COURSE STRUCTURE
M.SC. (MICROBIOLOGY)

EFFECTIVE FROM ACADEMIC SESSION – 2023-24

Approved in Academic Council Meeting held on 28 June, 2023

M. SC. (MICROBIOLOGY) PROGRAM

1st SEMESTER (MBI)

S.No.	New Code	Subject	L-T-P	Credits
1	21MS1MB111	General Microbiology and Bacteriology	3-0-0	3
2	20MS1MA111	Basics of Mathematics and Statistics	2-0-0	2
3	20MS1BT111	Biochemistry	3-0-0	3
4	21MS1MB112	Molecular Biology	3-0-0	3
5	20B1WBI831	Virology	2-0-0	2
6	21MS1MB113	Fungal Biology	2-0-0	2
7	21MS7MB171	General Microbiology and Bacteriology Lab	0-0-4	2
8	21MS7BT171	Biochemistry Lab	0-0-2	1
9	21MS7MB172	Molecular Biology Lab	0-0-4	2
10	21MS7MB173	GLP and Bioinstrumentation Lab	0-0-2	1
		Total	**27**	**21**

2nd SEMESTER (MBII)

S.No.	New Code	Subject	L-T-P	Credits
1	18MS1BT211	Immunology and Immunotechnology	3-0-0	3
2	21MS1MB211	Enzymes and Bioprocess Technology	3-0-0	3
3	23MS1MB211	Microbial Genetics and Physiology	3-0-0	3
4	18MS1BT313	Recombinant DNA Technology	3-0-0	3
5	20MS1BT213	Bioinformatics	2-0-0	2
6	18MS7BT211	Immunology and Immunotechnology Lab	0-0-2	1
7	21MS7MB271	Enzymes and Bioprocess Technology Lab	0-0-2	1
8	18MS7BI214	Basic Bioinformatics Lab	0-0-2	1
9	18MS7BT373	Recombinant DNA Technology lab	0-0-4	2
10	18MS9BI211	Masters Research Review seminar	0-0-2	1
		Total	**26**	**20**

3rd SEMESTER (MBIII)

S.No.	Code	Subject	L-T-P	Credits
1	21MS1MB311	Environmental Microbiology	3-0-0	3
2	21MS1MB312	Diagnostic Microbiology and vaccines	3-0-0	3
3		Elective-I	3-0-0	3
4	21MS9MB311	Master's Dissertation &Thesis Part-I	0-0-16	8
		Total	**25**	**17**

4th SEMESTER (MBIV)

S. No.	New Code	Subject	L-T-P	Credits
1	21MS1MB411	Food & Dairy Microbiology MBIV	3-0-0	3
2	21MS1MB412	Plant and Agricultural Microbiology MBIV	3-0-0	3
3		Elective-II	3-0-0	3
4	21MS9MB411	Master's Research Thesis Part-II	0-0-16	8
		Total	**25**	**17**

Total Credits: 75

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ELECTIVE - 1				
S. No.	**New Code**	**Subject**	**L-T-P**	**Credits**
1	21MS2MB311	IPR, Biosafety and Bioethics	3-0-0	3
2	21MS2MB312	Biosensors:Principles & Applications	3-0-0	3
3	23MS2MB311	Microbial Toxicology MBIV	3-0-0	3
4	21MS2MB314	Protein Engineering	3-0-0	3

ELECTIVE - 2				
S. No.	**New Code**	**Subject**	**L-T-P**	**Credits**
1	23MS2MB411	Computational Systems Biology	3-0-0	3
2	21MS2MB412	Experimental models in microbial Research MBIV	3-0-0	3
3	21MS2MB413	Nano-Biotechnology MBIV	3-0-0	3
4	21MS2MB414	QC Analysis and Management MBIV	3-0-0	3

I[st] SEMESTER (MBI)

GENERAL MICROBIOLOGY AND BACTERIOLOGY **COURSE CODE: 21MS1MB111** **L-T-P: 3-0-0** **CREDITS: 3**	**Course Objectives** To acquaint the students with the development and techniques of microbiology useful in biotechnology industry**.** Scientific evaluation of various characteristics of icroorganisms, especially bacteria their metabolism and role in various domains of life.	**Students Learning outcomes** Students should be able to: ▪ Acquire the principles of Microbiology and fundamental concepts related to microbial classification and methods ▪ Scientifically test the hypothesis provided under a given situation involving microbial world and demonstrate practical skills in basic microbiological techniques including growth and control of bacteria. ▪ Analyze and interpret the experiments/pathways relevant to bacterial analysis ▪ Designate vital role of the bacteria in the environment and their genetics and association with human beings. ▪ Retrieve and use cotemporary information and industrial potential related to microbial world.

Syllabus:

Unit	Topics Covered
Unit 1: Introduction, history and scope of Microbiology 4 lectures	Introduction, history and scope of Microbiology. General characteristics and composition of Prokaryotes and Eukaryotes. Classification of Microorganisms: Haeckel's three kingdom concept, Whittaker's five kingdom concept, three domain concept of Carl Woese, classification and salient features of bacteria according to Berger's Manual of Determinative Bacteriology. Nomenclature and modern methods of Bacterial taxonomy.
Unit 2: Morphology and Anatomy of bacteria 6 lectures	Morphology and ultra-structure of bacteria: size, shape, and arrangement of bacteria, ultra-structure of bacterial cell wall of eubacteria and archeabacteria. Protoplast and spheroplast formation and L-form. Components external to cell wall: Structure and function of flagella, fimbriae and pilli, capsule- types, composition and function, slime layers, S-layers. Prokaryotic cell membrane and cytoplasmic matrix – cell membrane structure and function of bacteria and archaebacteria, mesosomes, ribosomes, cytoplasmic inclusion bodies (polyhydroxy butyrate, polyphosphate granules, oil droplets, cyanophycean granules) and nucleoid. Bacterial response to external stimulus and bacterial endospores: Chemotaxis and phototaxis structure, formation and germination of bacterial

	endospore.
Unit 3: Analytic techniques and control measures in bacteriology 7 lectures	Staining methods: fixation, types of dyes, simple staining, differential staining - Gram and Acid-fast staining, staining of specific structures capsule, flagella and spore staining Control of microorganisms: Microbial death curve, concept of bio-burden, thermal death time and decimal reduction time. Factors influencing the effectiveness of antimicrobial agents. Control of bacteria by physical agents: heat - moist and dry, filtration and radiation. Chemical control of microorganisms: Halogens, phenol and other phenolic compounds, heavy metals, alcohols, ethylene oxide and aldehydes
Unit 4: Bacterial growth and kinetics 7 lectures	Bacterial nutrition: Basic nutritional requirements, growth factors, nutritional categories, physical requirements of bacterial growth. Bacteriological media: types (complex, synthetic, differential, enrichment and selective media) and their uses, culture characteristics of bacteria on different media. Cultivation of bacteria: aerobic and anaerobic culture, pure culture techniques, shaker and still culture, maintenance and preservation of microbial culture. Bacterial growth: growth kinetics, growth curve. Batch, continuous and synchronous culture. Measurement of growth and influence of environmental factors affecting growth.
Unit 5: Bacterial reproduction and genetics 7 lectures	General concept of Prokaryotic and Eukaryotic genome. Genome of *E. coli.* Genetic recombination and transformation. Transduction: generalized and specialized transduction, phage conversion. Plasmid: types and their significance. Conjugation and chromosomal mobilization. *E. coli* as model prokaryotes.
Unit 6: Bacterial epidemiology and diseases 5 lectures	Human diseases caused by bacteria; The epidemiology, pathogenesis, antigenic characteristics and diagnosis of diseases
Unit 7: Microbial Ecology and Industrial applications 6 lectures	Thermophiles, Alkaliphiles, Acidophiles, Halophiles, Psychrophiles, Radiophiles, Fermented foods and beverages, Biofertilizers, Biopesticides, Biofuels and Bioenergy

Recommended Textbooks and References:

1. Prescott, Harley and Klein: Microbiology, 6th Edition, McGraw Hill 2005.
2. Pelczar, Chan and Krieg: Microbiology by; Tata McGraw Hill.
3. Madigan, M.T., Martinko, J.M., Parker, J: Brock Biology of Microorganisms. 10th Edition.: Publisher: Prentice Hall 2003
4. Gerard J. Tortura, Berdell R. Funke, and Christine L: Microbiology An Introduction: Case. 8th Ed., Pearson/Benjamin Cummings, 2004.
5. Nester: Microbiology Study Guide McGraw Hill.
6. Black: Microbiology: Principles and Applications Prentice Hall

BASICS OF MATHEMATICS AND STATISTICS **COURSE CODE: 20MS1MA111** **L-T-P: 2-0-0** **CREDITS 2**	**Course objective** The objective of this course is to give conceptual exposure of essential contents of mathematics and statistics to students for application in biological sciences	**Students Learning Outcomes** On completion of this course, students should be able to: ▪ Gain broad understanding in mathematics and statistics; ▪ Recognize importance and value of mathematical and statistical thinking, training, and approach to problem solving, on a diverse variety of disciplines.

Unit I Algebra 8 lectures	Linear equations, functions: slopes-intercepts, forms of two-variable linear equations; constructing linear models in biological systems; quadratic equations (solving, graphing, features of, interpreting quadratic models *etc*.), introduction to polynomials, graphs of binomials and polynomials; Symmetry of polynomial functions, basics of trigonometric functions, Pythagorean theory, graphing and constructing sinusoidal functions, imaginary numbers, complex numbers, adding-subtracting-multiplying complex numbers, basics of vectors, introduction to matrices.
Unit II Calculus 6 lectures	Differential calculus (limits, derivatives), integral calculus (integrals, sequences and series *etc*.).
Unit III Mathematical models in biology 6 lectures	Population dynamics; oscillations, circadian rhythms, developmental patterns, symmetry in biological systems, fractal geometries, size-limits & scaling in biology, modelling chemical reaction networks and metabolic networks.
Unit IV Statistics 8 lectures	Probability: counting, conditional probability, discrete and continuous random variables; Error propagation; Populations and samples, expectation, parametric tests of statistical significance, nonparametric hypothesis tests, linear regression, correlation & causality, analysis of variance, factorial experiment design.

Recommended Textbooks and References:

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

BIOCHEMISTRY COURSE CODE: 20MS1BT111 L-T-P: 3-0-0 CREDITS 3	**Course objective** Following are the objectives of Biochemistry course. ▪ To understand the basic biochemical processes and their principles those govern complex biological systems. ▪ To understand the structure, functions of essential biomolecules and their interactions with each other. ▪ To understand the various metabolic and energy generation processes which areessential for sustainability of life.	**Students Learning outcomes** After learning and completion of Biochemistry course, student will be able to: ▪ Define the structural features of basic biomolecules ▪ Describe the functionality of biomolecules in relation to their usage for steady state of an organism. ▪ Get complete understanding of metabolic processes and their integration with each other.

Unit/ Module	Description
Unit I: Origin of Life (Biochemical basis) 4 lectures	Chemical basis of life: Miller-Urey experiment, abiotic formation of amino acid oligomers, composition of living matter; Water and its essential role for life, pH and its regulation in relation to microorganisms
Unit II: Biomolecules in Microbial world 8 lectures	**Carbohydrates:** Classification, basic chemical structures and their role in microbial life. **Lipids:** Classification, structure and function of major lipid subclasses in microbe's especial consideration bacterial membranes. **Proteins:** Amino acids: Classification, Properties, Protein Structure: primary, secondary, tertiary and quaternary structure, basics of enzymes and their catalysis. **Nucleotides:** Nucleotides, Nucleosides structures, Different confirmations of DNA
Unit III: Microbial nutrition and basic biochemical process for growth 4 lectures	Microbial metabolic diversity and classification based on nutritional types. Transport Mechanisms across membrane: Diffusion, facilitated Diffusion, Active and passive transport.
Unit IV: Central Metabolic Pathways and Carbohydrate metabolism 10 lectures	Bacterial aerobic respiration, Embden-Meyerhof pathway, Entner-Doudoroff pathway, Pentose phosphate pathway, Tricarboxylic acid cycle, components of electron transport chain, chemiosmotic theory, oxidative and substrate level phosphorylation, , Utilization of sugars other than glucose and complex polysaccharides. Bacterial anaerobic respiration and fermentation
Unit IV: Metabolism of lipids and hydrocarbons: 6 lectures	Biosynthesis and degradation of fatty acids and phospholipids, lipopolysaccharide biosynthesis
Unit V: Protein and amino-acid metabolism 6 lectures	Metabolism of amino acids: Amino acid biosynthesis and utilization, lysine and glutamine overproduction, polyamine biosynthesis and regulation.
Unit VI: Metabolism of nucleotides 4 lectures	Purine and pyrimidine biosynthesis, regulation of purine and pyrimidine biosynthesis, inhibitors of nucleotide synthesis.

