Mody University of Science & Technology

Master of Science (Biotechnology)

(Effective from Academic Year 2020-21)

The proposed programme shall be governed by the Department of - Biosciences, SLAS, MUST, Laxshmangarh.

Programme Level: Post Graduate **Duration:** Two Years (Four Semesters)

No. of Seats: 10

M.Sc. – Biotechnology

Vision

Biotechnology is a frontline area of science with immense potential for the benefit of the mankind. Therefore, the department of bioscience is committed to achieve high standards in teaching, and to become a sought-after destination for highly motivated students and faculty. The Programme aspires to lead in the areas of Molecular biology, cytogenetics, Biostatistics, Biophysical techniques, plant biotechnology, animal biotechnology, Bioinformatics & IPR, Immunology, genetic engineering, Bioprocess Engineering.

Mission

- To maintain high quality of education with latest techniques, inculcating in students, the ability to be lifelong learners, and continually upgrading the program curriculum to meet the requirement of industry.
- To provide a flexible curriculum that allows the students to study courses of her choice (through Elective courses) that will fulfill their aptitude and professional aspirations..
- To create opportunities and a supporting infrastructure for students – through laboratory courses, projects, dissertations.

Program Educational Objectives (PEOs)

PEO 1 : Post Graduates are prepared with analytical and critical thinking for finding the solution for the problems associated with the society in terms of human welfare.

PEO 2 : Post Graduates are provided with practical training, hands-on and project experience to meet the industrial needs.

PEO 3 : Post Graduates are motivated in career and entrepreneurial skill development to become global leaders.

Program Outcomes (POs)

At the end of the M.Sc Programme, Post-graduates will be able to

PO 1 Become well versed with the knowledge in interdisciplinary subjects to understand the need and impact of biotechnological solutions on environment and societal context keeping in view need for sustainable solution.

PO 2 The student gets hands-on experience in basic biology/molecular biology and related techniques to venture into research world for a good career within country and abroad.

PO 3 Practical hands on exposure and the institutional academic program, student develops a sustainable approach in both academia and corporate sectors.

Scope

The MSc Biotechnology is a postgraduate degree with a focus in science, medicine, engineering with a combination of two of these disciplines, focusing on biology and chemistry along with principles of design and engineering. The field of biotechnology uses living organisms to generate controlled processes or their final products. Students pursuing this degree can learn about genetics, microbiology, cellular biology, process design and genetic engineering and their applications in healthcare or food production. This degree program prepares students for biotechnology careers by encompassing a broad range of subjects that many degree programs do not. Besides providing students with necessary knowledge, the degree coursework fosters problem solving and critical thinking skills that prepare students to take on various design and engineering challenges. Additionally, earning the degree can improve likelihood of employment as science and engineering employers often prefer candidates with post graduate degrees. MSc Biotechnology graduates can work in research or development in a variety of bioengineering fields. These include pharmaceutical or medical design, genetic engineering, biofuel production, and industrial biotechnology systems.

Input Qualification:

Candidates should possess a Bachelor degree offered by a recognized university in the following fields, viz., Agriculture, Pharmacy, Biological, Physical, Veterinary and Fishery Sciences, Engineering/Technology, Medicine (MBBS) or BDS or 4-years BSc (Physician Assistance Course).

Programmed and Teaching Methodology

The teaching methods include lectures, practical's, field visits, workshops, seminars, field visits, guest lectures etc.

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Evaluation Procedure

All the Rules and Regulations as provided in the Ordinances and Regulations of the Mody University shall be followed. No student shall be admitted as a candidate for the examination for any of the Parts/Semesters after the lapse of [4] years from the date of admission to the Part-I/Semester-I of the Programme.

Minimum Credits (Excluding Proficiency credits) required for year up-gradation: Year up-gradation of the student will be as per the University ordinance.

Session 2020-2021 onwards										
Name of the Programme: M.Sc. Biotechnology							**Year: First**			
	Course Code	Course Title	Contact Hours per Week			Credits	ETE Duration Hours	Weightage (%)		
			L	T	P			CW[$]	MTE	ETE
	Core Courses									
	BT20.501	Biochemistry	3	-	-	3	3	25	25	50
	BT20.503	Genetics	2	-	-	2	3	25	25	50
	BT20.505	Microbiology	2	-	-	2	3	25	25	50
	BT20.507	Cell and Molecular Biology	3	-	-	3	3	25	25	50
	BT20.509	Biochemistry and Instrumentation Laboratory	-	-	6	3	6	25	25	50
	BT20.511	Biotechnology Laboratory-I	-	-	6	3	6	25	25	50
	BT20.513	IPR, Biosafety and Bioethics	2	-	-	2	3	25	25	50
	RM20.501	Research Methodology and Scientific Communication Skills	2	-	-	2	3	25	25	50
	MS20.501	Math and Statistics for Biology	2	-	-	2	3	25	25	50
	FL-I	Foreign Language-I	3	-	-	3	3	25	25	50
		Sub Total	**19**		**12**	**25**				
Autumn Semester	SF 101	Personal Grooming, Fine Dining (Non credit)				1				

	Course Code	Course Title	Contact Hours per Week			Credits	ETE Duration Hours	Weightage (%)		
			L	T	P			CW$	MTE	ETE
	Core Courses									
	BT20.502	Bioinformatics	3	-	-	3	3	25	25	50
	BT20.504	Immunology	3	-	-	3	3	25	25	50
	BT20.506	Genetics Engineering	3	-	-	3	3	25	25	50
	BT20.508	Genomics and Proteomics	2	-	-	2	3	25	25	50
	BT20.510	Plant and Animal Biotechnology	3	-	-	3	3	25	25	50
		Elective Course	3	-	-	3	3	25	25	50
	BT20.516	Bioinformatics and Immunology Laboratory	-	-	6	3	6	25	25	50
	BT20.518	Biotechnology Laboratory-II	-	-	6	3	6	25	25	50
	FL-II	Foreign Language-II	3	-	-	3	3	25	25	50
		Sub Total	**20**		**12**	**26**				
Spring Semester	SF 102	Social Grooming, Home & Decor and Business Comm unication (Non credit)				1				

$CW (Course work) includes teacher assessment, assignments, class /quiz test.

