrophotometer, microscopy.
c) Isolation of microorganisms from soil samples.

2. Experimental set-up
a) Assembly of bioreactor and sterilization.
b) Growth kinetics.
c) Substrate and product inhibitions.
d) Measurement of residual substrates.

3. Data Analysis
a) Introduction to Metabolic Flux Analysis (MFA).

4. Fermentation
a) Batch.
b) Fed-batch.
c) Continuous.

5. Unit operations
a) Microfiltrations: Separation of cells from broth.
b) Bioseparations: Various chromatographic techniques and extractions.
6. Bioanalytics
a) Analytical techniques like HPLC, FPLC, GC, GC-MS *etc.* for measurement of amounts of products/substrates.

RECOMMENDED TEXTBOOKS

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). B*iochemical 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.

PRACTICAL EVALUATION SCHEME

Examination	**Marks**
Practical Internal (Continuous) assessment:	40
End semester examination:	60
Total:	**100**

Laboratory VII: Bioinformatics

Course # MSBT309

Marks: 50 **Credits: 2**

COURSE OBJECTIVES

The aim of this course is to provide practical training in bioinformatic 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 ClustalW.
6. Phylogenetic analysis of protein and nucleotide sequences.
7. Use of gene prediction methods (GRAIL, Genscan, Glimmer).
8. Using RNA structure prediction tools.
9. Use of various primer designing and restriction site prediction tools.
10. Use of different protein structure prediction databases (PDB, SCOP, CATH).
11. Construction and study of protein structures using Deepview/PyMol.
12. Homology modelling of proteins.
13. Use of tools for mutation and analysis of the energy minimization of protein structures.
14. Use of miRNA prediction, designing and target prediction tools.

PRACTICAL EVALUATION SCHEME

Examination	**Marks**
Practical Internal (Continuous) assessment:	20
End semester examination:	30
Total:	**50**

Elective II Biological Imaging

Course # MSBT310 **Total Lecture Hr.=22**
Marks: 50 **Credits: 2**

OBJECTIVE

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.

LEARNING OUTCOME

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.

COURSE DESCRIPTION:

Sr. No.	Topics	Detail syllabus	No. of lectures
Unit I	Widefield fluorescent microscopy	One of the most basic techniques for live-cell imaging is widefield 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 widefield, 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 widefield 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. Widefield 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.	3 lectures

Unit II	Confocal laser scanning microscopy (CLSM)	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.	3 lectures
Unit III	Spinning disc confocal microscopy (SDCM)	This method utilises a 'Nipkow Disc' which is a mechanical opaque disc which has a series of thousands of drilled or etched pinholes arranged in a 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 though 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 useful if you are looking at dynamic changes within living cells over a wide spectrum of time-scales.	2 lectures
Unit IV	Light-sheet fluorescence microscopy (LSFM, or SPIM)	This method enables one to perform live-cell imaging on whole embryos, tissues and cell spheroids *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	2 lectures

		localization capabilities.	
Unit V	Super-resolved fluorescence microscopy	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.	8 lectures
Unit VI	Re-scan confocal microscopy	Structured Illumination Microscopy; Correlative Nanoscopy: AFM Super-Resolution (STED/STORM) ; Stochastic Optical Fluctuation Imaging.	4 lectures

EVALUATION SCHEME (THEORY)

Examination	**Duration**	**Marks**
Internal Exam	45 minutes	15
Attendance		5
End Semester Exam	1 hour 15 minutes	30
Total		**50**

BOOKS RECOMMENDED:

1. Rajagopal Vadivambal, Digvir S. Jayas. (2015). *Bio-Imaging: Principles, Techniques, and Applications*. ISBN 9781466593671 - CAT# K20618.
2. Alberto Diaspro, Marc A. M. J. van Zandvoort. (2016). *Super-Resolution Imaging in Biomedicine*. ISBN 9781482244342 - CAT# K23483.
3. Taatjes, Douglas, Roth, Jürgen (Eds.). (2012). *Cell Imaging Techniques Methods and Protocols*. ISBN 978-1-62703-056-4.

Elective II Computational Biology

Course # MSBT311 **Total Lecture Hr.=36**
Marks: 50 **Credits: 2**

OBJECTIVE

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

LEARNING OUTCOME

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.