Recommended Textbooks and References:

1. J M Berg, L Stryer, J Tymoczko, G Gatto, “Biochemistry”, 9th Ed., (2019) W H Freeman
2. D L Nelson and MM Cox, “Lehninger Principles of Biochemistry”, 7th Ed. (2017) WH Freeman
3. J Willey, L Sherwood, C J Woolverton “Prescott's Microbiology”, 10th Ed., (2016) Mc GRaW-Hill

MOLECULAR BIOLOGY COURSE CODE: 21MS1MB112 L-T-P: 3-0-0 CREDITS 3	**Course objective** The objective of this course is to equip students with detailed knowledge of molecular biology, applications of molecular biology, and enhance their abilities to understand modern research and developments in the life science sector.	**Students Learning outcomes** On successful completion of this course, student will be able to: ▪ Understand physical and chemical properties nucleic acids ▪ Develop deep understanding about DNA replication, damage and repair ▪ Understand the processes of transcription and translation at molecular level ▪ Will recognize the different mechanism of gene regulation in microbial systems ▪ Will get apprised with different molecular biology techniques and their applications in modem research and life science sector

Unit I **Chemical and Physical Properties of Nucleic acids** 3 lectures	Introduction to molecular Biology; Chemical and physical properties of Nucleic acids
Unit II **DNA replication Damage and repair** 8 lectures	DNA replication, Nature of replication, Enzymes and proteins involved, Replication Fork and priming, leading and lagging strand, Process of Replication: initiation elongation, termination, specific features of replication in Prokaryotes, fidelity of replication, inhibitors of replications and their applications, DNA damage repair and recombination: DNA damage, DNA Mismatch Repair, Double Strand Break Repair, Homologue and site-specific recombination,
Unit III **RNA synthesis and processing** 8 lectures	Transcription: Transcription machinery of prokaryotes, various transcription enzymes and cofactors, initiation, elongation and termination, sigma factors, post-transcriptional processes: RNA processing, splicing, capping and polyadenylation, rRNA and tRNA processing, RNAi and miRNAs, post-transcriptional gene regulation.
Unit IV **Protein synthesis and processing** 8 lectures	Translation: Mechanisms of translation in prokaryotes, initiation complex, ribosomes and tRNA, factors, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, and translational proof-reading, translational elongation and termination, inhibitors of translation

Unit V **Gene Regulation expression** 8 Lectures	Control of gene expression at transcription and translation level regulating the expression of phages, viruses, prokaryotic and
Unit VI **Molecular Biology Techniques** 7 Lectures	Labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes, Hybridization techniques: northern, southern, fluorescence in situ hybridization, Polymerase chain reaction and its variations

Recommended Textbooks and References:

Suggested Text Book(s):

1. Lehninger "Principles of Biochemistry".
2. Principles of Genetics – D. Peter Snustad, Michael J. Simmons

Suggested Reference Book(s):

1. Lewin's GENES XI
2. Lodish H, Berk A, Zipursky LS, Matsudaira P, Baltimore D, Darnell J (2000). Molecular Cell Biology.
3. W. H. Freeman and Company
4. Molecular Biology of the Gene by J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levin, R. Losick, 6th edition, Benjamin Cummings, San Francisco, USA, 2007.
5. Molecular Biology by R.F. Weaver, 4th edition, McGraw Hill. New York. USA, 2007.
6. Molecular Biology of the Cell by B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, P. Walter, 5th edition, Garland Science, New York and London, 2007. 5.

VIROLOGY COURSE CODE: 20B1WB831 L-T-P: 2-0-0 CREDITS: 2	**Course Objectives** To acquaint the students with the development and techniques of virology useful in biotechnology industry**.** Scientific evaluation of various characteristics of viruses, their metabolism and role in various domains of life.	**Students Learning outcomes** Students should be able ▪ To acquire the knowledge about fundamental concepts related virology and its history ▪ Scientifically test the hypothesis provided under a given situation involving microbial world and demonstrate practical skills in basic virological techniques including growth and control of viruses ▪ Analyze and interpret the experiments/pathways relevant to virus analysis

Unit 1 **Introduction and classification of viruses** 4 Lectures	Brief outline on discovery and origin of viruses. General properties of viruses, Classification and general properties of major families of viruses
Unit 2 **Structure and morphology of viruses** 4 Lectures	Morphology and ultra-structure of viruses, capsid and their arrangements, types of envelopes and their composition, measurement of viruses. Viral genome; their types and structure, viral related agents-viroids and prions.
Unit 3 **Cultivation and analytical techniques in virology** 7 Lectures	Cultivation of viruses in embryonated eggs, experimental animals, and cell cultures; primary and secondary cell cultures; suspension cell cultures and monolayer cell cultures; cell strains, cell lines and transgenic systems; serological methods – haemagglutination and HAI; complement fixation; immunofluorescence methods, ELISA and Radioimmuno assays; assay of viruses – physical and chemical methods (protein, nucleic acid, radioactivity tracers, electron microscopy) – Infectivity assay (plaque method, end point method) – Infectivity assay of plant viruses.
Unit 4 **Viral replication; uncoating, assembly and release** 6 Lectures	Bacteriophage: classification, morphology and ultra structure. One step growth curve (latent period, eclipse period, and burst of size.) Life cycle: lytic and lysogenic life cycle of bacteriophages. Brief account of M13, Mu, T4, Ø x174 and lambda phage. Uncoating, assembly and release

Unit 5 **Plant viruses: Infection and diseases of plants** 7 Lectures	Classification and nomenclature; effects of viruses on plants; appearance of plants; histology, physiology and cytology of plants; common virus diseases of plants; paddy, cotton, tomato and sugarcane; viruses of cyanobacteria, algae, fungi, life cycle; type species of plant viruses like TMV, Cauliflower Mosaic Virus and Potato Virus X; transmission of plant viruses with vectors (insects, nematodes, fungi) and without vectors (contact, seed and pollens); diagnostic techniques in seeds; seed stocks and diseased plants (seed morphology, seedling symptomatology, indicator plants, serological methods, histochemical tests and fluorescent microscopy); prevention of crop loss due to virus infection – virus- free planting material; vector control
Unit 6 **Animal viruses: infections and diagnosis** 7 Lectures	Classification and nomenclature of animal human viruses; epidemiology, lifecycle, pathogenicity, diagnosis, prevention and treatment of RNA virurses Picorna, Ortho myxo, Paramyxo, Toga and other arthropod viruses, Rhabdo, Rota, HIV and other Oncogenic viruses; DNA viruses; Pox, Herpes, Adeno, SV 40; Hepatitis viruses.
Unit 7 **Viral vaccines and antiviral agents** 7 Lectures	Viral vaccines (conventional vaccines, genetic recombinant vaccines used in national immunization programmes with examples, newer generation vaccines including DNA vaccines with examples) interferons and antiviral drugs.

Recommended Textbooks and References:

1. Reference Books 1. Virology; Renato Dulbecco and Harold S. Ginsberg

2. An Introduction to viruses, S. B. Biswas and Amita Biswas. Forth edition, Vikas Publishing House PVT LTD New Delhi.

FUNGAL BIOLOGY COURSE CODE: 21MS1MB113 L-T-P: 2-0-0 CREDITS 2	**Course objective** The objectives of this course are to introduce field of field biology with special emphasis on fungal diversity, morphology, physiology and reproduction; their application to industry and a human-host or plant- fungal interactions.	**Students Learning Outcomes** Students should be able to: Identify major categories of fungi and analyze their classification, diversity, and ubiquity Identify major categories of fungi, demonstrate and evaluate interactions between hosts (plant/human) and environment.

Unit I **Introduction and classifications** 3 lectures	Introduction to the course; characteristics of fungi Fungal life cycles, ecological role of fungi, and human-fungus interactions, Model organisms and genetics
Unit II **Division or Phylum Zygomycota** 04 lectures	**General overview** **Class Zygomycetes (Order Mucorales)** Fermented Foods etc
Unit III **Division or Phylum Basidiomycota (General overview) Class Basidiomycetes** 07lectures	Cultivation of mushrooms & other fungi Spore release and dispersal Poisonous and hallucinogenic mushrooms; Mycotoxins in the grain and other food products. **Class Urediniomycetes & Ustomycetes (Rusts and Smuts)**
Unit IV **Division or Phylum Ascomycota** 08 lectures	**General overview** Ergot & ergotism; Mycotoxins in Food Alcoholic fermentations, cheeses, and fungal metabolites Physiology of Fungal Growth Bioremediation Yeast-Model organism and expression system
Unit V **IMPERFECT FUNGI** **FUNGUS-LIKE ORGANISMS** 7 lectures	**Form Division or Form Phylum Deuteromycota: (General overview)** Symbiotic and Parasitic relations Allergies and Fungal Diseases of Animals & Humans Slime molds Zoosporic Fungi: Chytrids, Oomycetes, and others

Recommended Textbooks and References:

1. Introduction to Fungi. 3rd Edition (2007) Webster & Webster. Cambridge University Press.
2. Bessette, A. E., Bessette, A. F., & Lewis, D. P. (2019). Mushrooms of the Gulf Coast States: A Field Guide to Texas, Louisiana, Mississippi, Alabama, and Florida. University of Texas Press.
3. https://fungalbiolbiotech.biomedcentral.com/articles
4. https://www.frontiersin.org/research-topics/9823/innovative-approaches-in-diagnosis-of-emergingre-emerging-infectious-diseases
5. https://www.frontiersin.org/research-topics/11600/fungal-genetics-in-plant-biomass-conversion
6. https://www.frontiersin.org/research-topics/13305/plant-pathogenic-fungi-molecular-systematics-genomics-and-evolution

GENERAL MICROBIOLOGY AND BACTERIOLOGY LAB COURSE CODE: 21MS7MB171 L-T-P: 0-0-4 CREDITS: 2	**Course Objectives** The objective of this laboratory course is to provide practical skills on basic microbiological techniques.	**Students Learning outcomes** Students should be able to: ▪ Isolate, characterize and identify ▪ Common bacterial organisms ▪ Determine bacterial load of different samples ▪ Perform antimicrobial sensitivity tests ▪ Preserve bacterial cultures.

Syllabus:

1. To study construction and working of compound microscope and study of microbiology lab instruments
2. Sterilization, disinfection and safety in microbiological laboratory.
3. Preparation of media for cultivation of bacteria.
4. Isolation of bacteria in pure culture by streak plate method.
5. Pour plate technique and study of colony and growth characteristics of some common bacteria
6. Preparation of bacterial smear and Gram's staining.
7. Acid-fast staining for study and differentiation of acid-fast bacteria.
8. Enumeration of bacteria: serial dilution and standard plate count.
9. Antimicrobial sensitivity test and demonstration of drug resistance
10. Determination of Minimum Inhibitory Concentration (MIC)
11. Maintenance of stock cultures: slants, stabs and glycerol stock cultures
12. Determination of phenol co-efficient of antimicrobial agents.
13. Isolation and identification of bacteria from soil/water samples.
14. Study of bacterial growth kinetics.

Recommended Textbooks and References:

1. Cappuccino, J. G., & Welsh, C. (2016). *Microbiology: a Laboratory Manual*. Benjamin-Cummings Publishing Company.
2. Collins, C. H., Lyne, P. M., Grange, J. M., & Falkinham III, J. (2004). *Collins and Lyne's Microbiological Methods* (8th ed.). Arnolds.
3. Benson, Harold J. (2007) *Microbiological Applications : Laboratory Manual in General Microbiology*, McGraw-Hill Higher Education
4. Tille, P. M., & Forbes, B. A. *Bailey & Scott's Diagnostic Microbiology.*

BIOCHEMISTRY LAB COURSE CODE: 21MS7BT171 L-T-P: 0-0-2 CREDITS: 1	**Course Objectives** The Objective of the course is ▪ To provide training and skills for the handling and analysis of biomolecules. ▪ To acquaint the students with laboratory techniques related to detection and estimation of primary biomolecules which are essential in an organism for life sustainability.	**Students Learning outcomes** After completion of Biochemistry lab, student will be able ▪ To understand the basic biochemistry laboratory practices and independently handle different instruments utilized in a biochemistry lab. ▪ To identify and quantify accurately different biochemical identities in a given sample. ▪ To observe, analyze and record the results of biochemical experiments and independently draw reasonable conclusions from results.