Elective Courses	BT20.512 Food Technology FS20.510 Introduction to Forensic Biotechnology

Session 2020-2021 onwards											
Name of the Programme: M.Sc. Biotechnology							**Year: Second**				
	Course Code	Course Title	Contact Hours per Week			Credits	ETE Duration Hours	Weightage (%)		
			L	T	P			CW$	MTE	ETE
Autumn Semester										
	BT20.601	Bioprocess Engineering and Technology	3	-	-	3	3	25	25	50
	BT20.603	Emerging Technologies	2	-	-	2	3	25	25	50
	BT20.605	Bioentrepreneurship	2	-	-	2	3	25	25	50
	BT20.607	Environmental Biotechnology	3	-	-	3	3	25	25	50
	BT20.609	Critical Analysis of Classical Papers	2	-	-	2	-	100		
	BT20.611	Project Proposal	2	-	-	2	-	100		
	BT20.613	Research Seminar	1	-	-	1	-	100		
		Elective Course	3	-	-	3	3	25	25	50
	BT20.619	Biotechnology Laboratory-III	-	-	6	3	8	25	25	50
		Sub Total	**19**	**-**	**6**	**21**				
	Course Code	Course Title	Contact Hours per Week			Credits	ETE Duration Hours	Weightage (%)		
			L	T	P			CW$	MTE	ETE
Spring Semester										
	BT20.602	Dissertation	-	-	40	20	-	25	-	75
		Sub Total				**20**				
Total			**92**							

Elective Courses	BT20.615 Biocatalysis and Biotransformation BT20.617. Molecular Diagnostics

BT20.501	**Biochemistry**	**3-0-0-3**
Course Objective	The objectives of this course are to build upon undergraduate level knowledge of biochemical principles with specific emphasis on different metabolic pathways. The course shall make the students aware of various disease pathologies within the context of each topic.	7
	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; 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 dynamics simulation.	7
	Enzyme catalysis – general principles of catalysis; quantitation of enzyme activity and efficiency; enzyme characterization and Michaelis-Menten kinetics; relevance of enzymes in metabolic regulation, activation, inhibition and covalent modification; single substrate enzymes; concept of catalytic antibodies; catalytic strategies with specific examples of proteases, carbonic anhydrases, restriction enzymes and nucleoside monophosphate kinase; regulatory strategies with specific example of hemoglobin; isozymes; role of covalent modification in enzymatic activity; zymogens.	7
	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. 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	7

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.

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; F_1-F_0 ATP Synthase; shuttles across mitochondria; regulation of oxidative phosphorylation 7

Photosynthesis – chloroplasts and two photosystems; proton gradient across thylakoid membrane; Calvin cycle and pentose phosphate pathway; glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, roles of epinephrine and glucagon and insulin in glycogen metabolism; Fatty acid metabolism; protein turnover and amino acid catabolism; nucleotide biosynthesis; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and mevalonate pathway; elucidation of metabolic pathways; logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; principles of metabolic regulation; steps for regulation. 11

Course Outcome

Students should be able to –

- Gain fundamental knowledge in biochemistry.
- Understand the molecular basis of various pathological conditions from the perspective of biochemical reactions.

Suggested Readings

Text Book:

1. Stryer, L. (1988). Biochemistry. New York: Freeman.
2. Lehninger, A. L. (1982). Principles of biochemistry (4th ed.). New York, NY: Worth.

References:

1. Voet, D., & Voet, J. G. (2004). Biochemistry (4th ed.). Hoboken, NJ: J. Wiley & Sons.
2. Dobson, C. M. (2003). Protein folding and misfolding. Nature, 426(6968), 884-890. doi:10.1038/nature02261.
3. Richards, F. M. (1991). The Protein Folding Problem. Scientific American, 264(1), 54-63. doi:10.1038/scientificamerican0191-54.

BT20.503	**Genetics**	**2-0-0-2**
Course Objective	The objectives of this course are to take the students through the basics of genetics and classical genetics encompassing prokaryotic/phage genetics to yeast and higher eukaryotic domains. On covering all classical concepts of Mendelian genetics across these life-forms, the students will be exposed to the concepts of population genetics, quantitative genetics encompassing complex traits,	
	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; genetic complementation and other genetic crosses using phenotypic markers; phenotype to genotype connectivity prior to DNA- based understanding of a gene.	8
	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
	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 the context of developmental mechanisms.	4
	Population Genetics & Genetics of Evolution:Introduction to the elements of population genetics: genetic variation, genetic drift, neutral evolution; mutation selection, balancing selection, Fishers theorem, Hardy-Weinberg equilibrium, linkage disequilibrium; in-breeding depression & mating systems; population bottlenecks, migrations, Bayesian statistics; adaptive landscape, spatial variation & genetic fitness.	4
	Quantitative Genetics of complex traits (QTLs):Complex traits, mapping QTLs, yeast genomics to understand biology of QTLs. Plant Genetics:Laws of segregation in plant crosses, inbreeding, selfing, heterosis, maintenance of genetic purity, gene pyramiding.	4
Course Outcome	On successful completion of this course, the student will be able to – • Describe the fundamental molecular principles of genetics. • Understand the relationship between phenotype and genotype in human genetic traits. • Describe the basics of genetic mapping. • Understand how gene expression is regulated.	
Suggested Readings	**Text Book:** Hartl, D. L., & Jones, E. W. (1998). Genetics: Principles and analysis. Sudbury, MA: Jones and Bartlett.	

References:

Pierce, B. A. (2005). Genetics: A conceptual approach. New York: W.H. Freeman.

Tamarin, R. H., & Leavitt, R. W. (1991). Principles of genetics. Dubuque, IA: Wm. C. Brown.

Smith, J. M. (1989). Evolutionary genetics. Oxford: Oxford University Press.

BT20.505 Microbiology **2-0-0-2**

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

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
Microbial Diversity Microbial taxonomy and the 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.	8
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
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.	4
Host-Microbes Interaction Host-pathogen interaction, ecological impacts 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

Course Outcome Students should be able to –

- Identify the major categories of microorganisms and analyze their classification, diversity, and ubiquity.
- Identify and demonstrate the structural, physiological, and genetic similarities and differences of the major categories of microorganisms.

- Identify and demonstrate how to control microbial growth.
- Demonstrate and evaluate the interactions between microbes, hosts and environment.

Suggested Readings

Text Book:

Pelczar, M. J., Reid, R. D., & Chan, E. C. (1977). Microbiology (5th ed.). New York: McGraw-Hill.

References:

Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). Prescott's microbiology. New York: McGraw-Hill.

Matthai, W., Berg, C. Y., & Black, J. G. (1999). Microbiology, principles and explorations. Boston, MA: John Wiley & Sons.

BT20.507 Cell and Molecular Biology **3-0-0-3**

Course Objective

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

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

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, trancriptional initiation, elongation and termination; post-transcriptional control: splicing and addition of cap and tail, mRNA flow through nuclear envelope into cytoplasm, breakdown of selective and specific mRNAs through interference by small non-coding RNAs (miRNAs and siRNAs), protein translation machinery, ribosomes-composition and assembly; universal genetic codes, degeneracy of codons, Wobble hypothesis; Iso-accepting tRNA; mechanism of initiation, elongation and termination; co- and post-translational modifications, mitochondrial genetic code translation product cleavage, modification and activation. 12

Cellular Signalling: Transport and Trafficking Molecular mechanisms of membrane transport, nuclear transport, transport 6

across mitochondria and chloroplasts; intracellular vesicular trafficking from endoplasmic reticulum through Golgi apparatus to lysosomes/cell exterior.