COURSE DESCRIPTION:

Sr. No.	Topics	Detail syllabus	No. of Lectures
Unit I	Introduction to computational biology basics and biological databases	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.	4 lectures
Unit II	Pairwise and multiple sequence alignments	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.	5 lectures
Unit III	Genome analysis	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,	6 lectures

		extract and build sub databases; Visualization tools including Artemis and Vista for genome comparison; Functional genomics case studies.	
Unit IV	Structure visualization	Retrieving and drawing structures, Macromolecule viewing platforms, Structure validation and correction, Structure optimization, Analysis of ligand-protein interactions; Tools such as PyMol or VMD.	3 lectures
Unit V	Molecular modelling	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.	6 lectures
Unit VI	Structure-based drug development	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. Extraprecision docking platforms, Use of Small-molecule libraries, Natural compound libraries for virtual high throughput screenings.	6 lectures
Unit VII	Ligand-based drug development	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.	6 lectures

EVALUATION SCHEME (THEORY)

Examination **Duration** **Marks**

Internal Exam	45 minutes	15
Attendance		5
End Semester Exam	1 hour 15 minutes	30
Total		**50**

BOOKS RECOMMENDED:

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

Elective II Drug Discovery and Development

Course # MSBT312 **Total Lecture Hr.=29**
Marks: 50 **Credits: 2**

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

LEARNING OUTCOME
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.

COURSE DESCRIPTION:

Sr. No.	Topics	Detail syllabus	No. of lectures
Unit I	Target identification and molecular modelling	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 38 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.	7 lectures
Unit II	Lead optimization	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,	5 lecturesSS

		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	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.	5 lectures
Unit IV	Drug manufacturing	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.	4 lectures
Unit V	Clinical trial design	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.	4 lectures
Unit VI	Fundamentals of regulatory affairs and bioethics	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.	4 lectures

EVALUATION SCHEME (THEORY)

Examination	**Duration**	**Marks**

Internal Exam	45 minutes	15
Attendance		5
End Semester Exam	1 hour 15 minutes	30
Total		**50**

BOOKS RECOMMENDED:

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.

Elective II Environmental Biotechnology

Course # MSBT313 **Total Lecture Hr.=40**
Marks: 50 **Credits: 2**

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.

LEARNING OUTCOME

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.

COURSE DESCRIPTION:

Sr. No.	Topics	Detail syllabus	No. of Lectures
Unit I	Introduction to environment	Introduction to environment; pollution and its control; pollution indicators; waste management: domestic, industrial, solid and hazardous wastes; strain improvement; Biodiversity and its conservation; Role of microorganisms in geochemical cycles; microbial energy metabolism, microbial growth kinetics and elementary chemostat theory, relevant microbiological processes, microbial ecology.	6 lectures
Unit II	Bioremediation	Bioremediation: Fundamentals, methods and strategies of application (biostimulation, bioaugmentation) – examples, bioremediation of metals (Cr, As, Se, Hg), radionuclides (U, Te), organic pollutants (PAHs, PCBs, Pesticides, TNT *etc.*), technological aspects of bioremediation (*in situ*, *ex situ*).	6 lectures
Unit III	Role of microorganisms in bioremediation	Application of bacteria and fungi in bioremediation: White rot fungi *vs* specialized degrading bacteria: examples, uses and advantages *vs* disadvantages; Phytoremediation: Fundamentals and description of major methods of application (phytoaccumulation, phytovolatilization, rhizofiltration phytostabilization).	6 lectures
Unit IV	Biotechnology and agriculture	Bioinsecticides: *Bacillus thuringiensis*, Baculoviruses, uses, genetic modifications and aspects of safety in their use; Biofungicides: Description of mode of actions and mechanisms (*e.g. Trichoderma*, *Pseudomonas fluorescens*); Biofertilizers: Symbiotic systems between plants – microorganisms (nitrogen fixing symbiosis, mycorrhiza fungi symbiosis), Plant growth promoting rhizobacteria (PGPR) – uses, practical aspects and problems in application.	11 lectures

Unit V	Biofuels	Environmental Biotechnology and biofuels: biogas; bioethanol; biodiesel; biohydrogen; Description of the industrial processes involved, microorganisms and biotechnological interventions for optimization of production; Microbiologically enhanced oil recovery (MEOR); Bioleaching of metals; Production of bioplastics; Production of biosurfactants: bioemulsifiers; Paper production: use of xylanases and white rot fungi.	11 lectures

EVALUATION SCHEME (THEORY)

Examination	**Duration**	**Marks**
Internal Exam	45 minutes	15
Attendance		5
End Semester Exam	1 hour 15 minutes	30
Total		***50***

BOOKS RECOMMENDED:

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. Rehm and G. Reed, (2001), Biotechnology – A Multi-volume Comprehensive Treatise, Vol. 11, 2nd Ed., VCH Publishers Inc.