Syllabus:

1. Basic guidelines for safety measures to avoid hazards in biochemistry lab and preparing various stock solutions and working solutions.
2. To prepare buffer solution of varying pH by using Henderson-Hasselbalch equation and pH meter.
3. To identify and classify different sugars on the basis of qualitative methods.
4. To determine concentration of carbohydrates by Anthrone method: a quantitative approach.
5. To isolate the proteins from bacterial culture using differential centrifugation and their detection using qualitative methods.
6. To estimate concentration of proteins with Bradford's method.
7. To estimate concentration of proteins by Lowry's method.
8. To separate different bacterial proteins using SDS PAGE technique.
9. To study the enzyme activity (amylase enzyme) using DNS method.
10. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law.
11. To determine presence of lipid in a given sample through qualitative method.
12. To Estimate the Saponification value of oils.
13. To quantify the concentration of DNA using spectrophotometer.
14. To detect the presence of microorganism in milk using specific biochemical tests.

Recommended Textbooks and References:

1) Irwin H. Segel "Biochemical Calculations", 2ed (2010) Wiley
2) Andreas Hofmann & Samuel Clokie Wilson and Walker's "Principles and Techniques of Biochemistry and Molecular Biology" (2018) Cambridge university press

MOLECULAR BIOLOGY LAB COURSE CODE: 21MS7MB172 L-T-P: 0-0-4 CREDITS 2	**Course objective** The objective of this course is to familiarize the students with some basic and advanced techniques of molecular biology.	**Students Learning outcomes** On successful completion of this course, student will be able to: ▪ Understand the fundamentals of procedure of isolation, quantification and visualization of various biomolecules from different cellular or tissue. ▪ Interpret and conclude experimental results involving molecular biology

Syllabus

1. Introduction to molecular biology lab and facilities, Calculations of molarity and normality of the solutions
2. Preparation of Buffer Stocks (TBE, TAE, TE) and Buffers for gel electrophoresis
3. To perform agarose gel electrophoresis of DNA samples
4. Estimation of DNA quantity and quality by gel electrophoresis
5. To isolate genomic DNA from *E. coli* (DH5-α) using heat boiling method
6. To isolate *E. coli* (DH5-α) genomic DNA using phenol chloroform
7. Isolation of genomic DNA from human blood sample
8. Preparation of reagents and isolation plant genomic DNA using CTAB method
9. Quantification of DNA concentration and purity by spectrometric/nanodrop method
10. Introduction to Polymerase Chain Reaction and to amplify gene using genomic DNA of *E. coli.*
11. To separate serum and plasma proteins from human blood
12. To visualize human serum and plasma proteins using SDS-PAGE technique
13. To isolate RNA from bacterial cell and its quantification

Recommended Textbooks and References:

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

GOOD LABORATORY PRACTICE AND BIOINSTRUMENTATION LAB COURSE CODE: 21MS7MB173 L-T-P: 0-0-2 CREDITS: 1	**Course Objectives** The Objective of the course is to provide training of good laboratory practices and various instrumentations used in Biotech/Pharmaceutical industry. This course covers practical aspects of modern instrumentation used for analysis in biological research	**Students Learning outcomes** Students should be able to: ▪ To understand basic guidelines, importance of good laboratory practice, documentation and conduct of non-clinical studies ▪ To Understand basic principles and applications of bio-instruments ▪ To develop necessary critical thinking skills in order to do data analysis and interpretation in relation to the research process

Syllabus:

1. To introduce good lab practices, Lab safety and Bio hazard
2. Introduction to the OECD Principles of good laboratory practice. Overview and Purpose of GLP
3. Good Documentation practice and maintenance of lab note book
4. Quality control & Quality Assurance in laboratory
5. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law.
6. Instrumentation and working principles of infra red (IR) spectroscopy using salt plates.
7. Chromatography (Ion exchange, Molecular Sieve, Affinity, Thin layer, GC)
8. Instrumentation and working principles of HPLC
9. Instrumentation and working principles Electron Microscopy
10. Principle and application Gel electrophoresis
11. Principle and application of lypholization
12. Instrumentation and working principles of mass spectroscopy
13. Determination of molar mass of simple compounds using mass spectroscopy.
14. MALDI-TOF instrumentation and analysis of serum proteins
15. To study the effect of chemical denaturants on protein stability using CD spectroscopy.
16. Principle and applications of Centrifugation and ultracentrifugation

Recommended Textbooks and References:

1. Milton. A. Anderson (2002) GLP Essentials: a Concise Guide to Good Laboratory Practices
2. Sandy Weinberg (2007) Good Laboratory Practice Regulations
3. Nally, J. D. 6th edition. CRC Press (2006) *GMP for Pharmaceuticals*
4. Andreas Hofmann & Samuel Clokie Cambridge university press (2018) Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology

IInd SEMESTER (MBII)

IMMUNOLOGY AND IMMUNOTECHNOLOGY **COURSE CODE: 18MS1BT211** **L-T-P: 3-0-0** **CREDITS 3**	**Course objective** The objectives of this course are to learn about structural features of components of immune system as well as their function. The major emphasis of this course will be on development of immune system and mechanisms by which our body elicits immune response. This will be imperative for students as it will help them to predict about nature of immune response that develops against bacterial, viral or parasitic infection, and prove it by designing new experiments.	**Students Learning outcomes** On successful completion of this course, student will be able to: • Evaluate usefulness of immunology in different pharmaceutical companies; • Identify proper research lab working in area of their own interests; • Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses and figure out kind of immune responses in the setting of infection (viral or bacterial).

Unit I **Immunology fundamental Concepts:** 6 lectures	Historical perspectives, Cells and organs of the immune system, Types of immunity (innate and acquired immunity), Components of innate and acquired immunity, Antigens: mitogens Immunogenicity, antigenicity, epitopes, haptens.
Unit II **Immune responses generated by B and T lymphocytes** 8 lectures	Immunoglobulins - basic structure, classes & subclasses of immunoglobulins, antigenic determinants, B-cell receptor, B cell maturation, activation and differentiation; generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; functional T Cell subsets; cell-mediated immune responses, ADCC; cytokines: properties, receptors and therapeutic uses; antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; cell-cell co-operation, Hapten-carrier system,
Unit III **Antigen-antibody interactions** 5 lectures	Precipitation, agglutination and complement mediated immune reactions; advanced immunological techniques: RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence microscopy, flow cytometry and FACS.
Unit IV **Vaccinology** 7 lectures	A short history of vaccination, Active and passive immunization; live, killed, attenuated, subunit vaccines; vaccine technology: role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines; antibody genes and antibody engineering:chimeric, generation of monoclonal antibodies, hybrid monoclonal antibodies; catalytic antibodies and generation of immunoglobulin

Unit V **Clinical immunology** 8 Lectures	Autoimmunity: Types of autoimmune diseases (organ specific and systemic), Mechanisms of autoimmunity, Hypersensitivity reactions: Type I, II, II and IV, hypersensitivity reactions, treatment of autoimmune diseases; transplantation: immunological basis of graft rejection; clinical transplantation and immunosuppressive therapy
Unit VI **Immune response to infectious diseases and tumor immunity** 4 Lectures	Viral, bacterial, protozoan diseases, parasitic infections, Immunodeficiency diseases: Primary and secondary immunodeficiency diseases, Acquired immunodeficiency syndrome (AIDS)
Unit VII **Immunogenetics** 4 Lectures	Major histocompatibility complex genes and their role in autoimmune and infectious diseases, HLA typing. General organization and inheritance of MHC, structure of MHC class I and II molecules, peptide binding by MHC molecules, MHC and susceptibility to disease.

Recommended Textbooks and References:

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

ENZYMES & BIOPROCESS TECHNOLOGY COURSE CODE: 21MS1MB211 L-T-P: 3-0-0 CREDITS 3	**Course objective** The objectives of this course are to develop an understanding in students about the fundamental and important concepts of enzymes and bioprocess technology and its related applications, thus preparing them to meet the challenges of the new and emerging areas of biotechnology industry.	**Students Learning outcomes** On successful completion of this course, student will be able to: • Describe the fundamentals and importance of enzymes and its kinetics • Appreciate relevance of microorganisms from industrial context • Analyze bacterial growth kinetics in batch/continuous/Fed-batch reactor and thermal death kinetics • Give an account of bioreactor design and their applications • Calculate yield and production rates, the need for oxygen and oxygen transfer in a biological production process, and also interpret data; • Apply principles of various unit operations in designing and optimization of downstream processes • Give an account of importance of enzymes and microbials in food processing and production of various bioproducts.

Unit I **Enzymology** 5 lectures	Introduction to Enzymes; Classification; General properties; Kinetics; Reversible and irreversible inhibition; Coenzyme and cofactors; Isoenzymes
Unit II **Basic Principles of Bioprocess Technology** 4 lectures	Introduction to fermentation; Isolation, screening, preservation and maintenance of industrially important microbes; Strain improvement
Unit III Bioreactor Design and Analysis 10 lectures	Microbial growth and Death Kinetics; Factors affecting microbial growth; Batch and Continuous Fermentation; Modifying Batch and continuous Fermentation: Fed-batch, Chemostat with recycle, multistage chemostat systems; Cell and enzyme immobilization Criteria for ideal fermenter; Configuration; Bioreactor designs-mechanically agitated; Pneumatic and hydrodynamic fermenters. Whole Cell Immobilized Fermenters; Stability of microbial reactors
Unit IV **Upstream processing** 6 lectures	Fermentation media; Media formulation; Sterilization; Aeration, agitation and heat transfer in bioprocess; Measurement and control of bioprocess parameters; Scale up and scale down process

Unit V Downstream processing and Product Recovery 7 Lectures	Separation of insolubles: Filtration, Centrifugation, Sedimentation; Cell disruption; Separation of solubles: Liquid-liquid extraction; Precipitation; chromatographic techniques; Reverse osmosis and ultra and micro filtration; Final purification: Drying; Crystallization; Storage and packaging; Effluent Treatment and its disposal
Unit VI Applications of Enzyme technology in food processing 4 Lectures	Mechanism of enzyme function and reactions in process techniques; enzymatic bioconversions *e.g.* starch and sugar conversion processes; high-fructose corn syrup; 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 food processing
Unit VII Applications of microbial technology in bioproduct production 6 Lectures	Industrial Production of Bioproducts: Ethanol, Acids (Citric, acetic, Lactic and gluconic), Antibiotics (Penicillin, streptomycin, tetracycline), Semi-synthetic antibiotics, Ethanol, Single Cell Protein

Recommended Textbooks and References:

1. Berg, J.M., Tymoczko, J.L. and Stryer, L., "*Biochemistry*", 5th ed., W.H. Freeman and Company, New York, 2002
2. Nelson D.L., Cox M.M., "Lehninger Principles of Biochemistry", 5th ed., W.H. Freeman and Company, New York, 2008.
3. Pauline M. Doran, "Bioprocess Engineering Principles", 8th ed., Academic press, New York, 2003.
4. M.L. Shuler and F. Kargi, "Bioprocess Engineering--basic Concepts", 2nd Edn. Prentice-hall Of India Pvt Ltd (2008).
5. Peter F. Stanbury, Stephen J. Hall & A. Whitaker, "Principles of Fermentation Technology", Â Elsevier India Pvt Ltd. (2007).
6. Jackson AT., Bioprocess Engineering in Biotechnology, Prentice Hall, Engelwood Cliffs, 1991.
7. Illanes A, "Enzyme Biocatalysis", Springer Science, 2008.
8. Klaas Van't Riet, Johannes Tramper, "Basic Bioreactor Design", 2nd ed., Marcel Dekker, Inc., New York, 1991.
9. JE Bailey and DF Ollis, "Biochemical Engineering Fundamentals", 2nd ed., McGraw-Hill Book Company, New York, 1986.
10. Mansi EMTEL, Bryle CFA. Fermentation Microbiology and Biotechnology, 2nd Edition, Taylor & Francis Ltd, UK, 2007.
11. Abhilasha S. Mathuriya, "Industrial Biochnology" 1st ed., Ane Books Pvt. Ltd., New Delhi, 2009.