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.

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

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; oncogenes as transcriptional activators. 7

Course 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?

Suggested Readings

Text Book:

Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2002). Molecular biology of the cell. New York: Garland Science.

Lodish, H. F. (2000). Molecular cell biology. New York: W.H. Freeman.

References:

Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014). Lewin's genes XI. Burlington, MA: Jones & Bartlett Learning.

Cooper, G. M., & Hausman, R. E. (2009). The cell: A molecular approach. Washington: ASM ; Sunderland.

Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2012). Becker's world of the cell. Boston: Benjamin Cummings.

Watson, J. D. (1987). Molecular biology of the gene (7th ed.). Menlo Park, CA: Benjamin/Cummings.

BT20.509 Biochemistry and Instrumentation Laboratory **0-0-6-3**

Course Objective The objective of this laboratory course is to introduce students to experiments in biochemistry. The course is designed to teach students the utility of set of experimental methods in biochemistry

in a problem oriented manner.

- Preparing various stock solutions and working solutions that will be needed for the course.
- To prepare an Acetic-Na Acetate Buffer and validate the Henderson-Hasselbach equation.
- To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert‟s Law.
- Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by thin layer chromatography.
- Purification and characterization of an enzyme from a recombinant source (such as Alkaline Phosphatase or Lactate Dehydrogenase or any enzyme).
- Experimental verification that absorption at OD_{260} is more for denatured DNA as compared to native double stranded DNA.
- Identification of an unknown sample as DNA, RNA or protein using available laboratory tools. (Optional Experiments)
- Biophysical methods (Circular Dichroism Spectroscopy, Fluorescence Spectroscopy).
- Determination of mass of small molecules and fragmentation patterns by Mass Spectrometry.
- Protein characterization using different gel-based proteomic tools
- Agarose gel electrophoresis

Course Outcome

Students would 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.

BT20.511 **Biotechnology Laboratory-I** **0-0-6-3**

Course Objective

The objective of this laboratory course is to provide the students practical skills on basic microbiological and biotechnological techniques.

- Sterilization, disinfection and safety in microbiological laboratory.

- Preparation of media for cultivation of bacteria.
- Isolation of bacteria in pure culture by streak plate method.
- Study of colony and growth characteristics of some common bacteria: Bacillus, E. coli, Staphylococcus, Streptococcus, etc.
- Preparation of bacterial smear and Gram‟s staining.
- Enumeration of bacteria: standard plate count.
- Antimicrobial sensitivity test and demonstration of drug resistance.
- Maintenance of stock cultures: slants, stabs and glycerol stock cultures
- Determination of phenol co-efficient of antimicrobial agents.
- Determination of Minimum Inhibitory Concentration (MIC)
- Isolation and identification of bacteria from soil/water samples.
- Isolation of genomic DNA, Qualitative and quantitative analyses of the DNA
- Polymerase Chain Reaction, Isolation of plant RNA, cDNA synthesis and RT-PCR expression profiling of genes using RT-PCR
- Study of divisional stages in Mitosis and Meiosis.
- Genetics exercises based on Mendel' s Experiments

Course Outcome

Students should be able to

- Ability to isolate, characterize and identify common bacterial organisms.
- Determine bacterial load of different samples.
- Perform antimicrobial sensitivity test.
- Preserve bacterial cultures.

BT20.513 IPR , Biosafety and Bioethics **2-0-0-2**

Course Objective

- To provide basic knowledge on intellectual property rights and their implications in biological research and product development.
- To learn biosafety and risk assessment of products derived from biotechnology and regulation of such products.
- To understand ethical issues in biological research.

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; 5

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.

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 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. 5

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. 5

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

Bioethics Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient 6

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.

Course Outcome

Students will be able to –

- 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 environment release of genetically modified organisms, national and international regulations
- Understand ethical aspects related to biological, biomedical, health care and biotechnology research.

Suggested Readings

Text Book:

- Ganguli, P. (2001). Intellectual property rights: Unleashing the knowledge economy. New Delhi: Tata McGraw-Hill Pub.
- Complete Reference to Intellectual Property Rights Laws. (2007). Snow White Publication Oct.

References:

- Kuhse, H. (2010). Bioethics: An anthology. Malden, MA: Blackwell.
- Office of the Controler General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India. http://www.ipindia.nic.in/
- World Trade Organisation. http://www.wto.org
- World Intellectual Property Organisation. http://www.wipo.int
- International Union for the Protection of New Varieties of Plants. http://www.upov.int
- National Portal of India. http://www.archive.india.gov.in
- National Biodiversity Authority. http://www.nbaindia.org
- 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

- 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

RM20.501 **Research Methodology and Scientific Communication Skills** **2-0-0-2**

Course Objectives

- To give a background on the history of science, emphasizing the methodologies used to do research
- To use the framework of these methodologies for understanding effective lab practices and scientific communication
- To use the framework of these methodologies to understand and appreciate scientific ethics

History of Science and Science Methodologies **5**

Empirical science; The scientific method; Interrogative perturbation experiments and controls; Deductive and inductive reasoning; Descriptive science; Reductionist vs holistic biology. Preparation for Research

Choosing a mentor, lab and research question; Maintaining a lab notebook with date-wise entry.

Sampling, Scale and Analysis: Sampling and sampling distribution: Meaning, sampling Vs Census, Steps in Sampling process, Types of sampling - Probability and Non probability Sampling Techniques, Data collection: Primary and Secondary data Sources - Advantages/Disadvantages, Data collection Methods: Observations, Survey, Interview and Questionnaire design, Qualitative Techniques of data collection.Nominal Scale, Ordinal Scale, Interval Scale, Ratio Scale, Criteria for good measurement, Attitude measurement Scale – Likert's Scale, Semantic Differential Scale, Thurstone-equal appearing interval scale **10**

Scientific Communication **11**

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; Scientific publication writing: Elements of a scientific paper including Abstract, Introduction,

Materials & Methods, Results, Discussion, References; Drafting titles and framing abstracts; Publishing scientific papers - the 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.

Student Learning Outcomes

- Understanding of the history and methodologies of scientific research, applying these to recent published papers
- Understanding and practicing scientific reading, writing, presentations
- Appreciating scientific ethics through case studies.

Suggested Readings:

1. Valiela, I. (2001). Doing science: Design, analysis, and communication of scientific research. Oxford: Oxford University Press.
2. On being a scientist: A guide to responsible conduct in research. (2009). Washington, D.C.: National Academies Press.
3. Gopen, G. D., & Smith, J. A. (n.d.). The Science of Scientific Writing. American Scientist, 78(Nov-Dec 1990), 550-558.
4. Mohan, K., & Singh, N. P. (2010). Speaking English effectively. Delhi: Macmillan India.
5. Movie: Naturally Obsessed, The Making of a Scientist.