Elective II Protein Engineering

Course # MSBT314 **Total Lecture Hr.=21**
Marks: 50 **Credits: 2**

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

LEARNING OUTCOME
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.

COURSE DESCRIPTION:

Sr. No.	Topics	Detail syllabus	No. of lectures
Unit I	Introduction to protein engineering	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.	5 lectures
Unit II	Stability of protein structure	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.	5 lectures
Unit III	Applications	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	5 lectures

		yeast surface display; Applications to vaccines, Peptidomimetics and its use in drug discovery.	
Unit IV	Computational approaches	Computational approaches to protein engineering: sequence and 3D structure analysis, Data mining, Ramachandran map, Mechanism of stabilization of proteins from psychrophiles and thermophiles vis-à-vis those from mesophiles; Protein design, Directed evolution for protein engineering and its potential.	5 lectures
Unit V	Case studies	Case studies	1 lecture

EVALUATION SCHEME (THEORY)

Examination	**Duration**	**Marks**
Internal Exam	45 minutes	15
Attendance		5
End Semester Exam	1 hour 15 minutes	30
Total		**50**

BOOKS RECOMMENDED:

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.

Elective II Vaccines

Course # MSBT315 **Total Lecture Hr.= 30**
Marks: 50 **Credits: 2**

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

LEARNING OUTCOME
By the end of this course, students should be able to:
• Understand fundamental concepts of human immune system and basic immunology;
• Differentiate and understand immune responses in relation to infection and vaccination;
• Understand requirement and designing of different types of vaccines;
• Understand importance of conventional and new emerging vaccine technologies.

COURSE DESCRIPTION:

Sr. No.	Topics	Detail syllabus	No. of lectures
Unit I	Fundamentals of immune system	Overview of Immune system; Human Immune system: Effectors of immune system; Innate & Adaptive Immunity; Activation of the Innate Immunity; Adaptive Immunity; T and B cells in adaptive immunity; Immune response in infection; Correlates of protection.	6 lectures
Unit II	Immune response to infection	Protective immune response in bacterial; viral and parasitic infections; Primary and Secondary immune responses during infection; Antigen presentation and Role of Antigen presenting cells: Dendritic cells in immune response; Innate immune response; Humoral (antibody mediated) responses; Cell mediated responses: role of CD4+ and CD8+ T cells; Memory responses: Memory and effector T and B cells, Generation and Maintenance of memory T and B cells.	9 lectures
Unit III	Immune response to vaccination	Vaccination and immune response; Adjuvants in Vaccination; Modulation of immune responses: Induction of Th1 and Th2 responses by using appropriate adjuvants and antigen delivery systems - Microbial adjuvants, Liposomal and Microparticles as delivery systems; Chemokines and cytokines; Role of soluble mediators in vaccination; Oral	8 lectures

		immunization and Mucosal Immunity.	
Unit IV	Vaccine types & design	History of vaccines, Conventional vaccines; Bacterial vaccines; Viral Vaccines; Vaccines based on routes of administration: parenteral, oral, mucosal; Live attenuated and inactivated vaccine; Subunit Vaccines and Toxoids; Peptide Vaccine.	3 lectures
Unit V	Vaccine technologies	New Vaccine Technologies; Rationally designed Vaccines; DNA Vaccination; Mucosal vaccination; New approaches for vaccine delivery; 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).	4 lectures

EVALUATION SCHEME (THEORY)

Examination	**Duration**	**Marks**
Internal Exam	45 minutes	15
Attendance		5
End Semester Exam	1 hour 15 minutes	30
Total		***50***

BOOKS RECOMMENDED:

1. Janeway, C. A., Travers, P., Walport, M., & Shlomchik, M. J. (2005). *Immuno Biology: the Immune System in Health and Disease*. USA: Garland Science Pub.
2. Kindt, T. J., Osborne, B. A., Goldsby, R. A., & Kuby, J. (2013). *Kuby Immunology*. New York: W.H. Freeman.
3. Kaufmann, S. H. (2004). *Novel Vaccination Strategies*. Weinheim: Wiley-VCH.
4. Journal Articles (relevant issues) from: Annual Review of Immunology, Annual Review of Microbiology, Current Opinion in Immunology, Nature Immunology, Expert review of vaccines.

SEMESTER FOUR		
MSBT401	**DISSERTATION**	**24**
Total		**24**

MSBT401: 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.

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 designand 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.