MICROBIAL GENETICS AND PHYSIOLOGY COURSE CODE: 23MS1MB211 L-T-P: 3-0-0 CREDITS: 3	**Course objective** The objectives of this course are to take students through genetics and physiology covering prokaryotic/phage genetics to yeast and higher eukaryotic/ archea domains. Students will be exposed to concepts of complex traits encompassing, genetics and microbial metabolic regulation.	**Students Learning Outcomes** On successful completion of this course, student will be able to: ▪ Describe fundamental molecular principles of genetics. ▪ Describe the basics of genetic mapping. ▪ Understand the principles microbial genetic regulation. ▪ Various tools of the culturing and growth measurement of microorganisms. ▪ Acquaint with mechanisms of survival of various microorganisms.

Unit	Topics Covered
Unit I: **Genetics of bacteria, bacteriophages, and Yeast** 10 lectures	Concept of a gene in pre-DNA era; mapping of genes in bacterial and phage chromosomes by classical genetic crosses; fine structure analysis of a gene; genetic complementation and other genetic crosses using phenotypic markers; Yeast mating type switch; dominant and recessive genes/mutations, complementation groups
Unit II: **Mutants and Mutation** 7 lectures	Mutator genes, screening of mutations based on phenotypes and mapping the same, Loss of function mutants: null, leaky, and conditional mutations. Gain of function mutants, Are mutations random events or adaptive? Mutation rates, probability, and target theory, Uses of mutants
Unit III: **Genetic Exchange and restrictions** 5 lectures	Mechanisms of genetic exchange: Genotype vs phenotype, Genetic exchange in nature, Genetic exchange in the lab, Barriers to genetic exchange: host restriction and modification, Plasmids, Properties of some bacterial plasmids, Plasmid replication, Phage, General properties of phages, Lytic growth, Host specificity, Lysogenic phage, Phage Lambda

Unit IV: Microbial growth and metabolic regulations 10 lectures	Introduction, thermodynamics principles/ Eh-pH diagrams, Mitchell hypothesis and energetic, The Monod and Pirt models for microbial growth, Chemostats as an indispensible tool for physiological studies, Diversity of metabolism and selective enrichments, Mixed Cultures in the chemostat/selection, Metabolic genetic regulation, Regulatory systems during aerobic- anaerobic shifts.
Unit V: Growth and cell physiology of extremophilic microorganisms Lectures 10	Growth curve and diauxic growth curve and calculation of generation time and classification of microorganisms based upon nutrient and water activity. Determination of cell count by various methods. Cellular physiology of extremophilic microorganisms. Extremophilic physiological adaptations Methanotrophs, Thermophiles, Acidophiles , Sulfur reduction and SRBs, Mechanisms of survivals of various extremophiles.

Recommended Textbooks and References:

1. Hartl, D. L., & Jones, E. W. Genetics: Principles and Analysis. Sudbury, MA: Jones and Bartlett.
2. Pierce, B. A. Genetics: a Conceptual Approach. New York: W.H. Freeman.
3. Tamarin, R. H., & Leavitt, R. W. Principles of Genetics. Dubuque, IA: Wm. C. Brown.
4. Smith, J. M. Evolutionary Genetics. Oxford: Oxford University Press.
5. Klug, W.S., Cummings, R., Spencer, C. A., & Michael A. P., Concepts of Genetics. Pearson Publications
6. Albert G. M., & John W. F., Microbial Physiology, Wiley-Liss, A John Wiley& Sons, Inc. Publications.
7. Trudy T. A, Endang P. et al, Microbial Physiology and Genetics. Intelliz Press
8. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
   Brock Biology of Microorganisms, Michael T. Madigan, Kelly S. Bender, Daniel H. Buckley, David Stahl, W. Matthew Sattley.
9. Prescott's Microbiology, By Joanne Willey and Kathleen Sandman and Dorothy Wood

RECOMBINANT-DNA TECHNOLOGY COURSE CODE: 18MS1BT313 L-T-P: 3-0-0 CREDIT 3	**Course objective** The objectives of this course are to teach students with various approaches to conducting recombinant DNA technology and their applications in biological research as well as industries.	**Students Learning outcomes** Given the impact of recombinant DNA technology in modern society, the students should be endowed with strong theoretical knowledge of this technology. In conjunction with the practical in molecular biology & genetic engineering, the students should be able to take up biological research as well as placement in the relevant biotech industry.

Unit I **Introduction and tools for rDNA technology** 3 lectures	Recombinant DNA technology: gene cloning, Genetic engineering, - concept and basic steps - rDNA Glossary, history of rDNA-recombinant Insulin
Unit II **DNA modifying enzymes and cloning techniques** 06 lectures	Restriction Endonucleases, DNA Ligation Enzymes and, DNA Modifying Enzymes: Nucleases, Kinases, phosphatases, and Reverse transcriptase other tools used for DNA Modification
Unit III **Cloning Vectors and Expression Vectors** 12 lectures	Plasmid Vectors, Vectors based on Lambda Bacteriophage, Cosmids, M13 Vectors, Vectors for Cloning Large DNA Molecules Principles for maximizing gene expression, expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag *etc.*; Inclusion bodies; methodologies to reduce formation of inclusion bodies; mammalian expression and replicating vectors; Baculovirus and *Pichia* vectors system, plant-based vectors, Ti and Ri as vectors, yeast vectors, shuttle vectors
Unit IV **Construction libraries and sequencing technologies** 10 lectures	Genomic library, cDNA library, Growing & Storing Libraries, construction of microarrays, cDNA Cloning (5'&3' RACE) Basic DNA Sequencing, Whole genome sequencing, Next generation sequencing technologies
Unit V **Gene Expression in Microbial and Eukaryotic Systems** 06 lectures	Microbial, Yeast Saccharomyces *Cerevisiae* as heterologous protein expression platforms, Protein expression in insect Cells and Mammalian Cells; protein-protein interactions using yeast two-hybrid system;
Unit VI **Genetic Manipulation Of microorganisms** 05 lectures	Gene transfer techniques, Application of Genetically Engineered Strains of microbes; Biosafety Issues related to recombinant DNA Technology Genetic Manipulation of microorganisms

Recommended Textbooks and References:

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

BIOINFORMATICS COURSE CODE: 20MS1BT213 L-T-P: 2-0-0 CREDITS 2	**Course objective** The objectives of this course are to provide theory and practical experience of the use of common computational tools and databases which facilitate investigation of molecular biology and evolution-related concepts.	**Students Learning outcomes** On successful completion of this course, student will be able to: ▪ Develop an understanding of basic theory of these computational tools; ▪ Gain working knowledge of these computational tools and methods; ▪ Prediction of structure from sequence and subsequently testing the accuracy of predicted structures ▪ Appreciate their relevance for investigating specific contemporary biological questions; ▪ Critically analyse and interpret results of their study.

Unit I Introduction 4 lectures	Bioinformatics basics: Protein and nucleic acid databases; Structural databases; search tools: biological background for sequence analysis; searching of databases similar sequence; NCBI; publicly available tools; resources at EBI; sequence, sequence similarity, homology, alignment.
Unit II Pairwise Sequence Alignment 6 lectures	Different scoring models, Substitution matrices (PAM and BLOSUM), Pairwise Alignment: Concept of Global and Local Alignment, Dot matrix method, Dynamic programming (Needleman-Wunsch algorithm, Smith-Waterman algorithm, Choosing of best scoring matrix, gap penalties, Significance of score, FASTA and BLAST algorithms.
Unit III Multiple Sequence alignment 6 lectures	Multiple Sequence Alignment methods (MSA), Scoring of a MSA, Progressive (CLUSTALW and PILEUP), Iterative (Genetic) and Hidden Markov Model (HMM) based methods of MSA, Profile and BLOCK level analysis, Motif and Pattern searching and primer designing.
Unit IV Phylogenetic Analysis 4 lectures	Molecular evolution basics, phylogenetic tree and terminology, different methods of Phylogenetic tree prediction: maximum parsimony, distance (UPGMA, NJ), maximum likelihood methods, Phylogenetic and evolutionary analysis.
Unit V Structural Alignment Tools and Protein Tertiary Structure Prediction 5 Lectures	Protein structure prediction: protein folding and model generation; secondary structure prediction; analyzing secondary structures; homology modelling: potential applications, description, methodology, homologous sequence identification; align structures, align model sequence; construction of variable and conserved regions; structure aided sequence techniques of structure prediction; structural profiles.
Unit VI RNA Structure Analysis 3 Lectures	terminology of RNA secondary structure, inferring structure by comparative sequence analysis, RNA secondary structure prediction, Basic algorithms and methods of RNA folding.

Recommended Textbooks and Reference books:

Text Books:

1. D.W. Mount *Bioinformatics: Genome and Sequence Analysis*: (2001) Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York.
2. Ian Korf, Mark & Josaph: *BLAST*, Oreilly Publisher, 2003
3. R. Durbin, S. Eddy, A. Krogh and G. Mitchison, *Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids.* Cambridge University Press.
4. J. Pevsner (2002) Bioinformatics and Functional Genomics; Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York.
5. A.D. Baxevanis & B.F.F. Oulette *Bioinformatics – A practical guide to the Analysis of Genes and Proteins*,2002, Willey International publishers.
6. M.J. Bishop and C.J. Rawlings (editors), *DNA and Protein Sequence Analysis---A Practical Approach* IRL Press at Oxford University Press, ISBN 0 19 963464 7 (Pbk)
7. Lesk, A. M. (2002). *Introduction to Bioinformatics*. Oxford: Oxford University Press.

Reference Books:

1. J. Setubal and J. Meidanis (1997) *Introduction to Computational Molecular Biology***,** PWS Publishing Co.

2. J. Pevsner (2002) Bioinformatics and Functional Genomics; Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York.

IMMUNOLOGY AND IMMUNOTECHNOLOGY LAB COURSE CODE: 18MS7BT211 L-T-P: 0-0-2 CREDITS: 1	**Course Objectives** The objectives of this lab course are to develop an understanding about practical aspects of components of immune system as well as their function. Basic as well as advanced methods will be taught to detect different antigen and antibody interactions, isolation of different lymphocyte cells *etc.* and how they can be used in respective research work.	**Students Learning outcomes** **Students should be able** • Evaluate usefulness of immunology in different pharmaceutical companies; • Identify proper research lab working in area of their own interests; • Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses and figure out kind of immune responses in setting of infection. (viral or bacterial) by looking at cytokine profile.

Syllabus:

1. To perform blood typing by agglutination.
2. To antigen detection by Dot ELISA method.
3. To quantify the concentration of unknown antigen by radial Immunodiffusion (RID).
4. To perform ouchterlony antigen for antibody titration.
5. To quantify the concentration of unknown antigen by rocket Immunoelectrophoresis.
6. To characterized the given antibody by Immunoelectrophoresis.
7. To quantify the amount of precipitation by Quantitative precipitation assay.
8. To determine the concentration of antigen by sandwich ELISA method.
9. To separate mononuclear cells from peripheral blood
10. To isolate the lymphocyte from whole blood by density gradient centrifugation method
11. To estimate the antibody titer using haemagglutination assay.
12. To determine Total Leukocytes Count (TLC) of the given blood sample.
13. To determine the relative number of white cells in the blood by performing differential cell counts
14. To perform Erythrocyte Rosette-forming Cell Test, ERFC

Recommended Textbooks and References:

1. Lab Manual of the Department of Biotechnology and Bioinformatics, JUIT,Waknaghat.

2. Hay FC and Westwood OMR (2003) Practical Immunology, 4th Ed., Blackwell Publishing. 3.

3. Virtual Lab. (http://vlab.amrita.edu/?sub=3&brch=70),
https://vlab.amrita.edu/?sub=3&brch=69)

ENZYMES & BIOPROCESS TECHNOLOGY LAB COURSE CODE: 21MS7MB271 L-T-P: 0-0-2 CREDITS: 1	**Course Objectives** The objective of the course is to provide hands on training to students in bioprocess technology with the usage of microbials and enzymes. This course covers practical aspects of upstream processing and downstream unit operations with respect to current requirements of the manufacturing industries.	**Students Learning outcomes** **Students should be able** ▪ To investigate, design and conduct experiments, analyze and interpret data, and apply the laboratory skills to solve complex bioprocess technology problems; ▪ To learn how to operate bench scale bioreactor; ▪ To learn how to determine various Monod's Kinetics parameter; ▪ To learn how to determine various Michaelis Menten Kinetics parameter; ▪ To learn how to recover the various bioproduct after their production; ▪ To learn how to characterize the products after their recovery

Syllabus:

1. Describe the various parts of the bench-top fermenter (bioreactor) along with their functions.
2. Batch fermentation using shake-flask for ethanol production by *Saccharomyces cerevisae*.
3. To study growth kinetics parameters of *E. coli*.
   a) Specific growth rate (μ) h^{-1}
   b) Doubling time (t_d) h
   c) Maximum specific growth rate (μ_m) h^{-1}
   d) Saturation constant (K_s) gm/l
4. Setting up of a fermentation process for the production of extracellular industrial enzyme from the selected microbe of industrial importance
5. Determination of Growth yield coefficient ($Y_{x/s}$) and Productivity of biomass after setting of a fermentation

6. Downstream processing of the industrial enzyme produced by the fermentation process.
    a) Clarification
    b) Yield estimation
    c) Concentration using salt-induced precipitation
    d) Dialysis
    e) Purity check through SDS-PAGE and specific activity determination
7. Disruption of yeast cells using sonication to recover intracellular Invertase enzyme
8. Determination of protein and enzyme content in the cell lysate after the cell disruption
9. Determination of Michaelis Menten's kinetics parameters of purified amylase enzyme
10. Preparation of Immobilized yeast cells in calcium alginate beads
11. Characterization of immobilized yeast cells in terms of activity and stability
12. Preparation of Immobilized enzyme in calcium alginate beads
13. Characterization of immobilized enzyme in terms of activity and stability

Recommended Textbooks and References:

1) Lab Manual of the Department of Biotechnology and Bioinformatics, JUIT,Waknaghat.
2) M.L. Shuler and F. Kargi, "Bioprocess Engineering--basic Concepts", 2nd Edn. Prentice-hall Of India Pvt Ltd (2008).
3) Keith Wilson, John Walker, "Principles and Techniques of Biochemistry and Molecular Biology, 7th ed., Cambridge University Press, Singapore, 2010.
4) Raja Ghosh, "Principles of Bioseparation Engineering", World Scientific Publishing Co. Pte. Ltd., Singapore, 2006.
5) Pauline M. Doran, "Bioprocess Engineering Principles", 8th ed., Academic press, New York, 2003.
6) Peter F. Stanbury, Stephen J. Hall & A. Whitaker, "Principles of Fermentation Technology", Â Elsevier India Pvt Ltd. (2007).
7) Berg, J.M., Tymoczko, J.L. and Stryer, L., "*Biochemistry*", 5th ed., W.H. Freeman and Company, New York, 2002
8) Nelson D.L., Cox M.M., "Lehninger Principles of Biochemistry", 5th ed., W.H. Freeman and Company, New York, 2008.
9) Nicholas C. Price and Lewis Stevens, "Fundamental of Enzymology", Oxford University Press, Oxford. ISBN: 9780198502296.
10) Sawney S.K., Singh R. "Introductory Practical Biochemistry", Narosa Publisher, 2000. ISBN 9788173193026.

BIOINFORMATICS LAB COURSE CODE: 18MS7BI214 L-T-P: 0-0-2 CREDITS: 1	**Course Objectives** The objectives of this course are to provide practical experience of the use of common computational tools and databases which facilitate investigation of molecular biology and evolution-related concepts.	**Students Learning outcomes** **Students should be able** ▪ Understand the use of common bioinformatics resources (NCBI) ▪ Understand various databases and tools in NCBI (PubMed, Nucleotide, gene, proteins, BLAST) ▪ Understand various databases and tools in Expasy (Swissprot, PROSITE) ▪ Hands-on of pairwise sequence alignment tools-global and local ▪ Hands-on of multiple sequence alignment tools ▪ Developing three-dimensional model of a protein structure ▪ Hands-on of phylogenetic analysis tools and visualization

Syllabus:

1. Retrieval of literature and biological sequences from PubMed and NCBI.
2. BLAST program for comparing primary biological sequence information.
3. Protein resources: Use of ExPASy for sequence retrieval and analysis.
4. Use of EMBOSS tools for sequence analysis: Pairwise Sequence Alignment.
5. Use of Clustal and other tools (MAFFT, MUSCLE) for Multiple Sequence Alignment (MSA).
6. Use of PDB structural database and structure visualization using Pymol, Rasmol, and Discovery Studio.
7. Use of gene prediction methods (GRAIL, Genscan, Glimmer).
8. Phylogenetic analysis of protein and nucleotide sequences.
9. Secondary structure prediction using protein sequence.
10. Use of different protein structure prediction databases (SCOP & CATH).
11. Homology modelling of proteins in MODELLER.
12. Use of various primer designing and restriction site prediction tools.
13. Prediction of RNA secondary structure.
14. Use of tools for mutation and analysis of the energy minimization of protein structures.

Recommended Textbooks and References:

Text Books:

1. D.W. Mount *Bioinformatics: Genome and Sequence Analysis*: (2001) Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York.
2. Ian Korf, Mark & Josaph: *BLAST*, Oreilly Publisher, 2003
3. R. Durbin, S. Eddy, A. Krogh and G. Mitchison, *Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids.* Cambridge University Press.
4. J. Pevsner (2002) Bioinformatics and Functional Genomics; Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York.
5. A.D. Baxevanis & B.F.F. Oulette *Bioinformatics – A practical guide to the Analysis of Genes and Proteins*,2002, Willey International publishers.
6. M.J. Bishop and C.J. Rawlings (editors), *DNA and Protein Sequence Analysis---A Practical Approach* IRL Press at Oxford University Press, ISBN 0 19 963464 7 (Pbk)
7. Lesk, A. M. (2002). *Introduction to Bioinformatics*. Oxford: Oxford University Press.
8. J. Pevsner (2002) Bioinformatics and Functional Genomics; Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York.

RECOMBINANT DNA TECHNOLOGY LAB COURSE CODE: 18MS7BT373 L-T-P: 0-0-4 CREDITS: 2	**Course Objectives** The objectives of this course are to provide students with experimental knowledge and hands-on skills of methods and techniques for recombinant DNA technology and molecular cloning.	**Students Learning outcomes** Students should be able to gain hands-on experience in recombinant DNA technology techniques of gene cloning, protein expression. This experience would enable them to begin a career in industry that engages in genetic engineering as well as in research laboratories conducting fundamental research.

Syllabus:

1. Preparation of stock buffers (TBE, TAE, TE) and Agarose gel electrophoresis
2. Plasmid DNA isolation and DNA quantitation
3. Extraction of DNA from gel
4. In vitro amplification of DNA fragment by Polymerase Chain Reaction
5. Designing of Primers and PCR cycle for given DNA sequence and analysis by Gradient PCR
6. Restriction Enzyme digestion of plasmid DNA (Blunt & Cohesive)
7. Vector and Insert Ligation (Using T_4 DNA ligase)
8. Preparation of competent cells by $CaCl_2$ treatment
9. Transformation of *E. coli* with standard plasmids, Calculation of transformation efficiency
10. Electroporation of plasmid DNA into mycobacterial cells
11. Confirmation of the insert by Colony PCR and Restriction mapping
12. Expression of recombinant protein, concept of soluble proteins and inclusion body formation in *E. coli*
13. SDS-PAGE analysis of proteins
14. Plating of Bacteriophage

Recommended Textbooks and References:

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

ENVIRONMENTAL MICROBIOLOGY **COURSE CODE: 21MS1MB311** **L-T-P: 3-0-0** **CREDITS: 3**	**Course Objectives** To acquaint the students with the development and techniques of environmental microbiology useful in industry. Scientific evaluation of various characteristics.	**Students Learning outcomes** Students should be able to: ▪ Acquire the principles of Microbiology and fundamental concepts related to environmental safety and protection. ▪ Scientifically basic bioremediation techniques and their application in the environment. ▪ Analyze and interpret role of microbes as biofertilizers and biopesticides in agriculture field ▪ Designate vital role of the microbes in the environment and their association with human beings. Monitoring the environmental pollutants and their treatment using specific microorganisms.

Syllabus:

Unit	Topics Covered
Unit 1: Introduction to Environmental Microbiology 4 lectures	Introduction, history and scope of Environmental Microbiology. Role of microorganisms in waste management (domestic, industrial, hazardous) and pollution indicators strain improvement; Microbial biodiversity and its conservation; microbial energy metabolism, microbial growth kinetics and elementary chemostat theory, relevant microbiological processes, microbial ecology
Unit 2: Principles of Bioremediation 6 lectures	Bioremediation: Fundamentals, methods and strategiesof application (bio stimulation, bioaugmentation) – examples, Bioremediation of metals (Cr, As, Se, Hg), radionuclide (U, Te), organic pollutants (PAHs, PCBs, Pesticides, TNT etc.), technological aspects of bioremediation (*in situ*, *ex situ*)
Unit 3: Role of microorganisms in pollution control and bioremediation 7 lectures	Application of bacteria and fungi in bioremediation: White rot fungi vs. specialized degrading bacteria: examples, uses and advantages vs. disadvantages; Phytoremediation: Fundamentals and description of major methods of application (phytoaccumulation, phytovolatilization, Phytodegradation, Rhizofiltration, Phyto stabilization).

Unit 4: Microorganism in agriculture and crop protection 7 lectures	Bioinsecticides: *Bacillus thuringiensis*, Baculoviruses, uses, genetic modifications and aspects of safety in their use; Biofungicides: Description of mode of actions and mechanisms(e.g. *Trichoderma*, *Pseudomonas fluorescens*); Biofertilizers: Symbiotic systems between plants– microorganisms (nitrogen fixing symbiosis, Mycorrhiza fungi symbiosis), Plant growth promoting rhizobacteria (PGPR) – uses, practical aspects and problems in application.
Unit 5: Microorganisms in Biofuels and bioenergy generation 7 lectures	Environmental microbiology and biofuels: biogas; bioethanol; biodiesel; biohydrogen; Description of the industrial processes involved, microorganisms and biotechnological interventions for optimization of production; Microbiologically enhanced oil recovery (MEOR);Bioleaching of metals; Production of bioplastics; Production of biosurfactants: bioemulsifiers; Paper production: use of xylanases and white rot fungi.
Unit 6: Microorganism in Bioconversions and sustainable products synthesis 5 lectures	Modeling and economics of bioconversion of biomass (agriculture, poultry, waste food) to fuels, liquid and gaseous biofuels production, Bio adhesives, Biopolymers, Bio lubricants, Bio plastics, fibers and paper.
Unit 7:Detection of Pollutants and Environmental Monitoring: 6 lectures	Bio-Indicators or Biomarkers, Biosensors for Environmental Monitoring. Toxicity screening of samples using bioluminescence or fluorescence, Water quality monitoring, Atmospheric quality bio-monitoring, and soil-contamination bio-monitoring.

Recommended Textbooks and References:

1. Zeynep. A, (2018) Biosensors and nanotechnology: applications in health care diagnostics, Wiley.
2. Prickril, B and Rasooly, A, (2017) Biosensors and Biodetection: methods and protocol Electrochemical, Bioelectronic, Piezoelectric, Cellular and Molecular Biosensors, Human Press-Springer Protocol.
3. Yoon, J. Y, (2016) Introduction to Biosensors: From Electric Circuits to Immunosensors, Springer Nature
4. Turner A.P.F, Karube I and Wilson G.S, (1987) Biosensors- Fundamentals and applications, Oxford Univ. Press.
5. Yang V.C. and T.T.Ngo, (2000) Biosensors and their Applications, Academic/Plenum Publishers.
6. Ashok Mulchandani and Kim R Rogers, (1998) Enzyme and Microbial bio sensors: Techniques and Protocols, Humana Press Totowa, NJ.
7. Turner A.P.F and Wilsons G.S, (1997) Biosensors: Fundamentals and Applications, Oxford Science Publications

DIAGNOSTIC MICROBIOLOGY AND VACCINES COURSE CODE: 21MS1MB312 L-T-P: 3-0-0 CREDITS: 3	**Course Objectives** To familiarize the students with the principles & applications of the latest state-of-the-art microbial diagnostic techniques/ technology used in laboratories the world over and knowledge of vaccines against diverse microbial pathogens with current research in the domains. .	**Students Learning outcomes** ▪ Students should be able to: Learn and analyze what DNA based and molecular approaches and methodology should be used for diagnostic purpose in different settings, their comparative advantages and limitations. ▪ Identify and analyze what antigen - antibody based approach and methodology should be used for diagnostic purpose in different settings, their comparative advantages and limitations. ▪ The students would have in-depth knowledge of microscopy based methods and antimicrobial susceptibility and its application in the industry for diagnostics. ▪ The students would have in-depth knowledge of various vaccines against human pathogens along with immune response and technology used for the delivery of vaccines.