MS20.501 Math and Statistics for Biology 2-0-0-2

Objective: To acquire fundamental knowledge of bio statistics.

1.	**Introduction:** Collection of primary and secondary data, Classification and tabulation of data, Graphs of frequency distribution and Curves, Measures of central tendency — mean, median and mode, Mathematical properties of arithmetic mean, Geometric and harmonic Mean	**05**
2.	**Measures of Dispersion:** Absolute and Relative Measures of Dispersion, Range, Mean deviation, Standard deviation, Mathematical properties of standard deviation, Coefficient of variation, Variance, Skewness and its measures, Kurtosis and its measures	**05**
3.	**Correlation and Regression Analysis:** Meaning, significance and types, Scatter diagram method, Correlation graph, Karl Pearson's correlation coefficient, Coefficient of determination, Spearman's Rank correlation coefficient, Lines of Regression, Regression equations, Difference between correlation and regression analysis	**05**
4.	**Tests of Significance:** Student's t-test, Chi-square tests, Yate's correction factor, ANOVA– One and two way classification with examples	**05**
5.	**Probability and Probability Distributions:** Elements of probability-definition, addition and multiplication, Probability distribution function-Binomial, Poisson and normal, Area under normal probability distribution curve	**06**

Course Outcome: After completion of the course, students would be able to apply the knowledge of bio statistics in sciences and applied sciences with solve curriculum problems.

Text Books:

1. Fundamental of Mathematical Statistics by Gupta and Kapoor, SCS Publisher, 2002.
2. Bailey; Statistical Methods in Biology; Cambridge Publications, UK.

Reference Books:

1. Prasad S.; Elements of Biostatistics; Rastogi Publication, Meerut.
2. Probability, Random Variables and Stochastic Processes by Papoulis, TMH.

BT20.502	**Bioinformatics**	**3-0-0-3**
Course Objective	The objectives of this course are to provide students with the theory and practical experience of the use of common computational tools and databases which facilitate investigation of molecular biology and evolution-related concepts.	
	Bioinformatics basics: Computers in biology and medicine; Importance of Unix and Linux systems and its basic commands; Database concepts; Protein and nucleic acid databases; Structural databases; 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 the web; database mining tools.	7
	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.	7
	Multiple sequence analysis; multiple sequence alignment; flexible sequence similarity searching with the FASTA3 program package; use of CLUSTAL W and CLUSTAL X for multiple sequence alignment; submitting DNA protein sequence to databases: where and how to submit, SEQUIN, genome centres; submitting aligned set of sequences, updates and internet resources; methods of phylogenetic analysis.	7
	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	8
	Protein structure prediction: protein folding and model generation; secondary structure prediction; analyzing secondary structures; protein loop searching; loop generating methods; loop analysis; 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 insilico drug design.	10
Course Outcome	Student should be able to – • Develop an understanding of the 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 the results of their study.

Suggested Readings

Text Book:

- Lesk, A. M. (2002). Introduction to bioinformatics. Oxford: Oxford University Press.
- Mount, D. W. (2001). Bioinformatics: Sequence and genome analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

References:

- Baxevanis, A. D., & Ouellette, B. F. (2001). Bioinformatics: A practical guide to the analysis of genes and proteins. New York: Wiley-Interscience.
- Pevsner, J. (2015). Bioinformatics and functional genomics. Hoboken, NJ.: Wiley- Blackwell.
- Bourne, P. E., & Gu, J. (2009). Structural bioinformatics. Hoboken, NJ: Wiley-Liss.
- Lesk, A. M. (2004). Introduction to protein science: Architecture, function, and genomics. Oxford: Oxford University Press.

BT20.504 **Immunology** **3-0-0-3**

Course Objective

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

Immunology fundamental concepts and anatomy 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 6

disease susceptibility.

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-cell co-operation, Hapten-carrier system.	9
Antigen-antibody interactions Precipitation, agglutination and complement mediated immune reactions; advanced immunological techniques - RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence, flow cytometry and immunoelectron microscopy; surface plasmon resonance, biosenor assays for assessing ligand –receptor interaction, CMI techniques- lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays, apoptosis, microarrays, transgenic mice, gene knock outs.	7
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, 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
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, immunesenescence, immune exhaustion in chronic viral infection, immune tolerance, NK cells in chronic viral infection and malignancy.	9
Course Students should be able to –	

Outcome

- Evaluate the usefulness of immunology in different pharmaceutical companies.
- Identify the proper research lab working in the area of their own interests.
- Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses and figure out the kind of immune responses in the setting of infection (viral or bacterial) by looking at cytokine profile.

Suggested Readings

Text Book:

- Kindt, T. J., Goldsby, R. A., Osborne, B. A., & Kuby, J. (2006). Kuby immunology. New York: W.H. Freeman.
- Brostoff, J., Seaddin, J. K., Male, D., & Roitt, I. M. (2002). Clinical immunology. London: Gower Medical Pub.

References:

- Murphy, K., Travers, P., Walport, M., & Janeway, C. (2012). Janeway's immunobiology. New York: Garland Science.
- Paul, W. E. (1993). Fundamental immunology. New York: Raven Press.
- Goding, J. W. (1986). Monoclonal antibodies: Principles and practice: Production and application of monoclonal antibodies in cell biology, biochemistry, and immunology. London: Academic Press.
- Parham, P. (2005). The Immune System. New York: Garland Science.

BT20.506 Genetic Engineering **3-0-0-3**

Course Objective

The objectives of this course are to teach students with various approaches to conducting genetic engineering that they can apply to their future career 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. This technology has revolutionized the way modern biological research is done and has impacted mankind with a number of biological products and processes.

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 6

	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.	
	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
	Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR – multiplex, nested; real time PCR, touchdown PCR, hot start PCR, colony 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
	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; DNaseI footprinting; methyl interference assay, chromatin immunoprecipitation; protein-protein interactions using yeast two-hybrid system; phage display.	7
	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.	12
Course 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.

Suggested Readings

Text Book:

- Old, R. W., Primrose, S. B., & Twyman, R. M. (2001). Principles of gene manipulation: An introduction to genetic engineering. Oxford: Blackwell Scientific Publications.
- Green, M. R., & Sambrook, J. (2012). Molecular cloning: A laboratory manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

References:

- Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub.
- Selected papers from scientific journals, particularly Nature & Science.
- Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc.

BT20.508 Genomics and Proteomics **2-0-0-2**

Course Objective The objectives of this course are to provide introductory knowledge concerning genomics & proteomics and their applications.