Syllabus:

Unit	Topics Covered
Unit 1: Immunological and Histochemical Diagnostics 8 lectures	Application of immunological principles, Antibody generation, Detection of molecules using ELISA, RIA, western blot, immune precipitation, flowcytometry and immunofluorescence microscopy, detection of molecules in living cells, in situ localization by techniques such as FISH and GISH.
Unit 2: DNA Diagnostics and mutation analysis of Microbes 7 lectures	Amplification by PCR (Inverse PCR, Multiplex PCR, Nested PCR, Hot-start, *In situ* PCR, applications and limitations). DNA fingerprinting and polymorphism studies (SNP, RAPD, RFLP, AFLP, Mutation detection etc). Emphasis on analysis and interpretation of results.
Unit 3: Microscopic techniques: 3 lectures	Visualization of cells and subcellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells, scanning and transmission microscopes, different fixation and staining techniques for EM.

Unit 4: Molecular Diagnostics 6 lectures	DNA sequencing methods, strategies for genome sequencing. Methods for analysis of gene expression at RNA and protein level, expression analysis such as micro array based techniques. Real Time PCR. Molecular approaches to diagnosis and strain identification. Biosensors – types, applications, examples (glucose etc), telemedicine.
Unit 5: Detection and identity of microbial diseases, antimicrobial susceptibility testing 4 lectures	Direct detection and identification of pathogenic-organisms that are slow growing or currently lacking a system of *in vitro* cultivation. Antimicrobial Susceptibility Testing – concept, KB Method. Laboratory methodologies for bacterial antimicrobial disk diffusion, tube dilution, microbroth dilution methods.
Unit 6: Concept and Types of vaccines and delivery systems 4 lectures	Vaccines, primary and secondary immune response. Types of vaccines - sub-unit vaccines, recombinant vaccines, synthetic vaccines, idiotypic based - vaccines, edible vaccines, DNA vaccines, glycoconjugate vaccines, deletion vaccines. Vaccine delivery system and approaches to enhance immunogenicity, delivery of particulate antigens through liposomes, microspheres etc.
Unit 7: Examples of Vaccines against Microbes 10 lectures	Rabies vaccines, PPRV vaccines, Chimeric vaccines – JEV/West Nile, Meningococcal conjugate &protein-based vaccines, Oral B subunit + whole cell cholera vaccine, Multicellular Parasite vaccines, Malaria vaccine, Novel Vaccines against Mycobacterium tuberculosis.

Recommended Textbooks and References:

1. Burtis, Carl A, Ashwood, Edward R, Bruns, David E., "Tietz textbook of Clinical Chemistry & Molecular Diagnostics" USA: Saunders, 2006.
2. World Organization for Animal Health: "Manual of Diagnostic Tests and Vaccines for Terrestrial Animals" Volumes I & II, 6th Edition, 2010.
3. Rao, Juluri R, Fleming, Colin C., Moore, John E., "Molecular Diagnostics: current technology and Applications", Horizon Bioscience, U. K., 2006.
4. Goldsby, Richard A., Kuby, Janis, "Immunology", New York: WH Freeman and Company, 2003.

Mahon, Connie R. ; Lehman, Donald C. ; Manuselis, George "Textbook of Diagnostic Microbiology". USA: Saunders, 2007.

Campbell, A. M., &Heyer, L. J. (2006). Discovering Genomics, Proteomics, and Bioinformatics. San Francisc

FOOD & DAIRY MICROBIOLOGY **COURSE CODE: 21MS1MB411** **L-T-P: 3-0-0** **CREDITS: 3**	**Course Objectives** To understand the concepts of technology and safety issues of food and dairy microbiology	**Students Learning outcomes** Students should be able to learn: ▪ Basic understanding food and Dairy Microbiology ▪ Microorganism relevant in food and dairy, their significant and detection ▪ Food Preservation and safety issues ▪ Food fermentation, production technologies of selected products ▪ Starter cultures in dairy food products and production technologies of selected dairy products

Syllabus:

Unit	Topics Covered
Unit 1: Introduction, Sources of contamination and Hygienic food production practices 8 lectures	Food Microbiology; origin, subfields, scope and frontier areas, Dairy Microbiology; origin, subfields and scope, Sources of microbial contamination in foods and dairy products, and hygienic practices in food and milk production
Unit 2 Micro flora of Food and dairy and Detection of microorganisms in Food 8 lectures	Microflora of foods and dairy products and their significance, Sampling procedures of food for microbial detection, Quantitative method for microbial enumeration in food, Qualitative methods, Tests for bacterial toxin, Rapid detection tests Bacteriological Examination milk
Unit 3: Food Preservation and Packaging & Food Safety Issues 8 lectures	Food Spoilage; Survival of spoilage organisms, Traditional and advanced preservation methods, Food packaging , Packaging material, Advanced and innovative packaging technologies, Food safety; GAP, GMP, HACCP, TQM relevant to food production

UNIT 4: Food fermentation, Fermented Foods, Bread Fermentation and Alcoholic beverages 10 lectures	Food Fermentation, Types of fermentation, Types of substrates Benefit of fermentation - nutritive value of fermented food, Production technologies of some fermented foods: Sauerkraut, Soya based fermented products, Traditional fermented foods: Idli, dosa etc., Baker's yeast importance in bread fermentation, production technology of bread, Production of beer, wine and vinegar etc
Unit 5: Starter culture Technology and Fermented dairy products 8 lectures	Definition, types, propagation of starter cultures, Quality and activity of starter, factors affecting quality of starters, defects, Preservation of starter cultures. Production technology of selected Fermented dairy products; Cheese, Yoghurt, Cultured milk, sour cream etc

Recommended Textbooks and References:

1. Frazier W.C. and Westhoff D.C. (2008) Food Microbiology, 4th Edn. Tata McGraw Hill Publishing Co., New Delhi.
2. Fundamental of Food Microbiology, Bibek Ray 3rd Edition, CRC Press
3. Bamforth C.W. (2005) Food, Fermentation and Microorganisms, Blackwell Science.
4. Principles of Fermentation Technology 3rd Edition Peter Stanbury Allan Whitaker Stephen Hall Fundamentals of Food Biotechnology Byong H. Lee John Wiley and Sons
5. Food Microbiology M. R. Adams and M. O. Moss
6. Fundamental Dairy Microbiology Prajapati, J.B.
7. Doyle M.P. and Buchanan R.L. (Ed.) (2013) Food Microbiology: Fundamentals and Frontiers, 4th Edn. ASM press.
8. Jay J.M., Loessner M.J. and Golden D.A. (2005) Modern Food Microbiology, 7th Edn. Springer Publishers.
9. Robinson R.K. (2002) Dairy Microbiology: Milk and Milk Products, 3rd Edn. Wiley Publishers.
10. Biochemistry Stryer 7thEditionBiochemistry by Berg JM, Tymoczko JL, and Stryer L, published by W.H. Freeman and Company
11. Microbiology 5th edition E.C.S. Chan, Michael J. Pelczar, Jr., Noel R. Krieg
12. Lehninger Principles of Biochemistry, 5thEdition David L. Nelson and Michael M Cox.
13. Prescott's microbiology Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., and Willey, J. M. (2011). New York, McGraw-Hill.
14. Microbiology: An Introduction 12thEdition Gerard J. Tortora, Berdell R. Funke and Christine L. Case

PLANT AND AGRICULTURAL MICROBIOLOGY COURSE CODE: 21MS1MB412 L-T-P: 3-0-0 CREDITS: 3	**Course Objectives** Objective of this course is to make students aware about beneficial and harmful activities of microorganism which are significant to plant health and agriculture	**Students Learning outcomes** ▪ Understand the role of microbes in agriculture ▪ Learners will gain detailed idea on, harmful or beneficial effects of microorganisms on Agriculture ▪ Understand plant microbe interactions ▪ Understand general principles of plant disease management ▪ To understand infection process and control measures of important plant diseases.

Syllabus:

Unit	Topics Covered
Unit I: Concepts and scope of agricultural microbiology 3 lectures	Concepts and scope of agricultural microbiology, importance of microorganisms in agriculture
Unit II: Soil Microbiology Soil microorganisms 10 lectures	Distribution of microorganisms in soil, quantitative and qualitative estimation of microorganisms in soil, Decomposition of organic matter and soil health. Nitrogen cycle, nitrogen fixation, symbiotic, non-symbiotic, associative organisms, ammonification, nitrification, denitrification, reactions, Microbial transformations of phosphorus, sulphur and minor nutrients. Biofertilizers and their applications in agriculture.
Unit III: Plant Microbe interactions and General Principle of Disease management 10 lectures	Different types of Plant Microbe interactions, Chemical nature and classification of fungicides and antibiotics: Spraying and dusting equipment, their care and maintenance. Important cultural practices and their role in disease management, solarization, integrated disease management.
Unit IV: Fungal Diseases of Crop Plants 10 lectures	Important Fungal diseases of selected crops with special reference to etiology, disease cycle, perpetuation, epidemiology and management.

Unit V: Bacterial and Viral Diseases of Crop Plants 9 lectures	Bacterial and Viral Diseases of selected Crop Plants: Etiology, disease cycle, perpetuation, epidemiology and management.

Recommended Textbooks and References:

1. Introduction to Soil Microbiology, Wiley eastern Ltd., New Delhi
2. Agricultural Microbiology, D.J. Bagyaraj, G. Rangaswami, 2007 PHI learning Pvt. Ltd.
3. Plant Pathology by George Agrios 5th Edition, 2020
4. Agricultural Microbiology by N. S. Subba Rao 3rd Edition, 2020

IPR BIOSAFETY AND BIOETHICS COURSE CODE: 21MS2MB311 L-T-P: 3-0-0 CREDITS: 3	**Course Objectives** To provide basic knowledge about intellectual property rights, regulations and registrations. To provide insight about biosafety and bioethical issues associated in biological sciences.	**Students Learning outcomes** ▪ To enable students with basic concepts and knowledge of intellectual property rights. ▪ Understand the rationale for and against IPR at national and international level. ▪ Understand different types of intellectual property rights in general and protection of products derived from biotechnology research and issues related to application and obtaining intellectual properties. ▪ Gain knowledge of biosafety and risk assessment of products derived from recombinant DNA research and environmental release of genetically modified organisms, national and international regulations; ▪ Analyze and able to handle the ethical aspects related to biological, microbiological and biotechnology research.

Syllabus:

Unit	Topics Covered
Unit 1: Introduction of different tools of IPR 3 lectures	Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs. Protection and registration.
Unit 2: History and International Agreements of IP 4 lectures	International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies. Introduction to history of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; concept of 'prior art': invention in context of "prior art".
Unit3: IPR/Patent databases 3 lectures	Patent databases - country-wise patent searches (USPTO, EPO, India); analysis and report formation

UNIT4 : Patent: Drafting and Filing Procedures 5 lectures	Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application; role of a Country Patent Office; filing of a patent application; precautions before patenting-disclosure/non-disclosure - patent application- forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications
UNIT5: International Treaties 2 lectures	International IP treaties (Madrid Agreement, Trademark law treaty, Patent Law treaty etc.)WIPO, WTO, and TRIPS. International agreement; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications
UNIT6:Commercilaization of IPR 4 lectures	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. Patent infringement- meaning, scope, litigation, case studies and examples.
UNIT 7:Biosafety and Biosecurity 6 lectures	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;
UNIT8: Safety Mitigation 4 lectures	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 products derived from RNAi, genome editing tools
UNIT9: International regulations and Guidelines 5 lectures	International regulations – Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; Draft bill of Biotechnology Regulatory authority of India - containments – biosafety levels and category of rDNA experiments; field trails – biosafety research trials – standard operating procedures - guidelines of state governments; GM labeling – Food Safety and Standards Authority of India (FSSAI).

Unit 10:Bioethics principles and tools 6 lectures	Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. Bioethics in research – cloning and stem cell research, Human, animal and microbial experimentation, rights/welfare, Agricultural /environmental microbiology - Genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations - Protection of environment and biodiversity – biopiracy

Recommended Textbooks and References:

1. IPR- A primer by R. Anita Rao and Bhanoji Rao
2. Bioethics and Biosafety by M K Sateesh
3. Patent Search: Tools and Techniques- David Hunt
4. Intellectual Property Rights by NS Rathore, SM Mathur, Priti Mathur and Ansul Rathi
5. Ganguli, P. (2001). *Intellectual Property Rights: Unleashing the Knowledge Economy.* New Delhi: Tata McGraw-Hill Pub.
6. *National IPR Policy*, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI *Complete Reference to Intellectual Property Rights Laws*. (2007).
7. *Case Studies of Policy Challenges from New Technologies*, MIT Press

BIOSENSORS: PRINCIPLES AND APPLICATIONS **COURSE CODE: 21MS2MB312** **L-T-P: 3-0-0** **CREDITS: 3**	**Course Objectives** The course aims at providing a general and broad introduction to multi-disciplinary field of Biosensor technology	**Students Learning outcomes** ▪ On successful completion of this course, students should be able to understand the clinical and non-clinical uses of biosensors as well as the concepts behind the reagent less biosensors development. ▪ It will familiarize students with the concept of molecular reorganization for biosensor development.: Types, characteristics, operating condition and applications ▪ The course will also give an insight into complete systems where biosensor can be used to improve our everyday life.