Basics of Genomics and Proteomics Brief overview of prokaryotic and eukaryotic genome organization; extra-chromosomal DNA: bacterial plasmids, mitochondria and chloroplast.	3
Genome Mapping Genetic and physical maps; markers for genetic 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
Genome Sequencing Projects Human Genome Project, genome sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from the web.	4
Proteomics Aims, strategies and challenges in proteomics; proteomics technologies: 2D-PAGE, isoelectric focusing, mass spectrometry, MALDI-TOF, yeast 2-hybrid system, proteome databases.	6
Functional Genomics and Proteomics Transcriptome analysis for identification and functional annotation of gene, Contig assembly, chromosome walking and characterization of chromosomes, mining functional genes in the 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.	9

Course Outcome Students should be able to acquire knowledge and understanding of the fundamentals of genomics and proteomics, transcriptomics and metabolomics and their applications in various applied areas of

biology.

Suggested Readings

Text Book:

- Primrose, S. B., Twyman, R. M., Primrose, S. B., & Primrose, S. B. (2006). Principles of gene manipulation and genomics. Malden, MA: Blackwell Pub.

References:

- Liebler, D. C. (2002). Introduction to proteomics: Tools for the new biology. Totowa, NJ: Humana Press.
- Campbell, A. M., & Heyer, L. J. (2003). Discovering genomics, proteomics, and bioinformatics. San Francisco: Benjamin Cummings.

BT20.510 Plant and Animal Biotechnology **3-0-0-3**

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

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. 10

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.

Plant Genetic Manipulation Genetic engineering: Agrobacterium-plant interaction; virulence; Ti and Ri plasmids; opines and their significance; T-DNA transfer; disarmed Ti plasmid; Genetic transformation - Agrobacterium-mediated gene delivery; cointegrate and binary vectors and their utility; direct gene transfer - PEG-mediated, electroporation, particle bombardment and alternative methods; screenable and selectable markers; characterization of transgenics; chloroplast transformation; marker-free methodologies; 9

advanced methodologies - cisgenesis, intragenesis and genome editing; molecular pharming - concept of plants as biofactories, production of industrial enzymes and pharmaceutically important compounds.

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

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

Molecular Mapping & 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

Course Outcome Students should be able to gain fundamental knowledge in animal and plant biotechnology and their applications.

Suggested Readings

Text Book:

- Chawla, H. S. (2000). Introduction to plant biotechnology. Enfield, NH: Science.
- Razdan, M. K. (2003). Introduction to plant tissue culture. Enfield, NH: Science.

References:

- Slater, A., Scott, N. W., & Fowler, M. R. (2008). Plant biotechnology: An Introduction to Genetic Engineering. Oxford: Oxford University Press.
- Buchanan, B. B., Gruissem, W., & Jones, R. L. (2015). Biochemistry & molecular biology of plants. Chichester, West Sussex: John Wiley & Sons.

- Umesha, S. (2013). Plant biotechnology. The Energy And Resources.
- Glick, B. R., & Pasternak, J. J. (1994). Molecular biotechnology: Principles and applications of recombinant DNA. Washington, D.C.: ASM Press.
- Brown, T. A. (2006). Gene cloning and DNA analysis: An introduction. Oxford: Blackwell Pub.
- Primrose, S. B., & Twyman, R. M. (2006). Principles of gene manipulation and genomics. Malden, MA: Blackwell Pub.
- Slater, A., Scott, N. W., & Fowler, M. R. (2003). Plant biotechnology: The genetic manipulation of plants. Oxford: Oxford University Press.
- Gordon, I. (2005). Reproductive Techniques in Farm Animals. Oxford: CAB International. 11. Levine, M. M. (1997). New generation vaccines. New York: M. Dekker.

BT20.516 Bioinformatics and Immunology Laboratory 0-0-6-3

Course Objective

The objectives of this laboratory course are to make students develop an understanding about practical aspects of the components of the 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.

- Selection of animals, Preparation of antigens, Immunization and methods of bleeding, serum separation and storage.
- Antibody titre by ELISA method.
- Double diffusion, Immuno-electrophoresis and Radial Immuno diffusion.
- Complement fixation test.
- SDS-PAGE, Immunoblotting, Dot blot assays.
- Biological Databases: Sequence databases, Structure databases
- ORF Finder
- Pairwise sequence alignment using BLAST
- MSA using Clustal Omega and MEGA
- Phylogenetic analysis using MEGA software
- Primer Design
- 3-D structure Prediction

Course Outcome

Students should be able to –

- Evaluate the usefulness of immunology and Bioinformatics in different pharmaceutical companies.

- Identify proper research lab working in the area of their own interests.
- Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses and figure out the kind of immune responses in the setting of infection (viral or bacterial) by looking at cytokine profile.
- Apply the bioinformatics tools for evolutionary analysis and drug designing

BT20.518 **Biotechnology laboratory II** **0-0-6-3**

Course Objective The objectives of this course are to provide students with the experimental knowledge of molecular biology & genetic engineering.

- Plasmid DNA isolation and DNA quantitation.
- Restriction Enzyme digestion of plasmid DNA.
- Agarose gel electrophoresis.
- Polymerase Chain reaction.
- DNA Ligation.
- Preparation of competent cells.
- Transformation of E.coli with standard plasmids, Calculation of transformation efficiency.
- Confirmation of the insert, Miniprep of recombinant plasmid DNA, Restriction mapping.
- Vector mediated gene transfer in plants
- Surface sterilization of explants
- Plant tissue culture using leaf/ stem/seeds
- Effect of different pH, Temp, Moisture, and Salt Concentration on plant growth
- PGPRs and their activity analysis
- Primary and Secondary culture of Animal cell lines
- Maintenance and storage of animal cell lines

Course Outcome Students should be able to gain hands-on experience on 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.

BT20.601	**Bioprocess Engineering and Technology**	**3-0-0-3**
Course Objective	The objectives of this course are to educate students about the fundamental concepts of bioprocess technology and its related applications, thus preparing them to meet the challenges of the new and emerging areas of biotechnology industry.	
	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.	5
	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.	5
	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 biotransformations; 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.	10
	Downstream Processing and Product Recovery Separation of insoluble products - filtration, centrifugation, sedimentation, flocculation; Cell disruption; separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis; final purification: drying; crystallization; storage and packaging.	10
	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. 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.	9
Course 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 in a bioproduction process.
- Critically analyze any bioprocess from an economics/market point of view.
- Give an account of important microbial/enzymatic industrial processes in food and fuel industry.

Suggested Readings

Text Book:

- Shuler, M. L., & Kargi, F. (2002). Bioprocess engineering: Basic concepts. Upper Saddle River, NJ: Prentice Hall.
- Stanbury, P. F., & Whitaker, A. (1997). Principles of fermentation technology. Oxford: Pergamon Press.

References:

- Blanch, H. W., & Clark, D. S. (1997). Biochemical engineering. New York: M. Dekker.
- Bailey, J. E., & Ollis, D. F. (1986). Biochemical engineering fundamentals. New York: McGraw-Hill.
- El-Mansi, M., & Bryce, C. F. (2007). Fermentation microbiology and biotechnology. Boca Raton: CRC/Taylor & Francis.

BT20.603 **Emerging Technologies** **2-0-0-2**

Course 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 the basic principles of the new principles to the students and make them appreciate the current-day research tool-kit better.

Optical Microscopy Methods The Light Microscopy: lenses and microscopes, resolution: Rayleigh‟s Approach, Darkfield; Phase Contrast; Differential Interference Contrast; fluorescence and fluorescence microscopy: confocal microscope: scanning optical 8

	microscope, 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: Stimulated Emission Depletion (STED), Super-Resolution Summary, Super-Resolution Imaging with Stochastic Optical Reconstruction Microscopy (STORM) and Photoactivated Localization Microscopy (PALM).	
	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
	Systems Biology and Structural 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. X-ray diffraction methods, solution & solid-state NMR.	6
	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.	4
	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
Course Outcome	Students should be to learn the history, theoretical basis and basic understanding of some of the latest technologies in the area of biotechnology. They should also be able to learn about various applications of these technologies. They may learn one application in depth through an assignment and/or seminar.	
Suggested Readings	**Text Book:** • Campbell, I. D. (2012). Biophysical techniques. Oxford: Oxford University Press. • Serdyuk, I. N., Zaccai, N. R., & Zaccai, G. (2007). Methods in molecular biophysics: Structure, dynamics, function. Cambridge: Cambridge University Press.	

References:

- Phillips, R., Kondev, J., & Theriot, J. (2009). Physical biology of the cell. New York: Garland Science.
- Biological physics: Energy, information, life. New York: W.H. Freeman.
- Huang, B., Bates, M., & Zhuang, X. (2009). Super-Resolution Fluorescence Microscopy. Annu. Rev. Biochem. Annual Review of Biochemistry, 78(1), 993-1016. doi:10.1146/annurev.biochem.77.061906.092014.
- 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.

BT20.605	**Bioentrepreneurship**	**2-0-0-2**
Course Objective	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.	
	Basics of Bioentrepreneurship Importance of entrepreneurship; advantages of being entrepreneur - freedom to operate; introduction to bioentrepreneurship – biotechnology in a global scale; Scope in bioentrepreneurship; types of bio-industries – biopharma, bioagri, bioservices and bioindustrial; innovation – types, out of box thinking; skills for successful entrepreneur – creativity, leadership, managerial, team building, decision making; opportunities for bioentrepreneurship- entreprenuership development programs of public and private agencies (MSME, DBT, BIRAC, Startup & Make in India); patent landscape, IP protection & commercialization strategies.	5
	Accounting and Finance Business plan preparation; business feasibility analysis by SWOT, socio-economic costs benefit analysis; funds/support from Government agencies like MSME/banks and private agencies like venture capitalists:/angel investors for bioentrepreneurship; business plan proposal for „virtual startup company"; statutory and legal requirements for starting a company/venture; basics in accounting practices: concepts of balance sheet, profit and loss statement, double entry bookkeeping; collaborations & partnerships; information technology for business administration and expansion.	5
	Business Strategy Entry and exit strategy; pricing strategy; negotiations with financiers, bankers, government and law enforcement authorities; dispute resolution skills; external environment/ changes; avoiding/managing crisis.	5

Marketing Market conditions, segments, prediction of market changes; identifying needs of customers; Market linkages, branding issues; developing distribution channels - franchising; policies, promotion, advertising; branding and market linkages for „virtual startup company". 5

Knowledge Centre and R&D Knowledge centres e.g., in universities, innovation centres, research institutions (public & private) and business incubators; R&D for technology development and upgradation; assessment of technology development; managing technology transfer; industry visits to successful bio-enterprises, regulations for transfer of foreign technologies; quality control. 6

Course 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.

Suggested Readings

Text Book:

- Adams, D. J., & Sparrow, J. C. (2008). Enterprise for life scientists: Developing innovation and entrepreneurship in the biosciences. Bloxham: Scion.
- Shimasaki, C. D. (2014). Biotechnology entrepreneurship: Starting, managing, and leading biotech companies. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.

References:

- Onetti, A., & Zucchella, A. (n.d.). Business modeling for life science and biotech companies: Creating value and competitive advantage with the milestone bridge. Routledge.
- Jordan, J. F. (2014). Innovation, Commercialization, and Start-Ups in Life Sciences. London: CRC Press.
- Desai, V. (2009). The Dynamics of Entrepreneurial Development and Management. New Delhi: Himalaya Pub. House.

BT20.607 Environmental Biotechnology **3-0-0-3**

Course Objective To introduce the students to various regional and global concerns regarding the environment, including the natural challenges, various types of environmental pollutants and their effects, the changing environment, and the developments of diverse technologies to detect, study and address these concerns. The subject aims to introduce specific examples and cases, and explain how chemical, biological and molecular sciences can be applied to identify and

address issues of environmental concerns.

Sources, generation, classification & composition of pollutants; effect on living organism; Persistence and bio-magnification of xenobiotic molecules. Biological and Chemical methods for detection of Wastes; Need for management of resources.	8
Biodegradation. Acclimation, detoxification activation, bio-availability, effect of chemical structure on biodegradation, recalcitrance, predicting products of biodegradation, co-metabolism and biotransformation. Methods in determining biodegradability; Contaminant availability for biodegradation.	8
Microbial degradation of aliphatic and aromatic compounds; Microbial degradation of halogenated and sulfonated compounds; Biodegradation of pesticides.	6
Bioremediation, Constraints, advantages and applications; Types of bioremediation, Bioaugmentation and biostimulation; factors affecting bioremediation, treatability studies for bioremediation- purpose, experimental design and example protocol. Advantages and disadvantages of specific bioremediation technologies- land farming, prepared beds, biopiles, composting, bioventing, biosparging, pump and treat method, constructed wet lands, bioreactors; Phytoremediation.	9
Sources of heavy metal pollution; Microbial interactions with inorganic pollutants - Microbial metal resistance; Microbial transformation; Accumulation and concentration of metals; Biosorption - Biotechnology and heavy metal pollution; Oil field microbiology; Improved oil recovery; Biotechnology and oil spills.	8

Course Outcome

By the end of the course, the student should be able to

- Recognise the various global and regional environmental concerns due to natural causes and/or human activities, and the impact of these on various forms of life including native biodiversity.
- Investigate some examples of different types of environmental pollution and their impacts Describe the applications of various fields including chemistry, biochemistry, molecular biology and/or microbiology, in understanding and addressing the above issues, as well as exploring environmental resources for new technologies.
- Demonstrate an awareness of emerging concerns such as climate change, waste management or reductions in fossil fuels, and new technologies for addressing these.