Syllabus:

Unit	Topics Covered
Unit 1: Introduction 6 lectures	Overview of biosensor and applications: medicine, agriculture, bio-production, and environment, Desired characteristics of biosensors: reliability, simplicity, cost, and related parameters, Application notes: operating conditions, calibration, positive and negative controls, safety.
Unit 2: Principle of molecular recognition 4 lectures	Molecular reorganization: Enzymes, Antibodies and DNA, Modification of bio recognition molecules for Selectivity and sensitivity, Fundamentals of surfaces and interfaces.
Unit 3: Types of Biosensors 10 lectures	Optical sensors-colorimetric/ fluorimetric/ luminometric sensors, Surface Plasmon Resonance (SPR) sensors, Electrochemical Sensors, Potentiometric Electrodes, Amperometric Electrodes, Conductometric Measurement. Bioluminescence biosensors, Microbial biosensors, Affinity biosensors, Immunosensors.
Unit 4: Biosensors for Clinical Analysis 4 lectures	Biosensors for personal diabetes management (Glucose, Galactose, Sensors) Noninvasive Biosensors in Clinical analysis and health care

Unit 4: Non-Clinical Applications of Biosensors 6 lectures	Applications in Agriculture, Food production, Environmental control and pollution monitoring.
Unit 5: Reagent less Biosensors 6 lectures	Reagent less Immunoelectrodes, biomolecule conformational modulated effects, Biosensors based on DNA conformation changes, Biosensors based on protein conformation changes
Unit 6: Applications of Nanomaterials in Biosensors 6 lectures	Nano-Materials in biosensors; Carbon based Nano Material, Metal oxide and nano particle, Quantum dots, Role of nano material in Signal Amplifications, Detection and Transducer Fabrication.

Recommended Textbooks and References:

1. Zeynep. A, (2018) Biosensors and nanotechnology: applications in health care diagnostics, Wiley.
2. Prickril, B and Rasooly, A, (2017) Biosensors and Biodetection: methods and protocol Electrochemical, Bioelectronic, Piezoelectric, Cellular and Molecular Biosensors, Human Press-Springer Protocol.
3. Yoon, J. Y, (2016) Introduction to Biosensors: From Electric Circuits to Immunosensors, Springer Nature
4. Turner A.P.F, Karube I and Wilson G.S, (1987) Biosensors- Fundamentals and applications, Oxford Univ.Press.
5. Yang V.C. and T.T.Ngo, (2000) Biosensors and their Applications, Academic/Plenum Publishers.
6. Ashok Mulchandani and Kim R Rogers, (1998) Enzyme and Microbial bio sensors: Techniques and Protocols, Humana Press Totowa, NJ.
7. Turner A.P.F and Wilsons G.S, (1997) Biosensors: Fundamentals and Applications, Oxford Science Publications.

MICROBIAL TOXICOLOGY COURSE CODE: 23MS2MB311 L-T-P: 3-0-0 CREDITS: 3	**Course Objectives** To acquaint the students with the various toxin, their mechanism for toxicity and impact on human health. Scientific evaluation of various characteristics of toxin producing microorganisms, especially bacteria and fungi.	**Students Learning outcomes** Students should be able to: ▪ Acquire the fundamental concepts toxin producing microbes and their impact on human health ▪ Scientifically knowledge on structure-function of toxin ▪ Analyze and interpret the mechanism of toxicity to human cells ▪ Various diseases related to toxins ▪ Methods to detect toxins.

Syllabus:

Unit	Topics Covered
Unit I Introduction to toxins and toxicology 2 lectures	Introduction to toxins A brief history of toxicology, Dose–response relationships Sources of toxic compounds, Movement of toxicants in the environment Exotoxin and Endotoxins
Unit II: Bacterial toxin 8 lectures	Bacillus Toxins- Anthrax Toxins: A Presentation, Toxin Entry, Lethal Toxin Cell Targets, Edema Toxin Cell Targets, Anthrax Toxin Effects During Infection: Critical Virulence Factors Anthrax Toxin Effects at the Early Stage: Immune System Paralysis, Anthrax Toxin Effect at the Late Stage: Host Killer, Burkholderia Toxins- Severity of Potential Soil Pathogens, Clinical Implications of Bacterial Exotoxin, structure Activity Relationship of Bacterial Toxins, Effect of Exotoxin (CLT) on Pathogenicity, Culture and Infection of Invasive Rodent Models, Effect of Exotoxin (CLT) on Virulence, Secretion of Bacterial Molecules Responsible for Virulence, Toxins Modulating the Mechanism of Action and Cellular Signaling, *Clostridium* Toxins- Introduction: *Clostridium perfringens*, Its Toxins, and Disease, Toxin Plasmids: Expression and Regulation, ETX Mechanism of Action with an Overview of Animal and Cell Culture Studies, Evidence for ETX Neurotoxicity and Emerging Links with Multiple Sclerosis. Prospects for Developing Vaccines and Therapeutics. Spore forming Bacteria and Their Binary Enterotoxins

Unit III: Bacterial toxin 8 lectures	*Escherichia* Toxins- Introduction, Shiga Toxins; Genes, Proteins, and the Mechanism of Toxicity, Environmental, Gut, and Bacterial Growth Conditions. Enterotoxigenic *Escherichia coli*. STb (heat-stable toxin b) Toxin. Helicobacter Toxins- Introduction, *H. pylori* CagA Structure and Activities on Host Cells, Evidence of the Role of H. pylori CagA in Gastric Cancer. Listeria Toxins- Introduction, Listeriolysin O, Effects of LLO in the Host Organism, phospholipase, Listeriolysin S- Virulence at the Organism Level, and activity at the Cellular Level.
Unit IV: MYCOTOXINS AND MYCOTOXICOSIS 12 lectures	Introduction to *Aspergillus* Mycotoxin- Afaltoxin, Ochratoxin Introduction, Fusarium Mycotoxin- Zearalenone, Fumonisins, *Trcicothecens* mycotoxin. Most significant mycotoxins and mycotoxicosis in human and Animals- Afaltoxin B1, Ochratoxin A, Zearalenone, Fumonisins B1, Trcicothecens mycotoxin, Patulin, Vomitoxin or deoxynivalenol, T-2 toxin, Diacetoxyscirpenol, Monoacetoxyscirpenol, Diacetoxyscirpenol, Triacetoxyscirpenol, Escirpentril. Prevention, decontamination, detoxification and inactivation strategies.
Unit V: Method for Toxins detection 6 lectures	Detection of Bacterial Protein Toxins by Solid Phase Magnetic Immunocapture and Mass Spectrometry, Molecular Methods: Chip Assay and Quantitative Real-Time PCR: In Detecting Hepatotoxic Cyanobacteria, Sensitive and Rapid Detection of Cholera Toxin-Producing, Ultrasensitive Detection of Botulinum Neurotoxins and Anthrax Lethal Factor in Biological Samples by ALISSA Determination of Aflatoxins B1, B2, G1, and G2in Foods and Feed Materials
Unit VI: Toxicity of Heavy Metals to Microorganisms 6 lectures	Factors Affecting Microbial Remediation of Heavy Metals. Mechanism of Microbial Detoxification of Heavy Metal- Bio sorption Mechanism, Intracellular Sequestration, Intracellular Sequestration, extracellular Barrier of Preventing Metal Entry into Microbial Cell, Methylation of Metals, Reduction of heavy metals ions by microbial cells. Bioremediation Capacity of Microorganisms on Heavy Metals- Bacteria Remediation Capacity of Heavy Metal.

Recommended Textbooks and References:

2. Microbial Toxins: EditorsBrad Stiles, Alberto Alape-Girón, J. Daniel Dubreuil, Manas Mandal. Springer-Science Business Media B. V, 2018
3. Mycotoxins and mycotoxicosis in Animals and hman: Editors Alberto Gimeno and Maria Ligia Martins. Special Nutrients Inc., 2003
4. A Textbook of Modern Toxicology. Editors: Ernet Hodgson Wiley Publication, 2010

PROTEIN ENGINEERING **COURSE CODE: 21MS2MB314** **L-T-P: 3-0-0** **CREDITS: 3**	**Course Objectives** To introduce methods and strategies commonly used in protein engineering.	**Students Learning outcomes** Students should be able to: ▪ Understand the principles of protein engineering and different properties of the proteins for modification; ▪ Describe structure and classification of proteins; ▪ Analyze the structural and conformational changes using different spectroscopic techniques; ▪ Describe and use various approaches of protein engineering for modifying the proteins; ▪ Use of computational tools for protein engineering; ▪ Industrial applications of protein engineering with suitable case studies

Syllabus:

Unit	Topics Covered
Unit 1: Introduction to protein engineering 6 lectures	Protein engineering – definition, applications; Features or characteristics of proteins that can be engineered (definition and methods of study) – affinity and specificity; Spectroscopic properties; Stability to changes in parameters as pH, temperature and amino acid sequence, aggregation propensities, etc. Protein engineering with unnatural amino acids and its applications.
Unit 2: Protein structure and Folding 4 lectures	Protein Structure – Primary, Secondary, Tertiary and Quaternary Structure, Ramachandran Plot, Protein folding, Protein function and structure-function relationship
Unit 3: Structural Characterization of Proteins 8 lectures	Structural characterization of proteins, an overview of spectroscopic techniques for the analysis of protein secondary and tertiary structure (UV and near-UV CD; Fluorescence; UV absorbance; ORD), An overview of techniques for analysis of protein quaternary structure (X-Ray Crystallography, NMR Spectroscopy).
Unit 4: Approaches and Methodology for Protein engineering 12 lectures	Forces stabilizing proteins – Van der Waals, electrostatic, hydrogen bonding and weakly polar interactions, hydrophobic effects, Protein engineering approaches (Directed Evolution, Rational, Semi-rational), advantages and limitations. Rational design, prediction of the structure of enzyme variant, evaluation of the effect of mutations on enzyme structure and function. Directed evolution: Error-prone PCR, Cassette mutagenesis, Site-saturation mutagenesis, DNA shuffling, StEP, RACHITT, RETT, SHIPREC, SCRATCHY.

	Screening and selection of mutants
Unit 5: Computational approaches 4 lectures	Computational approaches to protein engineering: sequence and 3D structure analysis, Data mining, Ramachandran map, Protein design, Directed evolution for protein engineering and its potential.
Unit 6: Case Studies and Examples 8 lectures	Examples of application of protein engineering to improve enzyme catalytic efficiency, stability and enantioselectivity. Engineering of Enzymes: Asparaginase, tyrosyl-tRNA synthase, Engineering of Hormones: Insulin; Engineering blood clotting factors: Factor VIII; Engineering humanized Antibodies

Recommended Textbooks and References:

1 .Ed. T E Creighton, (1997), *Protein Structure: a Practical Approach*, 2nd Edition, Oxford university press.

2. Cleland and Craik, (2006), *Protein Engineering, Principles and Practice*, Vol 7, Springer Netherlands.

3. Arndt and Mueller, *Protein Engineering Protocols*, 1st Edition, Humana Press.

4. Ed. D E Robertson and J P Noel, (2004), *Protein Engineering Methods in Enzymology*, 388, Elsevier Academic Press.

5. Ed. Stefan Lutz and Uwe Bornscheuer, (2008), *Protein engineering handbook*. Wiley-VCH.

6. Ed. Frances Hamilton Arnold - George Georgiou, (2003), *Directed evolution library creation: methods and protocols*. Humana Press.

7. J Kyte, (2006), *Structure in Protein Chemistry*, 2nd Edition, Garland publishers.

COMPUTATIONAL SYSTEMS BIOLOGY COURSE CODE: 23MS2MB411 L-T-P: 3-0-0 CREDITS: 3	**Course Objectives** To enable students to understand, predict and ultimately control functionalities of complex biological systems.	**Students Learning outcomes** Students should be able to: ▪ The students will understand the holistic approaches of systems biology - combining acquisition, integration and management of experimental data with computer modeling and simulation. ▪ They will learn the designing Biocircuits to model the complex biological systems. ▪ They will also learn the engineering aspects of controlling biological network parameters.