Suggested Readings

Text Book:

- Bruce Rittman, Perry L. McCarty, Environmental Biotechnology: Principles and Applications, 2nd edition,

McGraw-Hill, 2000.
- Milton Wainwright, An Introduction to Environmental Biotechnology, Kluwer Academic Publishers, Boston. Hardbound, 1999.

References:

- K.G. Mukerji, B.P. Chamola, Rajeev K. Upadhyay, Biotechnological Approaches in Biocontrol of Plant Pathogens, Kluwer Academic/Plenum Publishers. Hardbound, 1999.
- Martin Alexander, Biodegradation and Bioremediation, 2nd edition, Academic Press, 1999.
- M.N.V. Prasad, Kazimierz Strzalka, Physiology and Biochemistry of Metal Toxicity and Tolerance in Plants, Kluwer Academic Publishers, Dordrecht Hardbound, 2002.
- Baker, K.H and Herson, D.S.BioremediationMcGraw Hill, Inc. New York, 1994.
- M.V.Levin&Gealt, M.A., Biotreatment of Industrial & Hazardous Waste McGraw Hill. Inc. 1993.
- Martin Alexander, Biodegradation and Bioremediation (2^{nd}editon). Elsevier Science & Technology. 1999.
- Raina M. Maier, Ian L. Pepper, Environmental Microbiology. Academic Press. 2001.

BT20.609 Critical Analysis of Classical Papers 2-0-0-2

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

Execution: There are sixteen classical papers. Each students will be taking one paper for analysis. Each week there may be a 1.5-hour presentation cum discussion for each of the papers. At the end of the semester each student will be asked to write a mini-review (2-3 pages long) on any of the sixteen papers, other than the one he/she presented/discussed.

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

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: 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 and 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

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.

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 signalling in the mouse requires intraflagellar transport proteins

Huangfu D, Liu A, Rakeman AS, Murcia NS, Niswander L, Anderson KV.; Nature. 2003 Nov 6;426(6962):83-7

Note: One of the architects of original fly mutagenesis screens conducted a mouse 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 cilia in it.

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

BT20.611 **Project Proposal** **2-0-0-2**

Course Objective

The objectives of this course are to prepare the students to present their topic of research and explain its importance to their fellow classmates and teachers.

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 in detail the work done by them. Along with summarizing their findings they should also be able to discuss the future outcomes of their work.

Course Outcome

Students should be able to learn how to present and explain their research findings to the audience affectively.

BT20.613 **Research Seminar** **1-0-0-1**

Course Objective

The objectives of this course are to train the students to evaluate research papers, to assess quality of the papers and how the papers are refereed and published as well as learn how to get the papers published.

Student presentations: Each student will need to present one paper during the term. They should select research papers, which deal with upcoming or most recent scientific findings/breakthrough and technologies developed.

Class evaluations and discussions: Every week, each student will be asked to write a short review and evaluations of the paper presented in the class and then indulge in discussion with flaws of the paper, important questions and impact of the overall paper. Recent technologies, can be discussed, where it can be applied.

Course Outcome

Students should be able to –

- Critically analyse the research papers from different upcoming topics.
- Understand the weaknesses and strengths of the paper and what additional experiments could have been done to strengthen the research study.
- Understand the context of the paper and identify important questions.
- Acquire the skills in paper writing and getting it published.

BT20.619 **Biotechnology Laboratory-III** **0-0-6-3**

Course Objective

To learn - microbial process fundamentals, enzyme catalysis. Bioreactor design and analysis.

- Kinetics of growth in batch cultivation- estimation of Monod kinetic parameters
- Temperature effect on growth-estimation of energy of activation and Arrhenius Constant for microorganisms.
- Development of enzyme assays and quantification of enzyme activity and specific activity
- Enzyme kinetics
- Effect of pH and temperature on enzyme activity
- Use of surfactants to enhance biodegradation of hydrophobic substrates
- Analysis of water quality/BOD/DO
- Tools for reference management like Mendeley, Zotero, EndNote
- Plagiarism Analysis using Urkund or TurnItIn softwares
- Research paper writing and citation analysis

Course Outcome

1. The student understands about biological and kinetic concepts underlying bioprocesses engineering.
2. The student able to learn procedures for the design and control of industrial scale fermentation and biological waste treatment processes.

BT20.602 **Dissertation** **0-0-40-20**

Course Objective

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.

Planning & performing of 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. 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.

Course Outcome 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 demonstration considerable improvement in the following areas:

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

BT20.615 Biocatalysis and Biotransformation 3-0-0-3

Course Objective To introduce the students about importance of biocatalysts in industry and role of biotransformation for product developments

Introduction: Importance of catalyst, Catalyst vs Biocatalyst, Kinetics, Mechanisms of action, Mode of Regulation, Allosteric enzymes, Investigation of active sites and catalytic mechanism, Enzyme Engineering, Non protein enzymes	8
Sources of a Biocatalyst, Isolation strategies, Assay Methods, Strain Improvement, Extracellular and Intracellular enzymes, Properties, Mechanisms of secretion, regulation of enzyme synthesis, Recovery and Purification of fermentation product, Enzymes in non-aqueous system	8
Industrial Application of Enzymes: Immobilization Kinetics, Batch and Continuous Mode of Fermentation	8
Application of enzymes in Diagnosis and Treatment, Research Sector, Biotransformation Industry and Biodegradation of Xenobiotic compounds	
Enzymes in soil nutrients recycling, Green House gases sequestration, Nitrogen Fixation etc.	8
Stresses related defense enzymes in plants and animals, Enzymes in energy production: Bioethanol, Biogas, Biohydrogen etc.	8

Course Outcome After successful completion of this course, students will be able to reflect a broad knowledge about enzymes and their applications in academia and industry and have an overview of relevant bio-transformations

Suggested Readings

Text Book:

- Comprehensive Biotechnology, 2004. Murray M Y (ed). Pergamon Press
- Enzyme Technology, 1990. Chaplin M F and Bucke C. Cambridge University Press

References:

- Biotol- Technological Applications of Biocatalysts, 1993. Barker R D J (ed). Butterworth Heinemann Ltd. Oxford
- Enzymes: Biochemistry, Biotechnology, Clinical Chemistry, 2007. Palmer T. and Bonner P L R. Harwood Publication, London.