Syllabus:

Unit	Topics Covered
Unit 1: Introduction to Systems biology and various network types 7 lectures	An introduction to Systems biology. A paradigm shift from components biology to systems biology. System and its properties. Types of biological networks and their respective characteristics. Comparison of bioinformatics, and other similar streams with systems biology and its progression and evolution towards synthetic biology.
Unit 2: Gene regulatory networks and simulation analysis 7 lectures	Basic characteristics of gene regulatory networks, Computational representations and modelling methods of GRN/TRN biological Systems. LAC operon and GAL regulon models, Biocircuit designs and Petri nets.
Unit 3: Characteristics of Protein-protein interactions and signal transduction networks 7 lectures	Basics of Protein-protein interactions (PPI) along with experimental and computational models. PPI networks. Signal Transduction Networks and Pathways, their biological characteristics and applications.
Unit 4: Detailed introduction of metabolic networks along with FBA 6 lectures	Basics of Metabolic pathways and Networks, Mass/Flux Balance Analysis (FBA). Stoichiometry matrix and analysis of pathways. Characteristics and applications of metabolic pathways.
Unit 5: Markup Languages used for the Systems biology model reconstructions 6 lectures	Introduction to HTML and XML. XML implementation towards Bioinformatics and systems biology: BioXML, SBML, CellML and their practical applications towards modeling and simulations of biological systems.

Unit 6: Introduction of various systems biology tools and databases 5 lectures	Interaction Networks, Online and offline tools and databases for SYSTEMS BIOLOGY- STRING, BIND, MINT, IPATH, Cytoscape, GeneGo, Gypasi, MetaCYC etc.
Unit 7: Introduction of Virtual cell, E-cell and other bio-electronic projects with case studies 4 lectures	Virtual cell, E-Cell and other bio-electronic projects and their respective applications in real life situations. Stem cell and vaccine based systems biology projects.

Recommended Textbooks and References:

1. Eberhard O. Voit, Systems Biology: A Very Short Introduction, 2020, Oxford University Press, ISBN: 9780198828372
2. Eberhard O. Voit, A First Course in Systems Biology, 2018, Routledge & CRC Press, ISBN 9780815345688
3. A.J. Marian Walhout, Marc Vidal and Job Dekker, Handbook of Systems Biology, 2013, Elsevier, ISBN- 9780123859440
4. B.O. Palsson, Systems biology properties of reconstructed networks, 2006, Cambridge university press, Cambridge, New York, ISBN:
5. Werner Dubitzky, Francisco Azuaje, Artificial Intelligence Methods and Tools For Systems Biology, 2004, Springer, ISBN 9781402028595
6. Seetharaman Vaidyanathan, George G. Harrigan, Royston Goodacre, Metabolome Analyses: Strategies for Systems Biology, 2005, Springer, ISBN 9780387252407
7. Z. Szallasi, J. Stelling, and V. Periwal, System Modeling in Cellular Biology: From Concepts to Nuts and Bolts, 2006, Cambridge, MA, USA: MIT Press

   L. Opresko, J. M. Gephart, and M. B. Mann, Advances in Systems Biology, Advances in Experimental Medicine and Biology Volume 547, 2002, ISBN: 1461346959

EXPERIMENTAL MODELS IN MICROBIAL RESEARCH **COURSE CODE: 21MS2MB412** **L-T-P: 3-0-0** **CREDITS: 3**	**Course Objectives** To impart knowledge about different experimental animal models respective to infectious diseases and its secondary effects.	**Students Learning outcomes** Students should be able to: ▪ Understand the basics of drugs and their mechanism of action. ▪ Selection and handling of experimental animals for microbial research ▪ Develop and evaluate experimental animal models for respective diseases ▪ Analyze and interpret experimental data

Syllabus:

Unit I: Drugs & Microbes 4 lectures	Introduction to antimicrobial agents. Anti-fungal agents, anti-viral agents, anti-protozoal agents, etc.
Unit II: Experimental Models Organisms 4 lectures	Introduction to some common model organisms such as *Caenorhabditis elegans,* Silkworm (*B. mori*), Fruit fly (*D. melanogaster*), Zebrafish (*D. rerio*), Mouse (*M. musculus*), Rat, Guinea pig, rabbit, etc.
Unit III: Regulation and handling of experimental animals 4 lectures	Techniques of blood collection in laboratory animals – Introduction, Animal welfare, Total blood volume, permanent cannulation, retro orbital puncture, cardiac puncture, etc., Anesthesia of experimental animals – Introduction, Local anesthesia, General anesthesia, routes of anesthesia, etc. Euthanasia of experimental animals – Introduction, Physical and Chemical method for euthanasia of animals. Ethical Concern and regulation of animal use.

Unit IV: Animal models in for microbial infection 6 lectures	Acute/chronic bacterial pneumonia models, Septicemia models, Skin and soft tissue infection models, Meningitis models, Urinary tract infections models, Animal models of infectious endocarditis, Animal models of intraperitoneal infection, etc.
Unit V: Animal Models of Viral Diseases 4 lectres	Introduction to viral diseases and Experimental models of some common Viral diseases such as Hepatitis, Dengue, Encephalitis, Influenza, SARS CoV, etc.
Unit VI: Animal Models of Fungal Infection 4 lectures	Overview of fungal infection and Animal models used to study fungal infections such as Candidiasis, Aspergillosis, Blastomycosis, Mucormycosis, Dermatophytoses, cryptococcosis, etc.
Unit VII: Miscellaneous models 8 lectures	Experimental study of tuberculosis, Animal models of chronic wound care, Animal models of Malaria, Leishmaniasis, Microbiome and Germ-Free – Animal Models for the study of GUT microflora, etc.
Unit VIII: **Experimental models for Functional assays** 8 lectures	Analgesic, anti-inflammatory, and anti-pyretic activity, Gastrointestinal tract –Ulcer, diarrhea, emesis, liver function, etc.Models of eye inflammation, Metabolic Disorder, Learning and memory, Respiratory activity, Immunomodulatory etc.

Recommended Textbooks and References:

1. Drug Discovery and Evaluation: Pharmacological Assays, edited by Hans Gerhard Vogel, 3rd Edition, 2008, Springer Publisher.
2. Kaito C, Murakami K, Imai L, Furuta K. Animal infection models using non-mammals. Microbiol Immunol. 2020 Sep;64(9):585-592. doi: 10.1111/1348-0421.12834
3. Loría-Cervera EN, Andrade-Narváez FJ. Animal models for the study of leishmaniasis immunology. Rev Inst Med Trop Sao Paulo. 2014 Jan-Feb; 56(1):1-11. doi: 10.1590/S0036-46652014000100001. PMID: 24553602; PMCID: PMC4085833.
4. Zhao M, Lepak AJ, Andes DR. Animal models in the pharmacokinetic/pharmacodynamic evaluation of antimicrobial agents. Bioorg Med Chem. 2016 Dec 15;24(24):6390-6400. doi: 10.1016/j.bmc.2016.11.008. Epub 2016 Nov 9. PMID: 27887963.

NANO-BIOTECHNOLOGY **COURSE CODE: 21MS2MB413** **L-T-P: 3-0-0** **CREDITS: 3**	**Course Objectives** The course aims at providing a general and broad introduction to multi-disciplinary field of nanotechnology.	**Students Learning outcomes:** ▪ On successful completion of this course, students should be able to describe basic science behind the properties of materials at nanometer scale, and the principles behind advanced experimental and analytical and microscopic techniques for studying nanomaterials. ▪ It will familiarize students with the combination of the top-down approach of nanomaterial synthesis and also give understanding of nanomaterial characterization. ▪ The course will also give an insight into complete systems where nanotechnology can be used to improve our everyday life.

Syllabus:

Unit	Topics Covered
Unit 1: Introduction to nanobiotechnology 6 lectures	Introduction to Nano-biotechnology; Concepts, historical perspective; Different formats of nanomaterial and applications with example for specific cases. Overview of current industrial applications.
Unit 2: Synthesis of nanomaterials 5 lectures	Method of preparation and properties of nanomaterial: Nanomaterial synthesis using top-down and bottom up approach. Physical Vapor Deposition, Chemical Vapor Deposition, Chemical Synthesis, Biological Synthesis.

Unit 3: Characterization of nanomaterial 7 lectures	Basic Characterization Technique, electron microscopy (TEM and SEM), Dynamic light Scattering (DLS), Atomic Force Microscopy (AFM), NMR(Nuclear magnetic Resonance) and X-ray diffractometer (XRD)
Unit 4: Nano – films 2 lectures	Thin films; Colloidal nanostructures; Self Assembly, Nanovesicles; Nanospheres; Nanocapsules and their characterization.
Unit 4: Nano – particles7 6 lectures	Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers.
Unit 5: Applications of nano – particles 6 lectures	Nanoparticles for diagnostics and imaging (theragnostic); concepts of smart stimuli responsive nanoparticles, implications in cancer therapy, nanodevices for biosensor development.
Unit 6: Nano – materials 5 lectures	Nanomaterials for catalysis, development and characterization of nanobiocatalysts, application of nanoscaffolds in synthesis, applications of nanobiocatalysis in the production of drugs and drug intermediates.
Unit 7: Nano – toxicity 5 lectures	Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment; Fate of nanomaterials in different strata of environment; Ecotoxicity models and assays; Life Cycle Assessment, containment.

Recommended Textbooks and References:

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

QC ANALYSIS AND MANAGEMENT **COURSE CODE: 21MS2MB414** **L-T-P: 3-0-0** **CREDITS 3**	**Course objective** The Objective of the course is to make acquaint of quality control techniques and process for routine analysis of various biotech and pharmaceutical products.	**Students Learning Outcomes** Student should be able to ▪ To understand concept of quality control & importance of quality control of various biotechnological products ▪ Able to design and prepare quality sheets for various process ▪ Able to learn quality control guidelines for maintaining various equipment and process used in biotech industry ▪ To be able to use quality tools to prepare process control chart ▪ They will learn design of QC laboratory for chemical, instrumental and microbiological analysis

Syllabus:

Unit	Topics Covered
Unit I **Quality management** 8 lectures	Evaluation of quality control, Quality Control & Quality Assurance, Using Quality Assurance for the Best Results; The Role of Inspection in Quality Control, Collecting Your Quality Data; Quality Models in business, Six Sigma Concept, Six Sigma tools, Continuous improvements and its applications, Lean concept for Process Improvements Ten Steps for Incorporating Quality into a New Product and/or Process; Quality Management: Practices, Tools, and Standards
Unit II Statistical quality control 8 lectures	Statistics Process control: control chart for variable and attributes, P charts C charts, Chebychew's in equations and normal distribution curve, Sampling plan and characteristics of OC curves,
Unit III **Quality control in biotech and pharma industry** 8 lectures	Quality Control techniques for routine analysis with HPLC: Quality control aspects of Pharmaceuticals and Food products, Quality control aspects of Bioactive natural products, QC Monoclonal antibody products QC rDNA products ,

Unit IV Quality control in biotech and pharma industry 10 lectures	Quality control laboratory: Design of QC laboratory for chemical, instrumental and microbiological analysis. Good Practices in QC laboratory, Schedule L1, standardization of reagents, labeling of reagents, control, Samples, controls on animal house, data generation and storage, QC documentation, LIMS Environmental monitoring, setting of limits and its evaluation. Control of contamination and cross contamination. Stability Studies, ICH Guidelines, WHO Guidelines Waste disposal, disposal procedures and records, current regulations for waste disposal Contract manufacturing and analysis
Unit V **Quality control of Raw material** 8 lectures	QA Lot release, non-conforming material review, failure review, QC Lot release testing –chemical assays & bioassays QC Raw material testing, in-process testing, validation support QA Audit procedures and vendor certification Handling out-of-specification results

Recommended Textbooks and References:

1. Fundamentals of Quality control and improvement by Ämitav Mitra A John Wiley & Sons, Inc., Publication, IV edition, 2016
2. Good Manufacturing Practices for Pharmaceuticals by Sidney H Willig, Marcel and Dekker
3. Quality Assurance in Environmental Monitoring by P. Quevauviller, Wiley VCH
4. Bioactive Natural Products: Quality Control & Standardization by V.K.Gupta, S.C. Taneja and B.D. Gupta, Studium Press LLC, U.S.A.