FS20.510 **Introduction to Forensic Biotechnology** **3-0-0-3**

Course Objective: To give insight of biotechnology applicable in forensic area

Serology and Immunology **6**

Cell structure and functions. Structure and function of carbohydrates, fats and proteins, serum proteins, haemoglobin and its variants, haptoglobins, HLA, polymorphic enzymes, blood groups-history, biochemistry and genetics of ABO, Rh, Mn and other systems, Methods of ABO blood grouping from fresh blood and biological stains, body fluids, determination of secretor status, polymorphic enzyme typing, serogenetic markers, determination of origin of species, immunology, immune response, antigens, haptens and antibodies, function and rising of antisera, lectins.Bloodstains investigations: Blood pattern analysis, ageing of bloodstains, difference between human and animal bloodstains, spectroscopic analysis.

Forensic Biology **8**

General plant classification schemes. Sub specialisation of forensic botany- plant morphology, plant anatomy, plant systematic, palynology, plant ecology.Wood and timber analysis.Diatoms and their forensic importance.Study and identification of various diatoms.Paper and pulp identification.

Hair examination **8**

Collection and preservation of hair samples.Morphological and microscopic examination of human and animal hair. Hair growth and development, determination of origin, race, sex, site from hair. Comparison between human and non-human hair.Macroscopic and microscopic features of hair.

Wildlife Forensics **8**

Introduction and importance of wild life. Protected and endangered species of animals and plants.Sanctuaries and their importance.Introduction to Wildlife (Protection) Act 1972 and CITES, Relevant provision of wild life and environmental act. Types of wildlife crimes, different methods of killing and poaching of wildlife animals

DNA Profiling **9**

Double helical structure of DNA, alternate forms of DNA double helix, denaturation and renaturation of DNA, DNA binding proteins, factors affecting DNA stability, types and structure of RNA. Chemical nature of DNA and RNA.Nature and structure of human genome and its diversity.mt-DNA, Y-Chromosomes and the peopling, migration, of modern humans, Forensic DNA profiling and its application in criminal and civil investigations.

Text Books

Butler, J; Advanced Topics in Forensic DNA Typing: Methodology, 1st Ed., Academic Press, London, 2009.

Easteal, S. McLeod, N. & Reed, K; DNA Profiling: Principles, Pitfalls and Potential, Harwood Academic Publishers, New Jersey, 1991.

Reference Books

Rudin, N. & Inman, K; An Introduction to Forensic DNA Analysis, Second Ed.,CRC press, New York, 2001.

Spencer, C; Genetic testimony: a guide to forensic DNA profiling, Pearson, New Delhi, 2004.

Brown, T; Gene cloning and DNA analysis: An Introduction , 5th ed. Blackwellpublishing, London, 2006

BT20.512	**Food Technology**	**3-0-0-3**
Course Objective	To impart knowledge of various areas related to Food Science and Technology, To enable the students to understand food composition and its physicochemical, nutritional, and microbiological aspects,	
	Food and Fermentation Technology: Origin, Scope and development of fermented food products, Microbial starters for food fermentations.	10
	Fermented Foods- Bread, Vinegar, Beer, Wine, polysaccharides, low calorie sweeteners, Vitamins, Fermented vegetables, Nutraceuticals, Prebiotic and Probiotic foods, Genetically modified foods, Nano foods.	
	Fermented dairy products- Milk and Curd, Yoghurt, Buttermilk, Cheese, Oriental fermented foods,	
	Single cell protein, Mushroom cultivation **Spoilage and Preservation**:	9
	Factors affecting microbial growth in foods- extrinsic and intrinsic,	
	Contamination of foods (cereals, Vegetables and Fruits, Meat and Meat products and Fish, Milk and milk products, canned foods) and their involvement in disease outbreaks,	
	Spoilage detection and characterization.	
	Methods of food preservation (thermal processing, refrigeration, dehydration, irradiation, microfiltration, chemical preservatives).	
	Food Borne Infections and Intoxications: Microbial toxins in food- Chemical Structure and Types, Food borne illnesses caused by- *Brucella, Clostridium, Escherichia, Salmonella, Shigella, Staphylococcus, Vibrio and Yersinia*, Diseases caused by Fungi, Emerging pathogens, *E.coli*O157:H7, *Listeria monocytogens*, *Campylobacter jejuni, Helicobacter pylori*	9
	Packaging and Quality Control:	5
	Need and method of packaging (glass, metal, plastics, moulded pulp and aluminium foil), Controlled atmosphere packaging, Tetra pack, Nano capsule, Nano membrane.	
	Detection of food pathogens- Culture methods, Rapid detection using PCR	6
	Food standards- Standards for Milk, Poultry, Food control agencies-	

BIS, Codex commission,

Food laws and current concepts in food safety (HACCP, quantitative risk assessment and prediction based systems)

Disposal and treatment of food industry waste

Course Outcome

The students will have knowledge about different processing and preservation methods and principals involved.
Students will have learnt about packaging materials, methods and their applications in food industry.

Suggested Readings

Text Book

- Frazier and Westhoff, Food Microbiology, Tata McGraw Hill Publishing Company, Ltd, New Delhi
- Banwart,GJ: Basis of Food Microbiology, CBS Publishers and Distributors, New, Delhi

References

- Adams and Moss, Food Microbiology, Royal Society of Chemistry Publication, Cambridge

BT20.617 **Molecular Diagnostics** **3-0-0-3**

Course Objective

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

Genome Biology in Health & Disease DNA, RNA, Protein: An overview; chromosomal structure & mutations; DNA polymorphism: human identity; clinical variability and genetically determined adverse reactions to drugs. 5

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. 6

		6
	Diagnostic Metabolomics Metabolite profile for biomarker detection in the body fluids/tissues under various metabolic disorders by making use of LCMS & NMR technological platforms. Detection & Identity of Microbial Diseases Direct detection & identification of pathogenic-organisms that are slow growing or currently lacking a system of invitro cultivation as well as genotypic markers of microbial resistance to specific antibiotics.	
	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 Syndrome: Paradigm of the new mutational mechanism of the unstable triplet repeats, von-Hippel Lindau disease: recent acquisition in the growing number of familial cancer syndromes.	4
	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
Course Outcome	Students should be able to understand the various facets of molecular procedures and basics of genomics, proteomics and metabolomics that could be employed in the early diagnosis and prognosis of human diseases.	
Suggested Readings	Text Book: • Campbell, A. M., & Heyer, L. J. (2006). Discovering genomics, proteomics, and bioinformatics. San Francisco: Benjamin Cummings. References • Brooker, R. J. (2009). Genetics: Analysis & principles. New York, NY: McGraw-Hill. • Glick, B. R., Pasternak, J. J., & Patten, C. L. (2010). Molecular biotechnology: Principles and applications of recombinant DNA. Washington, DC: ASM Press.	

- Coleman, W. B., & Tsongalis, G. J. (1997). Molecular diagnostics: For the clinical laboratorian. Totowa, NJ: Humana Press.